Final Weeks Bay Watershed Management Plan

November 2017

This Page Intentionally Left Blank

thompson
ENGINEERING

Weeks Bay Watershed Management Plan
Baldwin County, Alabama

Final – November 2017

Submitted to:

Mobile Bay National Estuary Program
118 North Royal Street, Suite 601
Mobile, AL 36602

Thompson Engineering Project No.: 16-1101-0012

Michael J. Eubanks
Project Manager

Stephen M. O'Hearn, P.G., LEED AP
Environmental Manager

2970 Cottage Hill Road, Ste. 190
Mobile, AL 36606
251.666.2443 ph. / 251.666.6422 fax
www.thompsonengineering.com

A THOMPSON HOLDINGS, INC. COMPANY

This Page Intentionally Left Blank

Acknowledgements

In recent years, the Mobile Bay National Estuary Program (MBNEP) has facilitated efforts to address problems and recommend solutions within the Mobile Bay estuarine system. Preparation of this Weeks Bay Watershed Management Plan (WBWMP) was made possible through the MBNEP and funding by the National Fish and Wildlife Foundation's (NFWF) Gulf Environmental Benefit Fund. The Baldwin County Soil and Water Conservation District (BCSWCD) provided management support for preparation of the WBWMP.

Thompson Engineering, Inc. was selected to organize and lead the work of its Consultant Team to prepare the WBWMP. Thompson Engineering personnel were responsible for evaluating problems in the Weeks Bay Watershed and developing conceptual management measures to address them; suggesting modifications to the regulatory framework guiding land use and development activities within the Watershed; and identifying possible funding sources to finance implementation of the management measures contained in the WMP. Other members of the Consultant Team included: (1) Higgins and Associates who led the public involvement phase; (2) Barry A. Vittor & Associates, Inc. who conducted the ecological evaluations; (3) Ecology and Environment, Inc. who performed the shoreline assessment and climate change/sea level rise analyses; (4) Dr. Latif Kalin who developed the Soil and Water Assessment Tool (SWAT) models for the Fish River and Magnolia River watersheds; and (5) Hand Arendall LLC who assisted in the review of the existing regulatory framework. Principal personnel from the Consultant Team who contributed to development of this WMP included: Mike Eubanks, Emery Baya, Steve O'Hearn, John Carlton, Mary Mekkers, Courtney Harkness, Christopher Grant, Caroline Garsed, Melissa Montgomery, Carl Pinyerd, Suzanne Sweetser, Cora Neely, and Phil McIntosh (Thompson Engineering); Bob Higgins (Higgins and Associates); Tim Thibaut and Barry A. Vittor (Barry A. Vittor & Associates); Scott Jackson and Doug Heatwole (Ecology and Environment Inc.); Latif Kalin (Auburn University); and Neil Johnston (Hand Arendall).

The Consultant Team would like to recognize the following individuals, organizations, and agencies that assisted in the conduct of various phases of work on the WMP. Roberta Swann, Christian Miller, Kelley Barfoot, Tiffany England, and Tom Herder of the MBNEP, along with Larry Morris with the BCSWCD, provided steady and consistent leadership in managing the contract. Special thanks to L.G. Adams, Mike Shelton, and Scott Phipps with the Weeks Bay National Estuarine Research Reserve for providing volumes of data on the Watershed, and to Rick Wallace and Yael Girard with the Weeks Bay Foundation for providing insights regarding strategic land acquisition and other environmental initiatives within the Watershed. In addition to those already named above in this paragraph, a big thanks to other members of the Weeks Bay WMP Stakeholders Working Group: Ronnie Northcutt (BCSWCD); Joey Koptis (NRCS); Shannon McGlynn and Randy Shaneyfelt (ADEM); Vince Calametti (ALDOT); Seth Peterson/Matthew Brown (Baldwin County); Mayor Dane Haygood (Daphne); Jennifer Fidler/Kim Burmeister (Fairhope); Miriam Boutwell (Foley); Brandon Allen/Scott Bankester (Loxley); Mayor Ken Underwood (Magnolia Springs); Bruce Porter (USFWS); Camilla English (Baldwin County Health Department); Heiko Einfeld (Eastern Shore Chamber of Commerce); Gerry McManus (Baldwin County Sewer Service); Michael Mullek and Joel Sirmon (agriculture); Tom Poulos, Joel Coleman, and Duane Miller (developers); and Sam Covert, Dick Sute, Steve Heath, and Teddy King (local homeowners/residents).

This Page Intentionally Left Blank

Executive Summary

ES.1 Introduction

A number of water quality and quantity issues have been documented within the Weeks Bay Watershed (WBW) over the past several decades. Population growth and urban development, as well as some agricultural practices, have continued to intensify problems in the Watershed's four principal Hydrologic Unit Code (HUC 12) subwatersheds (Upper Fish River, Middle Fish River, Lower Fish River, and Magnolia River). Since 1998, a number of stream segments in the WBW have been placed on Alabama's 303(d) list due to a variety of pollutants of concern. The WBW is a large area (approximately 130,000 acres), containing a large network of streams (approximately 362 miles) within central Baldwin County as shown on Figure ES.1. The Watershed includes all or portions of nine municipalities (Fairhope, Daphne, Spanish Fort, Loxley, Robertsdale, Silverhill, Summerdale, Foley, and Magnolia Springs) and associated unincorporated areas of Baldwin County. Increased volume and velocity of stormwater runoff, as well as some agricultural practices, have exacerbated concerns over water quality degradation, e.g., bacterial pollution, nutrient over-enrichment, and sedimentation within the Watershed. Flooding, particularly on the lower end of the Watershed, was one of the most concerns expressed by citizens. Flood control goals and stormwater treatment goals are often thought to be in opposition; the former concerned with removing water as quickly as possible, and the latter trying to slow release rates and/or volumes.

To respond to these concerns, the Mobile Bay National Estuary Program (MBNEP) and the Baldwin County Soil and Water Conservation District (BCSWCD) facilitated efforts to address the Weeks Bay Watershed problems. This involved award of a contract in January 2016 to Thompson Engineering, Inc. (Thompson), along with sub-consultants Ecology and Environment, Inc. (E&E), Barry A. Vittor and Associates, Inc. (BVA), Bob Higgins and Associates, Hand-Arendall LLC, and Dr. Latif Kalin of Auburn University for preparation of a comprehensive Weeks Bay Watershed Management Plan (WMP).

Development of the WMP has been guided by the goals, objectives, and expectations contained in the MBNEP's 2013 – 2018 Comprehensive Conservation and Management Plan (CCMP) with a view towards the six things that coastal residents most value (water quality, fish and wildlife, environmental health and resilience, access, culture and heritage, shorelines). The focus in preparation of the WMP has been to provide a strategy to conserve or restore those habitat types that are most stressed: freshwater wetlands; streams, rivers, and riparian buffers; and intertidal marshes and flats. The overall goal is to help Weeks Bay Watershed stakeholders develop a plan that offers specific and tangible management measures to protect, conserve, and preserve the unique qualities of the area and to recognize and encourage smart use of all Watershed features in a cooperative way. Weeks Bay has been recognized through designation as a National Estuarine Research Reserve (NERR) since 1986 and as an Outstanding National

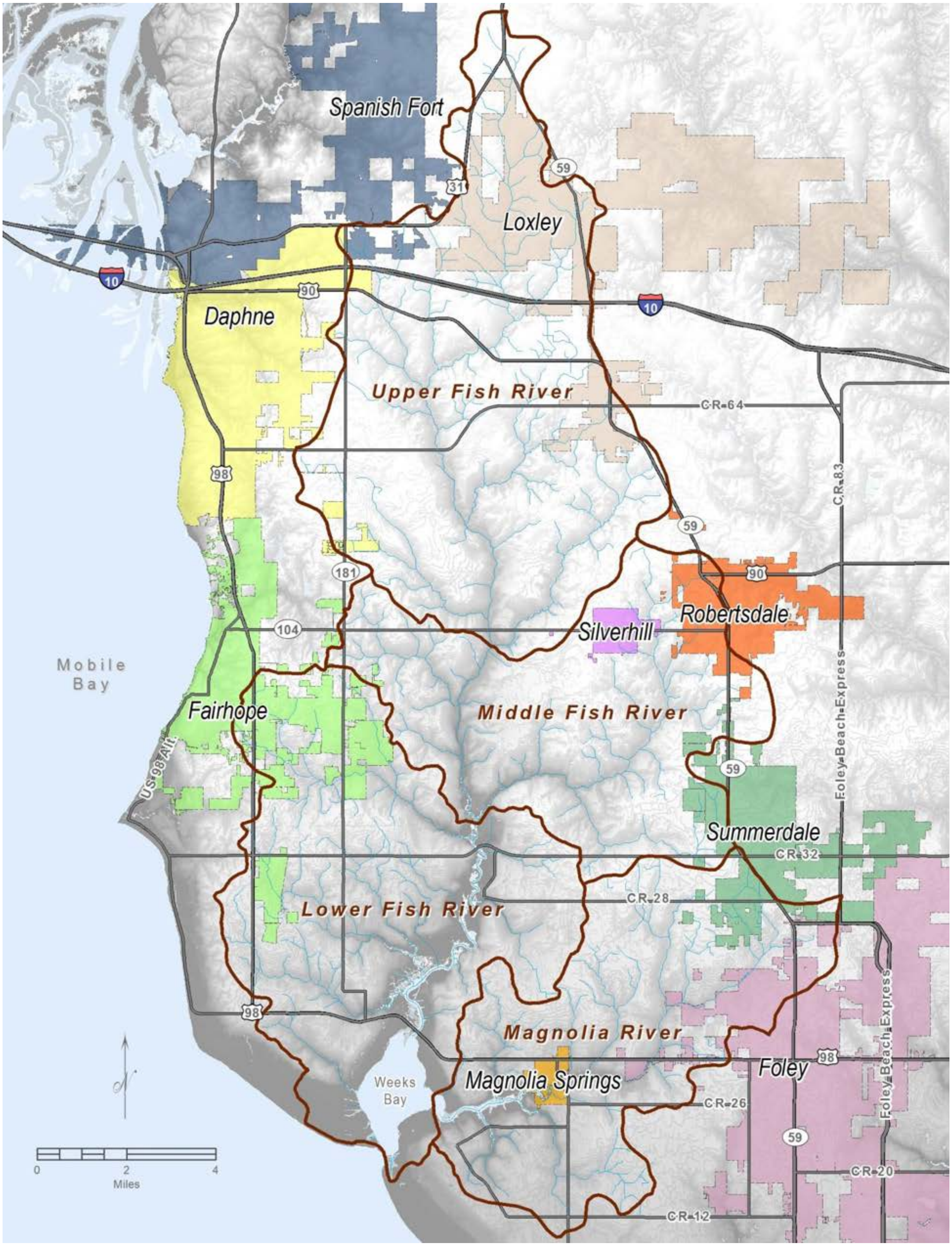


Figure ES-1 Weeks Bay Watershed

Resource Water (ONRW), one of only three within the State of Alabama, since 1992. The Magnolia River is recognized as an Outstanding Alabama Water (OAW) since receiving that designation in 2009.

Early in the watershed management planning process it became very obvious to the Thompson Team that two valuable entities exist within this Watershed that should be specifically recognized at this point – the Weeks Bay National Estuarine Research Reserve (WBNERR) and the Weeks Bay Foundation (WBF).

This WMP outlines a comprehensive approach to address the issues and concerns identified for the land and water areas within the Weeks Bay Watershed. The purpose of this WMP is to guide watershed resource managers, policy makers, community organizations, and citizens to protect the chemical, biological, and cultural integrity of the Weeks Bay Watershed, and specifically its waters and habitats supporting healthy populations of fish, shellfish, and wildlife and providing recreation in and on these waters of coastal Alabama. To accomplish these broad goals, this WMP identifies a range of measures that can be applied to more efficiently manage urban development and agricultural practices within the Weeks Bay Watershed. By successfully addressing the co-related problems identified with population growth, urban development, and some agricultural practices within this Watershed, the long-term health of the stream courses, Weeks Bay, and Mobile Bay will be enhanced.

ES.2 Public Participation

Preparation of the WMP was accomplished through a collaborative effort guided by the Thompson Team and the Stakeholders Working Group (SWG). The focus of this team was to elicit strong stakeholder participation. The SWG includes about 25 representatives from the municipalities and county, state and federal agencies; homeowners; agriculture; developers; and engineers. The SWG continued to meet on an approximate bimonthly schedule with the Thompson Team throughout the development process, holding a total of 10 meetings over the course of WMP development.

A large stakeholders workshop was held on March 2, 2016. Each constituency of the SWG was charged with inviting six to eight other people from their constituency to the workshop. The workshop, held in the Baldwin County Central Annex Auditorium in Robertsdale, was attended by approximately 86 participants a table set up for each of these constituency groups:

- Agriculture/Forestry
- Business
- City & County Staff Members
- Developers
- Engineers
- Environmental Organization Leaders
- Environmental Science

- Homeowners
- Mayors & Elected Officials

Each group was given time to consider the Watershed from their unique point of view and worked independently to identify:

- Strengths: What's right and should be preserved or strengthened?
- Weakness & Threats: What's not right? What negative trends do you see?
- Opportunities: Look at your top three strengths and opportunities What could be done to address them?

A major finding of the workshop was that almost every group had common interest in improving coordination between the various constituent groups, better coordination between the local governmental entities regarding regulations, and flooding/stormwater management concerns.

The Draft WBWMP was made available for public review on August 2, 2017, as it was posted on the MBNEP website for a 30-day review period. The Draft WMP was also presented to the public at a workshop on August 16, 2017. The workshop was held at the Baldwin County Central Annex on Palmer Street in Robertsdale, and was attended by 49 people. The review period for the Draft WMP ended on August 31, 2017. During that period, hardcopies of the Draft WMP were placed at several locations in and around the Watershed. No public or agency written comments were received on the Draft WMP.

ES.3 Watershed Description and Conditions

ES.3.1 Overview

The Watershed encompasses approximately 203 square miles, including the Fish River and Magnolia River drainage basins, as well as some small coastal streams such as Weeks Branch that enter Weeks Bay directly. The Watershed covers an area approximately 27 miles long and 12 miles wide. Nine municipalities lie either totally or partially within the Weeks Bay Watershed: Fairhope, Daphne, Spanish Fort, Loxley, Silverhill, Robertsdale, Summerdale, Foley, and Magnolia Springs. Fish River begins near the town of Stapleton, and flows in a southerly direction. The eastern boundary of the Fish River basin is near U.S. Highway 59 and the western boundary is near U.S. Highway 31 (Stapleton to Spanish Fort), thence southward near Alabama Highway 181 (Spanish Fort to Fairhope), thence southward near U.S. Highway 98 to Mobile Bay. The Magnolia River has its headwaters near Summerdale and flows in a southwestward direction to Weeks Bay.

The Upper Fish River Subwatershed covers approximately 42,300 acres. The dominant land use/cover (LULC) is agriculture (39%) consisting of row crops and pasture, followed by forest land (35%), urban development (14%), and wetlands (11%). The eastern part of the Upper Fish

River basin includes portions of Loxley, and the western part includes portions of Spanish Fort and Daphne. Commercial and residential development is occurring along the major transportation corridors of Interstate 10, U.S. Highways 31 and 90, Alabama Highways 59 and 181, and County Road 64.

The Middle Fish River Subwatershed covers approximately 26,800 acres. The dominant LULC is agriculture (58%) including both row crops and pasture. Forested land comprises about 20% of the basin and wetlands cover about 12%. Urban development makes up about 10%. The eastern portion of the Middle Fish River Subwatershed includes all or parts of Robertsdale, Summerdale and Silverhill, and the western part of the basin includes a small portion of Fairhope. Commercial and residential development is occurring along Alabama Highways 59, 104, and 181.

The Lower Fish River Subwatershed covers approximately 34,400 acres. LULC attributed to row crops and pasture is 43%. Wetlands and open water cover about 26%. Forest areas account for about 16%, with developed/urban use of 16%. The western portion of the Lower Fish River basin includes portions of Fairhope. Commercial and residential development is occurring along U.S. Highway 98, Alabama Highway 181, and numerous county roads.

The Magnolia River Subwatershed covers approximately 26,100 acres. LULC attributed to row crops and pasture is 64%. Wetlands and open water cover about 14%. Developed/urban use accounts for about 13%, and forest areas account for about 9%. The Magnolia River basin includes portions of Summerdale and Foley and all of Magnolia Springs. Commercial and residential development is occurring in U.S. Highway 98, Alabama Highway 59, and numerous county roads.

ES.3.2 Hydrology

The Weeks Bay Watershed comprises the following four USGS 12-digit Hydrologic Unit Code (HUC) areas:

- Upper Fish River (HUC 031602050201)
- Middle Fish River (HUC 031602050202)
- Lower Fish River (HUC 031602050204)
- Magnolia River (HUC 031602050203)

The primary named tributaries of the Upper Fish River basin are Turkey Branch (Upper), Bay Branch, Bull Branch, Doeneck Branch, Threemile Creek, Beiser Branch, Corn Branch, Perone Branch, Caney Branch, Picard Branch and Rockhead Branch. The major named tributaries of the Middle Fish River basin are Pensacola Branch, Worm Branch, Still Branch and Polecat Creek which includes Baker Branch, Silver Creek, and Halls Branch. The major named tributaries flowing into the Lower Fish River basin include Cowpen Creek, Waterhole Branch, Green Branch, Turkey Branch (Lower), Barner Branch, and Weeks Branch (flows directly into Weeks Bay). The major tributaries flowing into Magnolia River are Noltie Creek, Eslava Creek, Weeks

Creek, and Schoolhouse Branch. The southern edge of the Middle Fish River is tidally affected and variable salinity levels can be measured at depth in the river. The Lower Fish River tidal amplitude (approximately six inches) has been measured as far up river as the County Road 32 bridge. Tidal range at the mouths of the Lower Fish River and Magnolia River, including Weeks Bay, is approximately 1.3 feet. The lower reaches of the Magnolia River are tidally-influenced upstream to just east of County Road 49.

ES.3.3 Water Quality

Section 3.0, Watershed Conditions, provides a detailed review of the water quality programs and water quality standards applicable in the Weeks Bay Watershed and presents available water quality data. Over 40 scientific reports or sources of data relating to water quality were identified, and the more comprehensive ones were used to provide an assessment of Watershed conditions. Additionally, the Soil and Water Assessment Tool (SWAT) model was developed and calibrated for both Fish and Magnolia river watersheds and utilized to estimate current and future sediment and nutrient loadings from 237 subwatersheds and over 2,400 Hydrologic Response Units.

River discharge (flow) in Fish River (Alabama Highway 104) averages 113 cfs while the Magnolia River (U.S. Highway 98) averages 38 cfs. Many of the tributary streams exhibit very "flashy" discharges associated with locally heavy rainfall events.

Currently, Fish River is classified by the Alabama Department of Environmental Management (ADEM) as Swimming and Fish and Wildlife; Magnolia River is classified as Swimming, Fish and Wildlife, and Outstanding Alabama Water; and Weeks Bay proper is classified Swimming and Fish and Wildlife and also carries the special ADEM designation of Outstanding National Resource Water. Generally, the bay and mainstem of each river meet ADEM water quality standards, with water quality in Fish River being rated by ADEM as GOOD and Magnolia River being rated as FAIR as recently as 2011, according to their Rivers and Streams Monitoring Program.

However, there are four segments listed on the 2016 ADEM 303(d) list as impaired due to fish consumption advisories related to mercury (Fish River, Cowpen Creek, Polecat Creek and Magnolia River) and one segment listed as impaired due to organic enrichment (Baker Branch). The source of mercury is thought to be atmospheric deposition, and the source of organic enrichment is thought to be cattle grazing operations. It is also evident that pathogen levels frequently do not conform to the water quality standards, particularly following rainfall events. The ADEM pathogen Total Maximum Daily Load (TMDL) calls for a 68% load reduction from non-point sources in the Fish River Watershed. To date, efforts to identify the source of pathogens (human, wildlife, or livestock) and location have been inconclusive. Additional efforts are needed to provide information necessary to develop detailed management measures to achieve the ADEM-recommended reductions.

Water quality issues related to pathogens, dissolved oxygen, sediment, turbidity and nutrient loading (nitrogen and phosphorus) are also evident in the data reviewed for a number of tributaries throughout the Watershed. Sediment and nutrient concentrations and loads in the mainstem of Fish and Magnolia rivers appear to have increased over the past 20 years by 20 to 30%; this trend is also apparent in many of the tributaries. Very few tributaries currently have sediment or nutrient concentrations or loads expected in a natural unimpacted stream as defined by ADEM's Ecoregion Reference Reach values, and the Soil and Water Assessment Tool (SWAT) model predicts sediment and nutrient loading will continue to increase under most scenarios through 2040. The SWAT model results indicate that the likely sources of sediment and nutrient inputs are very concentrated or localized, with less than 15% of the Fish River Watershed area being responsible for 50% of the total annual loadings and less than 25% of the Magnolia River Watershed area being responsible of 50% of the total annual loadings. In a number of tributaries, nitrogen levels are highest with low flow, indicating the primary source is groundwater, and the SWAT model predicts that 35-95% of the nitrogen loading may be due to groundwater sources.

Although occasional water quality issues were reported for almost all tributaries that have been sampled, the most prominent water quality impacts have been documented in Corn Branch, Pensacola Branch, Baker Branch, Cowpen Creek, Waterhole Branch, and Turkey Branch (lower) in Fish River Watershed, and Weeks Creek and an unnamed tributary in the Magnolia River Watershed. The impacts appear to be associated with both increasing urban development around the perimeter of the Watershed and pervasive historical and on-going agricultural activities.

Although classified by ADEM as an Outstanding National Resource Water, Weeks Bay proper is considered by all accounts to be eutrophic, with high nutrient loads from Fish and Magnolia rivers frequently triggering increased algal activity and associated low dissolved oxygen levels. Because Weeks Bay is shallow, these low dissolved oxygen and stratification events are usually short-lived and overcome by wind action. Fish River supplies approximately 75% of the freshwater flow and approximately 19,361 metric tons of sediment, 440 metric tons of nitrogen and 64 metric tons of phosphorus into Weeks Bay on an annual basis. The remaining 25% of the freshwater flow, along with 1,371 metric tons of sediment, 136 metric tons of nitrogen, and 14 metric tons of phosphorus are attributable to the Magnolia River. ADEM has performed a study and preliminary modelling of nutrient loading and impacts (GOMA 2013) in Weeks Bay as the first step in developing nutrient criteria for estuaries, and other investigations are on-going to better understand nutrient cycling in Weeks Bay. The ADEM study speculates that up to 27% of the loadings may be anthropogenic and encourages nutrient reduction efforts throughout the Watershed. Ongoing water quality monitoring efforts by the Weeks Bay National Estuarine Research Reserve (WBNERR), ADEM, and Alabama Water Watch-trained volunteers occurs at several locations in Weeks Bay Watershed.

ES.3.4 Flora and Fauna

Most of the Watershed is in the Southern Pine Plains and Hills Ecoregion, which represents a relatively flat transition between the plateau-like Piedmont to the north and lower elevation coastal ecoregions. Weeks Bay and the lower reaches of Fish River and Magnolia River fall within the Gulf Coast Flatwoods Ecoregion, and a small portion of the study area occurs in the Gulf Barrier Island and Coastal Marshes Ecoregion. The Gulf Coast Flatwoods has wet, sandy flats and broad depressions that are locally swampy and forested. The Gulf Barrier Islands and Coastal Marshes region contains salt and brackish marshes. The Watershed has a high diversity of flora and fauna occurring across various habitat types.

Uplands in the Watershed are primarily evergreen forest (18,004 acres), mixed forest (1,501 acres), and deciduous forest (453 acres). The Watershed contains a total of 12,367 acres of wetlands, with 89.7% in the palustrine shrub/forested category. Tidally-influenced forested and herbaceous wetlands occur near Weeks Bay. Estuarine emergent marshes totaling 507 acres occur in the lower reaches of the Fish River HUC 12, which includes most of Weeks Bay, and the lower Magnolia River HUC 12.

The ecological condition of wetlands and riparian buffers was assessed using landscape scale determinations of habitat quality. For wetlands, the proportion of forested cover within a 300ft-upland buffer was used to predict quality. For riparian buffers, wetland and upland forest cover within a 100ft-wide corridor bordering each side of study area ditches, streams, and rivers was analyzed. Buffers with natural land cover between 100 and 75% were scored as good quality, 74 to 51% as fair quality, and 50% or less as poor quality. Wetland and riparian buffers were assessed separately for each of the 169 National Hydrology Dataset catchments comprised in the Watershed. Catchments with natural land cover between 100 and 75% of their total buffer acreage were scored as good quality, 74 to 51% as fair quality, and 50% or less as poor quality.

In general, the main stem of Fish River has intact riparian and wetland buffers. Poor-condition buffers in the Watershed are associated mostly with agricultural and pasture lands. These areas are concentrated especially in the Magnolia River HUC 12, but poor-condition buffers are present to some extent at the upper margins of all four constituent HUC 12s. Wetland buffers in the Upper Fish River drainage area are, for the most part, in good condition. The Middle Fish River Subwatershed has 43% of its catchments in fair condition, with around one third in good condition and nearly 25% in poor condition. The Lower Fish River basin has a majority of catchments with wetlands in good condition, but most of the total buffer acreage is only in fair condition. Wetland buffers in the Magnolia River Subwatershed are mostly in poor condition, including 51% of the catchments and 58% of the total buffer acreage.

Riparian buffers in the Upper Fish River HUC 12 have the highest proportion of catchments in good condition (76%), followed by Middle Fish River (66%), Lower Fish River (55%), and Magnolia River (50%). Most of the total buffer acreage in the Magnolia River HUC 12 is in poor condition, particularly due to association with drainage ways and ditches that traverse agricultural land.

Incidental observations made in January 2017 during field spot checks along roadways found numerous locations across the Watershed with degraded stream reaches and associated wetlands. Degradation was typically due to siltation, sometimes with visible streambank erosion. One or more invasive exotic plant species were found to occur at over 95% of the field check locations.

Public lands (3,412 acres) connected by State-owned, tidally-affected water bottoms located in the Lower Fish River basin are included in the federally-recognized protected area, the WBNERR. Habitats within the WBNERR support a large variety of aquatic, benthic, wetland, and upland plants and wildlife. Successful completion of the research, education, and land conservation mission of the WBNERR is predicated on the health of Weeks Bay, Fish River, Magnolia River, and associated habitats. Preservation and restoration of ecologically-sensitive habitats like salt marshes, pitcher plant bogs, and pine savannahs are ongoing on WBNERR lands. The USFWS website documents the following threatened, endangered, and candidate species for Baldwin County in habitats such as found in the Weeks Bay Watershed: West Indian manatee (*Trichechus manatus*), Alabama red-bellied turtle (*Pseudemys alabamensis*), wood stork (*Mycteria americana*), Gulf species of Atlantic sturgeon (*Acipenser oxyrinchus desotoi*), eastern indigo snake (*Drymarchon corais couperi*), and gopher tortoise (*Gopherus polyphemus*). Others species of concern listed in Alabama Comprehensive Wildlife Conservation Strategy include the diamondback terrapin (*Malaclemys terrapin pileata*) and the alligator snapping turtle (*Macroclemys temminckii*).

ES.3.5 Human Uses

The Creek Indians that lived in this area as early as 10,000 years ago thrived in the presence of the many waterways that encompassed the region, as well as the wide range of natural resources. The Spanish were the first explorers to find Weeks Bay in 1519 and establish a colony on the Gulf Coast which they controlled until 1670. After the American Revolution, Baldwin County was officially formed on December 21, 1809, and Alabama became a state in 1819.

Before European settlers arrived, the Weeks Bay Watershed portion of Baldwin County was mostly covered with old growth longleaf pine forests, forested wetlands, and marsh. Over the years, as the timber industry grew, clearcutting diminished the longleaf pine forests. Eventually, much of the leveled pine forests were settled by farmers who removed the stumps to allow agricultural crops to be grown.

The communities settled in and around the Watershed resulted in a very diverse ethnic area, e.g., Spanish and Italians in the Daphne/Spanish Fort area, Greeks in the Malbis area, Scandinavians/Bohemians in the Silverhill area, and Germans in the Foley/Elberta area. The Fairhope “single tax colony” group came to this area from Des Moines, Iowa, and many of the other areas in the Watershed were settled by people who came from Chicago, Illinois. The Civil War had an impact on the Watershed settlement, with overwintering of Admiral Farragut's Illinois-based troops in Magnolia and Fish rivers, resulting in many from the Chicago area relocating to this more pleasant southern climate after the war.

The introduction of the railroad aided timber, turpentine, and agricultural endeavors by improving transportation of people and goods beyond the local waterways and early road and trail network. Until the 20th century, forestry and agriculture were the main sources of revenue for Baldwin County. In the early 1900s, farmers used the practice of open range cattle grazing, which allowed cattle to have free range of the land. However, due to the increase in population and major highways in Baldwin County, the Livestock Laws were passed in the 1940s, making it mandatory for livestock to be confined within fences. During the 20th century, an increase in the number of automobiles and aircraft, led to the closure of the railway access into the Watershed area. Today, the major highways within the Watershed are Interstate 10, U.S. Highway 31, U.S. Highway 90, U.S. Highway 98, U.S. Highway 59, Alabama Highway 104, and Alabama Highway 181. These are supplemented with a dense network of paved and unpaved county roads. The major airports in the Watershed are in Fairhope and Foley.

Permanent and seasonal residential dwellings exist along the shorelines of the Weeks Bay Watershed. Recreational fishing and swimming are common uses throughout the Watershed. Paddlers frequent the northern reaches of the Middle Fish River basin, with power boating occurring in the southern reaches. In the Lower Fish River and Magnolia River basins, including Weeks Bay, swimming, recreational fishing, paddling, water skiing, and power boating are common. Limited (by statute) commercial crabbing is allowed in Weeks Bay. No other commercial fishing is allowed. There are 14 public access sites located within the Watershed. Six public access sites are located in the Middle and Lower Fish River basins. Four public access sites are located on Magnolia River, and three public access sites are available in and around Weeks Bay. Wildlife watching and photography are popular human uses of area water resources. The WBNERR offers a visitor center with trails and boardwalks through ecologically-sensitive wetland, bog, and salt marsh habitats that would typically be unavailable due to limited public access to most areas.

Baldwin County has been the fastest growing county in Alabama since 2005 and is projected to become the fourth most populous county in Alabama by 2040. Census data from 2010 estimated the population of the Weeks Bay Watershed at approximately 50,000 people, with approximate subwatershed totals of 16,300 in Upper Fish River, 8,200 in Middle Fish River, 16,000 in Lower Fish River, and 9,200 in Magnolia River. The Watershed population is projected to grow by 99% by 2040, resulting in a population of 99,000 people. Land use/land cover trends are projected to follow the historic trends with losses in agricultural and forest lands as a result of increased developed land areas. Developed (urban) land increased from 10.3% in 2001 to 13.0% in 2011. Developed areas are projected to increase to 33.9% and 44.1% for 2040 Medium and 2040 High Growth Scenarios, respectively. Increased developed areas will result in impervious surface area (impervious cover) increases. As a percentage of total Watershed area, impervious cover increased from 1.8 to 2.6% from 2001 to 2011, and is projected to increase to 7.8% and 12.9% for the 2040 Medium and 2040 High growth scenarios, respectively. Impervious cover when expressed as a percentage of developed area has been estimated at 17%, 20%, 34%, and 44% for 2001, 2011, 2040 Medium, and 2040 High, respectively.

ES.3.6 Shoreline Assessment

A shoreline assessment was performed for tidally-influenced portions of waterbodies within the Weeks Bay Watershed. The shoreline assessment included the following:

- An analysis of existing shoreline conditions consisting of a summary of findings from a 2009 study performed by Geological Survey of Alabama (GSA).
- An analysis of shoreline changes over time, performed by comparing shorelines visible in aerial photos from 1955 and 2015, in order to determine morphological changes that have taken place over that period.

Fish River has 30.1 miles of shoreline, which are classified into three major types:

- Vegetated (bluff, high bank, and low bank): 14.9 miles, 49.6 percent;
- Organic (marsh, swamp, and open shoreline vegetated fringe): 14.8 miles, 49.3 percent; and
- Pocket Beach (sediment): 446 feet, 0.3 percent of the total shoreline types.

About 30.1 miles of shoreline on Fish River were mapped with 22.8 miles (75.7 percent) natural and 7.3 miles (24.3 percent) armored.

Magnolia River has 15.4 miles of shoreline, which are classified into two major types:

- Organic (marsh, swamp, and open shoreline vegetated fringe): 7.8 miles, 50.4 percent; and
- Vegetated (high bank and low bank): 7.5 miles, 48.5 percent of the total shoreline types.

Of the total shoreline along Magnolia River, 12.9 miles (83.5 percent) are natural and 2.5 miles (16.5 percent) are armored.

Weeks Bay has 11.4 miles of shoreline, which are classified into three major types:

- Organic (marsh and open shoreline vegetated fringe): 7.3 miles, 63.8 percent;
- Vegetated (high bank and low bank): 4 miles, 42.6 percent; and
- Sediment (low bank): 338 feet, 0.6 percent of the total shoreline types.

Of the 11.4 miles of shoreline mapped in Weeks Bay, 8.4 miles (73.9 percent) were natural and unretained, and 3.0 miles (26.1 percent) were armored.

In order to assess changes to shorelines in the Watershed over time, aerial photographs from 1955 were compared with aerial photographs from 2015. These areas generally correspond with portions of the Watershed that are considered navigable by most recreational boats, and are the most tidally-influenced. The assessment focused on observable changes to features, such as shoreline geometry; width and route of the rivers and tributaries; major man-made alterations to the shoreline; size and shape of peninsulas and islands; and location and extent of marshes. Man-made alterations of the shoreline due to excavation and narrowing of peninsulas were observed in all three assessment areas (Fish River, Magnolia River, and Weeks Bay).

The two most notable changes observed in this assessment include: (1) the loss of emergent island area; and (2) the widening of coastal streams. The two locations exhibiting the most obvious loss of island area are at sites on Lower Fish and Lower Magnolia rivers. Both of these sites experience high levels of boat traffic and resulting wakes, which could lead to erosion along the shores of these islands. Additional factors related to the size of these islands include the occurrence of flood events and tropical systems, which can cause increased flow and velocity leading to greater potential for bank erosion. The widening of streams was noted at additional sites in Fish and Magnolia rivers. These streams are very small coastal streams typically running through marshes and with very small drainage areas. They are typically not wide or deep enough to be navigable by motorized boats.

Another possible cause for both the loss of island area and the widening of stream channels is sea level rise (SLR), as elaborated on in the following Section ES.3.7. Published data from the Dauphin Island tidal gauge show that relative mean sea level has risen 6.5 inches in the Mobile Bay area since the gauge was installed in 1966. Such a rise in mean sea level could also explain why the smaller streams, which experience little to no risk of erosion from boat wake and no significant upstream land use changes in their micro-scale watersheds, have widened to such an extent in a relatively short period of time.

ES.3.7 Climate Change Assessment

An assessment was performed of the current and future potential effects of climate change on the four HUC 12 watersheds that form the greater Weeks Bay Watershed. The assessment of potential climate change effects includes an overview of climate change; a presentation of recorded historical and predicted future SLR in the area; an examination of potential effects of SLR; and an analysis of predicted effects of various SLR scenarios on future habitat distribution in the Watershed, as predicted by existing Sea Level Affecting Marshes Model (SLAMM) output data.

The global sea level has risen by about eight inches since reliable record-keeping began in 1880. It is projected to rise another one to four feet by 2100. In some areas, such as the greater Mobile Bay system (including Weeks Bay), the recorded local sea level relative to the ground surface (relative sea level) has risen higher than the global sea level. This effect can be the result of multiple factors, such as subsidence of the land and the configuration of shorelines and bathymetric conditions.

Some of the most notable impacts associated with SLR include loss of marshes and other important riparian systems, damage to infrastructure, loss of inhabitable uplands, increased stress on less resilient species of plants and animals, increased storm surge, increased salinity in freshwater surface waters, and salt water infiltration into groundwater aquifers.

Mean sea level data recorded at the National Oceanic and Atmospheric Administration's (NOAA) nearest long-term monitoring gauge (#8735180) located at Dauphin Island, approximately 17 miles southwest of the mouth of Weeks Bay, show that mean relative sea level at this location has risen approximately 0.165 meter (6.5 inches) since it was installed in 1966.

Predictions have been made for the Dauphin Island tidal gauge by the NOAA and the U.S. Army Corps of Engineers (USACE). Both NOAA and the USACE predict that the lowest possible change in relative sea level at Dauphin Island in the year 2100 will result in an increase of 0.34 meter (1.1 feet). The USACE's highest predicted change by the year 2100 at this location is 1.66 meters (5.5 feet), while NOAA's highest possible SLR rate predicts a net increase of 2.15 meters (7.1 feet). There is still a large degree of uncertainty when it comes to the actual rate at which sea level will rise in the future.

Rising seas can submerge low-lying lands, erode beaches, convert wetlands to open water, and exacerbate coastal flooding due to the low flat elevations in the Lower Fish River and Magnolia River subwatersheds. Low-lying areas that occasionally experience coastal flooding problems at the present time will likely eventually become inaccessible for much of the year as relative sea level continues to rise. In estuarine areas like Weeks Bay, as marshes and similar riparian systems are converted to open water in response to SLR, their ability to buffer the effects of storm surge and prevent coastal erosion will greatly diminish. If the rate of sea level change accelerates significantly, coastal environments may not be able to respond accordingly and will decrease in size or be submerged. These changes can fundamentally change the state of the coast.

As local sea levels increase, some marshes may migrate into neighboring low-lying areas, while other sections of marsh will be lost to open water or convert to an intertidal mudflat. In undeveloped or less developed coastal areas, ecosystems are more likely to be able to shift upward and landward with the rising water levels. Coastal development often presents a barrier to this natural migration. This eventually results in the ecosystem converting to open water, rendering coastal development more vulnerable to storm and flooding impacts.

The Sea Level Affecting Marshes Model (SLAMM) predicts when marshes are likely to be vulnerable to SLR and where marshes may migrate uphill in response to changes in water levels. The SLR scenarios chosen for analysis of the Weeks Bay Watershed were 0.5, 1.0, and 2.0 meters (approximately 1.5, three, and six feet, respectively) of relative mean SLR in the area from the initial year (2002) to the year 2100.

Following the analysis of each individual HUC 12 watershed, predicted changes in habitat were compiled for the greater Weeks Bay Watershed as a whole. Review of the data yielded the following observations:

- In all three SLR scenarios, the largest proportion of habitat predicted to have a net reduction in acreage (via conversion to another habitat type or types) was the “Swamp” category, which constituted greater than 50 percent of total loss in all scenarios.
- “Undeveloped Dry Land” was predicted to experience the second highest proportional net loss for all three SLR scenarios. Loss in this category increased from 21 percent in the 0.5-meter (approximately 1.5 feet) SLR scenario to 30 percent in the 2.0-meter (approximately six feet) SLR scenario.
- “Riverine Tidal” losses decreased proportionally from the 0.5-meter to the 2.0-meter (approximately 1.5 feet to six feet) SLR scenarios.
- In general, habitat acreage lost resulted in a conversion to, and net acreage increase in, three major categories using the 0.5-meter (approximately 1.5 feet) SLR scenario: “Regularly-flooded Marsh” (58 percent), “Transitional Fresh Marsh” (27 percent), and “Estuarine Open Water” (16 percent).
- Under all three SLR scenarios, the “Regularly Flooded Marsh” category consistently showed the largest gains. However, as the SLR scenario was increased, this category’s proportion of total habitat gained decreased as additional habitat categories, such as “Transitional Fresh Marsh,” “Estuarine Open Water,” and “Flooded Forest,” began to increase.
- The SLAMM predicts that the Weeks Bay Watershed will experience a conversion of various wetland habitats by the year 2100, as these habitats are inundated and convert to open water. The amount of area predicted to convert into open water is approximately 155 acres for the 0.5-meter (approximately 1.5 feet) SLR scenario, 320.5 acres for the 1.0-meter (approximately three feet) scenario, and 1,057.8 acres for the 2.0-meter (approximately six feet) scenario.

ES.4 Regulatory Review

As part of the development of the Watershed Management Plan (WMP) for the Weeks Bay Watershed, a review of existing laws, regulations, permits and ordinances at the federal, state, and local levels was conducted. The geopolitical boundaries of the Weeks Bay Watershed include overlapping jurisdictions and adjacent portions of Baldwin County, the cities of Daphne, Spanish Fort, Fairhope, Foley, Robertsdale and Silverhill, and the towns of Loxley, Magnolia Springs and Summerdale, with all lands under state and federal jurisdiction. A total of 25 state, county, and local government regulations were reviewed relative to a number of factors influencing stormwater runoff, water quality, wetlands protection, stream protection, and shoreline protection. Each local entity was asked to complete a chart listing regulatory requirements and providing citations and to respond to a questionnaire relating to implementation of the local ordinances. Responses were compiled in a Regulatory Matrix for comparison.

In summary, it was determined that all local jurisdictions address both construction-phase BMP implementation and post-construction stormwater management. However, the degree to which each entity is engaged in these efforts varies greatly, as do the specific requirements. Half of the local jurisdictions have some form of wetland and/or stream protection initiative, usually in the form of a setback. Four local governments have some reference to Low Impact Development (LID), although only one appears to have a mandatory LID requirement, and only two have shoreline protection initiatives. Four currently have MS4 permit coverage.

ES.5 Financial Considerations

Successful implementation of local watershed management efforts requires adequate program funding. However, funding water quality improvements on a watershed basis is a challenging concept. There are a variety of different resources to consider for the Weeks Bay WMP, including federal, state, and local funding sources. A watershed approach to design, construct, and maintain stormwater improvements will require a significant and steady stream of funding. Municipalities and other political subdivisions should consider and compare various funding options for stormwater management, such as the creation of a stormwater utility authority and/or public-private partnerships. There are a number of different financial structures that could facilitate funding for the projects identified in this WMP. Some structures could be helpful across the entire Watershed and some within limited areas. Many would require public-private partnerships in the sense of cooperation among landowners and governments rather than being imposed by governmental entities. Alternatives for funding and financing stormwater improvements in the Weeks Bay Watershed are discussed based on the type of funding source: state, federal, private, or private-public partnerships.

There are considerable support opportunities to finance the management measures recommended by the Weeks Bay WMP. However, because Weeks Bay Watershed falls within ten governmental jurisdictions (nine municipalities and the county), it lacks a central authority to administer many of the potential funding sources. Establishment of an inter-governmental partnership may provide additional funding options for Watershed management. Additionally, it clearly illustrates to funders the community's active resolve to serve as vested and committed partners in Watershed management. This endeavor would significantly enhance the viability of the Weeks Bay WMP and its competitiveness and position going forward as federal, state, local, and private grant assistance needed for implementation is pursued.

Multi-organization partnerships are an important funding strategy for this WMP. They are effective ways to incorporate stakeholders across all sectors to ensure efforts are not duplicated. A structure is typically needed to guide multi-stakeholder watershed initiatives. Therefore, it is recommended that an organizational framework include a centralized infrastructure, a dedicated staff, and a structured process that leads to common goals, such as could be led by the WMP Implementation Team (WMPIT). The BCSWCD has expressed an interest in leading an effort to establish a publicly-funded position for a Weeks Bay Watershed Coordinator who would spearhead such an organization framework. Developing a cooperative approach would allow for nonprofits, governments, business, and the public to come together to collaborate on the many serious and complex issues.

ES.6 Management Recommendations

ES.6.1 Establish a Watershed Management Plan Implementation Team

In order to assure implementation of the Watershed Management Plan we must identify leadership and funding. A Watershed Management Plan Implementation Team (WMPIT) must be identified to carry forward the work necessary to prioritize site specific projects, work with various governmental entities within the Watershed, and locate the necessary funding. The membership of the WMPIT should reflect the diversity of entities represented on the SWG that served to guide development of the WMP. The WMPIT must agree on an organizational “homeroom” (general terminology for an agency or organization responsible for administrative matters, taskings, scheduling, etc. on a day-to-day basis) or multiple “homerooms” (MBNEP, WBNERR, BCSWCD, etc.). The SWG has discussed “homerooms” that best fit based on the subject matter of the specific recommendations. Notably the BCSWCD has approved a Watershed Coordinator position to provide oversight regarding the implementation of the WBWMP at their July 26, 2017 meeting. At the time of this writing, the BCSWCD has received a one-year commitment of $41,500 to partially fund the Watershed Coordinator position from the Baldwin County Commission, with continued funds if there is demonstrated progress/buy-in from other stakeholders. In addition, one-time donation commitments have been received from the Alabama Soil and Water Conservation Committee ($5,000), Alabama Association of Conservation Districts ($5,000), and Gulf Coast Resources Conservation and Development Council ($15,000). Other funding sources being explored by the BCSWCD include ADEM, EPA, and the municipalities in the Watershed. The BCSWCD staff position should not overlap or conflict with the existing roles of the WBNERR, MBNEP, or other local city/county staff positions, or other state/federal agencies, but rather complement those positions. The establishment of a Watershed Coordinator by the BCSWCD is vital to moving forward with plan implementation.

ES.6.2 Develop Inter-Governmental County/Municipal Watershed Management Mechanism

The focus of this recommendation would be to foster inter-governmental cooperation. The inter-governmental entity could be either an informal group with periodic meetings (sort of like the informal municipality/county planner meetings that have been held over the past several months), or something more formal such as a watershed management authority, as authorized under Alabama law (AL Act 91-602), similar to the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority. An inter-governmental coordination mechanism could help address planning and zoning matters across the entire Watershed. In addition, such a mechanism could enhance approaches to deal with comprehensive watershed stormwater management throughout this large Watershed. Model ordinances could be developed to help local communities achieve consistency in regulations, yet allow flexibility to best fit their local needs.

ES.6.3 Address Federal/State/County/Municipality Regulations

Based on the review of the regulatory framework throughout the Weeks Bay Watershed and to help further the goals of the WMP, the following management measures and recommendations related to identified gaps and inconsistencies are recommended:

- Convene a working group composed of local area planning officials, development entities, and engineering firms (as needed for technical input) whose purpose is to systematically review the identified gaps and inconsistencies, reach consensus on watershed management goals and appropriate levels of local government involvement, and address the regulatory framework recommendations. Given the complexity of the regulatory framework within the Watershed, the number of gaps and inconsistencies identified, and the relative differences in available resources of the local units of government, it is felt that such a working group could benefit from sharing experiences and ideas related to watershed management efforts. Open discussions on how to achieve consistent management goals, devise consistent regulatory requirements (where appropriate), and share information will be critical to implementing the recommendations. This activity was initiated through the WMP process by convening meetings of city, county, school board, and regional (South Alabama Regional Planning Commission [SARPC]) planners. This group has been meeting regularly since November 2016.

- Initiate educational programs on priority Watershed issues (wetlands, water quality, stormwater management, sea level rise, etc.) targeted toward municipal officials, agricultural interests, and homeowner associations. Given the varying degrees of knowledge regarding the effects of ongoing urbanization on land use and water quality issues in the Watershed, outreach and education products should be developed that target different messages to different target audiences on issues relating to implementation of the WMP. The activities should be focused on increasing the sensitivity and understanding of the target audiences of the necessity of implementing management measures outlined in the WMP to: (1) improve environmental quality; (2) enhance quality of life; and (3) reduce the need to pursue future actions with public funds to correct the consequences of unwise development practices.

ES.6.4 Address Stormwater Management and Flooding

Baldwin County is encouraged to regularly run flood prediction models with updated land use forecasts. The County is recommended to add a county GIS layer on which municipalities can list high potential development projects in order to improve inter-governmental coordination that could have impacts beyond the boundaries of an individual municipality. The County and all municipalities are recommended to conduct an inventory and assessment of stormwater detention systems (Homeowner Association [HOA]-owned and business-owned). Methods to incentivize maintenance, as well as retrofitting of HOA stormwater detention systems should be explored. Regional alternatives to multiple HOA systems should be considered.

A component of this recommendation is to inventory, map, and assess existing stormwater ponds and construct several demonstration project retrofit designs to improve water quality flowing from these ponds. The stormwater pond retrofits would be designed to not adversely impact flood protection but would provide substantial benefits for improving water quality. The project consists of in-depth mapping and data collection of the stormwater basins within the Watershed. The size, location, and type (wet or dry detention or retention) will be documented. Site visits will be performed to document the status of the ponds, their functionality during storm events, and potential for retrofitting projects. At the end of the project timeline, a second map will be created to show any new basins that have been created during the project time and the site location of the selected pilot retrofitting projects. The project will also include outreach to provide information to HOA groups or businesses on inspection and management activities to ensure the long-term functionality of their stormwater basins, including maintenance recommendations. Retrofit treatment options for the demonstration sites may include:

- extended detention,
- conversion of dry ponds to wet ponds,
- constructed wetlands within ponds,
- bioretention,
- additional filtering practices, including native grass plantings,
- swales, or
- other (roof runoff treatment using rain gardens, rain barrels, planters, etc.).

The option selected for each site will be based on the major issue impacting that site, such as flow rate, retention time, sedimentation within the pond, or invasive plant pressure.

ES.6.5 Sustain Watershed Hydrology by Promoting Low Impact Development (LID) and Green Infrastructure (GI)

Clearly, urbanization of the Weeks Bay Watershed can be expected to result in adverse impacts to water quality of the Watershed's streams, especially within the areas experiencing development. Such impacts can be minimized by adopting measures to sustain the Watershed's hydrology. Such management measures are termed Low Impact Development (LID) and Green Infrastructure (GI). Urbanization increases the variety and amount of pollutants carried into our nation's waters. In urban and suburban areas, much of the land surface is covered by buildings, pavement, and compacted landscapes. These surfaces do not allow rain to soak into the ground, which greatly increases the volume and velocity of stormwater runoff. Stormwater runoff is a major cause of water pollution in urban areas. Stormwater drains through gutters, storm sewers, and other engineered collection systems and is discharged, untreated, into nearby water bodies.

Interest in and awareness of the need to better manage stormwater runoff in urban and suburban landscapes has increased in recent years. Multiple studies have identified the negative impacts of poorly-managed, post-construction stormwater on our nation's waters. As landscapes become more urbanized, there is a corresponding increase in the amount of impervious surfaces that limit the ability of stormwater to infiltrate into the ground. In some watersheds, as much as 55% of rainfall runs off an urban landscape that is covered by parking lots, roads, and buildings, and only 15% of rainfall soaks into the ground. In comparison, a more natural landscape will infiltrate an estimated 45% of the rainfall with only 10% running off. The negative environmental impacts of an increase in stormwater runoff and subsequent instream flows in developed landscapes leads to increases in its delivery of pollutants such as nutrients, pathogens, metals, and sediment (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf).

The term LID refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration, or use of stormwater in order to protect water quality and associated aquatic habitat. USEPA currently uses the term *green infrastructure* (GI) to refer to the management of wet weather flows using these processes, and to refer to the patchwork of natural areas that provide habitat and flood protection, as well as cleaner air and cleaner water. At both the site and regional scale, LID/GI practices aim to preserve, restore, and create green space using soils, vegetation, and rainwater harvest techniques. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close where it falls as possible. LID employs principles such as preserving and recreating natural landscape features or minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles, such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels and permeable pavements. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions.

Some of the municipalities fringing the boundaries of the Weeks Bay Watershed have adopted (or are adopting) ordinances to require or encourage LID/GI practices. Those ordinances have different provisions and are not consistent. Other municipalities and the unincorporated Watershed areas of Baldwin County outside of municipal jurisdiction have no or only limited provisions for LID/GI. Refer to Section 7 for discussions of federal/state regulations and local ordinances applicable to the Watershed areas. It is recommended that the WMPIT (recommended in Section 6.1) and the inter-governmental mechanism (recommended in Section 6.2) promote and encourage LID/GI throughout the Watershed and promote consistency of those measures within the various jurisdictions.

There are several LID and GI projects in the Watershed, and the number is increasing as engineers, architects, developers, builders etc. embrace these technologies. A GIS database showing the locations of LID and GI projects is recommended to increase public awareness and education. The best "homeroom" for such a project would be the MBNEP or the WBNERR.

ES.6.6 Encourage Improved Agricultural/Forestry BMPs

Examples of agricultural BMPs that should be encouraged within the Watershed include:

- Exclude livestock from wetlands/streams and protection of riparian buffers along streams.
- Increase use of cover crops to decrease soil erosion and nutrient leaching, improve infiltration, and increase soil organics.
- Improve nutrient management through increased use of precision agriculture application of fertilizer and pesticides; split nitrogen application, etc. in order to reduce the potential for contaminated runoff and leaching.
- Identify/Remediate areas with high livestock numbers where manure runoff is found to be a source of pathogens associated with water quality issues.

There are a number of conservation programs available for both public and private landowners through the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA). A brief description of each appears below (Source: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/).

- Conservation Stewardship Program provides financial and technical assistance to agricultural producers to implement enhanced conservation practices to improve plants for wildlife and livestock grazing management to reduce soil compaction and improve riparian function.
- Environmental Quality Improvement 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 and non-industrial forestland. Within EQIP, the Air Quality Initiative provides financial assistance to implement conservation practices that address air resource issues (greenhouse gas emissions, ozone precursors, volatile organic compounds, airborne particulate matter, and some odor-related volatile compounds) for designated locations.
- Emergency Watershed Protection Program (EWP) provides financial assistance for recovery efforts in response to natural disasters and is designed to help people conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, drought, windstorms and other natural occurrences.
- Regional Conservation Partnership Program (RCPP) provides for public-private partnerships focused on improving water quality, combating drought, enhancing soil health, supporting wildlife and protecting agricultural viability.
- The Watershed and Flood Prevention Operations Program (WFPO) provides technical and financial assistance to state and local governments for planning and installing watershed projects.

- The Agricultural Water Enhancement Program (AWEP) and the Wildlife Habitat Incentive Program (WHIP) were repealed on February 7, 2014 and new enrollments are no longer accepted. Conservation practices previously covered under the two programs are usually eligible under EQIP.

Through these various programs, there are a number of conservation practices promoted by the NRCS that are on-going throughout the Weeks Bay Watershed for various agricultural/forestry activities including:

- Cropland: Contour farming, crop residue management, cover crop, crop rotation, field borders, terraces, tile outlet terraces, sod waterways, gully structures, conservation tillage, and sediment retention structures.
- Grassland: Pasture management, controlled grazing, weed control, stream crossing, gully structures, livestock exclusion, and cropland conversion.
- Forestland: Tree planting, planting desirable species, control burning, control undesirable invasive species, water breaks, gully structures, and access roads.

Representatives from the BCSWCD and NRCS have participated in the development of this WMP, and they should take the leadership role for implementation of this recommendation.

ES.6.7 Address Watershed Water Quality Issues

Summarizing the review of available water quality data and the SWAT model results, Table ES.1 indicates stream segments where water quality impacts have been most frequently documented and are considered the most threatened stream segments and where recommended management measures should be focused. The majority of these segments will require additional study to identify specific sources, i.e. targeted reconnaissance, modelling and/or sampling to confirm water quality issue and to develop a detailed plan of action to address the specific source(s).

These notwithstanding, there are relatively isolated areas of concerned, for example the SWAT indicates a potentially high sediment delivery to the Magnolia River from the area surrounding and just upstream of the confluence with Schoolhouse Branch. Field reconnaissance of the area revealed significant bank erosion and sediment deposition along a portion of the Magnolia River proper. Another example is the severe gully erosion and sediment deposition identified along a stretch of an unnamed tributary to Fish River in Marlow. These impacted areas have been identified and are prime candidates for immediate restoration action. Also a number of unpaved roads contribute sediment to streams and wetlands in the Watershed.

Table ES.1 Summary Water Quality Areas of Concern in Weeks Bay Watershed

Stream	D.O.	Sediment/Turbidity	Nutrients	Bacteria
Fish River			X	X
Corn Branch	X	X	X	
Pensacola Br.		X	X	
Cowpen Creek		X		
Polecat Creek			X	X
Baker Branch	X		X	
Waterhole Br.	X		X	X
Turkey Branch		X	X	
Magnolia River			X	X
Weeks Creek	X	X	X	X
Schoolhouse Br.				X
Eslava Creek				X
Brantley Br.			X	
UT to Magnolia River		X		
Weeks Bay	X		X	

The following list of recommended actions deal with various aspects of water quality issues that have been identified through the WMP process include:

- Identify instream erosional "hot spots" on Fish and Magnolia rivers (and tributaries) and prioritize and implement stream restoration and bank stabilization to reduce sediment contributions. For example, a number of unpaved roads, dirt pits, and other erosional areas have been identified within the Watershed, and they warrant further field investigation and development of remedial measures. Also two significant areas of bank erosion have been identified during the WMP development: one on lower Magnolia River and the second on a Fish River tributary near the junction of CR 9 and CR 32.
- Refine SWAT model results to identify and map "critical source areas" (CSAs) at the hydrologic response unit (HRU) level within the subwatersheds having high sediment and nutrient yields/loadings, with goal of remediation of sediment and nutrient "hotspots."
- Conduct a detailed turbidity source survey in tributaries with frequently elevated turbidity levels (Corn Branch, Pensacola Branch, Baker Branch and Cowpen Creek) to pinpoint sources of excessive turbidity and develop detailed plans to reduce, minimize, or eliminate the sources.

- Conduct detailed pathogen source tracking and identification in subwatersheds with frequent high pathogen levels to distinguish between wildlife, livestock, pets, and human contributions in order to develop detailed plans to remediate pathogen sources.
- Develop a pathogen monitoring program that will support development of a hydrologic model that can be used to predict the occurrence of high levels of bacteria and implement a public advisory system that warns of potential health risks associated with whole body contact recreation during period of elevated bacteria concentrations (similar to the model used to close waterbodies to oyster harvest).
- Develop an inventory of septic tanks that predate the existing ADPH inventory and design and implement an effort to quantify the contribution of septic tanks to both the pathogen and nutrient loadings within stream segments having water quality issues. After that inventory is complete, conduct a GIS analysis to identify "hot spots" where septic tank locations are in poor soil types for such facilities and are in close proximity to streams and wetlands.
- Identify and assess potential water quality impacts associated with bio-solids and animal manure application sites throughout the Watershed.
- Assess impacts of turf farms for runoff timing and volume, and pollutant loadings to streams.

ES.6.8 Address Environment/Habitat Issues

ES.6.8.1 Degraded Wetlands and Riparian Buffers

Poor condition wetland and riparian buffers in the Watershed are associated mostly with agricultural and pasture lands. These areas are concentrated especially in the Magnolia River HUC 12 but generally are present at the upper margins of all four subwatersheds. The Weeks Bay NERR 2017-2022 Management Plan cites riparian vegetation as performing an important role in trapping sediment, providing thermal cover to prevent water temperature extremes, and taking up excess nutrients that may be present in runoff. Catchments with relatively high nutrient loading in the 2011 SWAT Model output, particularly nitrogen, appear to correspond well with locations of poor quality riparian and wetland buffers. To determine potential buffer restoration sites, criteria should include:

- Locations identified as nutrient or sediment loading hotspots,
- ADEM 303d-listed streams,
- Former drainage ways and wetlands on crop land with marginal production, and
- Areas in proximity to Weeks Bay

Because most wetlands in the Watershed are associated with rivers, streams, and drainage ways, riparian buffer restoration actions will involve some level of wetland restoration. Based on the wetland and riparian buffer condition analyses, field observations, and SWAT Model output, potential demonstration areas containing sites for buffer restoration include:

- Upper Eslava Branch
- Upper Weeks Creek
- Baker Branch
- Green Branch
- Corn Branch
- Polecat Creek

In identifying demonstration sites in the Watershed for riparian buffer and wetland restoration, a number of factors should be considered, particularly if the intent is remediation or amelioration of nutrient and sediment loading from agricultural fields. Buffer restoration can be primarily designed and intended to prevent excessive nutrient and sediment loading; however, secondary purposes, such as for stormwater attenuation or wildlife habitat, should also be considered and evaluated.

ES.6.8.2 Vulnerable High Quality Habitats for Protection

Two important types of high quality habitat should be considered for protection: (1) coastal zone tidal areas around Weeks Bay, particularly tidal marshes currently outside of conservation easements, and (2) upstream strategic locations and ecologically significant habitats, e.g., locations with habitat or species tracked by the Alabama Natural Heritage Program (ALNHP), subwatershed areas with intact riparian buffers, and especially headwater areas.

In 1998 the MBNEP Habitat Loss Working Group report assessed the status of historic habitat loss in the MBNEP study area, considering habitat types of scientific concern and those identified by habitat user groups as at-risk ecological systems. The identified systems are widely recognized as those providing significant habitat values for many species, including rare and endangered fauna. Priority habitats include tidal marshes, freshwater wetlands, longleaf pine, pine savannah, maritime forest, oyster reefs, and submerged aquatic vegetation. Habitats identified by the ADCNR Comprehensive Wildlife Conservation Strategy (2016) as in greatest need of conservation include floodplain forests, swamps, wet pine savannah and flatwoods, maritime forest and coastal scrub, and estuarine and marine systems.

Tidal marsh systems are considered high quality habitat due to their level of ecosystem service provision, including habitat for fisheries and species of high conservation concern. Total estuarine emergent acreage in the Watershed is 507 acres. The total area of tidal marshes within existing protected ownership is 180 acres, with 327 acres not currently contained in protected ownership. All tidal wetlands are considered priority for acquisition and conservation.

The ALNHP identifies areas of switchgrass tidal fringe habitat at two locations in the Magnolia River HUC 12. This community type is considered a habitat of extreme rarity in Alabama (S1). Tidal pond cypress, also an S1 habitat, has identified occurrences in the area of lower Eslava Branch and near Weeks Creek. Other important habitats include an area of streamside white cedar swamp habitat (S1) in the Upper Fish River HUC 12, associated with Turkey Branch near U.S. Highway 90. Longleaf pine-turkey oak woodland habitat (S2) occurs near Fish River in the Middle Fish River HUC 12, south of CR 48. All of these locations should be investigated to verify the occurrence of these rare habitats and document their extent and ecological condition, prior to consideration of establishing conservation easements for their protection.

ES.6.8.3 Invasive and Exotic Species

In general, there is an absence of existing, comprehensive programs and mechanisms to detect infestations of invasive flora and fauna, and to take action to manage or eradicate them, once identified. Ongoing collection of data would be valuable to determine to what extent non-native species have impacted the Watershed and how best to predict the occurrence of notable plant pests for the purposes of eradication, maintenance of biodiversity, and management of threatened natural resources. Establishing invasive exotic plant management projects is most likely to be effective on public lands, where managers have right-of-access. In 2004 the MBNEP conducted a strategic assessment of habitats throughout Mobile and Baldwin counties to identify priority sites for acquisition, restoration, and conservation. The objective was to protect, enhance, restore, and manage valuable public lands and work with property owners to accomplish habitat protection goals on important, privately held lands. Establishing a public-private collaboration program for management of invasive exotic flora and fauna, and for inventorying important habitats and species, would be of significant value for long-term conservation and management.

ES.6.9 Address Coastal Erosion and Sea Level Rise Issues

Findings of the shoreline and climate change assessments have yielded the following recommendations that should help mitigate past and future impacts on shorelines and habitats in the Watershed, caused by both man-made and natural processes:

ES.6.9.1 Increase Public Awareness of Sea Level Rise

In order to adequately plan and prepare for sustainable coastal communities, the public (including policy makers) need to understand the reality and implications of SLR. Therefore, it is important to promote programs/workshops to improve stakeholder awareness of:

- Recorded SLR in the greater Mobile Bay area over the last 50 years;
- SLR predictions based on various agencies and models;
- Potential effects on infrastructure, residential properties, and habitats in the Watershed, due to future SLR; and
- SLR adaptation options.

ES.6.9.2 Protect and Enhance Coastal Habitats

In addition to providing habitat for a wide range of marine species, well-established, contiguous marshes and oyster reefs promote sediment accumulation and shoreline stabilization, protect riparian habitats, and buffer upland areas against wind and wave activities that expedite erosion, thereby helping to slow or offset the impacts of SLR. As a result, these habitats serve as an important buffer between uplands and estuaries, filtering pollutants before they enter the water and reducing waves before they reach land.

Identify specific sites, at the parcel level in the lower reaches of the Watershed, that are candidates for construction of living shoreline or other shoreline protection/restoration measures. Suitable sites would typically consist of areas that currently are (or anticipated in the future) exhibiting erosion or habitat loss. Some of the potential impacts of future SLR can be somewhat mitigated by construction of living shorelines. Specific activities can include: (1) creation and enhancement of oyster reefs, which can help attenuate wave energy and have the potential to increase in elevation at the rate of SLR; and (2) planting of emergent shoreline vegetation can help capture and stabilize sediments in areas with sufficient sedimentation or accretion rates and appropriate bathymetric conditions.

ES.6.9.3 Plan/Design for Sea Level Rise

Once adequate awareness and planning has occurred, implementation of SLR adaptation projects can be successful, including but not limited to:

- Implementation of coastal infrastructure retrofits (built for anticipated higher sea level);
- Development of adaptation and land use plans that account for anticipated future sea level;
- Acquisition of properties for conservation, where aquatic and riparian habitats are allowed to move up-gradient with the increase in sea level;
- Long-term monitoring and adaptive management of implemented SLR adaptation measures in the Watershed; and
- Increased current and future investments in coastal green infrastructure projects (such as living shorelines) that will protect shorelines and adapt to changes in sea level.

ES.6.9.4 Other Potential Actions

Additional actions to help mitigate the impacts of SLR may include efforts to replace lost habitat. These may include the following: (1) assess the current and potential ecological benefits provided by the protection and/or restoration of multiple disappearing (drowning) islands found in the lower reaches of Fish River and Magnolia River; and (2) develop new intertidal habitat (with upland opportunities for marsh migration) by beneficial use of dredged material.

ES.7 Develop Appropriate Monitoring and Adaptive Management Mechanisms

The monitoring program should track the number of management measures that are implemented in each HUC 12 watershed and the degree to which they are implemented. Potential indicators would be such things as: acres of wetlands preserved; acres of wetlands restored, miles or acres of riparian buffer restored, acres treated for invasive plant removal, number of septic tanks inspected and serviced and/or taken out of service, number of alternative on-site sewage disposal systems installed, miles of livestock exclusion fencing installed, number and type of agricultural BMPs implemented, acres enrolled in NRCS conservation programs, number or miles of stream restoration, etc. Since this WMP identifies several areas where additional investigation is needed to identify pollutant sources in order to develop appropriate management measures, the number of source identification studies or investigations conducted should also be tracked.

There have been a number of various sample collection locations throughout the Weeks Bay Watershed over the past 20 years, including those of the USGS, ADEM, Weeks Bay NERR, Geological Survey of Alabama, USEPA, Cook, and several other investigators. Samples should be collected on a monthly or quarterly basis at each location site or consistently enough to accurately monitor trends in Watershed conditions and parameters. The sampling schedule should not be burdensome to the field teams or an excessive drain on budgets. All monitoring activities should be conducted in accordance with ADEM or Alabama Water Watch (AWW) protocols, as appropriate for the parameter being monitored.

A vital element of the Watershed Monitoring Program will be citizen participation through volunteering as an AWW monitor. With the help of volunteers, the Watershed Monitoring Program will enable successful implementation and establish a sense of community ownership within the Watershed. Efforts should be made to recruit as many volunteer monitors as possible.

ES.8 Continue Stakeholder and General Public Outreach and Education

Community outreach and public education about the Weeks Bay Watershed has been and will continue to be the responsibility of the WBNERR and the Weeks Bay Foundation. According to OutdoorAlabama.com, "*education and training programs at Weeks Bay Reserve target K-12 students, teachers, university and college students and faculty, as well as coastal decision maker audiences. Components of our education program include school field trips, summer camps, teacher training programs, science-based workshops and seminars, community outreach, exhibits, and the production of curricular, informational and technical materials. All Reserve education, training, and outreach activities are designed to enhance public awareness of the importance of estuarine systems and provide opportunities for public education and interpretation.*" The current WBNERR Management Plan which describes many of their outreach and education activities can be found on www.OutdoorAlabama.com.

Our focus in the development of this WMP was to respond to the key issues identified in the workshop at the beginning of the project: The top issues were flooding and water quality caused by development and population growth exacerbated by the lack of a comprehensive, multi-jurisdictional stormwater management plan. The top recommendation on how to develop a stormwater management plan was to develop ways to continue discussions between stakeholders in order to address issues where multiple regulatory groups (municipalities, Baldwin County, state, and federal entities) are involved.

We did this in two major ways. The first was to maintain a large (25-30-member) Stakeholder Work Group with members from the types of constituencies and interest groups in the Watershed. We recommend that this group stay engaged during the implementation phase of the WMP.

The second was to partner with the City of Foley to host approximate monthly meetings with planning staff from the municipalities and the County since November 2016. They were joined by others who are also concerned about growth in this, the fastest growing county in Alabama: school system, utilities, SARPC, and members of the Thompson Team. At the time of this writing, six city/county planner meetings have been conducted, and the planners have seen value in these frequent meetings and intend to continue meeting monthly.

Another key outreach has been with members of the agricultural community. Several members of the SWG are farmers and have shared with us that the farming technology has improved dramatically over the last 25 years. Even so, the effects of production of food and other agricultural products will continue to be seen in the Watershed. The BCSWCD has agreed to take a leadership role with the agricultural community. This will likely use the same format as the planning community: regular meetings with farmers to share low impact and productivity improvement practices and other topics of interest to the participants.

ES.9 Watershed Management Plan Recommendation Summary

The Weeks Bay Watershed Management Plan identifies the presence of significant high quality resources within the Watershed boundaries, but also enumerates several issues that pose threats to the long-range sustainment of the high quality resources that residents and visitors have enjoyed for generations. Table ES-2 provides a concise list of the management recommendations presented earlier in this Executive Summary and elaborated on in more detail in Sections 6 and 11 of the Watershed Management Plan. This table also provides cross reference notations where more information can be found in the main report on these recommendations.

Table ES.2 Weeks Bay Watershed Management Plan Summary of Recommendation

1. **Organizational:** Add a Watershed Management Plan Implementation coordinator position to the BCSWCD; Establish a WMP Implementation Team to take the long-term lead for oversight of implementation of the recommendations; Establish an inter-governmental partnership to speak with one voice when applying for funding; Establish watershed coordination meetings for Mayors/County Commissioners level, annually or semiannually (Sections 4.1, 6.1, 8.2, 8.4, 11.1, 11.2). 2. Continue **monthly municipal/county planners meetings** addressing: overall population growth; local government wetland/stream protection and LID/GI requirements; improve the inspection, maintenance and reporting for post construction stormwater management facilities; more consistent construction phase erosion and sediment control and stormwater management ordinances; post construction stormwater management ordinances; address internal inconsistencies in existing ordinances and subdivision requirements that impact stormwater management; and other issues shown on Table 6.1 (Sections 4.1, 4.2, 6.1, 6.2, 6.3, 6.4, 6.5, 7, 11.1, 11.2). 3. **Promote LID/GI practices and education** throughout the Watershed, as well as consistency in application of those measures across the various jurisdictions (Sections 4.2, 6.1, 6.2, 6.3, 6.4, 6.5, 7, 11.1, 11.2, 11.3). 4. Encourage County to regularly **run the flood model with updated land use forecasts** (Section 6.4, 11.1, 11.2). 5. Encourage County to **add a county GIS layer** on which municipalities can list high potential development projects (Section 6.4, 11.1, 11.2). 6. The County and all municipalities are recommended to conduct an inventory and assessment of **stormwater basin systems** (HOA owned and business owned). Methods to incentivize maintenance, as well as retrofitting of HOA stormwater basins for water quality improvements are recommended. Regional alternatives to multiple HOA systems should be considered (Sections 6.4, 7.4, 11.1, 11.2, 11.3). 7. Encourage use of **conservation programs** available for both public and private landowners through the NRCS and Farm Service Agency (FSA) programs (Sections 3.2.4.2, 4.3, 6.6, 11.3). 8. Encourage broader implementation of **good agricultural/forestry practices**. BCSWCD to take a lead role in convening farmers/foresters, and other agricultural groups (Sections 3.2.4.2, 4.3, 6.6, 9, 11.3). 9. Support efforts to **implement sediment loading reduction** measures (BMPs, restoration, etc.), with expanded SWAT data analysis/field review for subwatersheds with the highest sediment yield (Figure 3.13) (Sections 3.4, 4.3, 4.4, 6.7, 10, 11.3). 10. **Pave roads:** Lipscomb Road, Norris Lane, Mannich Lane [S2], Mannich Lane [S4], Paul Cleverdon Road, and Sherman Road. Consider paving roads listed in Tables 3.9 – 3.12 (Sections 3.4, 6.7, 11.3). 11. Support efforts to **implement nutrient loading reduction management measures** (BMPs, restoration, etc.) with expanded SWAT data analysis for subwatersheds with the highest nutrient yield (see Figure 3.16) (Sections 3.4.5.1, 4.3, 4.4, 6.7, 10, 11.3). 12. **Address pathogen source location and remediation** measures for human and livestock sources (Sections 4.4, 6.7, 11.3). 13. **Restore degraded streams, wetlands, and riparian buffers** in the Watershed (Sections 4.5, 6.8.1, 11.3). 14. **Implement strategic acquisition** of high quality coastal and headwater habitats (Sections 4.5, 6.8.2, 11.3). 15. Develop **invasive species detection and management** program (Section 4.5, 6.8.3, 11.3). 16. Long term municipal and county planning to recognize uncertainties of **potential future sea level changes** in the Watershed over the next century (Sections 3.9.4, 4.6, 6.9, 11.3). 17. Identify specific oyster reef and contiguous marshes that are candidates for construction of **living shoreline or shoreline protection/restoration measures** (Sections 6.9.2, 11.3). 18. Develop Appropriate **Monitoring and Adaptive Management Mechanisms** (Section 6.10, 10, 11.1, 11.2, 11.3). 19. Continue Stakeholder and General **Public Outreach and Education** (Sections 6.11, 10, 11.1, 11.2, 11.3).

This Page Intentionally Left Blank

Final Weeks Bay Watershed Management Plan
Table of Contents

List of Tables

List of Figures

LIST OF APPENDICES

Appendix A	Public Involvement Information
Appendix B	Soils of Weeks Bay Watershed
Appendix C	HUC 12 Enlarged Wetland Maps
Appendix D	Detailed Land Use Tables
Appendix E	Detailed Impervious Surface Tables
Appendix F	Agriculture and Forestry Best Management Practices
Appendix G	SWAT Modeling Report and Output Spreadsheets
Appendix H	SLAMM Information
Appendix I	LID/GI Information
Appendix J	Funding Information
Appendix K	Watershed Management Plan Component Checklist
Appendix L	Stormwater Pond Management Information
Appendix M	Proposed Project Summary Sheets from Deepwater Horizon Portals

ACRONYMS AND ABBREVIATIONS

A or Ac	Acre
ACAB	Alabama Coastal Area Board
ACAMP	Alabama Coastal Area Management Program
ACEP	Agricultural Conservation Easement Program
ACF	Alabama Coastal Foundation
ACNPCP	Alabama Coastal Nonpoint Pollution Control Program
ADCNR	Alabama Department of Conservation of Natural Resources
ADECA	Alabama Department of Economic and Community Affairs
ADEM	Alabama Department of Environmental Management
ADID	Advanced Identification of Wetland Disposal Areas
ADPH	Alabama Department of Public Health
AFC	Alabama Forestry Commission
AFO	Animal Feeding Operations
A&I	Agricultural and Industrial Water Supply
AHC	Alabama Historic Commission
AL	Alabama
ALDOT	Alabama Department of Transportation
ALGAP	Alabama Gap Analysis Program
ALGP	Alabama General Permit
ALNHP	Alabama Natural Heritage Program
AMCMP	Alabama-Mississippi Clean Marina Program
ASY	Alabama Smart Yards
AWPCA	Alabama Water Pollution Control Act
AWW	Alabama Water Watch
BCWC	Baldwin County Watershed Coalition
BDHD	Baldwin County Health Department
BFE	Base Flood Elevation

BMP	Best Management Practices
BRC	Bioretention
BST	Bacterial Source Tracking
BVA	Barry. A. Vittor and Associates, Incorporated
CAFO	Concentrated Animal Feeding Operations
CBC	Christmas Bird Count
CBMPP	Construction Best Management Practices Plan
CBOD	Chemical Biological Oxygen Demand
CC	Curb Cuts
CFR	Code of Federal Regulations
CFS	Cubic Feet Per Second
CGP	Concrete Grid Pavers
CI	Collective Impact
CR	County Road
CRS	Community Rating System
CSO	Combined Sewer Overflows
CSP	Conservation Steward Program
CSW	Constructed Stormwater Wetlands
CWA	Clean Water Act
CWASRF	Clean Water Act State Revolving Fund
CWP	Center for Watershed Protection
CZARA	Coastal Zone Act Reauthorization Amendment of 1990
CZMA	Coastal Zone Management Act of 1972
DD	Disconnected Downspouts
DO	Dissolved Oxygen
ECHO	Environmental Compliance History Online
E&E	Ecology and Environment, Incorporated
EFH	Essential Fish Habitat
EPA	Environmental Protection Agency
EO	Executive Order
EQIP	Environmental Quality Incentives Program
ESMPO	Eastern Shore Metropolitan Planning Organization
ETJ	Extraterritorial Jurisdiction
°F	Degree Fahrenheit
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FHA	Federal Highway Administration
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FS	Grass Filter Strips
Ft	Feet
FW	Fish River
F&W	Fish and Wildlife
FWPCA	Federal Water Pollution Control Act
GCN	Greatest Conservation Need
GCPLCC	Gulf Coast Prairie Landscape Conservation Cooperative
GCRA	Global Change Research Act
GI	Green Infrastructure

GMFMC	Gulf Coast of Mexico Fisheries Management Council
GOMA	Gulf of Mexico Alliance
GP	General Permit
GR	Green Roofs
GS	Grass Swales
GSA	Geological Survey of Alabama
GSSHA	Gridded Surface Subsurface Hydrologic Analysis
Ha	Hectare
HES	Hydro Engineering Solutions, LLC
Hg	Mercury
HOA	Homeowners Association
HUC	Hydrologic Unit Code
HRU	Hydrologic Response Unit
IC	Impervious Cover
ICM	Impervious Cover Model
IEA	Impervious Effect Area
IPaC	Information for Planning and Conservation
IS	Infiltration Swales
ISA	Impervious Surface Area
JD	Jurisdictional Determination (for regulated wetlands)
LA	Load Allocation
LEED	Leadership in Energy and Environmental Design
LFD	Letter of Final Determination (FEMA)
LID	Low Impact Development
LiDAR	Light Detection and Ranging
LRTP	Long Range Transportation Plan
LS	Level Spreaders
LULC	Land Use Land Cover
LWF	Limited Warmwater Fishery
MBNEP	Mobile Bay National Estuary Program
MDN	Mercury Deposition Network
MGD	million gallons divided by one day
mg/l	milligrams per liter
MPN	Most Probable Number
MPO	Eastern Shore Metropolitan Planning Organization
MR	Magnolia River
MRLC	Multi-Resolution Land Characteristics
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MSA	Metropolitan Statistical Areas
MS4	Municipal Separate Storm Sewer System
MUSLE	Modified Universal Soil Loss Equation
NADP	National Atmospheric Deposition Program
NASS	National Agricultural Statistical Service
NEP	National Estuary Program
NERR	National Estuarine Research Reserve
NHD	National Hydrology Dataset
NLCD	National Land Cover Dataset

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NSE	Nash-Sutcliffe Efficiency
NTU	Nephelometric Turbidity Units
NWI	National Wetland Inventory
NWP	Nationwide Permit
OAW	Outstanding Alabama Water
OCM	Office of Coastal Management of NOAA
ONRW	Outstanding National Resource Water
OSDS	On-Site Sewage Disposal System
OWR	Office of Water Resources (ADECA)
PA	Porous Asphalt
PBIAS	Percent Bias
PC	Pervious Concrete
PCIP	Permeable Interlocking Concrete Pavers
pH	potential of Hydrogen (measure of acidity)
POA	Property Owners Association
POTW	Publicly Owned Treatment Works
PP	Permeable Pavements
ppb	parts per billion
ppm	parts per million
PRG	Plastic Reinforcement Grids
PWS	Public Water Supply
RB	Riparian Buffers
RCW	Red-Cockaded Woodpecker
RFP	Request For Proposal
RG	Rain Gardens
RGL	Regulatory Letter (USACE)
RH	Rainwater Harvesting
RHA	Rivers and Harbors Act
RMSE	Root Mean Square Error
RSR	Standard Deviation Error
S	Swimming and Other Whole Body Water-Contact Sports
SAM	South Atlantic Mobile, USACE Mobile District Office
SARPC	South Alabama Regional Planning Commission
SAV	Submerged Aquatic Vegetation
SFTE	Sources, Fate, Transport, and Effect (Study)
SH	Shellfish Harvesting
SHPO	State Historic Preservation Office
SITES	Sustainable Sites Initiative
SLAMM	Sea Level Affecting Marshes Model
SLR	Sea Level Rise
SOP	Standard Operating Procedure
SSO	Sanitary Sewer Collection System Overflows

SSURGO	Soil Survey Geographic Database
SWAT	Soil and Water Assessment Tool
SWAT-CUP	Soil and Water Assessment Tool-Calibration and Uncertainty Procedures
SWG	Stakeholder Work Group
SWMPP	Storm Water Management Program Plan
TAL	Treasured Alabama Lake
TAZ	Traffic Analysis Zones
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
t/mi2/yr	Tons per square mile per year
TN	Total Nitrogen
TNC	The Natural Conservancy
TOC	Total Organic Carbon
TP	Total Phosphorous
TSS	Total Suspended Solids
USA	University of South Alabama
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	Unites States Fish and Wildlife Service
USGBC	United States Green Building Council
USGCRP	United States Global Change Research Program
USGS	United States Geological Survey
VBH	Volume Based Hydrology
WB	Weeks Bay
WBNERR	Weeks Bay National Estuarine Research Reserve
WBW	Weeks Bay Watershed
WBWMP	Weeks Bay Watershed Management Plan
WLA	Wasteload Allocation
WMP	Watershed Management Plan
WOTUS	Waters of the United States
WRAP	Wetland Rapid Assessment Procedure
WS	Wet Swales
WWTP	Wastewater Treatment Plant

1.0 Introduction

1.1 Purpose

A number of water quality and quantity issues have been documented within the Weeks Bay Watershed (WBW) over the past several decades. Population growth and urban development, as well as some agricultural practices, have continued to intensify problems in the Watershed's four principal Hydrologic Unit Code (HUC 12) subwatersheds (Upper Fish River, Middle Fish River, Lower Fish River, and Magnolia River). Since 1998, a number of stream segments in the WBW have been placed on Alabama's 303(d) list due to a variety of pollutants of concern. The WBW is a large area (approximately 130,000 acres), containing a large network of streams (approximately 362 miles) within central Baldwin County as shown on Figure 1.1. The Watershed includes all or portions of nine municipalities (Fairhope, Daphne, Spanish Fort, Loxley, Robertsdale, Silverhill, Summerdale, Foley, and Magnolia Springs) and associated unincorporated areas of Baldwin County. Increased volume and velocity of stormwater runoff, as well as some agricultural practices, have exacerbated concerns over water quality degradation, e.g., bacterial pollution, nutrient over-enrichment, and sedimentation within the Watershed.

Flooding, particularly on the lower end of the Watershed, was one of the concerns most expressed by citizens. Flood control goals and stormwater treatment goals are often thought to be in opposition; the former concerned with removing water as quickly as possible, and the latter trying to slow release rates and/or volumes.

To respond to these concerns, the Mobile Bay National Estuary Program (MBNEP) and the Baldwin County Soil and Water Conservation District (BCSWCD) facilitated efforts to address the Weeks Bay Watershed problems. This involved award of a contract in January 2016 to Thompson Engineering, Inc. (Thompson), along with sub-consultants Ecology and Environment, Inc. (E&E), Barry A. Vittor and Associates, Inc. (BVA), Bob Higgins and Associates, Hand-Arendall LLC, and Dr. Latif Kalin of Auburn University for preparation of a comprehensive Weeks Bay Watershed Management Plan (WBWMP).

Development of the WMP has been guided by the goals, objectives, and expectations contained in the MBNEP's 2013 – 2018 Comprehensive Conservation and Management Plan (CCMP) with a view towards the six things that coastal residents most value (water quality, fish and wildlife, environmental health and resilience, access, culture and heritage, shorelines). The focus in preparation of the WMP has been to provide a strategy to conserve or restore those habitat types that are most stressed: freshwater wetlands; streams, rivers, and riparian buffers; and intertidal marshes and flats. The overall goal is to help Weeks Bay Watershed stakeholders develop a plan that offers specific and tangible management measures to protect, conserve, and preserve the unique qualities of the area and to recognize and encourage smart use of all watershed features in a cooperative way.

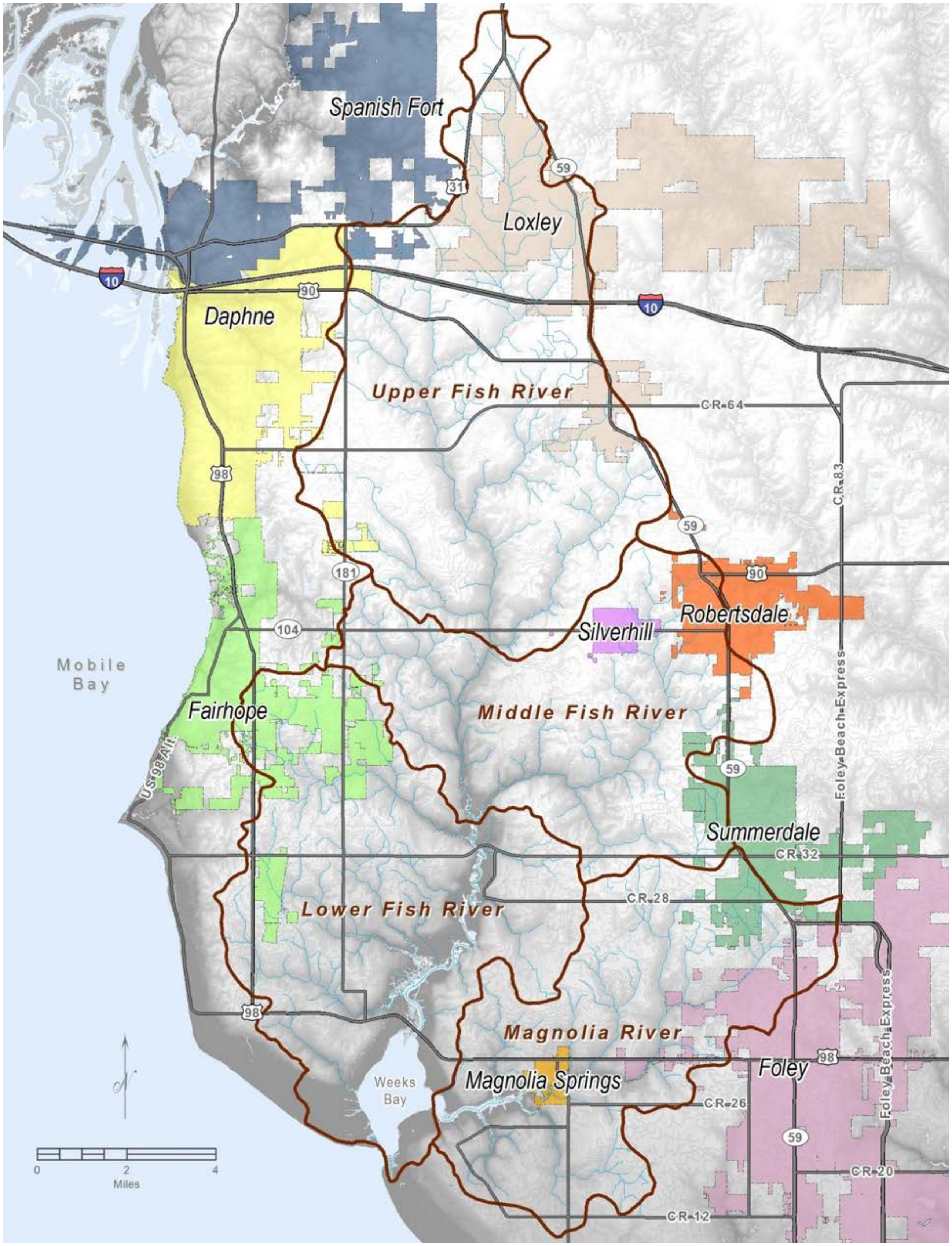


Figure 1.1 Weeks Bay Watershed

Weeks Bay has been recognized through designation as a National Estuarine Research Reserve (NERR) since 1986, and as an Outstanding National Resource Water (ONRW), one of only three within the State of Alabama, since 1992. The Magnolia River is recognized as an Outstanding Alabama Water (OAW) since receiving that designation in 2009.

This WMP outlines a holistic approach to address the issues and concerns identified for the land and water areas of Weeks Bay Watershed. The purpose of this WMP is to guide watershed resource managers, policy makers, community organizations, and citizens to protect the chemical, biological, and cultural integrity of the Weeks Bay Watershed, and specifically its waters and habitats supporting healthy populations of fish, shellfish, and wildlife and providing recreation in and on these waters of coastal Alabama. To accomplish these broad goals, this WMP identifies a range of measures that can be applied to more efficiently manage urban development and agricultural practices within the Weeks Bay Watershed. By successfully addressing the co-related problems identified with population growth, urban development, and some agricultural practices within the Watershed, the long-term health of the stream courses, Weeks Bay, and Mobile Bay will be enhanced.

1.2 Environmental Protection Agency's Nine Key Elements for Watershed Planning

The objectives for plan development are: Build Partnerships, Characterize the Watershed, Set Goals and Identify Solutions, and Design Implementation Program. The Environmental Protection Agency's (EPA) "Handbook for Developing Watershed Plans to Restore and Protect Our Waters" (2008) and the 2013 "Quick Guide" have served as guides to prepare the Weeks Bay WMP. The nine minimum elements identified to be included in the watershed plans under the Clean Water Act Section 319 Nonpoint Source Program have been specifically addressed in the WMP:

- Build Partnerships, including identification of key stakeholders and solicitation of community input and concerns (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 (2)
- Set Goals and Identify Solutions including determination of pollutant reduction loads needed and management measures to achieve goals (2-3)
- Design Implementation Program including implementation schedule, interim milestones, criteria to measure progress, monitoring component, information/education program, and identification of technical and financial assistance needed to implement plan (4-9)

The eight Expected Watershed Plan Components itemized by the MBNEP have also been included in the WMP:

- Literature/Data Review
- Data Compilation, Inventory, Characterization
- Demographic Profile
- Community Participation and Stakeholder Engagement
- Development of Management Alternatives and Restoration Opportunities
- Examination of the Regulatory Framework
- Development of Implementation Program and Financing Alternatives
- Monitoring and Evaluation

1.3 Period Addressed by the Plan

Based on the intense growth that the Baldwin County has consistently experienced since the 1990s, there is a strong possibility that the Weeks Bay Watershed could reach a significant level of "build out" condition by 2040. In 2011, approximately 70% of the Watershed was covered in forest and agriculture. Over the 30-year period leading to 2040, it is anticipated that much of the remaining forest and agricultural lands will be converted to urban development, primarily residential uses. While some aspects of the WMP address the planning horizon out to 2040 (population and land use projections), the realistic period for most components of the WMP, e.g., recommended management measures is ten years from the date of this report – 2017 through 2027.

1.4 Document Overview

This WMP is organized in the following manner:

- Section 2 describes the Weeks Bay Watershed, addressing its pertinent resource characteristics and providing historical context to enable an understanding of the scope of the problems of concern.
- Section 3 evaluates the existing conditions within the Watershed to lay the foundation upon which the management measures were formulated.
- Section 4 identifies the critical areas within the Watershed that have been most affected by urban development and agricultural practices.
- Section 5 explains the goals and objectives that were used to guide development of the management measures.
- Section 6 describes the recommended management measures considered to address the urban development, agricultural practices, and other Watershed issues. These measures range from: pure engineering solutions, to modifications of the regulatory framework, controlling development, to approaches to better manage the future of the Watershed. Implementation strategies are also discussed.
- Section 7 contains a summary of the regulatory review, including discussions of federal, state, Baldwin County, and municipality laws, regulations, and ordinances.
- Section 8 presents the results of an investigation of potential sources to fund implementation of the management measures.

- Section 9 describes a public education and community outreach program to explain the need to pursue corrective measures and to gain the support of the Watershed stakeholders that is necessary to effectively implement the WMP in a holistic fashion.
- Section 10 outlines a monitoring program to evaluate the success of the management measures to reduce urban development and agricultural practice problems.
- Section 11 describes implementation strategies to address Watershed issues.
- Section 12 identifies the extensive literature considered to develop this WMP.

1.5 Watershed Management Team

A primary goal in the development of any watershed management plan is to understand what people who live, work or simply care about the environment think of the watershed. What's great about it and should be preserved? What is wrong or trending in the wrong direction? The development of the Weeks Bay Watershed Management Plan was structured around frequent in-depth discussions with various stakeholders. The hope is that these same stakeholders, and the groups that they are a part of, will feel ownership and be strong supporters of the recommendations in this Plan.

Early in the watershed management planning process it became very obvious to the Thompson Team that two valuable entities exist within this Watershed that should be specifically recognized at this point – the Weeks Bay National Estuarine Research Reserve and the Weeks Bay Foundation. More details about these entities are provided in the following paragraphs regarding the valuable role they play in the resource management within the Weeks Bay Watershed.

1.5.1 Weeks Bay National Estuarine Research Reserve

The Weeks Bay National Estuarine Research Reserve (WBNERR or Reserve) is just one of numerous coastal reserves across the country. Each Reserve System was established for long-term scientific research and education to promote management for the nation's estuaries and coastal habitats. The Alabama Department of Conservation and National Resources (ADCNR) and the National Oceanic and Atmospheric Administration (NOAA) both manage the Weeks Bay Reserve, which was designated in 1986. Local reserves manage their resources on a daily basis through regional and state partnerships.

The Estuarine Research Reserve System consists of 28 reserves in 23 states. The reserve system attracts more than half a million students, educators, and visitors annually. It protects over one million acres of estuarine lands and waters. At its designation, the Weeks Bay Reserve occupied 3,042 acres of land and water bottoms. Currently the Reserve boundary includes 9,317 acres of land and water habitat. The Reserve includes coastal wetlands that provide rich and diverse habitat for a variety of plants and animals. In addition, the Weeks Bay Interpretive Center is available to the public to learn more about coastal habitats through its exhibit. The Weeks Bay Reserve was visited by approximately 8,000 people in 2016.

The vision of the Reserve is "a healthy Weeks Bay estuary and watershed appreciated by the community", and further elaborated on by its mission to "provide leadership to promote informed management and stewardship of estuarine habitats through research, partnerships, education, and training using a place-based system of protected areas." Since 2007 the Reserve has participated in more than 37 research projects from which at least 29 peer-reviewed journal articles or reports were published.

The Weeks Bay Reserve operates on four main activities: (1) long-term research and monitoring of water quality and overall watershed health through the Research program, (2) tools and training for coastal managers through the Coastal Training Program, (3) coastal education for students through the Education program, and (4) management of natural resources and restoration through the Stewardship Program.

Current facilities at the Reserve include a 4,500 square foot Visitor Center that houses the administrative offices on U.S. Highway 98; a 3,500 square foot Research and Education Facility; the Arthur C. "Skipper" Tonsmeire Resources Center for meetings, workshops, and public events at the Fish River U.S. Highway 98 bridge; and a Research Dormitory with approximately 3,500 square feet. In addition, there is a 3,600 linear feet elevated boardwalk with an observation deck overlooking Weeks Bay behind the Visitor Center, plus another boardwalk at the Weeks Bay Pitcher Plant Bog.

The WBNERR has played an instrumental role in watershed planning, leading the way for preparation of the first Weeks Bay Watershed Management Plan in 1998, followed by updates in 2002 and 2009. These plans were some of the first watershed management plans developed in the State of Alabama. The 1998 plan was initiated in 1993 by the Natural Resources Conservation Service (NRCS), EPA, Gulf of Mexico Program, and ADEM in cooperation with many other federal and state agencies, as well as several local organizations. These plans were governed by a Citizen Advisory Committee (CAC) and supported by a Technical Advisory Committee (TAC) and an Education Subcommittee. In addition to development of these watershed plans, the WBNERR has been highly involved in monitoring of water quality in the Weeks Bay Watershed. In April 1995, the Alabama Water Watch (AWW) assisted the WBNERR in establishment of a citizen volunteer monitoring program (Weeks Bay Water Watch chapter of AWW) that still continues.

1.5.2 Weeks Bay Foundation

The Weeks Bay Foundation was established in 1990 as the "Friends Group" to the Weeks Bay National Estuarine Research Reserve. The Foundation works to support the Reserve through strategic land acquisition, grant administration, state and federal advocacy, and community engagement. In addition, the Foundation functions as a Nationally Accredited Land Trust conserving coastal land throughout Baldwin and Mobile County, Alabama. Since its inception, the Foundation has protected more than 7,000 acres of habitat. Resource preservation is accomplished through a number of means including purchases, conservation easements, and donations of land. Currently, the Foundation manages close to 1,000 acres in both coastal counties of Alabama. These lands will be managed for their conservation values and will be protected in perpetuity.

1.5.3 Stakeholders Working Group

Preparation of the WMP was accomplished through a collaborative effort that was guided by the Thompson Team and the Stakeholders Working Group (SWG). The focus of this team was to elicit strong stakeholder participation. The Watershed is in parts of nine different municipalities and their planning jurisdictions in Baldwin County: We needed representation from the cities and the county. We also needed representation from homeowners on the Fish and Magnolia Rivers. Agriculture represents a very large percentage of land use in the Watershed: We needed farmers. Baldwin County is the fastest growing county in Alabama: We needed developers and engineers. We also needed people who are currently involved in managing the Watershed. We started in January 2016 by building the SWG with representatives from each of these constituencies or interest groups, as shown in Table 1.1.

The SWG continued to meet on an approximate bimonthly schedule with the Thompson Engineering team throughout the development process, having a total of 10 meetings over the course of the WMP development. While some of the SWG members were not able to participate for the full duration of the effort, replacements in those constituent groups were found to ensure good representation throughout the WMP development. Copies of meeting SWG meeting minutes are contained in Appendix A. The SWG meetings are summarized in Table 1.2.

1.5.4 Stakeholders Workshop

Each constituency of the SWG was charged with inviting six to eight other people from their constituency to a large workshop held on March 2, 2016. The workshop was attended by approximately 86 participants. The workshop, held in the Baldwin County Central Annex Auditorium in Robertsdale, was attended by approximately 86 participants with a table set up for each of these constituency groups:

- Agriculture/Forestry
- Business
- City & County Staff Members
- Developers
- Engineers
- Environmental Organization Leaders
- Environmental Science
- Homeowners
- Mayors & Elected Officials

Table 1.1 Weeks Bay Watershed Stakeholders Working Group

Constituency/Entity	Representative
Government/Mobile Bay National Estuary Program	Roberta Swann
Government/ Mobile Bay National Estuary Program	Christian Miller
Government/Baldwin County Soil and Water Conservation District	Larry Morris
Government/Baldwin County Soil and Water Conservation District	Ronnie Northcutt
Government/USDA-NRCS, District Conservationist	Joey Koptis
Government/Alabama Department of Environmental Management	Shannon McGlynn/Randy Shaneyfelt
Government/Alabama Department of Transportation	Vince Calametti
Government/Baldwin County	Matthew Brown/Seth Peterson
Government/Baldwin County Mayors Association	Dane Haygood
Government/Department of Public Works Representative (Fairhope)	Jennifer Fidler/Kim Burmeister
Government/Loxley Public Utilities Department	Brandon Allen/Scott Bankester
Government/US Fish and Wildlife Service	Bruce Porter
Government/Baldwin County Health Department	Camilla English
Environmental-Science/Weeks Bay National Estuary Research Reserve	Mike Shelton
Environmental-Science/Weeks Bay Foundation	Rick Wallace
Business/Eastern Shore Chamber of Commerce	Heiko Einfeld
Business/ Baldwin County Sewer Service	Gerry McManus
Agriculture	Michael Mullek
Agriculture	Joel Sirmon
Development/DR Horton	Tom Poulos/Joel Coleman/Kenny Pfeiffer/Duane Miller
Homeowner Interest – Fish River	Sam Covert
Homeowner Interest—Fish River	J.R. “Dick” Sute
Homeowner Interest—Fish River	Steve Heath
Homeowner Interest—Magnolia River	Ken Underwood
Homeowner Interest -- Magnolia River	Teddy King
Stakeholder Outreach Coordinator	*Bob Higgins*
	bob@rjhiggins.com
	251-752-2274

Table 1.2 Summary of SWG Meetings

SWG Meeting Date	Key agenda items
Feb 3, 2016	Introductions of members, description of WMP process
Feb 17, 2016	Develop list of invitees to March workshop; county Stormwater presentation
Mar 16, 2016	Discuss learnings from workshop
May 18, 2016	Dr. Latif Kalin SWAT model presentation; overall project status update
July 20, 2016	Project status update; discuss potential WMP recommendations
Sep 14, 2016	Project status; SWAT model status; regulatory matrix; growth forecast
Nov 16, 2016	Regulations comparison; shoreline trends; wetlands & ecosystem status
Jan 18, 2017	Population growth; SWAT 2040 projections; water quality; WBNERR draft plan
Apr 5, 2017	In depth discussion of draft WMP recommendations; who should "own" each
July 25, 2017	Discussion of Draft WMP and public review plan

Each group was given time to consider the Watershed from their unique point of view and worked independently to identify:

- Strengths: What's right and should be preserved/strengthened?
- Weakness & Threats: What's not right? What negative trends do you see?
- Opportunities: Look at your top 3 strengths and weaknesses- What could be done to address them?

Pick one opportunity and develop an action plan: What, who, how, roadblocks, help needed from others

A spokesperson from each group then shared their group's work with all of the workshop participants. A summary of the major learnings is in Table 1.3. The complete results including each table team's work is in Appendix A.

Table 1.3 Summary of March 2, 2016 Public Workshop

Top Issues:

- **Flooding**
- **Water quality**
- **Non point sedimentation, mud**
- Erosion
- Loss of habitat, wetland loss
- Shoreline hardening

Top Causes:

- **Development, population growth**
- **Lack of a comprehensive, multi-jurisdictional storm water management plan**
- **Lack of consistency in regulations between jurisdictions**
- Lack of a process in which stakeholders and regulators meet regularly to address issues
- Lack of money to implement changes, both in public and private sectors
- Education on low impact development and agriculture not reaching everyone
- Septic tank discharge from failing systems
- Fertilizer
- Livestock in wetlands/streams
- Lack of riparian buffers

Top Action Plans:

- **Develop a comprehensive, multi-jurisdictional storm water management plan**
- **Develop ways to continue discussions between stakeholders to address issues where multiple regulatory groups (cities, county, state, federal) are involved**
- Educate agricultural producers about incentives available to help offset cost associated with exclusion fencing and alternative water sources
- Form a developer organization that meets at least semi-annually to discuss experiences, challenges and strategies
- Develop more effective ways to encourage Low Impact Development practices
- Strategic land acquisition
- Reduce pathogens from septic tanks
- Identify flood prone mini-areas prior to development

1.5.5 Online Watershed Survey

We took some of what we learned from the focus groups in the Workshop and put them out for public comment via an online "Survey Monkey survey. We asked each respondent to rank in order of importance the strengths, weaknesses, and opportunities for improvement that were identified in the Workshop. The survey was advertised by direct emails and articles in city and environmental organization newsletters. Forty-seven people answered the questions in the survey. The complete results are in Appendix A, but here are a few key findings:

- Strengths: The most important strengths were recreational opportunities, a caring community, and that the Watershed is largely undeveloped.
- Weaknesses and threats: The top three in this category were not enough public access, flooding, and inconsistency of rules/regulations.
- Opportunities: The top four in this category were regular meetings with stakeholders, identify livestock operations that affect the water, reduce pathogens from leaking septic systems, and public education and awareness.

1.5.6 Newsletters

Mobile Bay NEP published email newsletters on the progress toward developing the plan as needed. We published several as the project kicked off in the spring and summer, then one at the end of 2016 that summarized work done over the year. MBNEP used this as an opportunity to continue to build their database of people who are interested in the environment. Copies of the newsletters are available in Appendix A.

1.5.7 Website

Because MBNEP maintains a website with sections describing each of the 13 watersheds in its jurisdiction, we used the Weeks Bay Watershed section of www.mobilebaynep.com for this watershed management plan. We also set up a temporary shortcut, www.weeksbaywatershed.org (now discontinued), which pointed directly to our portion of the MBNEP website. The website contains general information about the Watershed itself as well as meeting schedules and minutes, technical reports, and the final Watershed Management Plan.

1.5.8 Other Outreach

Because Weeks Bay has an excellent existing public outreach education resource in the Weeks Bay Foundation and Weeks Bay Reserve, this team did not try to duplicate any of this. Instead, we partnered with them throughout the process to make sure that they were learning from our work and we from theirs.

We were a part of the Weeks Bay Foundation annual "Bald Eagle Bash" fundraisers in April 2016 and 2017 with a booth on the WMP. We talked to over 150 people who stopped by to look at the maps of the Watershed and share their thoughts. The Thompson Team also participated in Coastal Cleanup activities in 2016.

We provided talking points to MBNEP staff members to include when talking to civic and community groups in our area.

1.6 Draft Watershed Management Plan Coordination

The Draft WBWMP was made available for public review on August 2, 2017, as it was posted on the MBNEP website for a 30-day review period. The Draft WMP was also presented to the public at a public workshop on August 16, 2017. The workshop was held at the Baldwin County Central Annex on Palmer Street in Robertsdale, and was attended by 49 people. The review period for the Draft WMP ended on August 31, 2017. During that period, hardcopies of the Draft WMP were placed at several locations in and around the Watershed. Appendix A contains the minutes documenting the principal discussions held during the public workshop. No public or agency written comments were received on the Draft WMP.

2.0 Watershed Description

2.1 Watershed Boundary

The Weeks Bay Watershed encompasses approximately 130,000 acres (203 square miles) located in southwest Baldwin County, Alabama. Weeks Bay is a shallow, approximate 1,700 acre, sub-estuary of Mobile Bay and has been part of the National Oceanographic and Atmospheric Administration (NOAA) National Estuarine Research Reserve (NERR) system since 1986. The Watershed is comprised of the following four USGS 12-digit Hydrologic Unit Code (HUC) areas: Upper Fish River (HUC 031602050201), Middle Fish River (HUC 031602050202), Lower Fish River (HUC 031602050204), and Magnolia River (HUC 031602050203) and encompasses an area approximately 27 miles long and 12 miles wide. Portions of nine municipalities lie within the Weeks Bay Watershed: Fairhope, Daphne, Spanish Fort, Loxley, Silverhill, Robertsdale, Summerdale, Foley, and Magnolia Springs. Fish River begins near the town of Stapleton, and flows in a southerly direction. The eastern boundary of the Fish River basin is near U.S. Highway 59 and the western boundary is near U.S. Highway 31 (Stapleton to Spanish Fort), thence southward near Alabama Highway 181 (Spanish Fort to Fairhope), thence southward near U.S. Highway 98 to Mobile Bay. The Magnolia River has its headwaters near Summerdale and flows in a southwestward direction to Weeks Bay.

2.2 Hydrology

2.2.1 Climate and Rainfall

The climate of the Weeks Bay Watershed is considered humid subtropical, with abundant rainfall. Summers are normally dominated by high pressure and southerly winds that frequently result in afternoon thunderstorms. Summer temperatures generally range from 80° to 90° F, with 100° F not uncommon. Winters are generally mild, with frequent cold fronts and showers originating from the northwest and low temperatures of 20° F or below occurring most every year. The ground rarely freezes to a depth of more than a few inches.

Tropical storms and cyclones are also fairly common along the northern Gulf coast. Although "direct hits" are not particularly frequent, approximately 15 total hurricane strength storms made landfall within 50 miles of Baldwin County between 1900 and 2010, of which 7 were major. The estimated return frequency for a hurricane passing within 50 miles of Baldwin County is 10 years and the return frequency for a major hurricane (Category 3 or higher) is 28 years (NOAA National Hurricane Center http://www.nhc.noaa.gov/climo/). When these events do occur, significant amounts of rainfall can occur resulting in flooding conditions, high erosion rates and the transport of large amounts of sediment and debris into the wetlands, rivers and bay. Destruction of trees from wind damage and saltwater intrusion from storm surge flooding often results in the land being converted to uses other than forest land (Bianchette et al., 2009). In addition to potential changes in forest cover, estuarine emergent wetlands can also be significantly impacted by hurricanes (Rodgers et al., 2009) having long term impacts to stormwater runoff patterns and the environment.

Rainfall is the primary natural factor affecting soil loss and stormwater runoff within the Weeks Bay Watershed. Stormwater generated from rainfall is also the main transport mechanism for eroded soils and other pollutants (nutrients, pathogens, etc.), particularly in urban areas with high percentages of impervious cover. The mild, humid climate favors rapid decomposition of organic matter and hastens chemical reaction in the soil. On uplands, the large amount of moisture and the warm temperature favor the growth of bacteria and fungi and speed the decomposition of organic matter, resulting in soils that are low in organic matter content. The plentiful rainfall leaches large amounts of soluble bases and carries the less soluble fine particles downward, resulting in acid soils that have a sandy surface layer and that are low in natural fertility.

The Alabama Gulf coast is one of the wettest areas in the United States, second only to the Pacific Northwest, with average annual rainfall of 67 inches and approximately 60 rain days per year. Rainfall occurs throughout the year with the most precipitation during the months of April through September. Rainfall is usually of the shower type. Storms with long periods of continuous rainfall are less common. Tropical summer thunderstorm events are capable of producing localized heavy rainfall totals of several inches with a 1-2 hour timeframe. The annual mean rainfall from 2000-2016 reported for Fairhope and Robertsdale is 66.5 inches and 71.7 inches, respectively (NOAA-National Weather Service, http://w2.weather.gov/climate/) (Figure 2.1).

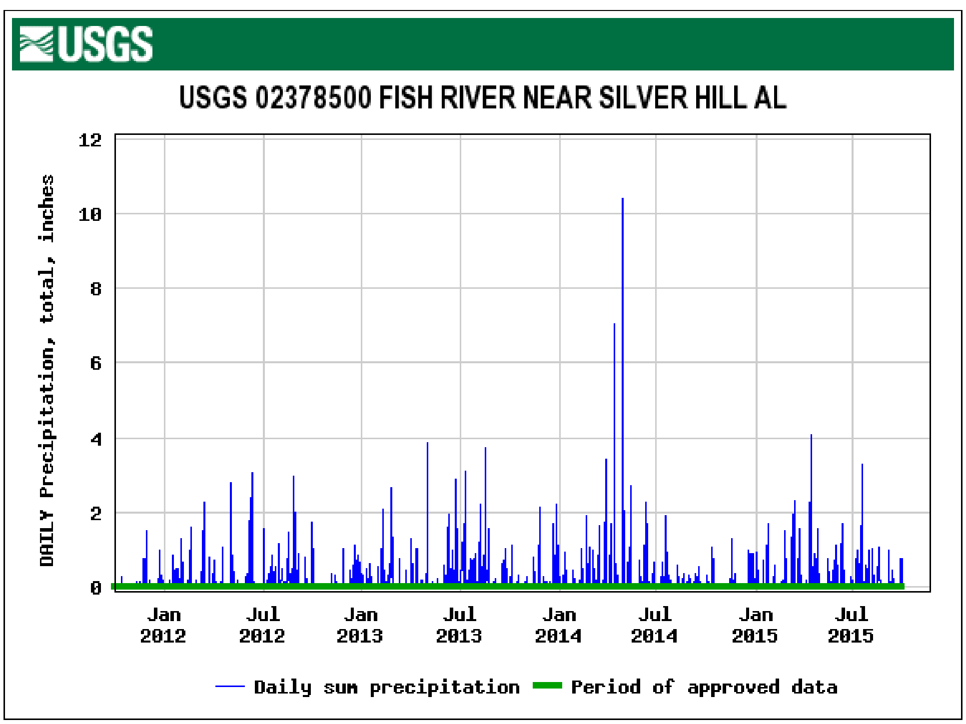


Figure 2.1 Daily Precipitation Measured Near Silverhill

Also of significance is the intensity or type of rainfall events that occur. The Natural Resources Conservation Service (formerly the Soil Conservation Service) categorizes rainfall into four types of rainfall distribution patterns (I, IA, II, III) based on rainfall intensity (inches/hour). Most of the northern Gulf coast, including the southern 2/3 of Alabama, experience NRCS Type III events with approximately 50% of the rain falling during a short interval around the middle of the event. Another measure of the intensity of rainfall events is reflected in the Universal Soil Loss Equation by the "R" factor, a value determined from the raindrop energy, rainfall intensity, rainfall frequency and storm duration. The R factor along the Alabama coastal area is around 650 (Figure 2.2). By comparison, the R factor in the Olympic National Forest in Washington State which receives on average twice the volume of rain (~120 inches/year) is only 340. These high intensity rainfall events that occur in the Week Bay Watershed only makes the proper use of appropriate best management practices and stormwater management practices that much more critical.

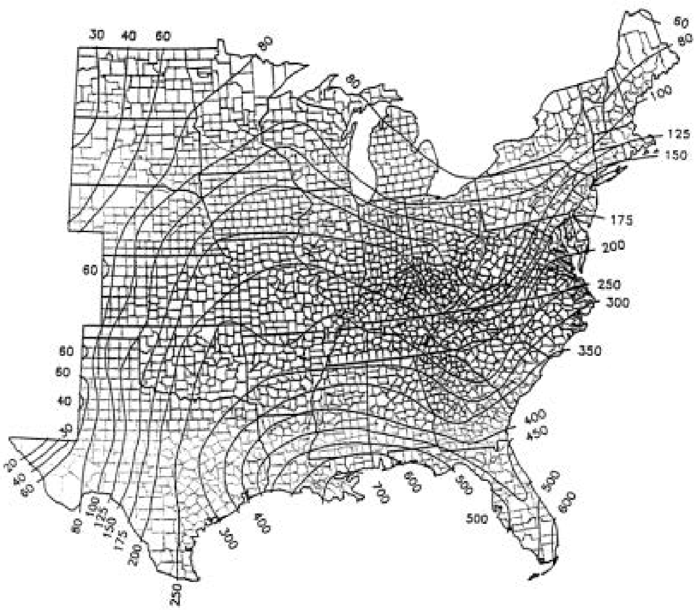


Figure 2.2 Isoerodent Map of Eastern U.S.
Source: Renard et al., 1987

2.2.2 Surface Water Resources

The Weeks Bay Watershed contains an estimated 361.6 miles of surface water streams, while Weeks Bay itself has a surface area of approximately 1,700 acres, according to the National Hydrology Dataset (2016). Table 2.1 and Figure 2.3 show the stream lengths for the Fish and Magnolia Rivers plus the major named tributaries. Fish River contributes, on average, an estimated 75% of the flow into Weeks Bay with the Magnolia River contributing the remaining 25% (Figure 2.4). The freshwater stream segments are typical blackwater streams with low pH and planktonic activity (GOMA, 2013b).

Table 2.1 Weeks Bay Watershed Surface Stream Segment Lengths

Watershed	Stream	Length (Miles)
Upper Fish River	Fish River	17.3
	Bay Branch	3.9
	Beiser Branch	1.4
	Bull Branch	2.0
	Caney Branch	2.5
	Corn Branch	5.1
	Doeneck Branch	1.2
	Perone Branch	7.3
	Picard Branch	2.8
	Rockhead Branch	1.5
	Threemile Creek	3.8
	Turkey Branch	4.6
	Unnamed Stream Segments	70.4
Total		123.6
Middle Fish River	Fish River	5.0
	Baker Branch	6.2
	Halls Branch	1.7
	Pensacola Branch	4.3
	Polecat Creek	7.9
	Silver Creek	4.1
	Still Branch	1.9
	Worm Branch	0.9
	Unnamed Stream Segments	39.8
Total		71.7
Lower Fish River	Fish River	7.7
	Barner Branch	2.1
	Cowpen Creek	7.0
	Green Branch	2.9
	Louis Branch	2.1
	Turkey Branch	6.7
	Waterhole Branch	7.2
	Weeks Branch	2.9
	Unnamed Stream Segments	52.8
Total		91.4
Magnolia River	Magnolia River	12.4
	Eslava Creek	3.5
	Noltie Creek	2.4
	Schoolhouse Branch	3.8
	Weeks Creek	3.6
	Unnamed Stream Segments	49.2
Total		74.9
Weeks Bay Watershed Total		361.6

Source: USGS National Hydrology Dataset, 2016

Source: USGS National Hydrology Dataset, 2016

Figure 2.3 Stream Network within Weeks Bay Watershed

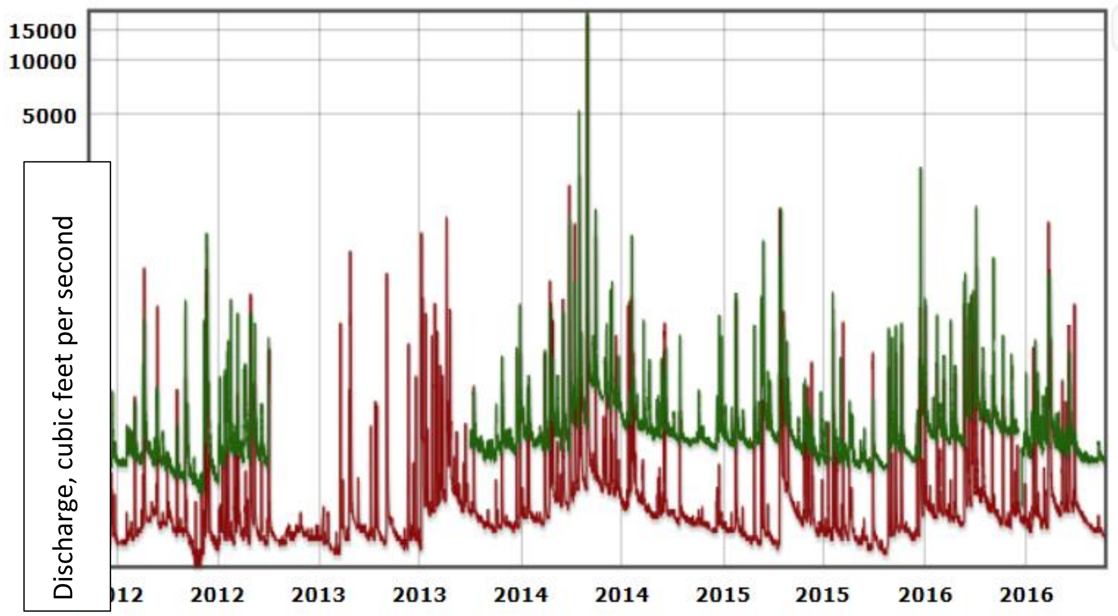


Figure 2.4 Stream Discharge in Fish and Magnolia Rivers

------- Fish River at AL Highway 104

------- Magnolia River at US Highway 98

Source: www.waterdata.usgs.gov/nwis

2.2.3 Subwatersheds

Due primarily to the spatial coverage of the available water quality data, the general discussion regarding watershed conditions (Section 3.0) considers the entire watershed. However, Fish River, Magnolia River and Weeks Bay were assessed independently, and Fish River was further broken into the three 12-digit Hydrologic Unit Codes (HUCs). The Soil and Water Assessment Tool (SWAT) model further segmented the four 12-digit HUCs into 237 subwatersheds and 2,449 hydrologic response units (HRUs) that were determined by similarities in soils, topography and land use. These subwatersheds and HRUs were evaluated for their relative inputs of sediment and nutrients in an attempt to determine potential "areas of concern".

The Upper Fish River basin (HUC 031602050201) covers approximately 42,000 acres. The dominant land use/cover is agriculture (39%) consisting of row crops and pasture, followed by forest land (35%), urban development (15%), wetlands (11%), according to the 2011 National Land Cover Dataset (Homer et al., 2012). The eastern and northern part of the Upper Fish River basin includes portions of Loxley, and the western part includes portions of Spanish Fort and Daphne. Commercial and residential development is occurring along the major transportation corridors of Interstate 10, U.S. Highways 31 and 90, Alabama Highways 59 and 181, and County Road (CR) 64. The downstream extent of this HUC is approximately 200 feet downstream of the Alabama Highway 104 bridge crossing, at the confluence with Perone Branch. Major first order tributaries include: Threemile Creek, Turkey Branch, Bay Branch, Corn Branch, Caney Branch and Perone Branch. There are two wastewater treatment facilities that discharge into this basin, Spanish Fort and Loxley, having permitted flows of secondary effluent totaling 2.0 MGD discharging to the main stem of Fish River. The SWAT model delineated 79 subwatersheds within the Upper Fish River basin.

The Middle Fish River (HUC 031602050202) basin covers approximately 27,000 acres. The dominant land use/cover is agriculture (58%) both row crops and pasture. Forested land comprises about 20% of the basin and wetlands cover about 12%. Urban development makes up about 10% (Homer et al., 2012). The eastern portion of the Middle Fish River Subwatershed includes all or parts of Robertsdale, Summerdale and Silverhill, and the western part of the basin includes a small portion of Fairhope. Commercial and residential development is occurring along Alabama Highways 59, 104, and 181. Major first order tributaries include: Pensacola Branch, and Polecat Creek. Major second order tributaries include: Silver Creek and Baker Branch. Both Polecat Creek from Fish River to its source is 303(d) listed for Hg (atmospheric deposition) and Baker Branch from Polecat Creek to its source is 303(d) listed for organic enrichment (pasture grazing). There are no permitted wastewater treatment facilities that discharge into this basin. The SWAT model delineated 58 subwatersheds within the Middle Fish River basin.

The Lower Fish River basin (HUC 031602050204) covers approximately 34,500 acres. Land use/cover attributed to row crops and pasture is 43%. Wetlands and open water cover about 26%. Forest areas account for about 16%, with developed/urban use with 15% (Homer et al., 2012). The western portion of the Lower Fish River basin includes portions of Fairhope. Commercial and residential development is occurring along U.S. Highway 98, Alabama Highway 181, and numerous county roads. Major first order tributaries include: Cowpen Creek, Barner Branch, Green Branch, Waterhole Branch and Turkey Branch. There are no wastewater treatment facilities that discharge into this basin. The SWAT model delineated 60 subwatersheds within the Lower Fish River basin.

The Magnolia River basin (HUC 031602050203) covers approximately 26,000 acres. Land use/cover attributed to agriculture (row crops, sod farms and pasture) is 64%. Wetlands and open water cover about 14%. Developed/urban use accounts for about 13%, and forest areas account for about 9% (Homer et al., 2012). The Magnolia River basin includes portions of Summerdale and Foley, and all of Magnolia Springs. Commercial and residential development is occurring along U.S. Highway 98, Alabama Highway 59, and numerous county roads. Major first order tributaries include: Nolte Creek, Eslava Creek, Weeks Creek and Schoolhouse Branch. The Magnolia River from Weeks Bay to its source is 303(d) listed for Hg (atmospheric deposition). There are no wastewater treatment facilities that discharge into this basin. The SWAT model delineated 40 subwatersheds within the Magnolia River basin.

2.2.4 Groundwater Resources

The Weeks Bay Watershed is underlain by two major aquifers: the watercourse aquifer (sometimes referred to as the Beach Sand aquifer) and the Miocene-Pliocene aquifer. The watercourse aquifer consists of the Quaternary alluvial, coastal, and terrace deposits and is hydraulically connected to the underlying Miocene-Pliocene aquifer. The Miocene-Pliocene aquifer consists of the Citronelle Formation and the Miocene Series undifferentiated and is approximately 3,400 feet thick in southern Baldwin County (Gillett et al., 2000).

The Miocene-Pliocene aquifer system flows through sand and gravel beds that are irregular in thickness and of limited lateral extent. The clay intervals between the sand units are considered aquitards because the clays are not laterally extensive enough to prevent downward movement of groundwater. However, they do provide semi-confinement to many of the deeper sand and gravel intervals. The watercourse aquifer system also flows through sand and gravel beds. The watercourse aquifer and the sand and gravel beds at shallow depths in the Miocene-Pliocene aquifer are hydraulically connected to the land surface and therefore are considered unconfined (Gillett et al., 2000).

2.2.4.1 Groundwater Use and Recharge

The Weeks Bay Watershed is 100 percent dependent on groundwater for potable water supply. The majority of the public-water supply wells within the Weeks Bay Watershed derive water from the Miocene-Pliocene aquifer, although a few wells are completed in the watercourse aquifer. The Miocene-Pliocene aquifer system is also heavily utilized for self-supplied domestic, agricultural, and recreational purposes (Robinson et al., 1996). According to the Estimated Use of Water in Alabama study (Harper and Turner, 2010), 60 percent of Baldwin County's groundwater use was for irrigation and 37 percent was for public supply in 2010.

According to the ADEM 2013 public well supply data, there are a total of 25 public supply wells from the Miocene-Pliocene aquifer in the Weeks Bay Watershed. There are six public supply wells within the Upper Fish River Subwatershed, ten in the Middle Fish River Subwatershed, eight in the Lower Fish River Subwatershed, and one in the Magnolia Subwatershed. Figure 2.5 below identifies each well location.

The source of recharge to the aquifers is rainfall. The amount of water that infiltrates the soil depends on the hydraulic conductivity and permeability of the soil, the amount of water present in the soil during rainfall, and the slope of the land surface. Infiltration is greater in a flat area that is underlain by gravel and coarse sands rather than in an area with a sloping land surface that is underlain by dense clay. The amount of recharge to the aquifers may be estimated from the base (dry-weather) flow of streams, which is groundwater discharge (Gillett et al., 2000).

Source: MBNEP, Alabama Coastal Resources Comprehensive GIS Inventory

Figure 2.5 Public Groundwater Wells and Aquifer Recharge Areas

A literature search for impacts of impervious cover on groundwater recharge found a 1996 report titled "*Ground-Water Resource Data for Baldwin County, Alabama*" that was performed by the U.S. Geological Survey (Robinson et al., 1996). In that report, geologic and hydrologic data for 237 wells were collected, and water levels in 223 wells in Baldwin and Escambia Counties were measured. Data was collected during the period of investigation from September 1994 to November 1995. Long-term water level data, available for many wells, indicated that groundwater levels in most of Baldwin County showed no significant decline. This suggested that groundwater use levels at the time of the study were sustainable in Baldwin County. However, groundwater levels showed that there may be a declining trend in the general area of Spanish Fort and Daphne (cities with major growth). Additionally, groundwater levels in Gulf Shores and Orange Beach areas were less than 5 feet above sea level in places.

2.2.4.2 Groundwater Quality

The quality of water in the Miocene-Pliocene aquifer system of Baldwin County generally is good, and many self-supplied homeowners use groundwater with no treatment. Wells in the Miocene-Pliocene aquifer generally yield soft water that has a dissolved solids content of less than 250 milligrams per liter (mg/L). Water in alluvium and low terrace deposits generally is soft and has a dissolved solids content less than 100 mg/L, but commonly contains iron in excess of 0.3 mg/L and may be corrosive (Gillett et al., 2000).

The Miocene-Pliocene and watercourse aquifers are considered to be highly vulnerable to contamination from surface sources throughout the Watershed due to their unconsolidated nature and the permeability of the soils. Numerous surface sources of potential contamination include point sources such as gasoline/diesel tanks, chemical spills, etc. and nonpoint sources such as pesticides and herbicides applied to agricultural fields, lawns, and gardens, urban run-off, etc. (Gillett et al., 2000).

In a 2006-2007 study to assess the extent and source of nitrate contamination in the aquifer system of southern Baldwin County, it was discovered that isolated pockets of severe nitrate contamination were present in the Miocene-Pliocene aquifer. An area of contamination was identified southeast of Weeks Bay along the Magnolia River and Skunk Bayou Subwatersheds. The maximum nitrate concentrations were 121.37 mg/L and 53.40 mg/L in 2006 and 2007, respectively. The study concluded that the likely source of this nitrate contamination is related to sewer breakthrough from leaking, outdated, and/or improperly installed septic tanks. The chloride and nitrate concentrations for points located within this area are consistent with contamination derived from sewer breakthrough, animal waste, and to some extent from the application of fertilizers (Mugulet and Tick, 2009).

2.3 Geologic Setting

2.3.1 Physiographic Provinces

The Weeks Bay Watershed is located entirely within the East Gulf Coastal Plain section for the Coastal Plain physiographic province. The Upper Fish River is located entirely within the Southern Pine Hills physiographic district, while the Middle Fish River, Lower Fish River, and Magnolia River Subwatersheds encompass portions of the Southern Pine Hills and Coastal Lowland districts (Figure 2.6).

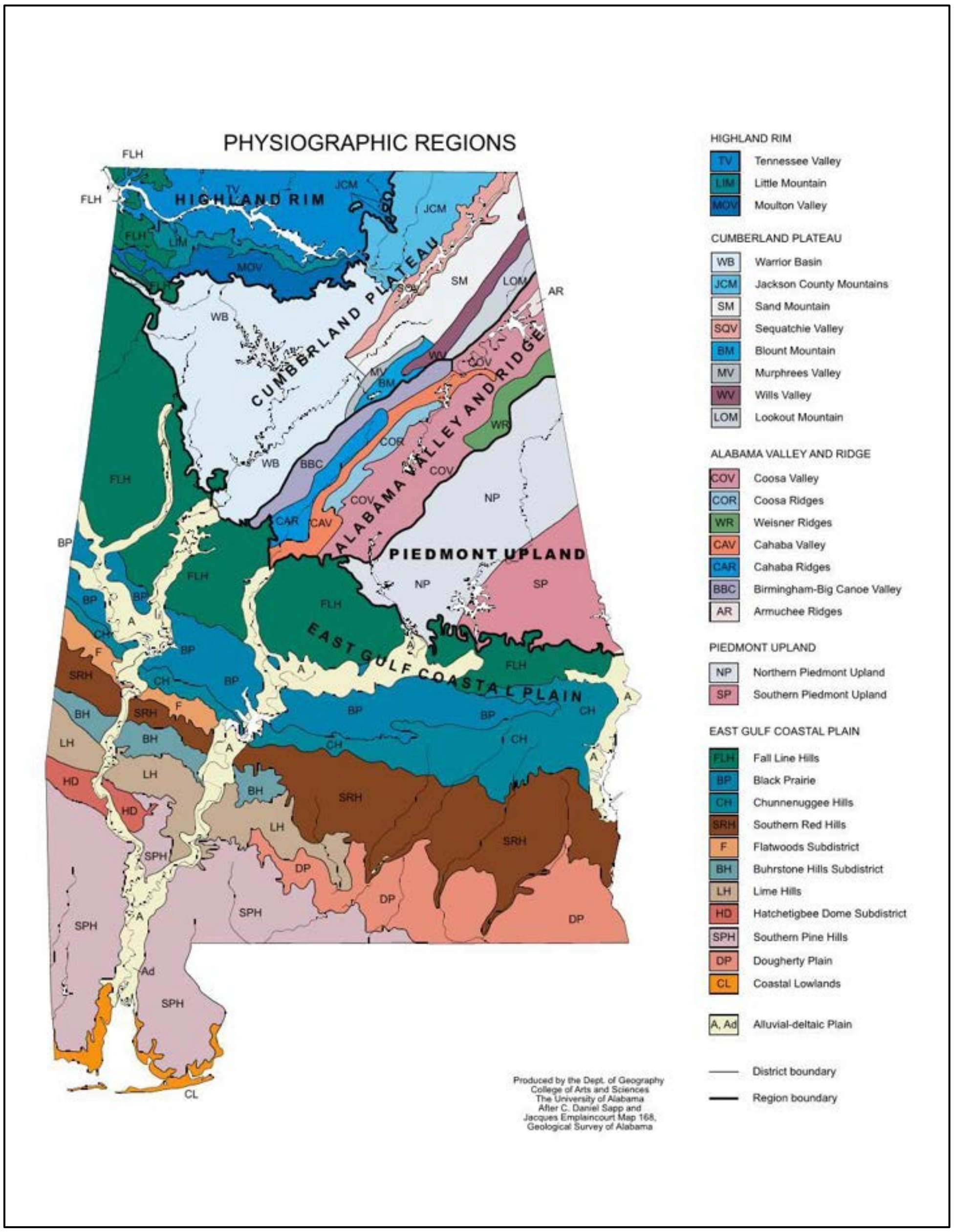


Figure 2.6 Physiographic Provinces of Alabama
Source: University of Alabama (2017)

The Southern Pine Hills district consists of mostly upland areas with terrain that slopes gradually southward. The Coastal Lowlands district consists of flat to gently rolling plains, tidal streams, marshes, and wetlands (Gillett et al., 2000).

2.3.2 Topography

The terrain in the northern portions of the Weeks Bay Watershed is marked by long, rolling hills, entrenched streams and rivers with steep banks. The streams and rivers drop to base level in relatively short distances and are characterized by as much as 250 feet of relief. Relief in the southern portions of the Watershed is comparatively small; most streams and rivers have broad channels and low, gently sloping banks (Davis, 1987).

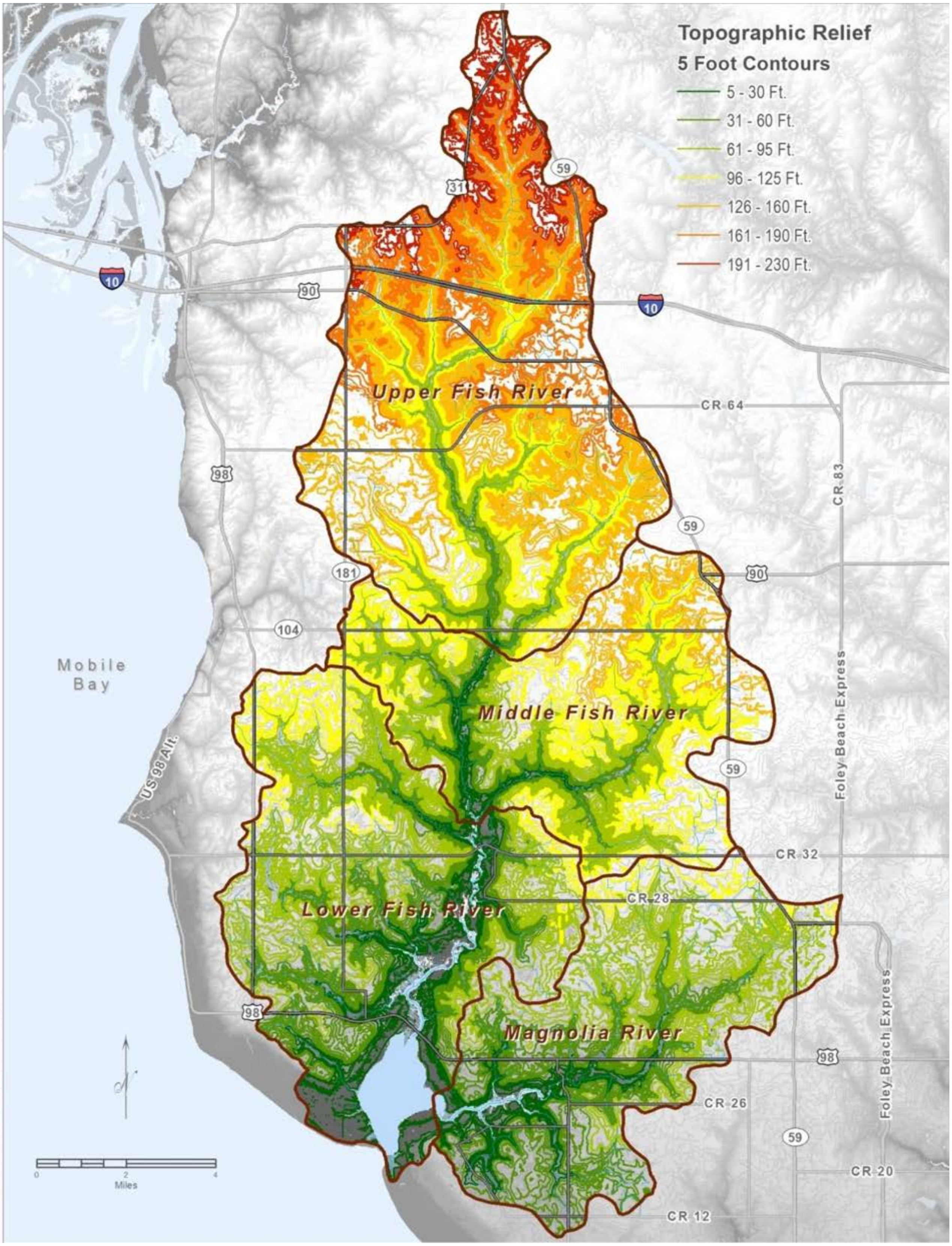
The elevations within the Weeks Bay Watershed range from zero/sea level along the bottoms of creeks and rivers and southern portions of the Watershed to approximately 230 feet National Geodetic Vertical Datum (NGVD) in the northern portions of the Watershed (Figure 2.7).

2.3.3 Geological Formations

Portions of the Weeks Bay Watershed overlie three geologic formations—the Miocene Series undifferentiated, the Citronelle Formation, and the alluvial, coastal, and low terrace deposits (Figure 2.8).

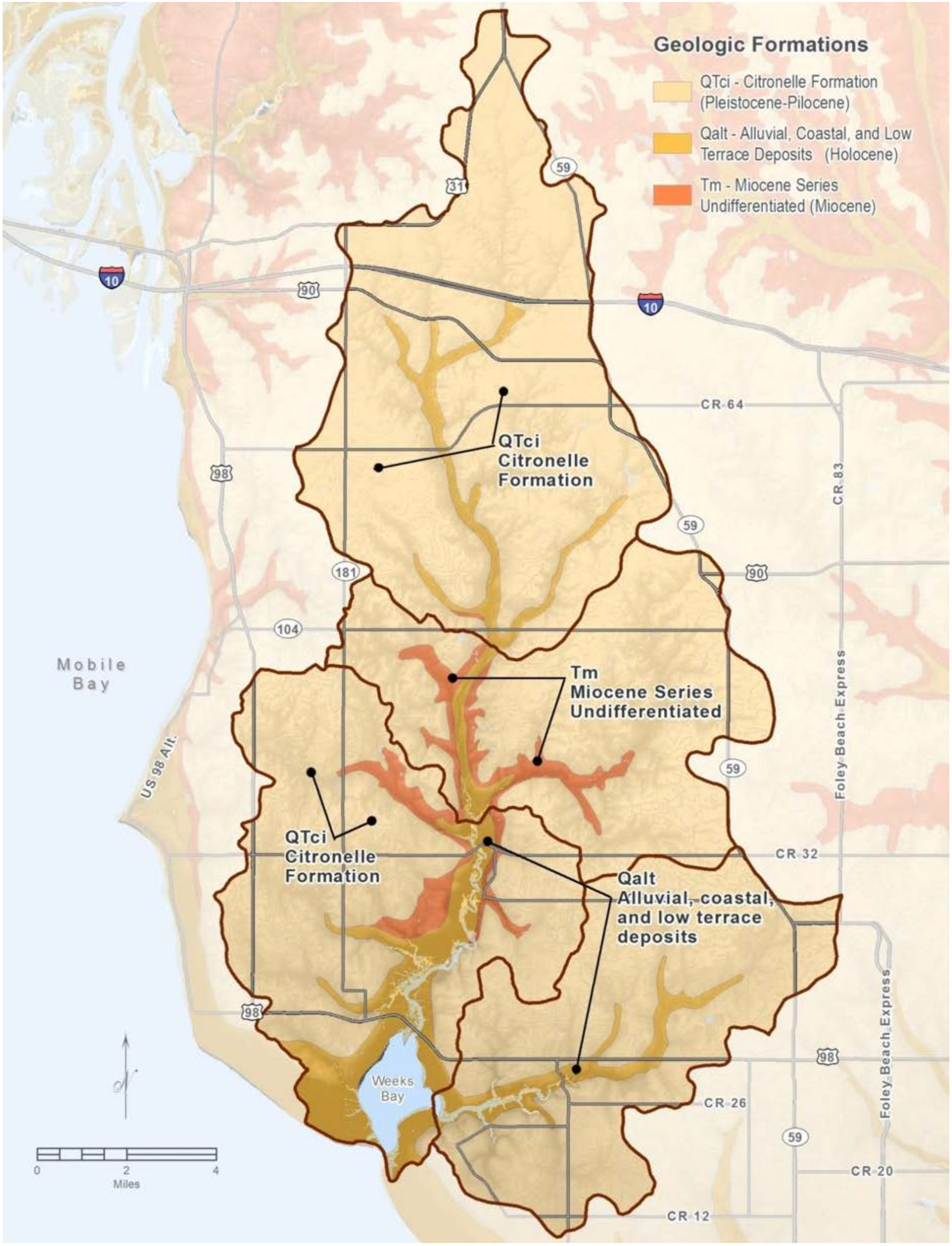
The oldest and deepest geologic formation exposed by the Watershed streams and creeks is the Miocene Series undifferentiated. The Miocene Series undifferentiated underlies portions of the Middle and Lower Fish River Subwatersheds and in a very small area in the south Upper Fish River Subwatershed. The Miocene Series undifferentiated consists of sedimentary deposits of marine and estuarine origin. These Miocene aged sediments consist of laminated to thinly bedded clays, fine to coarse quartz sand, gravelly sand, and sandy clay (Gillett et al., 2000).

The Citronelle Formation underlies the majority of all four Subwatersheds and overlies the Miocene Series undifferentiated. The Citronelle Formation ranges from middle Pliocene to pre-Nebraskan Pleistocene in age and is confined to higher elevations due to erosion that has occurred along streams and the edges of Mobile Bay. The Formation consist of nonfossiliferous, moderate-reddish-brown, fine to very coarse quartz sand; light-gray, orange, and brown sandy clay; and clayey gravel of nonmarine origin. In many areas, lenses of clayey sand and sandy clay, which range in thickness from 5 to 15 feet, are interbedded with gravelly sand. The Citronelle Formation sediments were deposited under a combination of fluvial and estuarine conditions and vary both laterally and vertically. Sediment type often changes abruptly over short distances (Gillett et al., 2000).



Source: Baldwin County, one-foot contour data, 2005

Figure 2.7 Topography of Weeks Bay Watershed



Source: USGS Digital Geologic Map of Alabama
Figure 2.8 Geologic Map

The alluvial, coastal, and low terrace deposits underlie portions of all four Subwatersheds in the low-lying and coastal areas. The deposits are Quaternary in age and generally consist of white, gray, orange, and red, very fine to coarse quartz sand containing gray and orange clay lenses and gravel in places. The gravel is composed of quartz and chert pebbles. These deposits represent complex beach, dune, lagoonal, estuarine, and deltaic depositional environments. The deposits range from 0 to 200 feet in thickness (Gillett et al., 2000).

2.3.4 Ecoregions

The Weeks Bay Watershed lies within two physiographic or ecoregions, the Southern Pine Plains and Hills (Ecoregion 65f), and the Gulf Coast Flatwoods (Ecoregion 75a), which are described as follows (Griffith et al., 2001; O'Neil and Chandler, 2003, in GOMA 2013a):

> **Ecoregion 65f**. The Southern Pine Plains and Hills have a different mix of vegetation and land use compared to 65d, and streams tend to be darker tea-colored and more acidic as one moves south. The oak-hickory-pine forest of the north in 65d grades into Southern mixed forest and longleaf pine forest in this region. The longleaf pine forest provided habitat for now rare or endangered species such as the red-cockaded woodpecker, gopher tortoise, eastern indigo snake, and Florida pine snake. Loblolly and slash pine plantations now cover wide areas. The hill summits and higher elevations are composed of the Citronelle formation, generally sandy, gravelly, and porous, and more resistant to erosion than the older underlying Miocene sandstones.
>
> **Ecoregion 75a**. The Gulf Coast Flatwoods ecoregion stretches from eastern Louisiana, across southern Mississippi and Alabama, and into west central Florida. In Alabama, it is a narrow region of nearly level terraces and delta deposits composed of Quaternary sands and clays. Wet, sandy flats and broad depressions that are locally swampy are usually forested, while some of the better-drained land has been cleared for pasture or crops.

2.3.5 Soils

The principal soil associations located within the Weeks Bay Watershed includes the Bowie-Tifton-Sunsweet association, the Marlboro-Faceville-Greensboro association, the Lakeland-Plummer association, the Norfolk-Klej-Goldsboro association, and the Lakewood-St. Lucie-Leon association. These associations are comprised of a few major soils and several minor soils that are grouped together based on characteristic patterns. The associations are useful to people who want a general idea of the soils in an area, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use (McBride and Burgess, 1964).

The Bowie-Tifton-Sunsweet association is characterized by dominantly well drained or excessively drained, nearly level to moderately steep soils of uplands. The soils in this association are well suited for agriculture. The Marlboro-Faceville-Greenville association is characterized by nearly level to gently sloping well drained soils. The soils in this association developed in unconsolidated Coastal Plain material and are highly developed for agriculture in the area. The Lakeland-Plummer association is characterized by deep, somewhat excessively drained to very poorly drained, nearly level soils of bottom lands and nearly level to moderately steep soils of uplands. A large acreage in this association is probably best suited to pines and has little potential for row crops. The Norfolk-Klej-Goldsboro association is characterized by nearly level or gently sloping soils of uplands and of soils of the associated bottom lands. The soils in this association are well drained but depressions in the level areas and bottom lands along small streams may drain poorly. They are also well suited for both crop and livestock agriculture. The Lakewood-St. Lucie-Leon association consists of sand and muck found on low sand dunes, in the low, wet areas between the dunes, and the beaches along the Gulf of Mexico. These soils tend to either drain very poorly due to a hardened sand layer and muck or drain too quickly due to a high content of unconsolidated sand. The soils of this association have little or no value for agriculture (McBride and Burgess, 1964).

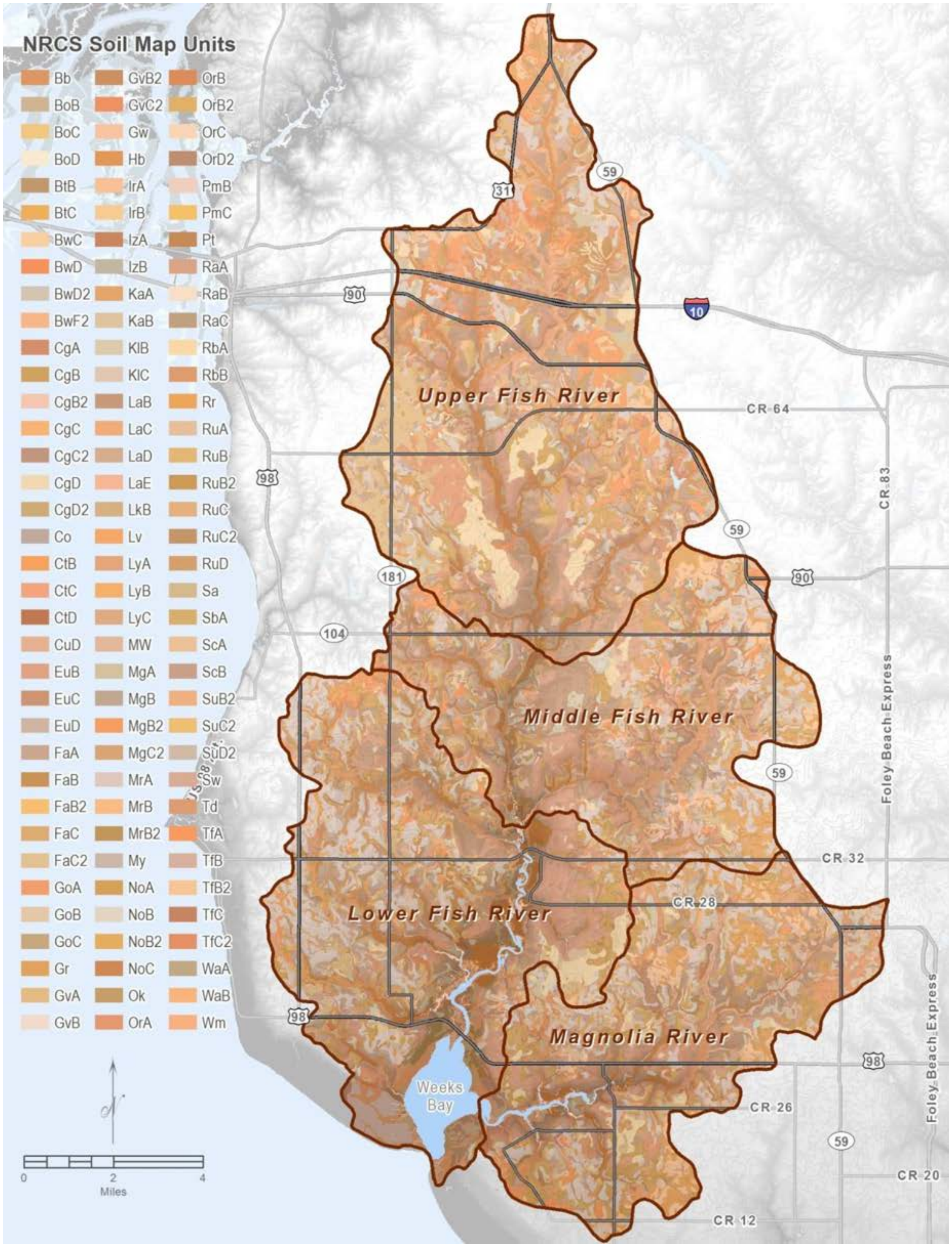
There are approximately 104 different major soil types located within the Weeks Bay Watershed. Figure 2.9 shows the major soil groups within the Watershed. A detailed description of each major soil group is provided in Appendix B.

2.3.5.1 Soil Erodibility Factor

The soil erodibility factor (K factor) indicates the susceptibility of a soil to erosion and the rate of runoff. The K factor is based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity. Values of K range from the lowest erodibility, 0.02, to the highest, 0.69. All other factors being equal, the higher the K value, the greater the susceptibility of the soil to rill and sheet erosion by rainfall. In general, soils with greater permeability, higher levels of organic matter, and improved soil structure have a greater resistance to erosion and, therefore, a lower K value.

Typically subsoils have higher K-factors and are more erodible than topsoils. When land clearing and grading activities expose subsoils, the K-Factor increases. Exposed subsoils can be expected to erode faster because they have less organic matter and plant root mass to hold the soil particles together structurally. The formation of micropores that allow percolation of rainfall is reduced in subsoils, resulting in increased runoff. Increased runoff produces greater sheer forces for detaching soil particles from the surface, and accelerating erosion.

The parent subsoil materials within the Weeks Bay Watershed are more highly variable with clay, silt and sand strata than are the weathered and more homogenous superficial soils. As such, some of these subsoil strata contain fine sand and silty stratum that are highly erodible when exposed to precipitation and stormwater runoff.



Source: USDA-NRCS Soil Survey Geographic Database (SSURGO)
Note: soil map unit descriptions described in Appendix B
Figure 2.9 Major Soil Types within Weeks Bay Watershed

The K factors for the soil series occurring within the Weeks Bay Watershed vary from 0.02 to 0.43 (Web Soil Survey). Soils having K factors less than 0.23 are considered to have low erodibility, soils with K factors from 0.23 to 0.36 are considered to be moderately erodible, and soils having K factors from 0.37 to 0.69 are highly erodible. Each of the four Subwatersheds has soils with K factors within each of the three erodibility categories. Figure 2.10 presents a visual summary of the soil erodibility within the Watershed based on the soil K factors. The summary of K factor ratings within the Watershed is found in Appendix B.

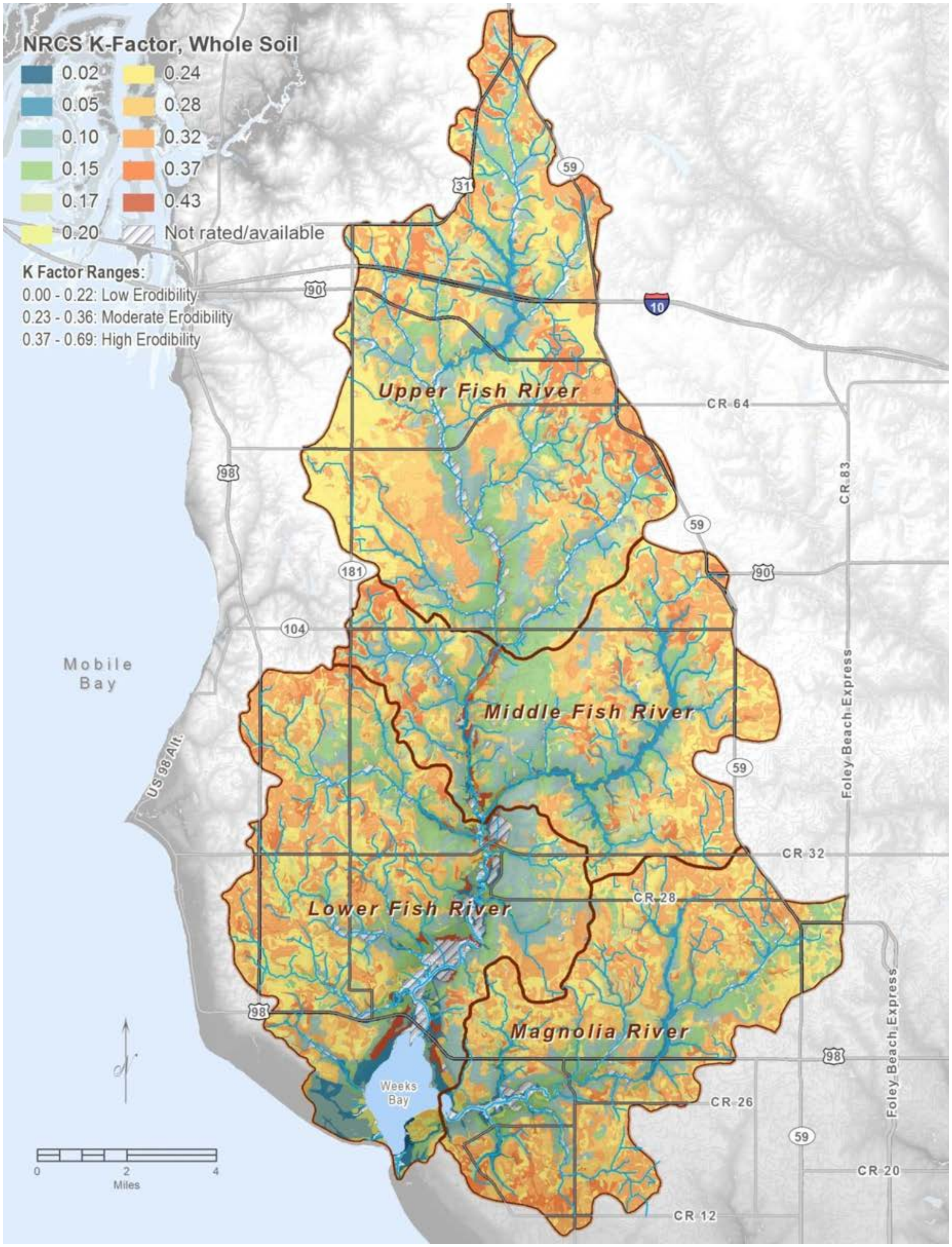
2.4 Floodplains and FEMA Flood Zones

Flood control laws and local ordinances were not specifically reviewed in detail for this Watershed Management Plan development. Flooding is not one of the stated primary issues (i.e., the eight MBNEP Expected Watershed Plan Components, or nine EPA Minimum Elements) to be addressed in preparation of a Watershed Management Plan. However, flooding, particularly on the lower end of the Weeks Bay Watershed is and will likely continue to be one of the highest priority concerns expressed by citizens and stakeholders in the Watershed, as previously discussed in Section 1 of this WMP. This concern is especially pertinent in the Lower Fish River Subwatershed that has experienced several major flooding events over the past decade.

Flood control goals and stormwater treatment goals are often erroneously thought to be in opposition; the first trying to remove water as quickly as possible, and the latter trying to slow release rates and/or volumes. A more detailed review of flood control requirements compared to stormwater management requirements would be beneficial to identify potential conflicts and solutions to support low impact development and land management.

Floodplains within the Weeks Bay Watershed and their flood hazard area designations are depicted on Figure 2.11. The flood hazard areas shown are designated by the Federal Emergency Management Agency (FEMA) and include Zone A (subject to inundation by the 1-percent-annual-chance flood event [referred to as the “100 year storm” in other literature] with no base flood elevation (BFE) determined), Zone AE (subject to inundation by the 1-percent-annual-chance flood event with BFE determined), and Zone VE (subject to inundation by the 1-percent-annual-chance flood event with additional hazards due to storm waves with BFE determined.

The effective date of all Flood Insurance Rate Maps (FIRMs) within the Weeks Bay Watershed is July 17, 2007. FEMA is in the process of updating all flood maps within Baldwin County through a cooperative agreement with the Alabama Department of Economic and Community Affairs (ADECA), Office of Water Resources (OWR) (ADECA, 2012 and 2014).



Source: USDA-NRCS Soil Survey Geographic Database (SSURGO)
Note: Erosion factor aggregation report can be found in Appendix B
Figure 2.10 Soil Erodibility K Factors within Weeks Bay Watershed

Figure 2.11 Federal Emergency Management Agency Flood Zones within Weeks Bay Watershed

The process of updating the maps is conducted in four phases:

1. Scoping
2. Map Production
3. Preliminary FIRM and Flood Insurance Study (FIS)
4. Effective FIRM and FIS

The Scoping phase was completed in December 2010. It included initial community coordination, a scoping meeting, review and validation of existing flood risk data and discussion of mapping needs and flood risk concerns. FEMA, ADECA, and Baldwin County stakeholders prioritized mapping needs for the county, utilizing data from the county and communities. This data included historical flooding information, existing flood hazard data, physical characteristics of the county and base mapping. The Coastal Scoping Report was published March 2011.

The Map Production phase is complete. It included the following seven processes:

1. Topographic and field surveys
2. Riverine engineering analysis
3. Coastal engineering analysis
4. Hydrologic and hydraulic simulations
5. Delineation of preliminary floodplain boundaries, base flood elevations and flood insurance risk zones
6. Preparation of preliminary Flood Insurance Study (FIS) Report
7. Preparation of preliminary FIRM panels for community review

The Scoping phase identified 55 riverine miles and 111 coastal miles for detailed engineering study. ADECA performed hydrologic and hydraulic modeling for these areas. Riverine flooding occurs in defined inland waterways such as rivers, streams and ditches when these waterbodies overflow their banks, resulting in flooding, flash floods and inundation of urban storm sewer systems. Riverine studies use the characteristics of the Watershed, such as topography and precipitation, to determine flood depths and flood profiles. These are used to describe the special flood hazard areas associated with riverine features on flood maps.

Coastal flood studies include storm surge with wave modeling, wave hazard analysis and mapping. Hurricanes cause storm surge which is the rise in water level. Wave modeling determines the magnitude of the surge, based on a number of parameters. These parameters include track and speed of the storm, atmospheric pressure, offshore water depths and location of landfall. The results of the modeling are stillwater elevations which are used to establish the special flood hazard areas along the coastline.

The Preliminary FIRM and FIS Phase is nearing completion. The maps and studies have been prepared. They are presently going through the quality assurance process and are scheduled to be posted on the ADECA website (http://adeca.alabama.gov/Divisions/owr/floodplain/Pages/default.aspx) on July 31, 2017. Hardcopies of the documents will be mailed to their respective communities approximately one week prior to posting on the website.

Before the maps become effective, FEMA holds meetings with community officials to discuss the maps. FEMA then publishes notices that the maps are available for inspection. After the second notice, a 90-day appeal period begins. Appeals must include technical and/or scientific data to demonstrate that the proposed Base Flood Elevations (BFEs) are scientifically or technically incorrect. Non-technical data such as incorrect street names can also be appealed. After all appeals are resolved, FEMA issues a Letter of Final Determination (LFD). The new map becomes effective six months after the date the LFD is issued. The estimated effective date for Baldwin County maps is September 18, 2018.

Hydro Engineering Solutions, LLC (HES, 2011) conducted a Fish River and Magnolia River Watershed Study in October 2011. Both rivers drain into Weeks Bay, and then into Mobile Bay. The Watersheds of the two rivers drain approximately 203 square miles. Significant rain events are not unusual in the Watersheds due to proximity to the coast and the occurrence of tropical storms. More than 80% of the land use in the Watersheds is agricultural, forested or wetland.

HES used a Gridded Surface Subsurface Hydrologic Analysis (GSSHA) to model the hydrology and evaluate the Watersheds. Parameters used in this model include rainfall data, digital terrain data, land use data and soils data. HES's GSSHA model focused on the 100-year, 24-hour storm event. Different scenarios were applied to the model to evaluate Watershed reactions to various changes within each basin. These scenarios were addition of new development to various locations in the Watersheds. The next set of objectives was to evaluate possible areas for regional detention in a scenario where all municipalities are built out. The most effective regional pond placement in the Fish River Watershed occurs on Corn Branch downstream of Loxley. However, if this pond were built with existing conditions it would negatively impact Fish River. This could be alleviated by another regional pond downstream of the confluence of Turkey Branch and Fish River. Regional ponds alone are not sufficient to handle discharge increases along Fish River. Local detention will be required in some areas of the Watershed. Specifically, the HES report indicates that all flood events, including the 100-year, must be detained locally for the properties located basically above CR 64, in the headwaters of the Belforest area, and the headwaters of Waterhole Branch. Results from the Magnolia River Watershed indicate a negative impact to Magnolia River from any undetained development extending from Foley. Regional ponds evaluated for this Watershed are ineffective as the dam height is restricted to avoid flooding of adjoining properties.

A major rainfall event occurred in Baldwin County on April 29, 2014 which caused significant loss throughout the area. HES reran the models of the Fish River and Magnolia River Watersheds using the rainfall data from this storm (HES, 2014). They again evaluated the following regional pond combinations: (1) Fish River Pond; Fish River Pond C, and Corn Branch Pond; (2) Fish River Pond C, Corn Branch Pond, and Perone Branch Pond; (3) Fish River Pond C, Corn Branch Pond, Perone Branch Pond, and Polecat Creek Pond; (4) CR 48 Pond; (5) CR 9 Pond; and (6) Fish River Pond C, Corn Branch Pond, Perone Branch Pond, Polecat Creek Pond, CR 48

Pond, and CR 9 Pond. In all combinations of the ponds, discharges and flood levels at downstream road culverts was reduced in comparison to no ponds. For example, with all upper Fish River ponds above SR 104 (Fish River Pond C, Corn Branch Pond, and Perone Branch Pond), the CR 48 Pond, the Polecat Creek Pond, and the CR 9 Pond, the model results are were summarized as below in Table 2.2.

Table 2.2 HES Flood Model Predictions for 2014 Event with All Fish River Watershed Regional Detention Ponds

Site Location	SR 104	CR 32	Hwy 98
No Pond Peak Discharge (cfs)	16,441	28,400	28,732
With Pond Peak Discharge (cfs)	14,275	24,384	24,499
% Decrease in Peak Discharge	13%	14%	15%
No Pond Flood Level (ft)	38.4	12.18	7.57
With Pond Flood Level (ft)	37.55	10.87	6.39
% Decrease in Flood Level	2%	11%	16%

Source: From Hydro Engineering Solutions, LLC, 2014 Power Point

2.5 Flora and Fauna

2.5.1 Introduction

Most of the Weeks Bay Watershed, approximately 113,602 acres (88%), is located within the Southeastern Plains Level III Ecoregion (Griffith et al., 2001). This geographically broad area ranges from southern Virginia to south Florida, and then westward across Alabama, Mississippi, and Louisiana into eastern Texas. The ecoregion represents a relatively flat transition between the adjacent plateau-like Piedmont and the lower elevation coastal ecoregions (Napton et al., 2010).

The remainder of the Watershed (15,996 acres; 12%) falls within the adjacent Level III Southern Coastal Plain Ecoregion, which includes Weeks Bay and the southernmost portion of the study area. These near-coastal lands are generally lower in elevation, with less relief and wetter soils than the Southeastern Plains.

Further delineation of Level III Ecoregions into smaller ecological units (i.e., Level IV mapping) identifies three separate subdivisions occurring within the study area. The Southern Pine Plains and Hills Level IV Ecoregion is the only component of the Southeastern Plains in the Watershed. Weeks Bay and the lower reaches of Fish River and Magnolia River fall within the Gulf Coast Flatwoods Level IV Ecoregion, whereas a portion of the study area along the Mobile Bay shoreline occurs in its Gulf Barrier Island and Coastal Marshes (Griffith et al., 2001). The Gulf Coast Flatwoods has wet, sandy flats and broad depressions that are locally swampy and forested. The Gulf Barrier Islands and Coastal Marshes region contains salt and brackish marshes, with xeric coastal strand and pine scrub vegetation occurring on parts of the dunes, spits, and barrier islands.

2.5.2 Uplands

In the drier and warmer climate that followed the Pleistocene glaciations of 8,000 to 12,000 years ago, longleaf pine (*Pinus palustris*) came to dominate upland forests of the Southeastern U.S. (Conner et al., 2001). To tell the story of the Southeastern Plain is to tell the story of longleaf pine (Duncan, 2013). Historically, approximately 62 million acres of longleaf pine-dominated communities occurred across the Southeastern Coastal Plain (Conner et al., 2001). Today, these native pinelands occupy less than 3% of their former range (Outcalt and Sheffield, 1996).

Prior to colonization of North America by European settlers, the Southeastern Coastal Plain was dominated by expanses of open longleaf pine woodlands possessing a hyper-diverse herbaceous understory of grasses and forbs (Conner et al., 2001; Carr et al., 2010). Early travelers described the pinelands they encountered as vast park-like forests containing massive, widely-spaced old growth trees, some of which reached over 100 feet in height and were upwards of 500 years old (Bartram, 1791 [1988]; Conner et al., 2001; Whitney et al., 2004). The entire Southeastern Plain is recognized as one of thirty-six important global biodiversity hotspots based on its high endemism of vascular plant species (Conservation International, 2014; Noss et al., 2015). Longleaf pine occurs across upland and wetland systems. The longleaf mosaic includes sandhills, mesic flatwoods, and wet flatwoods communities (FNAI, 2010).

The natural history of the longleaf pine is intrinsically tied to fire. The open, park-like aspect of these forests seen by early explorers was the result of frequent burning, occurring both from a combination of natural lightning strikes and anthropogenic ignition by Native Americans (Carr et al., 2010; Noss et al., 2015). Frequent fires also maintained their species-rich herbaceous groundcover vegetation (Carr et al., 2010). If fire is suppressed for long periods in longleaf pine communities, fire-intolerant hardwood shrub species will colonize these areas and outcompete the diverse herbaceous understory (Carr et al., 2010). It is estimated that prior to European settlement the fire frequency of longleaf pinelands averaged 2 to 4 years (Frost, 2006; Guyette et al., 2012, White and Harley, 2016). Modern fire regimes have been severely reduced in frequency or excluded all together (Carr et al., 2010).

Modern fire regimes are severely reduced in frequency or prevented completely, due in large part to public safety and economic concerns (Carr et al., 2010). In addition, changes in land use resulted in a marked reduction in our native pinelands former range (Frost, 2006; Carr et al., 2010; Napton et al., 2010). Mohr (1901) and Harper (1913) described vegetation of the Coastal Plain region of Alabama, noting that open, upland forests of the time were dominated by large tracts of continuous longleaf pine (Figure 2.12). Longleaf pine forests were the main timber source at sawmills in coastal Alabama (Mohr, 1901). At the time, the cutover pinelands of Baldwin County were increasingly converted to farms **(**Harper, 1913). Silvicultural timber lands comprising planted slash pine (*Pinus elliottii*) and loblolly pine (*Pinus taeda*) plantations have largely replaced the natural longleaf systems that once dominated the landscape (Griffith et al., 2001).

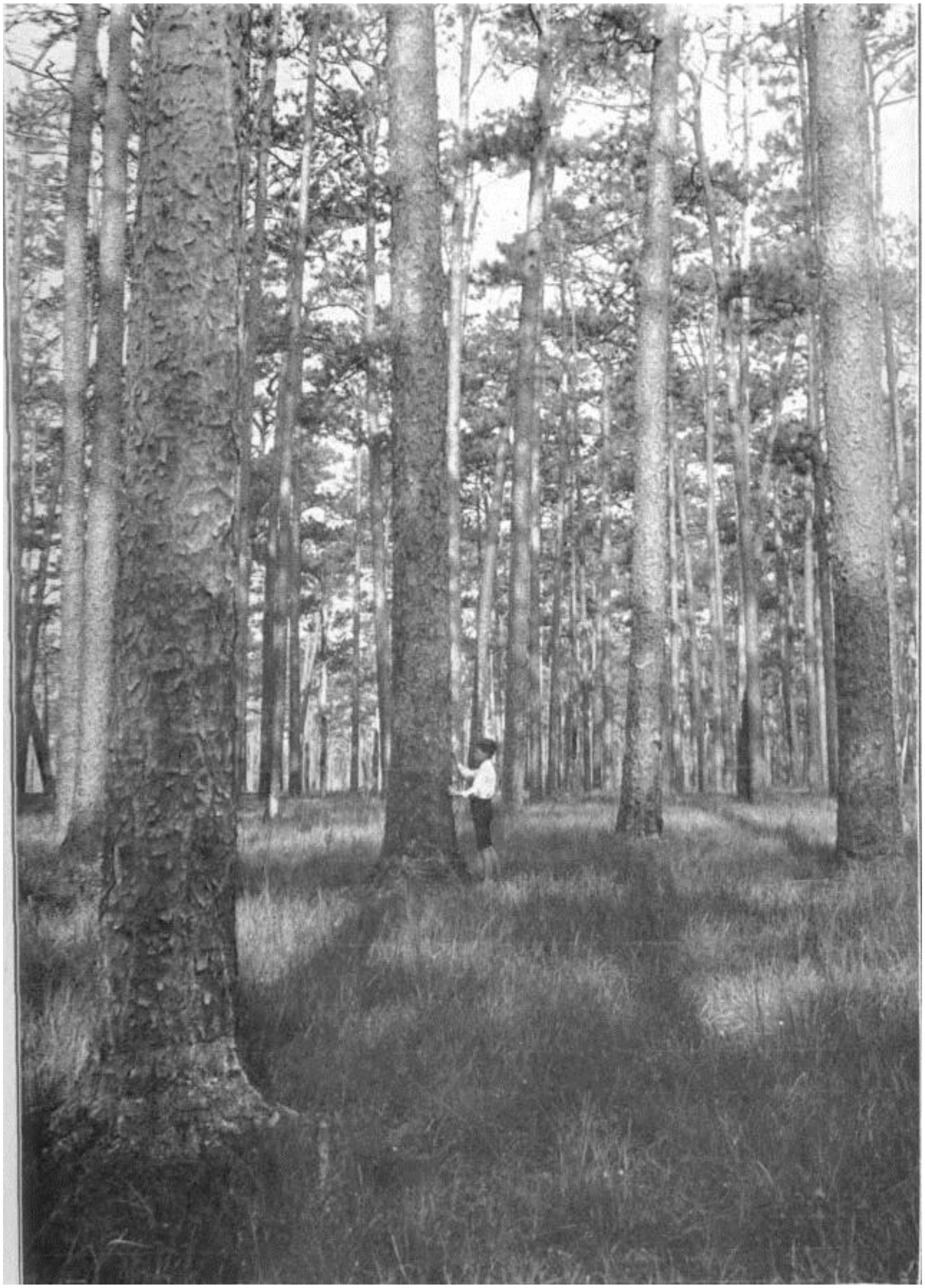


Figure 2.12 Primeval Forest of Longleaf Pine about 10 Miles East of Fairhope, August 1902
Source: Harper 1913; Photograph by Dr. E.A. Smith and R.S. Hodges

Upland habitats in the Watershed today consist primarily of mixed pine/hardwood forest and managed pine forest. The Alabama Gap Analysis Program (ALGAP, 2001) mapped longleaf pine and associated communities using remote sensing techniques and a classification scheme of open understory (true) longleaf, a loblolly modifier, and a hardwood modifier. The classification was produced to describe current vegetation that exists on 23,712 acres that were once longleaf woodlands (Figure 2.13).

NLCD 2011 land cover data includes upland evergreen, mixed, and deciduous forests totaling 19,956 acres in the study area. Evergreen forest comprises the vast majority of forested uplands at 18,004 acres, followed by mixed forest (1,501 acres) and deciduous forest (453 acres).

In areas not extensively planted in loblolly pine, and with native vegetation, longleaf pine often comprises the dominant canopy species. Turkey oak (*Quercus laevis*) tends to be a major component of these communities. Several other oak species are typically present, including sandhill taxa such as sand live oak (*Q. geminata*), bluejack oak (*Q. incana*), and sand post oak (*Q. margaretta*). Sand laurel oak (*Q. hemispherica*) is common in many areas. The presence of these oak species suggests historic fire exclusion. Upland hardwood forest occurs on rolling hills and slopes above river floodplains, and occasionally on rises within floodplains.

Near some streams, especially in forks and on bluffs, where fire is practically barred, the forests are of the hammock type (Harper, 1913). Hammock lands, more or less extensive tracts of a black soil, well-drained, rich in decayed remains of former vegetation, skirt the lower river swamps of the near-coastal region (Mohr, 1901). The species common to hammocks include southern magnolia (*Magnolia grandiflora*), laurel oak (*Quercus laurifolia*), water oak (*Quercus nigra*), and beech (*Fagus grandifolia*), with characteristic understory shrubs including wax myrtle (*Morella cerifera*), and yaupon (*Ilex vomitoria*) (Mohr, 1901).

Upland areas can have gradual or abrupt transitions to lower elevation wetlands. Transitional ecotonal zones located between uplands and wet bottomlands frequently occur as mesic slope forest communities in undisturbed areas. Sweetleaf (*Symplocos tinctoria*) and star anise (*Illicium floridanum*) are common shrubs in these systems. The transition zone between moist pine forests and upland pine-oak forests may support growth of plants adapted to somewhat better drained condition such as water oak, laurel oak, sweetgum (*Liquidambar styraciflua*), southern magnolia, and devilwood (*Cartrema americanum*) (Stout and Lelong, 1981).

In some locations of the study area, uplands have been logged repeatedly and fire suppressed for extended periods of time. Logged uplands with sandy soils typically have a canopy primarily of planted loblolly pine with relatively few mature tree species. The mid and understories are often thickly vegetated with low growing shrubs, with sparse herbaceous vegetation. In other areas, sandy upland ridges bordering Fish River have an understory more open in nature, dominated by hardwoods with a widely spaced distribution, and established herbaceous communities.

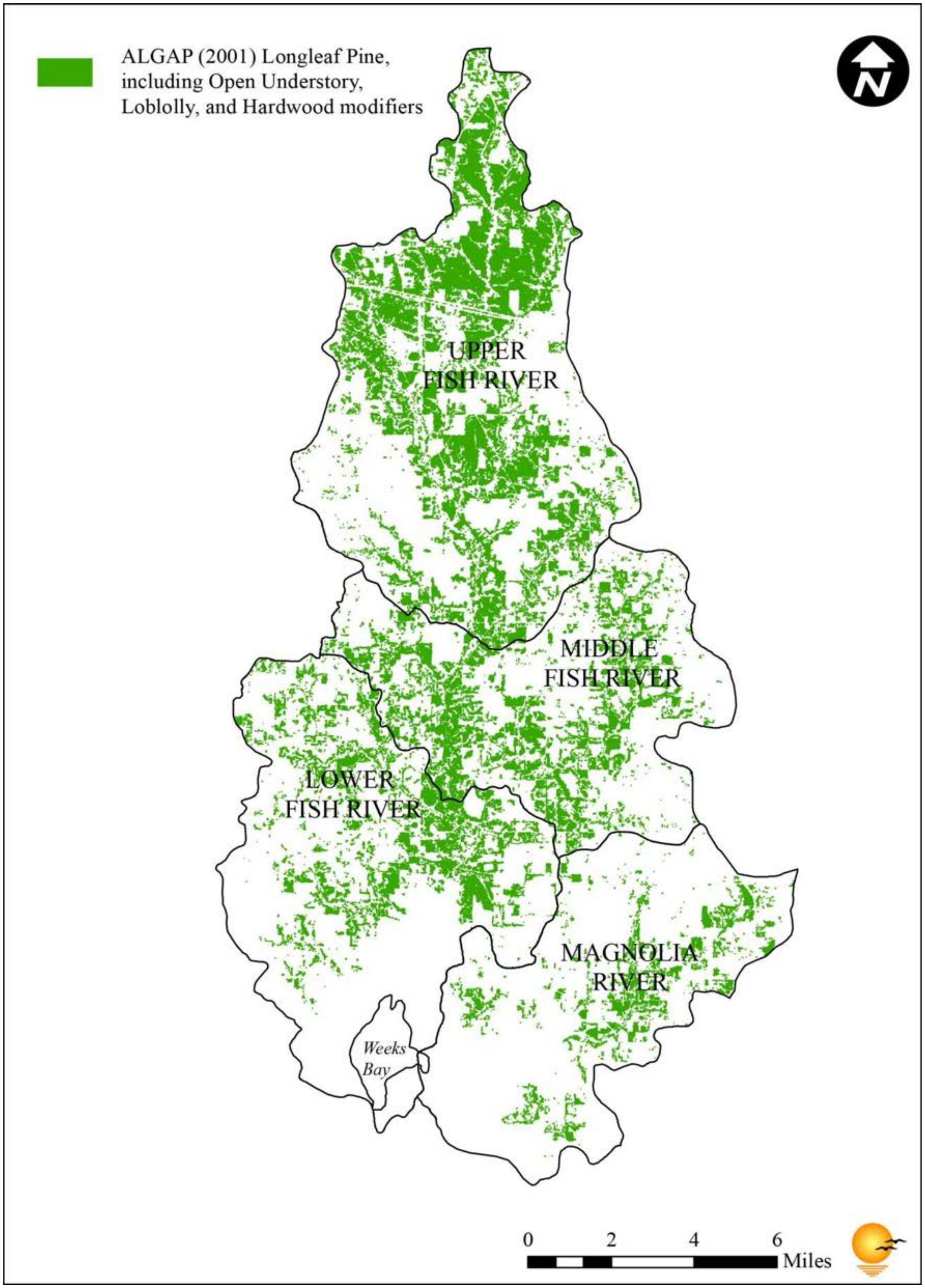


Figure 2.13 Longleaf Pine Distribution
Source: Alabama Gap Analysis Program (ALGAP, 2001)

2.5.3 Wetlands

Wetland ecosystems share a number of features including relatively long periods of inundation or saturation, hydrophytic vegetation, and hydric soils. Wetlands occur under a wide range of geologic and physiographic situations and exhibit a wide variety of physical, chemical, and biological characteristics and processes (Cowardin et al., 1979). In Baldwin County, freshwater wetlands include those associated with streams and rivers, swamps, pine flatwoods, bogs, and Grady ponds. Tidally influenced forested and herbaceous wetlands occur near Weeks Bay.

Baldwin County produced a wetland map in 2005 called the Wetland Advanced Identification Map, or ADID (Baldwin County Planning and Zoning Department, 2005). Creation of the ADID database used the 1979 USFWS National Wetland Inventory (NWI) map, which was modified at some locations through field verification methodologies used by the U.S. Army Corps of Engineers for jurisdictional wetland determinations under Section 404 of the Clean Water Act. The County acquired 2001 color infrared aerial photography to aid in wetland determinations.

For the Weeks Bay Watershed analysis, the ADID wetland map was updated at a landscape-scale, using ADCNR/MBNEP true color 2015 aerial photography to account for changes due to land conversion. In addition, Baldwin County Light Detection and Ranging (LiDAR) elevation contour data (2002) were used to further refine wetland-upland boundaries, including locations where the ADID map was incomplete. The LiDAR dataset contains accurate topographic data derived at one-foot intervals, usable for resolving seepage spring wetlands, forested floodplains, streams, and ditches.

Spatial soil survey data were used to identify natural ponded wetlands with Grady soils. NWI and Alabama GAP (2001) provided supplemental information, including for wetland type. These digital spatial data sets were viewed and analyzed in ArcGIS 10.3.1. Where available, field data were incorporated into the wetland map to provide site-specific information on wetland-upland boundaries. Study area wetlands are shown in Figure 2.14. Wetland maps for each of the four HUC 12 Subwatersheds are provided in Appendix C.

The palustrine shrub/forested wetlands of floodplains, swamps, and wet pinewoods account for most of the study area acreage, 40% of which is located in the Lower Fish River HUC 12 Subwatershed (Table 2.3). Estuarine emergent marshes (507 total acres) occur in the lower reaches of the Fish River HUC 12, which includes most of Weeks Bay, and the lower Magnolia River HUC 12. Lacustrine wetlands, including Grady ponds, man-made ponds, and impoundments, are relatively evenly distributed across the Watershed study area (Figure 2.14).

2.5.3.1 Forested Wetlands

Most rivers and streams and many of the bays in coastal Alabama are bordered by forested wetlands (Harper, 1913; Stout and Lelong, 1981). Non-alluvial peaty swamps bordering small streams are the most common type of forested wetland in the study area (Harper, 1913). Harper (1913) described streams in the study area as usually coffee colored from peaty matter in solution and suspension, and not subject to much fluctuation. Soils in the drainageway wetlands are poorly drained black muck (which is extremely acid), and mostly organic material to a variable depth of one to six feet (Mohr, 1901).

Table 2.3 Total Acreage of Modified 2005 ADID Wetlands in Weeks Bay Watershed

Wetland Type	Lower Fish River[1]	Middle Fish River	Upper Fish River	Magnolia River	Total
Estuarine Emergent	407	0	0	100	507
Estuarine Shrub/Forested	58	0	0	6	64
Palustrine Emergent	25	34	0	17	76
Palustrine Shrub/Forested	4,191	1,954	3,041	1,909	11,095
Lacustrine[2]	304	92	115	114	625
HUC 12 Total	4,985	2,080	3,156	2,146	12,367

[1]Includes Weeks Bay; [2]Includes surface water area

Mohr (1901) described near-coastal cypress brakes as predominantly bald cypress trees (*Taxodium distichum*) in areas that are almost perpetually submerged, along with tupelo gum (*Nyssa aquatica*). Stout and Lelong (1981) referred to these extensively flooded areas as Bay-Tupelo-Cypress Swamp. In less frequently submerged areas, a variety of hardwood trees occur including water oak, water hickory (*Carya aquatica*), sweet bay (*Magnolia virginiana*), red maple (*Acer rubrum*), swamp tupelo (*Nyssa biflora*), swamp bay (*Persea palustris*), and tulip tree (*Liriodendron tulipifera*). Atlantic white cedar (*Chamaecyparis thyoides*) becomes increasingly more common in swamps along upper reaches of streams (Stout and Lelong, 1981).

Shade-tolerant shrubs of forested swamps include Virginia willow (*Itea virginica*), star anise, doghobble (*Leucothoe axillaris*), devilwood, and possumhaw (*Ilex decidua*) (Mohr, 1901; Stout and Lelong, 1981). A small number of shade-tolerant herbaceous plants are found in flooded zones including netted chain fern (*Woodwardia areolata*), Virginia chain fern (*Woodwardia virginica*), cinnamon fern (*Osmundastrum cinnamomeum*), American royal fern (*Osmunda spectabilis*), spiderlily (*Hymenocallis choctawensis*), and arrow arum (*Peltandra virginica*) (Mohr, 1901; Stout and Lelong, 1981). The more open borders of swampy woods may have dense thickets of swamp cyrilla (*Cyrilla raecmiflora*), black titi (*Cliftonia monophylla*), and large gallberry (*Ilex coriacea*). Wax myrtle and yaupon also grow in this habitat and are especially common along the margins of brackish waters (Stout and Lelong, 1981).

Seepage swamps are forested wetlands characterized by saturated soils rather than periodic inundation, often occurring on the edges of floodplains. They include baygalls at the base of seepage slopes and bayheads in peat-filled depressions. These evergreen forests typically include red bay (*Persea borbonia*), sweetbay, loblolly bay (*Gordonia lasianthus*), red maple, slash pine, wax myrtle, dahoon (*Ilex cassine*), large gallberry, Virginia willow, buttonbush (*Cephalanthus occidentalis*), laurel greenbrier (*Smilax laurifolia*), poison ivy (*Toxicodendron radicans*), cinnamon fern, and netted chain fern.

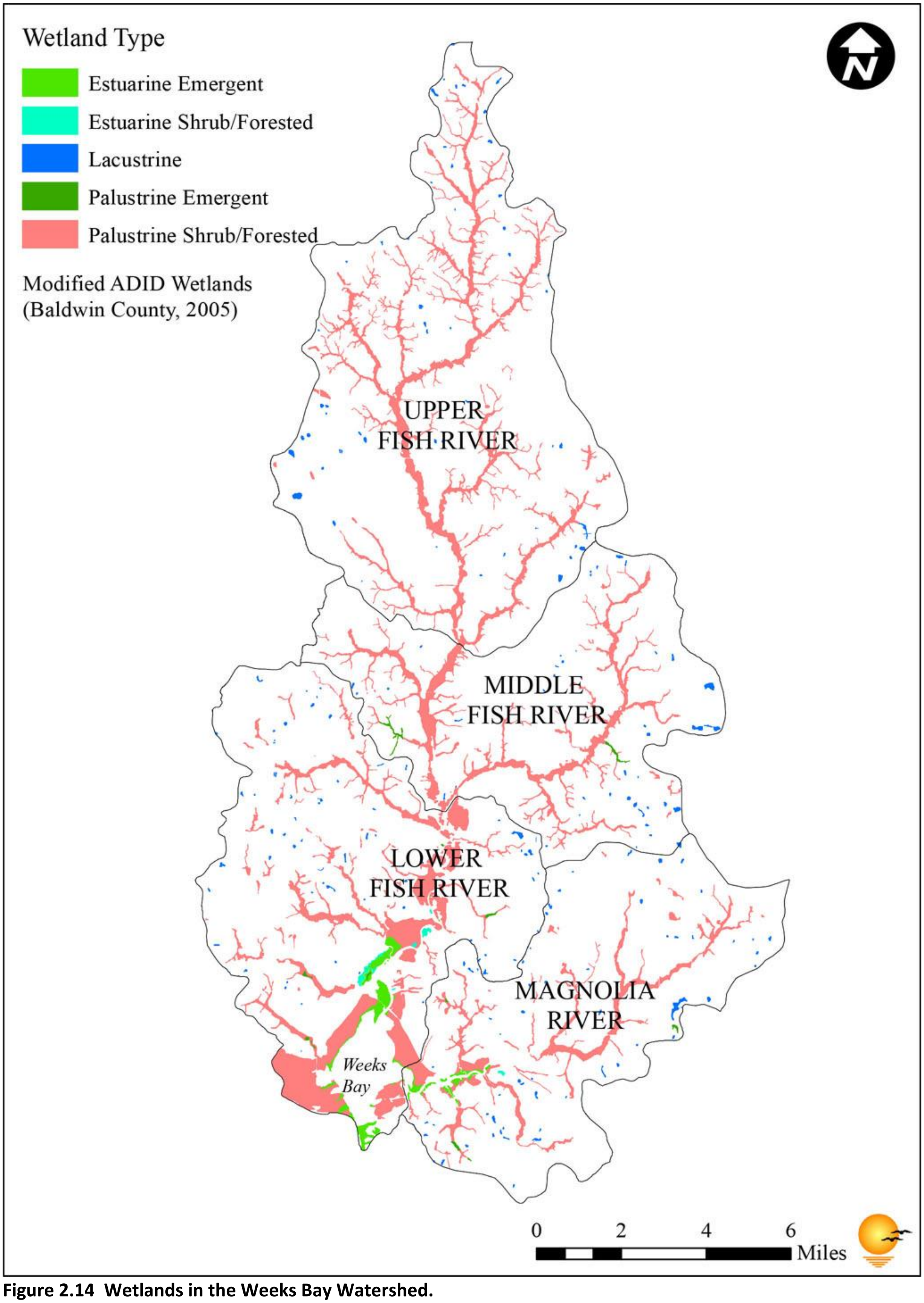


Figure 2.14 Wetlands in the Weeks Bay Watershed.

Pine meadows contain sluggish watercourses, and are subject to flooding of adjacent forest and to tidal fluctuation. Dominant trees include pines, cypress, and Atlantic white cedar, which line stream banks with characteristic stunted growth (Mohr, 1901). Stout and Lelong (1981) described the moist pine forest as prevalent in the area of low relief and poor drainage between streams, noting it often forms a more or less extensive strip between floodplain swamps and upland pine-oak forest. The most common tree of moist pinelands is the slash pine, although longleaf pine can also grow there (Stout and Lelong, 1981).

Wet pine forests naturally have a sparse or absent midstory and a dense groundcover of hydrophytic grasses, herbs, and low shrubs. The understory of moist pinelands may be very dense, especially if fire has been prevented, consisting largely of gallberry (*Ilex glabra*), wax myrtle, saw palmetto (*Serenoa repens*), and occasional sweet bay, swamp bay and swamp tupelo (Stout and Lelong, 1981). Herbs include grass-like plants, mostly of the sedge family (Cyperaceae), but also with true grasses (Poaceae), rushes (Juncaceae), and yellow-eyed grasses (*Xyris* spp.) (Mohr, 1901).

Wetland pine areas possessing carnivorous pitcher plants (*Sarracenia* spp.) are rare, restricted habitats found across the Southeastern Coastal Plain in widely scattered localities. These habitats, comprised of several distinct sub-communities, are often collectively called pitcher plant bogs, referencing their most conspicuous feature (Folkerts, 1982; 1991). Other names for pitcher plant habitats include wet pine barrens (Mohr, 1901, Harper, 1914, Harper, 1922), seepage bogs (Folkerts 1991), herb bogs (Whitney et al., 2004), pine savannahs (Peet and Allard, 1993), wet mineral flats (Rheinhardt et al., 2002), and East Gulf Coastal Plain Shrub Bogs (Duncan, 2013; NatureServe, 2015). These plants have highly modified leaves used to capture insects and other small fauna (Figure 2.15).

Pitcher plant bogs, typically located on deep acid soils, are saturated at least during a portion of the year (Folkerts, 1982; 1991). Topographically, the habitats occupy a wide range of sites from hillside slopes ("hanging bogs") to perched wetland areas of low relief (Folkerts, 1982; 1991). They are also pyrogenic communities characterized by frequent low intensity fires that maintain their herbaceous structure by preventing the encroachment of fire-intolerant hardwood shrubs. In addition, pitcher plant bogs possess a unique and distinctive biota, many of which are considered globally rare (Folkerts, 1991; Noss et al., 2015). Over 97% of the Coastal Plain's seepage bogs have been lost (Duncan, 2013).

At least three pitcher plant bogs are known in the Watershed, including the Kurt G. Wintermeyer Nature Trail bog on Weeks Bay NERR property and the Juniper Lane bog on Weeks Bay Foundation-owned land, near the confluence of Barner Branch and Fish River. A third bog is located on private land, east of CR9 (B. Summerour, personal communication).

2.5.3.2 Freshwater Marshes

Low marshes occupy margins of watercourses with relatively slow flow, at frequently flooded elevations (Stout and Lelong, 1981). Sedges, grasses and rushes are the dominant vegetation of those marshes, including Mauritius reed (*Phragmites mauritianus*), switch grass (*Panicum virgatum*), wild rice (*Zizania aquatica* and *Zizaniopsis miliacea*), and saw grass (*Cladium jamaicense*). Species such as wild rice and cattails (*Typha* spp.) occupy the lowest elevations in some areas (Mohr 1901). Numerous species of beak rushes (*Rhynchospora* spp.),

Figure 2.15 Coastal Alabama Pitcher Plants in Wet Pine Savannah
(Photo: H. Horne).

spikerushes (*Eleocharis* spp.), flatsedges (*Cyperus* spp.), and rushes (*Juncus* spp.) typically occupy these habitats (Mohr, 1901; Stout and Lelong, 1981)

Other plants commonly encountered in freshwater marshes of the study area are beggar ticks, especially smallfruit beggar ticks (*Bidens mitis*), pennyworts (*Hydrocotyle* spp.), numerous species of primrose willows (*Ludwigia spp.*), climbing hempweed (*Mikania scandens*), golden club (*Orontium aquaticum*), arrow-arum (*Peltandra virginica*), cowbane (*Tiedemannia filiformis*) bishop weed (*Ptilimnium capillaceum*), marsh fleabane (*Pluchea* spp.), pickerelweed (*Pontederia cordata*), and lizard's tail (*Saururus cernuus*) (Stout and Lelong, 1981).

Scattered shrubs and small trees occur in higher spots or ridges in freshwater marshes, including button bush, wax myrtle, elderberry (*Sambucus nigra*), and black willow (*Salix nigra*).

2.5.3.3 Saline and Brackish Marshes

Shorelines flooded by tidal saline or brackish waters support marshes dominated by salt tolerant herbs and grass-like plants (Mohr 1901; Stout and Lelong, 1981). The marshes typically occur as narrow shoreline fringes along bays and at and near the tidal mouths of tributary rivers. Black needlerush (*Juncus roemerianus*) is by far the most abundant species in the saline marsh (Stout and Lelong, 1981). Saltmarsh cordgrass (*Spartina alterniflora*) and big cordgrass (*Spartina cynosuroides*) are locally abundant in the intertidal zone of saline and brackish marshes, respectively. Other frequent species of the saline marsh are salt grass (*Distichlis spicata*), saltmeadow cordgrass (*Spartina patens*), perennial salt marsh aster (*Symphyotrichum tenuifolium*), saltmarsh false foxglove (*Agalinis maritima*), and sea lavender (*Limonium carolinianum*) (Stout and Lelong, 1981).

A greater diversity of species occurs within the less saline, brackish marshes. Open river marshes in the tidewater region support associations of reed-like grasses and large rushes (Mohr 1901). Of the saline marsh species, only needlerush and saltmeadow cordgrass are found frequently in the brackish environment (Stout and Lelong, 1981). Common brackish species include wild rice, cattails, spike rush, Mauritius reed, bullrushes (*Scirpus* spp. and *Schoenoplectus* spp.) and sawgrass (Mohr 1901; Stout and Lelong, 1981).

2.5.4 Terrestrial Fauna

Animal communities of the Southern Pine Plains and Hills and Gulf Coast Flatwoods ecoregions are highly diverse, due in part to habitat diversity. Natural habitats include stream and river floodplain forests, swamps, wet pine savanna and flatwoods, maritime forest and coastal scrub, and estuarine and marine systems. Some animals are generalists, moving between different habitats, including uplands, whereas many species are dependent on high quality freshwater or estuarine wetland systems.

In urbanized areas, amphibians such as green tree frog (*Hyla cinerea*), squirrel treefrog (*Hyla squirella*), and southern leopard frog (*Rana utricularis*) are common. Snakes include rat snake (*Pantherophis spiloides*), eastern kingsnake (*Lampropeltis getula*), cottonmouth (*Agkistrodon piscivorus*) and southern black racer (*Coluber constrictor*). Common lizards include the green anole (*Anolis carolinensis*), racerunner (*Aspidoscelis sexlineatus*), and ground skink (*Scincella lateralis*). Mammals include Virginia opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), gray squirrel (*Sciurus carolinensis*), southeastern shrew (*Sorex longirostris*), striped skunk (*Mephitis mephitis*), common raccoon (*Procyon lotor*), and whitetail deer (*Odocoileus virginianus*).

Many fauna are dependent on minimally disturbed, natural habitats. The Alabama Department of Conservation and Natural Resources (ADCNR), Wildlife and Freshwater Fisheries Division developed an update to Alabama’s Comprehensive Wildlife Conservation Strategy, a plan to conserve wildlife and their native habitats (ADCNR, 2016). Study area habitats identified by ADCNR and federal and state agency experts as those in greatest need of conservation include floodplain forests, swamps, wet pine savanna and flatwoods, maritime forest and coastal scrub, and estuarine and marine systems.

An updated list of the Species of Greatest Conservation Need (GCN) within these ADCNR priority habitats was produced. GCN species of highest conservation concern (Priority 1) known to occur or potentially occur in the study area include southern dusky salamander (*Desmognathus auriculatus*), river frog (*Lithobates heckscheri*), southern hognose snake (*Heterodon simus*), eastern indigo snake (*Drymarchon couperi*), Alabama red-bellied cooter (*Pseudemys alabamensis*), Mississippi diamondback terrapin (*Malaclemys terrapin pileata*), and black bear (*Ursus americanus floridanus*). High conservation concern GNC species (Priority 2) include reptiles such as Gulf salt marsh snake (*Nerodia clarkii*), alligator snapping turtle (*Macroclemys temminckii*), and gopher tortoise (*Gopherus polyphemus*), and birds including bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), Cooper's hawk (*Accipiter cooperi*), merlin (*Falco columbarius*), loggerhead shrike (*Lanius ludovicianus*), and peregrine falcon (*Falco peregrinus*).

Over 250 bird species are known from the study area, which contains a wide diversity of habitats considered crucial for migratory species. Table 2.4 lists some important migratory bird species of high conservation concern that are likely to occur in the Weeks Bay Watershed study area. Some of the birds are uncommon to rare, or accidental visitors, but many are resident breeders expected to be in the study area. These include Kentucky warbler, prothonotary warbler, and wood thrush. Common wintering migrants include Le Conte's sparrow and Nelson's sparrow (Rosenberg et al., 2016).

The Alabama Coastal Birding Trail has two stops within the Watershed, part of the Trail's South Baldwin County Loop. These sites include the Weeks Bay NERR and the Magnolia Springs Landfill. A third birding trail location, Mullet Point County Park, is located just outside the Watershed boundary.

2.5.5 Federal-Listed Threatened and Endangered Species

Federal-listed threatened and endangered species occur within the study area, and are protected under Section 7 of the Endangered Species Act (ESA). The Information for Planning and Conservation (IPaC) decision support system (USFWS, 2016) identifies several ESA species as potentially affected by activities within the region of the Weeks Bay Watershed, which are listed in Table 2.5. Additional ESA species in Table 2.5 are noted as possibly occurring in Baldwin County. Critical habitat has been designated for some of these species, but none of these areas occur within the Weeks Bay Watershed.

There are both historic and recent records of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) from the vicinity of Mobile Bay. Hastings and Parauka (2004) cite recent collections (since 1991) of Gulf sturgeon from the Tensaw and Blakely Rivers, and a recent survey collected two Gulf sturgeons in Mobile Bay near Fairhope (Mettee et al., 2009). Gulf sturgeon is an anadromous fish, with reproduction occurring in fresh water. They are thought to return to breed in the river system in which they hatched. Genetically distinct subunits of Gulf sturgeon have been identified throughout the Gulf of Mexico (Stabile et al., 1996), but the Mobile River basin is not known to support a breeding sub-population. The occurrence of Gulf sturgeon in the study area is likely infrequent, though the possibility exists that transient individuals sometimes pass through Weeks Bay and surrounding areas.

Table 2.4 Migratory Birds in the Weeks Bay Study Area

Wintering Residents
Yellow Rail (*Coturnicops noveboracensis*)
Whimbrel (*Numenius phaeopus*)
Marbled Godwit (*Limosa fedoa*)
Short-billed Dowitcher (*Limnodromus griseus*)
Red Knot (*Calidris canutus rufa*)
Lesser Yellowlegs (*Tringa flavipes*)
Magnificent Frigatebird (*Fregata magnificens*)
American Bittern (*Botaurus lentiginosus*)
Short-eared Owl (*Asio flammeus*)
Peregrine Falcon (*Falco peregrinus*)
Sedge Wren (*Cistothorus platensis*)
Henslow's Sparrow (*Ammodramus henslowii*)
Le Conte's Sparrow (*Ammodramus leconteii*)
Nelson's Sparrow (*Ammodramus nelsoni*)
Rusty Blackbird (*Euphagus carolinus*)
Breeding Residents
Chuck-will's-widow (*Antrostomus carolinensis*)
Snowy Plover (*Charadrius nivosus*)
Wilson's Plover (*Charadrius wilsonia*)
Least Tern (*Sternula antillarum*)
Gull-billed Tern (*Gelochelidon nilotica*)
Least Bittern (*Ixobrychus exilis*)
Swallow-tailed Kite (*Elanoides forficatus*)
Mississippi Kite (*Ictinia mississippiensis*)
Wood Thrush (*Hylocichla mustelina*)
Prothonotary Warbler (*Protonotaria citrea*)
Swainson's Warbler (*Limnothlypis swainsonii*)
Kentucky Warbler (*Geothlypis formosus*)
Painted Bunting (*Passerina ciris*)

Source: IPaC Trust Resources Report (USFWS, 2016)

Table 2.5 Federal-Protected Species Potentially Occurring in the Weeks Bay Watershed

Species	Federal Status
Fishes	
Gulf Sturgeon (*Acipenser oxyrinchus desotoi*)	**T**
Reptiles	
Eastern Indigo Snake (*Drymarchon corais couperi*)	**T**
Alabama Red-bellied Cooter (*Pseudemys alabamensis*)	**E**
Gopher Tortoise (*Gopherus polyphemus*)	**T, C**
Kemp's Ridley Turtle (*Lepidochelys kempii*)	**E**
Loggerhead Turtle (*Caretta caretta*)	**T**
Birds	
Wood Stork (*Mycteria americana*)	**E**
Red-cockaded Woodpecker (*Picoides borealis*)	**E, P**
Mammals	
West Indian Manatee (*Trichechus manatus*)	**E**
Plants	
Louisiana Quillwort (*Isoetes louisianensis*)	**E, P**
American Chaffseed (*Schwalbea americana*)	**E, P**

KEY: E – Endangered; **T** – Threatened; **C** – Candidate Species; **(P)** – Possible Occurrence in Baldwin County.
Source: USFWS, 2016

Godwin (2004) lists only four documented occurrences (all over 50 years old) of eastern indigo snake in Alabama, with a single record from Baldwin County. The last confirmed record in Alabama was from Covington County in 1954, although unverified sightings continue to be reported, some of which may be valid (Hart, 2002). An experimental restocking program was initiated in 1979 and lasted to 1980, and included Baldwin County as a release location. Given the large size of the study area, it is possible that a small, undetected breeding population of eastern indigo snake exists locally, although the lack of any recent sightings in Alabama suggests that occurrences are unlikely.

Alabama red-bellied cooter is found in Mobile and Baldwin counties. Its distribution is primarily restricted to the lower Mobile Tensaw Delta in densely vegetated backwater areas of freshwater streams, rivers, and bays adjacent to Mobile Bay. These turtles occur in tidal creeks and bask on debris or beaches in tidally influenced habitats. A three-year trapping survey performed by Nelson and Turner (2004) did not capture any red-bellied cooters from brackish waters in Alabama, though records of occurrence in the study area exist (Table 2.4). Wandering individuals may occur infrequently as rare, accidental waifs. No nesting is known to occur in the Watershed.

Gopher tortoise is a common inhabitant of fire maintained upland sandhill communities containing a lush herbaceous groundcover and little woody cover (Aresco and Guyer, 2004; Ashton and Ashton, 2008). In Alabama, gopher tortoise is federally protected only in Mobile, Washington and Choctaw counties. The species does not receive federal protection in Baldwin County, but is currently a candidate for listing. Gopher tortoise is however, protected by Alabama's nongame regulation act, which prohibits the outright killing of individual tortoises.

Loggerhead (*Caretta caretta*) and Kemp's ridley (*Lepidochelys kempii*) sea turtles do not nest within the study area. Wandering juveniles may occur in the area of Weeks Bay.

Wood storks (*Mycteria americana*) are typically found in Alabama during periods of post-breeding dispersal in mid to late summer. The species is not known to nest in the state, although there is a recent suggestive report of breeding based upon an individual seen in the Mobile/Tensaw River Delta carrying nesting material in 2002. Another separate report involved an apparently injured individual found in a field near Elberta that subsequently perished. Suitable foraging areas (i.e., ponds) for wood stork may be present in the study area, but would only be utilized by wandering individuals, and not breeding storks.

Red-cockaded woodpecker (RCW) (*Picoides borealis*) is a specialist of fire-maintained pine ecosystems of the Southeastern United States. RCW typically prefer old growth longleaf pine forest, but other pine species are known to be utilized for nesting (Conner et al., 2001; Tucker and Robinson, 2004). RCW was historically known from the general vicinity of CR 4 and Roscoe Road, in Gulf Shores. This small population was regularly recorded for several years on the Gulf Shores Christmas Bird Count (CBC) conducted through the National Audubon Society, but has not been observed on the Gulf Shores CBC count circle since January 1999 (National Audubon Society, 2010). RCW was also noted from Gulf Shores State Park during the CBC count's period from 1973 to 1987. Although the species has not recently observed at these locations, it is possible that RCW still exists in Baldwin County.

The West Indian manatee (*Trichechus manatus*) is protected under both the ESA and the Marine Mammal Protection Act of 1972. West Indian manatee sightings in Alabama, including in the study area, have been increasing in recent years as they extend their presence farther west of Florida during warmer months. Manatees are opportunistic herbivores, consuming submerged aquatic vegetation in marine, estuarine, and freshwater systems.

The Alabama Plant Atlas (Keener et al., 2016) lists only two county occurrences of Louisiana quillwort (*Isoetes louisianensis*) in Alabama, from nearby Monroe and Conecuh Counties. There are no documented records of the species from Baldwin County; however, observations of a non-reproductive, unidentified *Isoetes* sp. were made in the early 2000's from a small tributary to Cowpen Creek, east of Fairhope, and could possibly be this species. Subsequent searches of the original discovery site over the intervening years have failed to find any plants, and there is no evidence that a population persists at this location. It is possible that the species could be overlooked due to the difficulty of surveying its natural habitat along creek floodplains and swamp bottoms.

The Alabama Plant Atlas (Keener et al. 2016) records three county occurrences of American chaffseed (*Schwalbea americana*) from the state (Mobile County, 1868; Geneva County, 1971; and Bullock County, 2012). There is also a 2001 occurrence from Splinter Hill bog in Baldwin County (Baldwin County Planning and Zoning Department, 2005) located near the community of Perdido. This fire-dependent species is found in seasonally moist to xeric sandy acidic soils of species-rich communities that include pine flatwoods, savannas, and ecotonal areas occurring between peat wetlands and sandhills (NatureServe, 2015).

2.5.6 Other Rare and Sensitive Species and Habitats

Alabama Natural Heritage Program (ALNHP) data include 28 rare, threatened, or endangered species and natural community occurrences in the study area (Table 2.6). ALNHP element occurrence data comprise records of species and natural communities classified as critically imperiled in Alabama because of extreme rarity (S1), rarity (S2), or as being rare or uncommon in the state (S3). Several of the ALNHP occurrence records (including buffer) overlap existing conservation easements in the study area (Table 2.6).

2.5.7 Aquatic fauna

Aquatic environments in the study area include the Fish and Magnolia River systems, Weeks Bay, and the broader Mobile Bay system. Aquatic fauna include benthic (bottom-dwelling) invertebrates (e.g., clams, insect larvae, segmented worms), motile epifauna (e.g., snails, amphipods, shrimps, crayfishes), resident and transient fishes, herpetofauna (amphibians and reptiles), waterfowl, and mammals such as porpoises and manatees.

Weeks Bay is a shallow coastal bay characterized by diurnal, seasonal, and annual fluctuations in its chemical, hydrologic, and physical properties. Benthic invertebrates are dominated by species adapted to and constrained by the fluctuating environment, exhibiting spatial and temporal patchiness in their community structure. There is typically low diversity in estuaries, with total abundance dominated by relatively few species (Odum, 1988; Hyland et al., 1998). Community structure tends to vary with sediment habitat type, with species assemblages differing between sand and mud bottoms, and influenced by the degree of sediment sorting, organic content, flow regime, and hydrologic variation.

Weeks Bay and its connecting waterways provide foraging, nursery, migratory, and spawning habitat to numerous fishes and epifaunal invertebrates. Motile epifauna and fishes of coastal Alabama have been collected by Swingle and Bland (1974), Shipp (1979), ADCNR MRD (Valentine et al., 2006), Rozas et al. (2013), and others. Abundant estuarine invertebrates include grass shrimp (*Palaemonetes* spp.), blue crab (*Callinectes sapidus*), brown shrimp (*Farfantepenaeus aztecus*), and white shrimp (*Litopenaeus setiferus*). Abundant fishes include Gulf menhaden (*Brevoortia patronus*), Atlantic croaker (*Micropogonias undulatus*), bay anchovy (*Anchoa mitchilli*), spot (*Leiostomus xanthurus*), tidewater silverside (*Menidia beryllina*), and rainwater killifish (*Lucania parva*).

Table 2.6 ALNHP Element Occurrence Data in the Weeks Bay Watershed

ALNHP Tracked Habitats and Species	Occurrence Record Location (HUC 12)	State Rank
Natural Communities		
Northern Gulf Tidal Pond-cypress Forest	Magnolia R, Lower Fish R	S1
Southern Switchgrass Tidal Fringe Grassland	Magnolia R, Lower Fish R	S1
Gulf Coastal Plain Streamside White-cedar Swamp	Upper Fish R	S1
East Gulf Coastal Plain Wet Prairie	Lower Fish R	S2
Longleaf Pine / Turkey Oak Woodland	Middle Fish R	S2
Ferns and relatives		
Nodding Clubmoss (*Lycopodiella cernua*)	Middle Fish R	S1S2
Flowering Plants		
Powdery Thalia (*Thalia dealbata*)	Lower Fish R	S1
Crestless Eulophia (*Pteroglossaspis ecristata*)	Upper Fish R	S1
Flax-leaf False-foxglove (*Agalinis linifolia*)	Lower Fish R, Upper Fish R	S2
Yellow Fringeless Orchid (*Platanthera integra*)	Lower Fish R	S2
Whitetop Pitcher-plant (*Sarracenia leucophylla*)	Lower Fish R	S3
Atlantic St. John's-wort (*Hypericum reductum*)	Upper Fish R	S2
Drummond's Yellow-eyed Grass (*Xyris drummondii*)	Middle Fish R	S3
Turtles		
Alabama Red-bellied Cooter (*Pseudemys alabamensis*)	Magnolia R, Lower Fish R	S1
Florida Softshell Turtle (*Apalone ferox*)	Magnolia R	S2
Alligator Snapping Turtle (*Macrochelys temminckii*)	Magnolia R, Lower Fish R	S3
Gopher Tortoise (*Gopherus polyphemus*)	Lower Fish R, Middle Fish R	S3
Crayfishes		
Lavender Burrowing Crayfish (*Fallicambarus byersi*)	Lower Fish R	S2

Extreme rarity (S1), Rarity (S2), or Rare or Uncommon (S3) in Alabama

Swingle and Bland (1974) conducted monthly seine sampling at the mouth of Weeks Bay from December 1970 to May 1972. Mullet (*Mugil cephalus*) were most abundant, followed by Gulf menhaden, tidewater silverside, and bay anchovy. Grass shrimp were also abundant. At a station in lower Fish River, tidewater silverside was most abundant, followed by Gulf menhaden, grass shrimp, bay anchovy, and spot (Swingle and Bland, 1974). These species comprise important forage and fishery populations throughout coastal Alabama (Shipp, 1979; Valentine et al., 2006), and are among the most abundant nekton occurring across the northern Gulf (e,g, Christmas and Waller, 1973; Gorecki and Davis, 2013).

Many species spawn in more saline waters, but use northern Gulf estuaries as nursery habitat (Pattillo et al., 1997). Small estuarine fish such as bay anchovy, sheepshead minnow (*Cyprinodon variegatus*), killifish, and silversides spend their entire lives within the estuary, whereas adult spot, Atlantic croaker, sheepshead (*Archosargus probatocephalus*), and mullet occupy the estuary seasonally. Strong patterns of seasonality of assemblage composition coincide with seasonal recruitment of juveniles (Gorecki and Davis, 2013; Rozas et al., 2013).

Benthic invertebrates are abundant in most rivers and streams, and spend all or part of their life cycle in or on the river or stream bottom. The most common groups include various insects, particularly the Orders Diptera (flies), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The Alabama Department of Environmental Management conducted stream bioassessment in 2006 in Fish River at AL Highway 104 and found relatively high taxa richness of mayflies, stoneflies and caddisflies, indicating the macroinvertebrate community was in good condition.

Deeper streams and rivers with consistent flow support many fish species. In 2004, the Geological Survey of Alabama conducted instream fish sampling in Fish River, Cowpen Creek, and Green Branch tributary (O'Neil et al., 2004). In that survey, bay anchovy was the most abundant species, followed by weed shiner (*Notropis texanus*), striped mullet, bluegill (*Lepomis macrochirus*), and spotted gar (*Lepisosteus oculatus*). In 2010 and 2011, the GSA conducted fish sampling in Fish River (AL Highway 104 and AL Highway 90) and Cowpen Creek (Baldwin Co. Highway 33) (O'Neil and Shepard, 2012). Blackbanded darter (*Percina nigrofasciata*) was the most abundant fish species at all three locations. In addition, flagfin shiner (*Pteronotropis signipinnis*) and weed shiner were abundant at Fish River (Highway 90), and speckled darter (*Etheostoma stigmaeum*) was abundant at the Cowpen Creek station.

Colvin et al. (2016) studied environmental and fish assemblage differences between blackwater and clearwater streams in coastal Alabama. Sites in the Weeks Bay Watershed included Baker Branch, Cowpen Creek, Magnolia River, Pensacola Branch, and Perone Branch. Blackwater streams, with characteristic tea-colored water, woody debris, and low flow and dissolved oxygen during summer, were characterized by species such as redfin pickerel (*Esox americanus*) and lake chubsucker (*Erimyzon sucetta*). Clearwater streams, which have less woody debris and tend to be perennial with relatively higher water velocities, had a characteristic assemblage that included blackbanded darter, bluegill, green sunfish (*Lepomis cyanellus*), longear sunfish (*Lepomis megalotis*), largemouth bass (*Micropterus salmoides*), and weed shiner (Colvin et al., 2016).

The aquatic communities of river and stream reaches with more diverse biological habitat, little instream disturbance, and undisturbed riparian zones tend to be of higher quality than stressed systems. Instream cover includes substrate features such as fallen trees, logs, branches, undercut banks, and hard substrates that aquatic organisms can use as habitat, feeding sites, or for spawning. As the variety and prevalence of natural instream substrates decrease, biodiversity generally decreases.

Riparian zones are transitional areas between aquatic and upland terrestrial habitats, comprised of vegetation adjacent to and along the length of streams and rivers. Riparian buffers and upland-wetland boundaries are important to broad range of mammals, birds, reptiles, amphibians, and insects (Marczak et al., 2010). Terrestrial areas surrounding wetlands are core habitats for many semiaquatic species, particularly amphibians and reptiles that depend on wetland-upland transition zones to complete their life cycle. This biological interdependence between aquatic and terrestrial habitats is essential for the persistence of these populations (Semlitsch and Bodie, 2003).

Commercial shrimping is not allowed within Weeks Bay; however, commercial crabbing and gill netting, as well as recreational crabbing and fishing are allowed. According to local residents (Rick Wallace, personal communication, July 18, 2017) the recreational fishery in Weeks Bay, Fish River, and Magnolia River provide a year-round resource. The mouth of Weeks Bay is heavily fished throughout the year, and concentrated in the Fall in the Rivers. Weeks Bay and the Rivers support good seasonal populations of spotted sea trout, red fish, and croakers, with year-round fishing for bass and bream in the Rivers. In addition, recreational crabbing and cast-netting for mullet are popular activities in the tidal portions of the Watershed.

2.5.8 Essential Fish Habitat

Essential Fish Habitat, or EFH, is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity", covering the complete life cycle of species managed by the National Marine Fisheries Service (NMFS) and the Gulf of Mexico Fisheries Management Council (GMFMC). The estuarine component of EFH comprises tidal waters and substrates (mud, sand, shell), including submersed grasses (SAV) and adjacent intertidal marshes (GMFMC, 1998).

The GMFMC generic document (GMFMC, 1998) presented maps depicting EFH for all life stages of 26 managed invertebrate and fish species. In 2005 the GMFMC prepared Fishery Management Plans (FMP) for corals and coral reefs, shrimps, stone crab, spiny lobster, reef fishes, red drum, coastal migratory pelagic fishes, and highly migratory species (GMFMC, 2005). The Highly Migratory Species FMP was amended in 2009 to update EFH for tunas, swordfishes, billfishes, and sharks (NMFS, 2009).

Many of the species and groups of GMFMC managed fisheries do not have defined EFH in Weeks Bay, including corals, certain reef and pelagic fishes, and most of the highly migratory species (GMFMC, 1998; GMFMC, 2005; NMFS, 2009). Juveniles of some EFH reef species (gag grouper, and yellowtail, lane, and gray snappers) occupy estuaries to some extent (Bortone and Williams, 1986). Of these, gray snappers are most likely to occur in inshore coastal waters such as Weeks Bay.

Estuaries are important habitats for most of the major prey species of coastal pelagics (GMFMC and SAFMC, 1985; 1990), and estuarine habitats and factors affecting them are considered part of the coastal pelagic management unit. Coastal pelagic species forage on locally abundant prey, many of which are estuarine-associated, including a variety of fishes, squid, and shrimps. Of the coastal migratory pelagics, juvenile Spanish mackerels are most likely to occur in estuaries, which offer year round nursery habitat (GMFMC and SAFMC, 1985). Table 2.7 lists managed fishery species with EFH in tidal waters of the Weeks Bay Watershed.

Benthic habitat in Weeks Bay consists mostly of unconsolidated, mixed sediments, with oyster shell and submerged aquatic vegetation covering small areas. The bottom sediments within the interior of Weeks Bay are silts and clays, principally deposited by outflow from the Fish and Magnolia Rivers. Around the periphery of the bay are relatively clean quartz sands (Haywick et al., 1994).

Table 2.7 Managed Fishery Species with Mapped EFH Overlapping Weeks Bay

Species	Life Stage(s)
Brown shrimp (*Farfantepenaeus aztecus*)	Adult, juvenile, postlarval
Pink shrimp (*Farfantepenaeus duorarum*)	Adult, juvenile, postlarval
White shrimp (*Litopenaeus setiferus*)	Adult, juvenile, postlarval
Gulf stone crab (*Menippe adina*)	Adult, juvenile, postlarval
Gray snapper (*Lutjanus griseus*)	Adult, juvenile, postlarval
Red drum (*Sciaenops ocellatus*)	Adult, juvenile, postlarval
Spanish mackerel (*Scomberomorus maculatus*)	Adult, juvenile

Source: Pattillo et al., 1997; GMFMC, 1998; GMFMC, 2005

Intertidal marshes regularly inundated with salt or brackish water represent one of the most biologically productive natural communities known, and support numerous important fishery populations. These coastal wetlands serve as nursery grounds for more than 95% of the recreational and commercially important fish and shellfish species found in the Gulf of Mexico. Post-larval shrimp and other motile epifauna seek out and occupy vegetated habitats in particular (Zimmerman and Minello, 1984; Wenner and Beatty, 1993; Petersen and Turner, 1994). The 507 acres of estuarine emergent marshes in the study area are distributed across the lower reaches of the Fish River HUC 12, which includes Weeks Bay, and the lower Magnolia River HUC 12.

In subtidal waters, submerged aquatic vegetation (SAV) similarly provides important nursery habitat and refuge for fishery species. SAV in the study area is limited in distribution mostly to the lower areas of the Fish and Magnolia Rivers (Barry A. Vittor & Associates, Inc., 2016). Beds of wild celery (*Vallisneria neotropicalis*) were mapped in 2015-2016 in the Magnolia River between Nolte Creek and Eslava Branch, with the densest beds extending into Nolte Creek. To the north, sparse widgeon grass (*Ruppia maritima*) was found along the margins of the river near Weeks Creek. In Fish River, wild celery occurs in small patches near its confluence with Turkey Branch, and just off the main river in a shallow basin near Barner Branch (Barry A. Vittor & Associates, Inc., 2016). It is likely that additional, undetected areas with SAV exist in the study area.

Historic and ongoing alterations to the physical environment of the study area contribute to the cumulative loss and impairment of EFH. Bulkheads are the predominant non-natural, hardened shoreline in the study area (Jones et al., 2009).

2.5.9 Invasive Flora and Fauna

The introduction of invasive exotic plants such as Chinese privet (*Ligustrum sinense*), Chinese tallowtree (*Triadica sebifera*), and cogongrass (*Imperata cylindrica*) has resulted in changes to vegetative structure and plant species composition across virtually every type of upland and wetland habitat in coastal Alabama. These aggressive species can spread rapidly to outcompete native flora, with consequent losses of biodiversity and habitat degradation. Exotic invasive plants are prevalent in and near disturbed areas, especially maintained lands such as along roadsides and trails, farmland fringes, and urbanized areas generally. Many exotic plant species have invaded floodplains, perhaps more than in any other habitat type in Alabama (ADCNR, 2016).

The most damaging invasive plants include Chinese privet, Chinese tallowtree, and cogongrass, which invade and take over disturbed areas to form monotypic stands. Habitat values are severely degraded due to heavy infestation by these invasive exotic plants. The Weeks Bay NERR 2017-2022 Management Plan cites privet, tallowtree, and cogongrass, as well as aquatic invasive species water hyacinth (*Eichhornia crassipes*) and waterthyme (*Hydrilla verticillata*) as being notable in the Reserve.

The NERR Management Plan also cites feral pigs as a serious problem in the Reserve. These invasive fauna present a serious management issue due to their destructive rooting behavior and general trampling of riparian areas, wetlands, and other priority habitats.

2.6 Political Institutions

The Weeks Bay Watershed area of approximately 203 square miles (approximately 130,000 acres) falls under the management and control of ten different local governmental entities. These include Baldwin County and the municipalities of Daphne, Fairhope, Foley, Loxley, Magnolia Springs, Robertsdale, Silverhill, Spanish Fort, and Summerdale as shown in Figure 2.16. A great portion of the Watershed; approximately 109,838 acres, or 85% of its area, is in unincorporated Baldwin County with the majority of municipality jurisdictions bordering the Watershed. As population growth has increased over time, cities and towns have extended annexations into the Watershed around its periphery (the 'headwaters' of Fish River and Magnolia River), with future growth expected to result in additional annexations inside the Watershed. All municipalities with the exception of Silverhill and Magnolia Springs have the majority of their incorporated areas lying outside the Watershed. Table 2.8 lists the total acreage controlled by each jurisdiction within the entire Weeks Bay Watershed. The municipalities of Daphne, Fairhope, Summerdale, and Silverhill have, to some extent, jurisdictional lines that extend across more than one Subwatershed (HUC 12). Table 2.9 lists the breakdown of jurisdictional control of each municipality within each of the four Subwatersheds (HUC 12s).

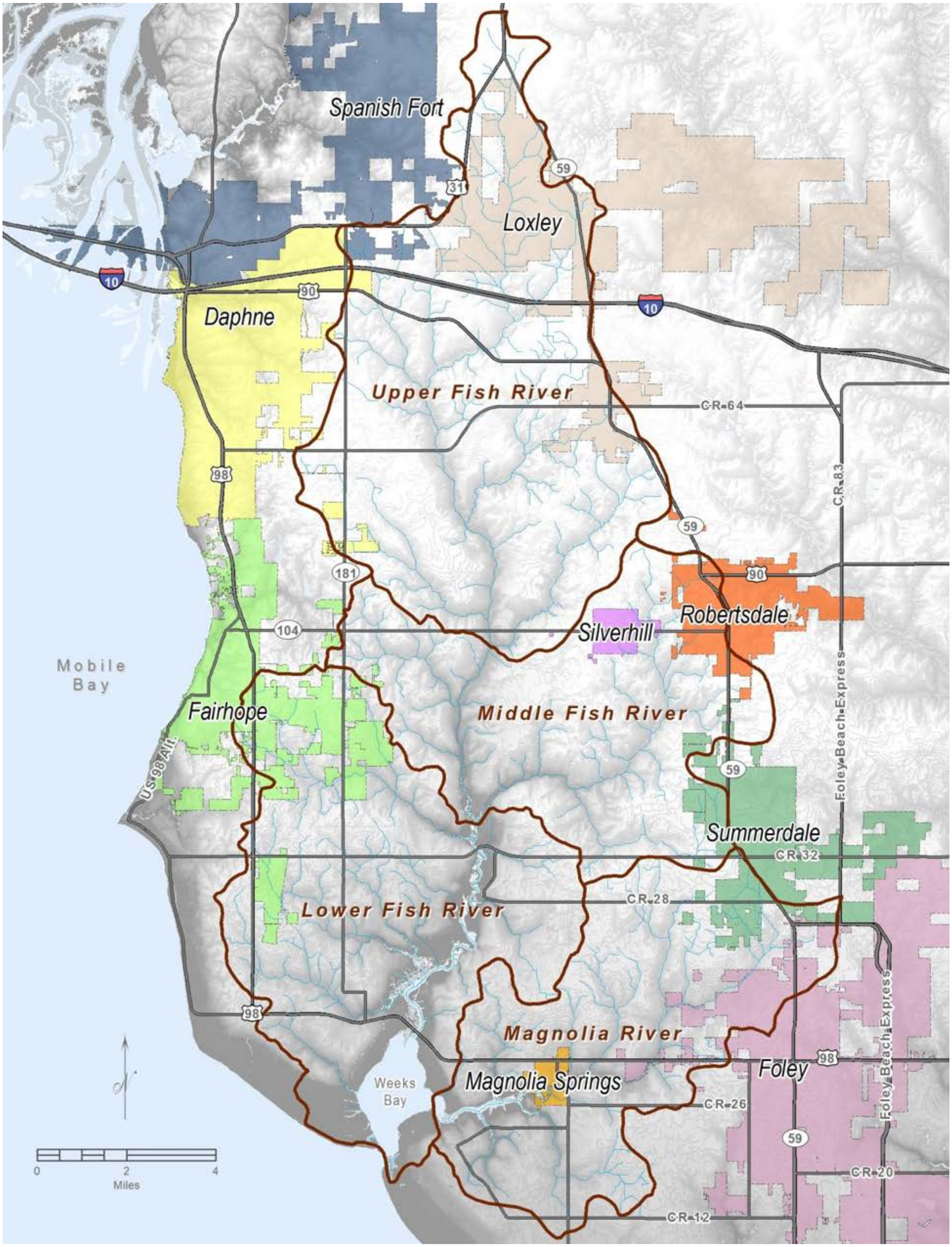


Figure 2.16 Incorporated Areas in Weeks Bay Watershed

Table 2.8 Total Jurisdictional Acreage in the Weeks Bay Watershed

Total Jurisdictional Acreage in Weeks Bay Watershed		
Jurisdiction	**Area, ac**	**% of Total Jurisdictional Area in Weeks Bay Watershed**
Daphne	688	0.5%
Fairhope	4,027	3.1%
Foley	2,411	1.9%
Loxley	6,780	5.2%
Magnolia Springs	578	0.4%
Robertsdale	1,666	1.3%
Silverhill	787	0.6%
Spanish Fort	483	0.4%
Summerdale	2,340	1.8%
Unincorporated Baldwin County	109,838	84.8%

Table 2.9 Jurisdictional Acreage in Weeks Bay Subwatersheds (HUC-12s)

Jurisdictional Acreage Per HUC 12 Subwatershed			
Upper Fish River (42,269 acres)	**Jurisdiction**	**Area, ac**	**% of Jurisdiction's Area Lying within Subwatershed**
	Daphne	688	6.4%
	Loxley	6,780	40.1%
	Robertsdale	2	0.0%
	Silverhill	34	4.3%
	Spanish Fort	483	2.5%
	Unincorp. Baldwin County	34,282	2.6%
Middle Fish River (26,767 acres)	**Jurisdiction**	**Area, ac**	**% of Jurisdiction's Area Lying within Subwatershed**
	Fairhope	62	0.7%
	Robertsdale	1,664	39.4%
	Silverhill	753	95.7%
	Summerdale	1,004	14.4%
	Unincorp. Baldwin County	23,284	1.8%
Lower Fish River (34,448 acres)	**Jurisdiction**	**Area, ac**	**% of Jurisdiction's Area Lying within Subwatershed**
	Fairhope	3,965	45.3%
	Unincorp. Baldwin County	30,483	2.3%
Magnolia River (26,113 acres)	**Jurisdiction**	**Area, ac**	**% of Jurisdiction's Area Lying within Subwatershed**
	Foley	2,411	11.8%
	Magnolia Springs	578	100.0%
	Summerdale	1,336	19.2%
	Unincorp. Baldwin County	21,788	1.7%

The planning jurisdictions of cities and towns extend beyond their respective boundaries as allowed by the Extraterritorial Jurisdiction (ETJ) provision of Alabama State Law (Ala. Code §11-52-30). The ETJ provision allows municipalities the authority to review all planned subdivision developments within their ETJ which can extend to a maximum of five miles outside their corporate limits. Therefore, all developments that occur within the neighboring unincorporated lands of Baldwin County are subject to review by the corresponding jurisdiction. This provides for many square miles of unincorporated County lands within the Watershed that fall under the ETJ review responsibilities of these nine municipality jurisdictions, as depicted on Figure 2.17.

Additionally, Baldwin County divides unincorporated lands into Planning Districts. Of the thirty Planning Districts county wide, the unincorporated lands within the Weeks Bay Watershed are located in Planning Districts 7, 12, 14, 15, 17, 18, 20, 21, 26 and 28. Of these, six Districts (Districts 12, 15, 20, 21, 26, and 28) have elected to adopt zoning provisions consistent with the County's planning and zoning authority to control growth within their portion of the county, as shown in Figure 2.18. These zoned Districts are, therefore, subject to the planning and zoning authority of the Baldwin County Commission (Article 2, §2.1).

Consequently, while 85% of the Watershed lies in unincorporated Baldwin County, only 29% (37,254 acres) lies outside an ETJ and is not subject to municipal review for planned developments. However, of these 37,254 acres, 9,116 acres (7%) are subject to Baldwin County zoning provisions. Since County Planning Districts and ETJs overlap and do not share the same borders other than City Jurisdictional lines, the breakdown of jurisdictional control of lands within the Watershed is more detailed. As depicted in Figure 2.19, 35% (45,383 acres) of lands fall under ETJ review; 21% (27,201 acres) under both ETJ review and County zoning provisions; leaving in reality only 22% (28,138 acres) outside any jurisdiction of County review.

In areas where a zoned County Planning District and an existing ETJ overlap, developments must meet planning approval of both entities; the Baldwin County Planning and Zoning Commission and the respective municipality ETJ. Section 7.2.3 provides additional information on the zoning plan for county lands within the Watershed.

Almost every residential subdivision within the Watershed has an established home owners association (HOA). The powers of the individual HOAs are limited to their respective areas of influence. Further, the knowledge and aggressiveness of the individual HOAs in undertaking specific activities may vary considerably between residential subdivisions. As will be explained in Section 7 of this WMP, the HOAs have the potential to contribute to the implementation of specific watershed management measures, particularly related to maintenance of stormwater management facilities, e.g. detention ponds.

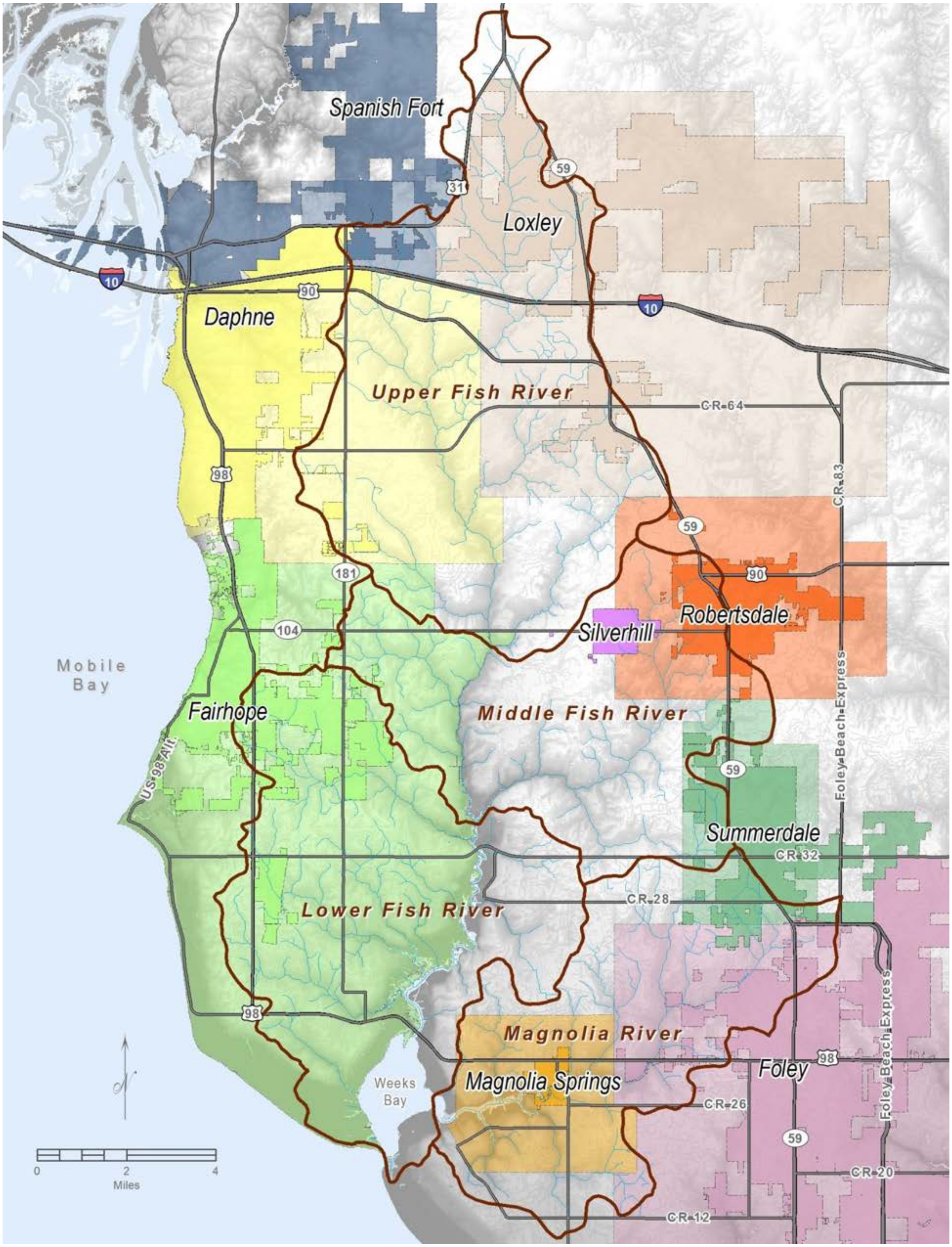


Figure 2.17 Extraterritorial Jurisdictions in Weeks Bay Watershed

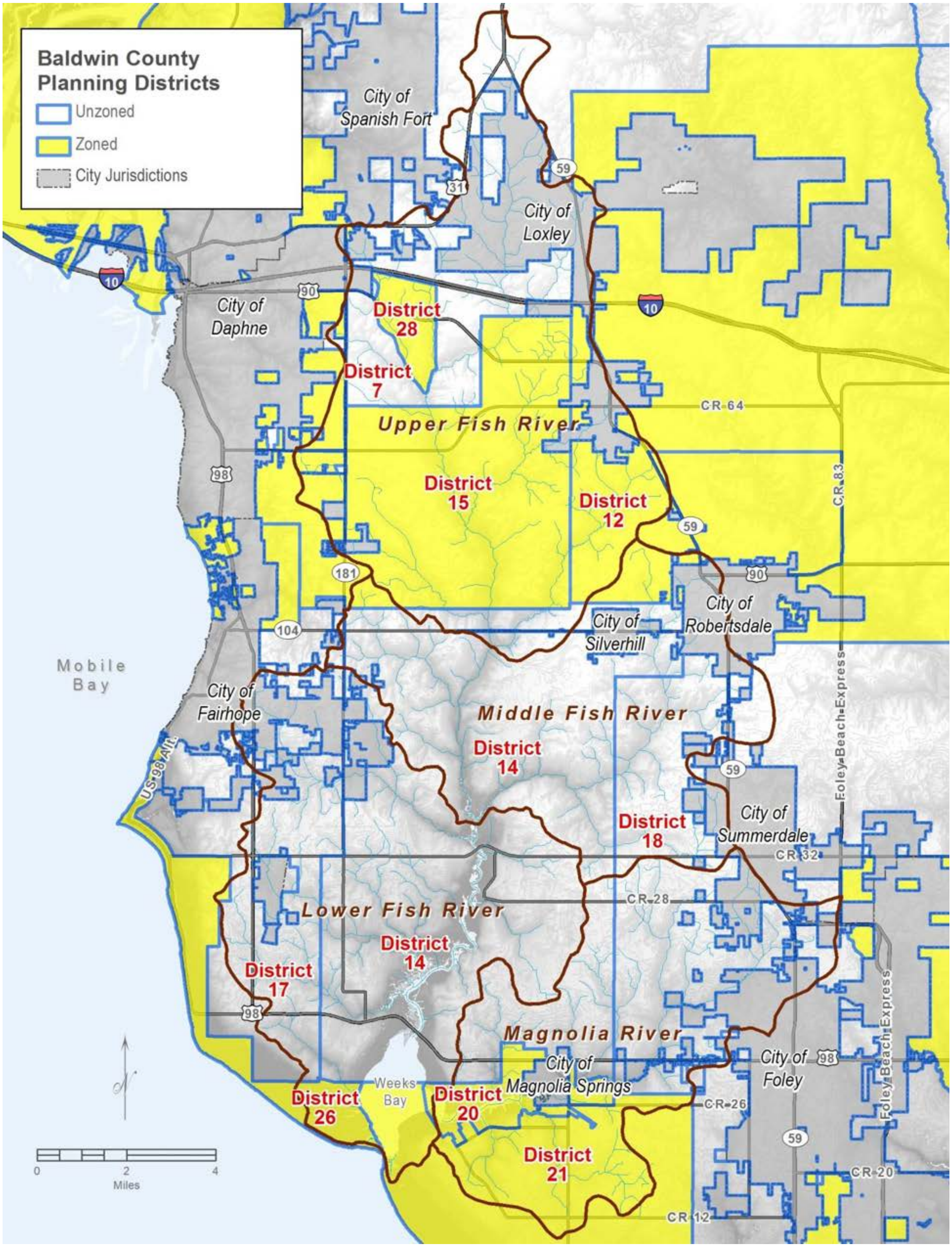


Figure 2.18 County Planning Districts in the Weeks Bay Watershed

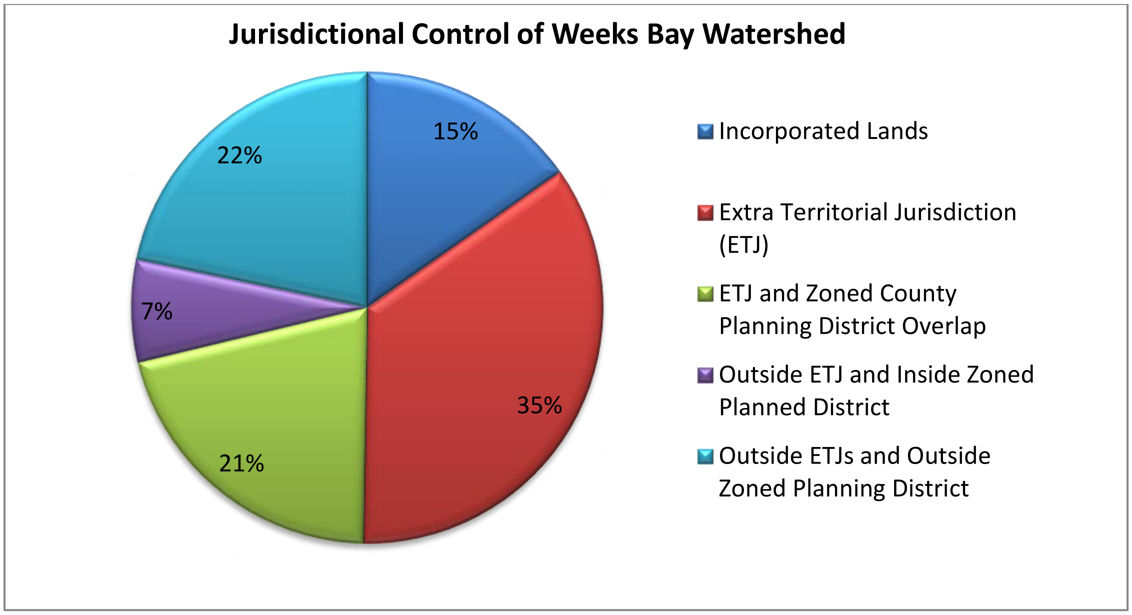


Figure 2.19 Jurisdictional Control of Weeks Bay Watershed

2.7 Demographics

2.7.1 History and Culture of the Watershed

2.7.1.1 Pre-Settlement and Early Settlement

The Native Americans who lived in this area as early as 10,000 years ago were the Creek Indians (Historic Compilations Comprehensive History, May 2016). They have a rich history that is intertwined with the history of the South as well as America as a whole. The tribes of the Creek nation in the early 1800s consisted of somewhere between 18,000 and 24,000 people that occupied around 300 square miles (Ft. Mims Massacre, Baldwin County, Alabama 1813, May 2016). After the American Revolution, all of the powerful countries that had land in southern Alabama sought out an alliance with the Creek Indians. The Creek tribes had been using the land since before any of the European settlers arrived and had an unsurpassable knowledge of it as a result. The Creek Indians were mainly hunters and gatherers. They thrived in the presence of the many waterways that encompassed the region as well as the wide range of natural resources. One group of Creeks was called the Shell Mound people because of their love of shellfish and the resulting 25-feet tall historic midden mounds that can still be seen in southern Baldwin County today (Historic Compilations Comprehensive History, May 2016).

In 1519, the Spanish were the first explorers to find Weeks Bay and establish a colony on the Gulf Coast which they controlled until 1670. The French arrived soon after, with azaleas and chinaberry trees in tow, and founded Mobile in 1702 as a capital of French Louisiana (Historic Compilations Comprehensive History, May 2016). After the French and Indian Wars ended in 1763, the British had gained control of southern Alabama. Then, during the American Revolution, Spain regained control of the area and captured Mobile in 1780. They also expanded to the Eastern Shore and built “Old Spanish Fort”. After the American Revolution, Baldwin County was officially formed on December 21, 1809, which actually predates the founding of the State of Alabama in 1819 (Historic Compilations Comprehensive History, May 2016). The name of the county comes from the Unites States Senator Abraham Baldwin (Morton, 2007).

During the Civil War in 1865, the Confederate ironclad, CSS Tennessee, made the last stand of the Confederacy against the famous Union officer, Admiral Farragut, and the union fleet at Spanish Fort. Admiral Farragut is famed for yelling, “Damn the torpedoes! Full speed ahead” after the USS Tecumseh sank from hitting a floating mine (Historic Compilations Comprehensive History). Farragut’s Basin is the widest part along Fish River and is about 0.6 mile south of the current CR 32 bridge. The basin is named after the famous Admiral Farragut and the Union troops that disembarked at that location. Shortly after disembarking, the Union troops turned around and headed for Mobile Bay (Jackson, 2013). In addition to the Union troops that occupied this area on Fish River, another detachment stayed in the Magnolia River. According to local history buffs, a number of these troops were from the Chicago area and found the mild winter to their liking, so much that they moved to the area of Magnolia Springs after the Civil War (Scott Phipps, WBNERR, personal communication, 2016). Before the cities in the Watershed were officially founded, many European immigrants came to the area in and around the Weeks Bay Watershed. The ones from Italy migrated to the Daphne area, the Scandinavians to the Silverhill area, the Bohemians (currently known as the Czech Republic) to the Robertsdale, Summerdale, and Silverhill areas, the Poles to the Summerdale area, and the Greeks to the Malbis area. This level of diversity birthed an eclectic county (Causey, 2014).

2.7.2 Settlement/History of Towns

Fairhope was founded in November 1894 as a single tax colony. Henry George along with 28 followers from Des Moines, Iowa moved to Fairhope and settled hoping to “be free from all forms of private monopoly.” Their settlement was meant to secure to its members equality of opportunity, the full reward of individual efforts, and the benefits of co-operation in matters of general concern” (Fairhope, AL, 2016). The members chose the name for the town because they believe they had a “fair hope” of success (Gaston, 2007). Currently, the town has grown exponentially and the eastern portion of Fairhope is part of the Weeks Bay Watershed.

The Daphne area was first settled by Spanish immigrants in 1557, but in 1710 the French took over the area. In 1763, the city that would one day be known as Daphne had come under British control. In November 1814, General Andrew Jackson and his army defeated the British and gained control of southern Alabama including the City of Daphne. Since 1814, the only period Daphne was not a part of America was the Civil War. Daphne was named and established on April 9, 1874. William Howard, a wealthy hotel owner, eventually became the postmaster of the city and supposedly named the city after a bush that his wife loved (Thompson-Messina, 2009). Italian immigrants came to Daphne beginning in about 1888. Greek immigrants settled in the Malbis community. The city of Daphne was incorporated on

July 8, 1927 (Daphne, Alabama, 2016). The southeastern part of the city is within the Weeks Bay Watershed.

Originally, Spanish Fort was a trading post established by the French. After the French and Indian War in 1763, it was under British control (Historic Compilations Comprehensive History, May 2016). During the Revolutionary War, the Spanish built a fort at the trading post site and people referred to it as the Spanish Fort. This is where the name of the city originated. After the War of 1812, Spanish Fort officially became part of the United States. The City of Spanish Fort was established on July 19, 1993 (History of the City of Spanish Fort, AL, 2016). The southeastern edge of the city is within the Weeks Bay Watershed.

Loxley was founded by a man named John Loxley from Chicago along with several men that traveled with him. He started a lumber camp for the longleaf pines in the area. The train depot for the Town of Loxley opened on May 5, 1906 (Loxley Alabama, 2016). In 1906, a line from the Louisville and Nashville (L&N) Railroad ran to Loxley (Kaetz, 2012). The town was incorporated in March 1957 (Loxley Alabama, 2016). The western portion of the town is included in the Weeks Bay Watershed.

Robertsdale was founded by the Southern Plantation Corporation of Chicago in 1905 and was incorporated in 1921. The town was named after one of the officials of the company, B.F. Roberts. The founders chose the location of the town based upon the railroad extension to Foley. The industry workers would create temporary railroad tracks to haul goods to the L&N Railroad in order to sell them in northern Alabama (City of Robertsdale, Alabama, 2016). For Robertsdale, the agriculture and timber industries were vital to the economic success of the city (Kaetz, 2012). The western part of the city is included in the Weeks Bay Watershed.

Oscar Johnson, C.O Carlson and C.A. Valentin founded Silverhill in 1897. These men were from Chicago, but Oscar Johnson was born in Sweden. After the town was officially founded, Scandinavian and Bohemian immigrants came from all over the country and settled in this community (Silverhill, Alabama, 2016). The name of the town originated from the turpentine workers who were paid with silver coins (Kaetz, 2013). All of Silverhill is within the Weeks Bay Watershed.

Eli Summer founded Summerdale in 1904. He wanted to establish a tobacco farm but was not successful. Other industries such as turpentine distillation and canning factories would prove profitable for the town. Summerdale was incorporated in January 1929 (Kaetz, 2013).

The City of Foley was named after its founder, John B. Foley who came to the area from Chicago. Foley used his own money to extend the railroad down to Foley. The first depot was built in 1905 to bring supplies down to southern Baldwin County, and to export the abundant natural resources (Foley, Alabama, 2016). The northwestern corner of the city is within the Weeks Bay Watershed.

Magnolia Springs was settled by Union soldiers from the Chicago area, along with their families after the Civil War, as well as families from New England (Town of Magnolia Springs, 2013). The town's name originated from the abundant presence of natural springs and magnolia trees (Kaetz, 2013). Around 1865, Magnolia Springs had the largest turpentine industry in the area. These turpentine distilleries were burned by the owners to avoid capture by Union troops (Magnolia Springs, Alabama, 2016). The Magnolia River runs through the town and is said to have been the only postal river delivery system in the United States (Town of Magnolia Springs, 2013). The town became incorporated on June 29, 2006. All of Magnolia Springs is within the Weeks Bay Watershed.

The National Register of Historic Places provides a listing of the Nation's historic places that are recognized as worthy of preservation, as authorized by the National Historic Preservation Act of 1956. The list is maintained by the National Park Service, U.S. Department of the Interior. Currently there are 12 sites within the Weeks Bay Watershed, as shown on Table 2.10.

Table 2.10 National Register of Historic Sites within Weeks Bay Watershed

Name of Site	Lat/Long	Date Added	Subwatershed	Significance	Address
Malbis Plantation	30°39'19.0, 87°51'3.81	2011	Upper Fish River	The Plantation was founded by Greek Immigrants following the Gospel to locate their dream farm in Daphne Alabama.	10145 US 90 Daphne, AL
St. Patrick's Catholic Church	30°33'38.2, 87°42'57.58	1988	Upper Fish River	This church was founded in 1925 and was added to the historic register due to its religious significance to the Town of Loxley.	E side Hwy. 90 , Loxley, AL
Jenkins Farm and House	30°38'49.36, 87°48'14.55	2016	Upper Fish River	The house of an influential African American farmer who was an innovator for social change in Loxley, Alabama.	29040 Jenkins Farm Rd. Loxley, AL
People's Supply Company	30°32'41.8, 87°45'2.31	1997	Middle Fish River	This company opened in 1902 in Silverhill and acted as a local general store founded by Theodore Johnson. It now serves as a bank and artifacts from its earlier history are on display to preserve the building's character.	21950 Broad St. Silverhill, AL
State Bank Silverhill	30°32'43.3, 87°45'5.21	2001	Middle Fish River	This was the first state bank of Silver Hill.	15950 Silverhill Ave. Silverhill, AL
Oscar Johnson Memorial Library	30°32'42.1, 87°45'6.25	1985	Middle Fish River	This was the second structure built in Silverhill and was completed June 1898. It was also used as an office, school, and church.	21967 6th St, Silverhill, AL

Table 2.10 National Register of Historic Sites within Weeks Bay Watershed (continued)

Name of Site	Lat/Long	Date Added	Subwatershed	Significance	Address
Governor's Club	30°23'49.7, 87°46'33.90	1995	Magnolia River	The Governor's Club, also known as the Brunell house, is an architectural record of the history of resorts during the early 1900s. It is associated with bootlegging during the prohibition years, however the club has never been condemned for illegal alcohol activities.	11866 Magnolia St. Magnolia Springs, AL
Moore Store	30°24'4.61, 87°46'14.30	2001	Magnolia River	This general store was built in 1922 and served the community for over 70 years. The old store was such a large part of the history of the town that local resident, Charlie Houser, reopened the general store in 1997. It was renamed "Jesse's" as a tribute to the well-known employee, Jesse King, who worked at Moore Brothers store for over 60 years.	14770 Oak St. Magnolia Springs, AL
St. Paul's Episcopal Church	30°24'5.41, 87°46'17.33	1988	Magnolia River	The chapel was founded in 1902 and was built from the local pine timber. The church is a historic monument for the Town of Magnolia Springs.	N side Oak Ave. Magnolia Springs, AL
Sunnyside Hotel	30°23'58.5, 87°45'5.21"W	1998	Magnolia River	This house was referred to as the McLennan House during the early 1900s and is over 100 years old. It is currently a bed and breakfast and serves as a tourist attraction for Magnolia Springs now called the Sunnyside Hotel.	14469 Oak St. Magnolia Springs. AL
Magnolia Springs Historic District		2012	Magnolia River	The Historic District is made up of older houses that have some historical significance.	Approx. Oak, Spring, Bay , Jessamine, Magnolia, Pine and Rock Streets, and Magnolia Springs Highway

2.7.2.1 Forestry Practices

2.7.2.1.1 **Longleaf Pine Lumber**

Before European settlers came to the land, the Weeks Bay Watershed portion of Baldwin County was mostly covered with old growth longleaf pine forests and forested wetlands. Figure 2.12 in the earlier Flora and Fauna section of this plan shows an example of the old growth longleaf pine on August 13, 1902 in Baldwin County, Alabama. That picture was taken about 10 miles east of Fairhope.

Over the years, as the timber industry grew, timberman clearcut the longleaf pines forests. Figure 2.20 shows an example of a clearcut area in south Mobile County in June in 1912.

Figure 2.20 Clearcut of Pine Forest in Mobile County, 1912 (Harper 1913)

Eventually, much of the leveled pine forests were settled by farmers who removed the stumps to allow agricultural crops to be grown. The amount of land left for longleaf pine to grow on was progressively decreasing as the years went by. Almost every lumber mill in the area used the longleaf pine for their source of lumber (Harper, 1913). John Loxley established a lumber camp that had a sawmill and a small, temporary railroad system. Many of the towns in Baldwin County harvested trees for lumber. Some areas created their own temporary railroad system in order to make hauling lumber easier and more efficient. According to Roland Harper's book that was published in 1913, lumber was the leading wood product in the area, and it was also used for fuel for locomotives (Harper, 1913).

2.7.2.1.2 **Turpentining**

Another industry related to the longleaf pines dealt with collection and processing of the sticky sap – turpentine. Turpentine is used in soaps, fuel, varnish, and to caulk the seams of wooden ships. Turpentining was a large industry in Baldwin County, especially in Magnolia Springs. Turpentine originated from longleaf pine trees, which were plentiful in Baldwin County, Alabama (Magnolia Springs, AL, 2016). Turpentine season lasted for 8 months and involved three steps to extract the turpentine from the pine trees. First, workers would cut a "box" into the base of the tree in order to collect the falling sap. After the "boxing" was finished, they would cut a "streak" above the box which was designed to release the collecting sap. Finally, they would use steel spatulas to extract the liquid from the box, a process they called "dipping." The sap then needed to be placed in barrels and sent to a distillery. Collecting the sap via this method would eventually cause the trees to die, which would consequently force workers to expand and find another pine forest (Gyllerstrom, 2011). Figure 2.21 shows a pine that had five scarred faces with a 2 foot diameter. Dr. Charles H. Herty invented a more efficient method around 1902 that increased the flow of the sap and prolonged the life of the trees – the “cup and gutter” method. His new method reduced the likelihood that the pines would break off at the base due to wind (Harper, 1913). Herty’s method used a clay pot to collect the sap.

Figure 2.21 Early Turpentine Procedure (Harper 1913)

However, as the industry evolved, better ways were invented to extract the sap from inside the pine trees. The introduction of the railroad aided the turpentine industry by giving the distillery a larger customer margin. Harvesting the turpentine in this manner with an ever-increasing population greatly accelerated the settlement in the area (Gyllerstrom, 2011). In Figure 2.22, a turpentine still is pictured in Washington County. On the left of the picture, there are rosin barrels, and on the right, there is fuel. This picture was taken in August 1900.

Figure 2.22 Turpentine Still (Harper 1913)

2.7.2.2 Farming

As stated previously, the first people to live in Baldwin County were the Creek Indians who were primarily hunter-gatherers.

Until the mid-1860s, the rest of the country recognized Alabama as the "Cotton State" because cotton was the primary crop, and it covered almost four million acres across Alabama. Cotton dominated southern Alabama's farmland until after the end of WWII, when a larger diversity of crops was introduced to the area. Some of the most common crops to be grown in Alabama in the 1920s were peanuts, cotton, soybeans, grain, peach orchards, and pecan orchards. Around this time, the farmers started using nitrate, superphosphate, and potassium minerals as fertilizers to reintroduce nutrients into the depleted soil. To correct for more acidic soils, the farmers would use ground limestone and slag (Mitchell, 2007).

Until the 20th century, agriculture was the main source of revenue for Baldwin County. At this point, the most lucrative industry in the area became timber as the economy shifted to industry. By the 1960s, farmers had replaced workers with machinery, which resulted in workers relocating to other industries such as timber and turpentine. Today, most farmers in Baldwin County work part-time, and most of them rotate growing different crops on an average of 2,000 acres of land (Mitchell, 2007). Today the most common crops grown in Baldwin County are wheat and other grains, cotton, potatoes, corn, peas, butterbeans, soybeans, tomatoes, squash, okra, peanuts, eggplant, turnip and collard greens (Baldwin County, Alabama, 2016a).

The Europeans were the first to introduce cattle to Baldwin County around the colonial era (Mitchell, 2007). In the early 1900s, farmers used the practice of open range cattle grazing which allowed cattle to have free range of the land (Harper, 1913). Farmers would let their cattle wonder wherever they pleased. Branding your cattle was the way to tell them apart from others. The only fences in the early 1900s were to keep cattle off of gardens or yards. When it was time to round up the cows, many farmers left several cows free that were older and knew the land. Cows can be fairly territorial. Men who drove the cattle herd were called crackers. They got their name from the cracking sound a whip makes when used. There were several fatal diseases that cows were subject to from different parasites, so dipping vats filled with creosote were placed throughout the county. The cattle herders would drive them each through the vat in an attempt to dispose of any pests. Today, there is a historic dipping vat preserved near Silverhill that is available for public viewing (Figure 2.23). However, due to the increase in population and major highways in Baldwin County, the Livestock Laws were passed in the 1940s making it mandatory for livestock to be confined within fences. Figure 2.24 was published by the Baldwin County Cattle and Fair Association and it shows free range cattle that have been corralled for auction (Memory of the Good Old Day: Free Range Cattle, 2009). Raising cattle was popular in the county during the 19th century and continues to be popular in southern Baldwin County today, although the total number of livestock has decreased over the years.

Figure 2.23 Dipping Vat for Cattle near Silverhill
(photo by Thompson Engineering)

Figure 2.24 Baldwin County Cattle Corralled and Ready for Auction

2.7.2.3 Transportation

2.7.2.3.1 **Water Transportation**

The first use of the land in Weeks Bay Watershed occurred when it was primarily just forests and wetlands. As the years progressed, the land was used for cultivating crops and grazing livestock. During pre-European settlement the main transportation routes were the waterways, along with a few trails and wagon routes. The major waterways in the Watershed are Fish River, Magnolia River, and Weeks Bay. The waterways in southern Baldwin County were vital to the economic and industrial growth of Baldwin County. The timber, turpentine and agricultural industries all relied on the waterways to transport construction supplies, crops, and any type of materials. The timber companies would send boats of timber to another city to earn a profit.

Fish River had only about 9 miles that were navigable and the Magnolia River had only about 3.9 miles of navigable stream, which made them quite small in comparison to the larger rivers flowing into Mobile Bay. The Fish River stretches down near Marlow where the Marlow Ferry would transport people and various items across the river (Figure 2.25). This ferry played a major role in the history of southern Baldwin County.

Figure 2.25. Marlow Ferry
Source: University of South Alabama archives

General Andrew Jackson camped at Marlow Ferry on his way to defend New Orleans against the British attack. Jackson's army that was camped at the ferry also defended Fort Morgan and Pensacola. In the early 19th century, the Marlow Ferry was the heart of commerce and transportation in Marlow (Jackson, 2013). The Fish River was named by the French colonists that were originally in the area, calling it "Riviere Aux Poissons" which translates to Fish River in English (Fish River, 2016).

The Magnolia and Fish Rivers drain into Weeks Bay, which flows into Mobile Bay. Weeks Bay is fairly shallow having an average depth of 4.8 feet, with an area of 1,718 acres. In 1808, H. Baudin sold the land around what would become known as the Magnolia River to Nicholas Weeks. Weeks Bay is named after the Weeks family, which still has descendants in that area today (Borom and Hosking, 1987). The pictures shown in Figures 2.26, 2.27, 2.28, and 2.29 are bathymetric surveys of Weeks Bay that shows how the depths in the bay have remained relatively constant for the most part over the years. Figure 2.26 is a map of Weeks Bay from 1852, Figure 2.27 from 1919, Figure 2.28 from 1988, and Figure 2.29 from 2010. Weeks Bay has always been very shallow and continues to be.

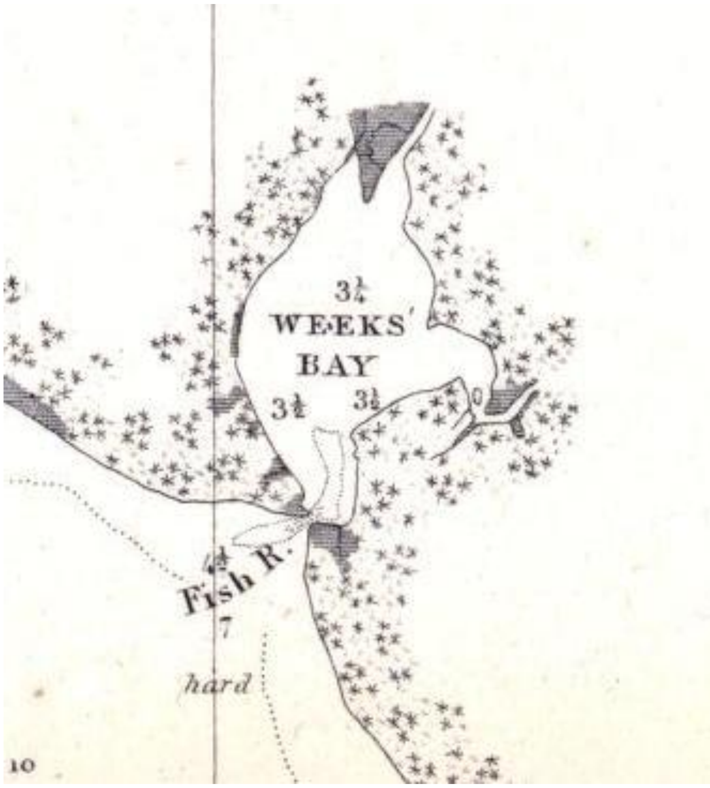


Figure 2.26 Weeks Bay Depth Chart, 1852 (U.S. Coast Survey)

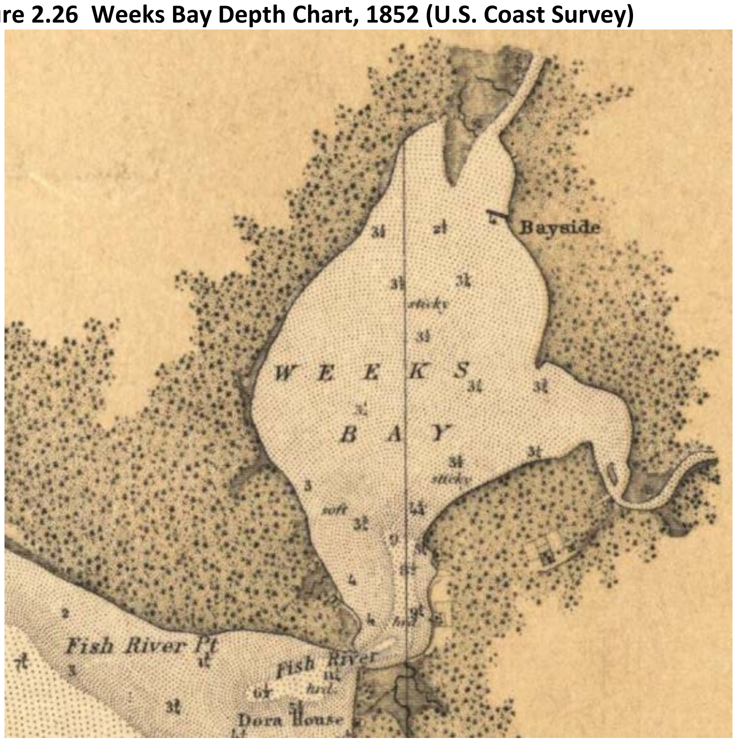


Figure 2.27 Weeks Bay Depth Chart, 1919 (Navigation Chart)

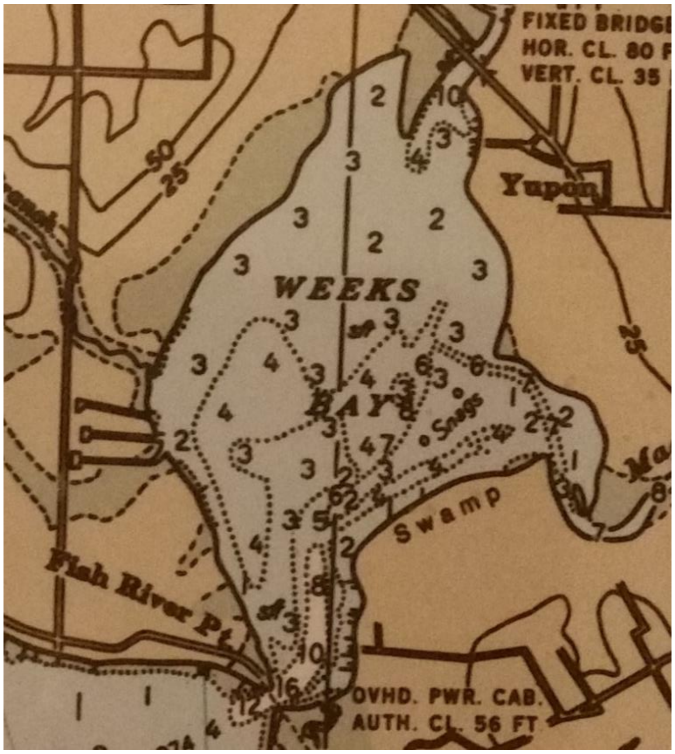


Figure 2.28 Weeks Bay Depth Chart, 1988 (Navigation Chart)

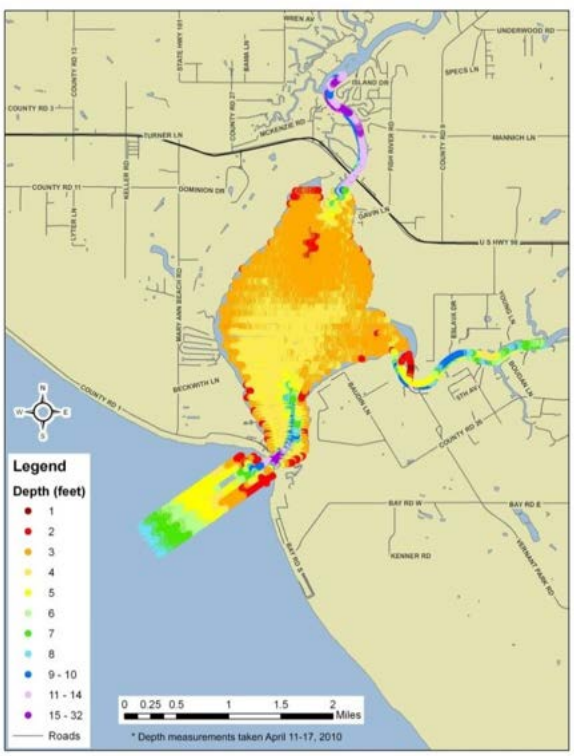


Figure 2.29 Weeks Bay Depth Chart, 2010 (Weeks Bay NERR)

2.7.2.3.2 **Railroads**

The major railroad in Baldwin County was the Louisville and Nashville Railroad, more commonly known as the L&N Railroad. Having the railroad route enabled significant economic and population growth for Baldwin County. It carried passengers as well as goods. The railroad was one of the most prominent railroads in the Southeast and earned the nickname “Old Reliable” because of its durability. It allowed the county to bring supplies that could not otherwise be transported to southern Alabama (Louisville and Nashville Railroad, 2016). The L&N ran from Bay Minette to Foley, a route that would run closely along the present day Highway 59 (Lee, 2009).

Another railroad to play a role in the history of southern Baldwin County was the Bay Minette & Fort Morgan railroad. This railroad was backed by the L&N Railroad and ran a distance of 62 miles. It was incorporated on June 21, 1904. Many early maps indicate that the BM & FM railroad used the first 11 miles of the Hand Lumber Company Private Railway all the way down to around Stapleton. One mile south of Stapleton, the BM & FM turned west and followed Fish Creek until the railway ended at a lumber camp just west of Loxley. The BM & FM turned east to Stapleton slightly then headed south down to Foley and was completed in May 1905. The BM & FM was supposed to continue all the way down to Fort Morgan, but was never completed. The L&N Railroad provided the materials to complete the BM & FM railroad including the last wood-burning locomotive used in southern Baldwin County (Lawson, 1996). Figure 2.30 shows a map of the L&N Railroad Route in 1944.

Figure 2.30 Railroad Map, 1944

Another local railroad constructed in the late 1800’s was the Loxley & Thompson Railroad to facilitate transportation of timber. The Loxley & Thompson Railroad bought its first locomotive in 1889 and named it “Samson.” “Samson” was a 28-ton Shay that the owners hoped would be the only one of its kind in Baldwin County. The railroad was a standard-gauge line that ran from Spanish Fort to Stapleton in a northeastern path. The logs harvested were dumped into Bay Minette Creek around Spanish Fort and floated to Mobile for delivery. The logs were also carried by the Blakely River. “Samson” had 12 logs cars to pull originally, but in 1891, the locomotive had increased to pulling 22 cars (Lawson, 1996).

Around 1950, there was an increase in the number of aircraft and automobiles, which usurped most of the transportation business in the state. Today, the L&N locomotive does not run anymore and is in a museum in Foley (City of Foley Railroad Museum Archives, 2008). Figure 2.31 shows the Old and New L&N Locomotive in 1913.

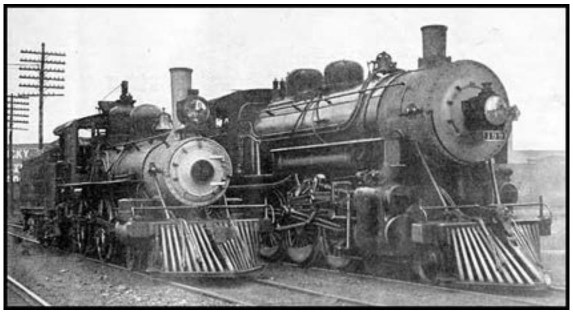


Figure 2.31 Locomotives on the Local L&N Railroad, 1913

2.7.2.3.3 **Roadways**

Today, the major highways within the Watershed are Interstate 10, US Highway 31, US Highway 90, US Highway 98, Alabama Highway 59, Alabama Highway 104, and Alabama Highway 181. These are supplemented with a dense network of paved and unpaved County Roads. But during the settlement times in the 1800's roads were not much more than wagon trails that tended to follow natural high ground at major watershed boundaries. As more settlers moved in and as the forest and agriculture produced materials, goods were transported to larger markets such as Mobile, Pensacola, and beyond as needed. An early road map of southern Baldwin County is shown on Figure 2.32.

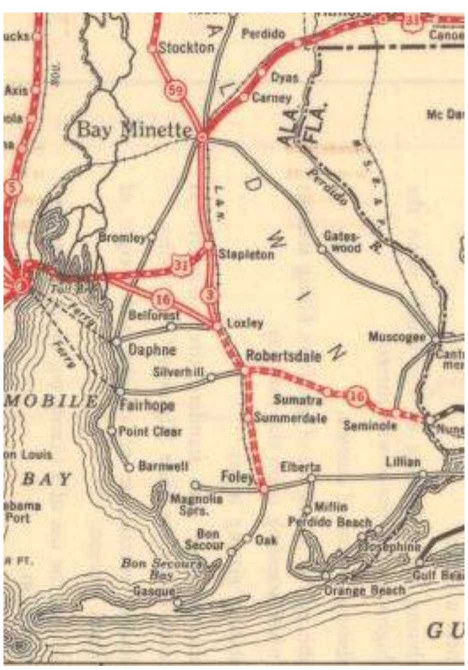


Figure 2.32 Roadmap of Baldwin County in 1928 (University of Alabama website)

However, prior to the 1970s, Interstate 10 was not completed. Prior to that time Interstate 10 extended eastward from Alabama Highway 59, outside of the Weeks Bay Watershed. In 1953, there were many county roads that ran through the Watershed, as well as U.S. Highways 31, 90, and 98, along with Alabama Highways 59, 181, and 104. In 1941, U.S. Highways 31, 90, and 98, along with Alabama Highway 59 were operational (Baldwin County, Alabama, 2016b). In 1978, the I-10 Bridge over Mobile Bay was completed.

2.7.2.3.4 **Airports**

The major airports in the Watershed are in Fairhope and Foley. The Fairhope airport has a single runway 6,604 feet long. The airport in Foley also has a single runway, but it is only 3,700 feet long (Baldwin County, Alabama, 2016b).

There were several small airfields in southern Baldwin County. The Magnolia Springs and Silverhill Naval Outer Landing Fields (NOLFs) were built during WWII as flight training facilities. Both were uniquely shaped having three triangular shaped bituminous runways. The fields were owned by the US Government; and the Navy operated them (Freeman, 2002). The Magnolia Springs NOLF airfield has been sold by the government and now the site of a sanitary landfill. The Silverhill NOLF airfield is farther north of US Highway 104 and southwest of US Highway 54, and remains in governmental ownership.

2.7.3 Public Access in Weeks Bay Watershed

The public access sites in the Weeks Bay Watershed help the community by providing outdoor recreation and helps in public education about these coastal ecosystems. There are many reasons that parks are important to communities and watersheds. Giving the public an outlet to engross themselves in their natural surroundings adds a sense of ownership, which in return helps take care of the natural amenities of the area. Getting the community involved through public parks, reserves, and piers helps the community have a stake in the wellbeing of Weeks Bay Watershed. There are 14 public access sites that are located within the Watershed. The sites listed in Table 2.11 include water-based and land-based parks that allow public access. These sites do not include the many privately owned boat ramps and access sites, as well as small county/municipality parks or recreation sports fields. There are a few private boat ramps that allow public launching for a nominal fee, such as at Noltie Creek on the Magnolia River. Figure 2.33 shows the location of these public access facilities within the Watershed.

Table 2.11 Public Water Access and Trail Sites in Weeks Bay Watershed

Name	Water body	Boatramp	Beach	Latitude/Longitude
Bohemian Park	Fish River	No	Sandy	30.523824/ -87.809962
Honey Road Extension Park	Fish River	No	Rocky	30.463762/ -87.802672
Boone Lane Fish River Access	Fish River	No, carry down	Sandy	30.493805/ -87.80779
Historic Marlow Ferry and Farragut's Basin	Fish River	Yes	Rocky	30.461967/-87.801242
Weeks Bay Pitcher Plant Bog and the Kurt G. Wintermeyer Nature Trail	Fish River	No, trail and pier	None	30.420219/ -87.83463
Weeks Bay Reserve, Bay Watch Public Boat Access	Fish River	Yes	Marsh	30.41917/ -87.82368
Manatee Park	Fish River	No, carry down	None	30.415153/ -87.82341
Weeks Bay National Estuarine Research Reserve, Boardwalk/Nature Trail	Weeks Bay	No, trail, boardwalk	Marsh	30.419164/ -87829676
Weeks Bay National Estuarine Research Reserve Nature Trailhead	Weeks Bay	No, trail	None	30.41615/ -87.81902
Magnolia Springs Public Pier	Magnolia River	No, pier	Marsh	30.396581/ -87.778242
Rock Street Magnolia River Access	Magnolia River	No, carry down	None	30.39945/ -87.772785
Magnolia Springs Park (The Springs)	Magnolia River	No	None	30.401726/ -87.770374
Magnolia Landing Boardwalk	Magnolia River	No	None	30.400879/ -87.770301
Weeks Bay Park/Pelican Point	Weeks Bay	Yes	Rocky	30.376648/ -87.837234

Source: ADCNR, 2014

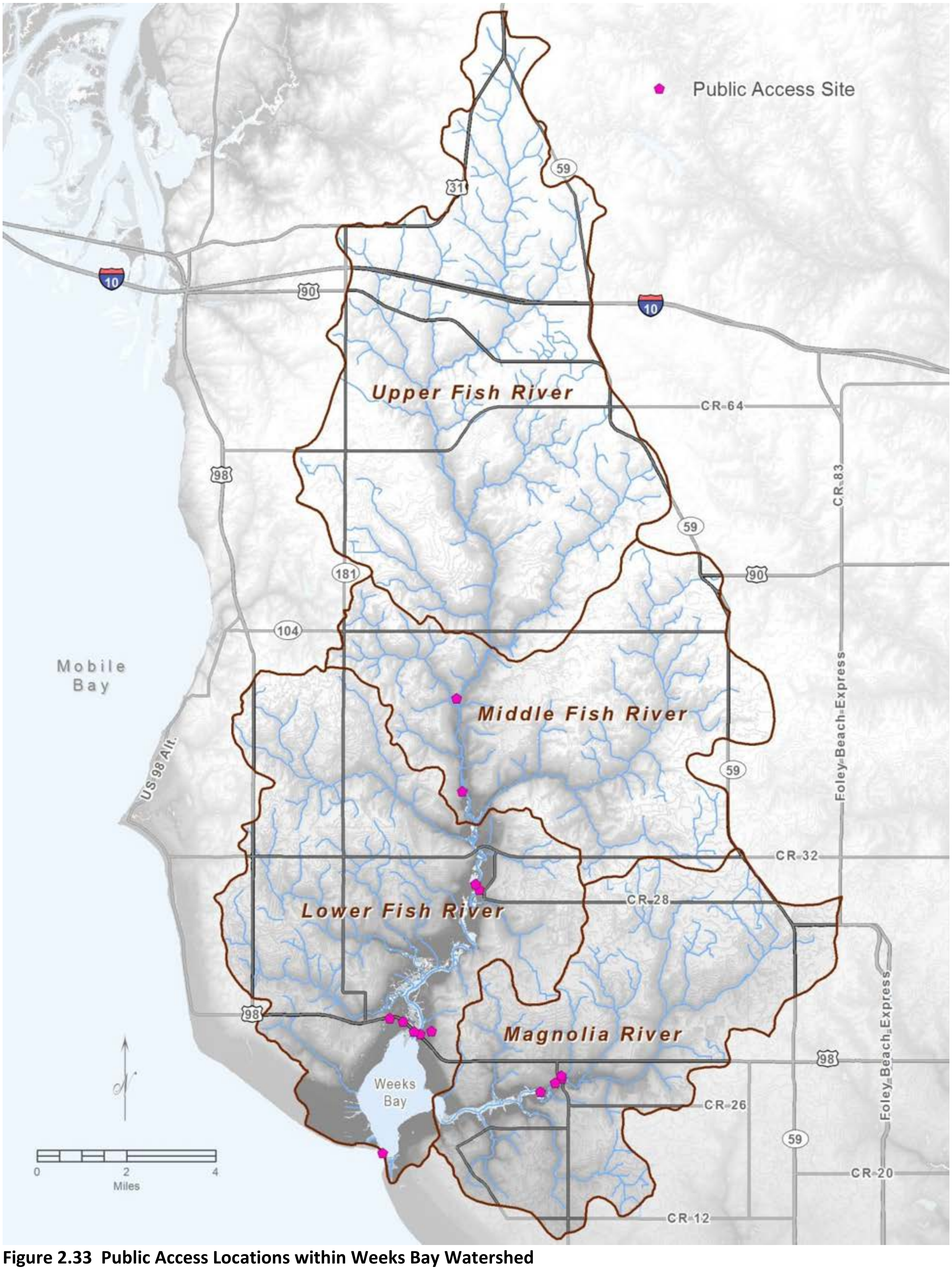


Figure 2.33 Public Access Locations within Weeks Bay Watershed

2.7.4 Population

In assessing the population of the Weeks Bay Watershed, historic and projected population data have been evaluated (in context of the various sources considered) to gain an appreciation of existing and future population characteristics within the Watershed. The nature and location of the Watershed provide a unique condition for evaluating population trends as most of the incorporated urban areas affecting the Watershed lie on its periphery. Projections made by these incorporated areas, as well as other entities, were assessed in order to infer population trends in the unincorporated and rural areas of the Watershed.

2.7.4.1 Historic Population Trends

Baldwin County is, by area, the largest county in the State of Alabama with approximately 2,027 square miles (U.S. Census Bureau). Established in 1809, it has been the fastest growing county in Alabama by total population increase since 2005, and is projected to become the fourth most populous county in Alabama by 2040 (Baldwin County Development Alliance, "*Baldwin By The Numbers 2016"*). It currently has the largest projected growth among all Alabama Metropolitan Statistical Areas (MSA).

The unique location of Baldwin County may account in part for the recent population increases. It is located just east of the City of Mobile - the third largest City in Alabama (U.S. Census 2010 and 2015 Population Estimates). Most of Baldwin County's western and southern borders lie along the shorelines of Mobile Bay, Bon Secour Bay, Weeks Bay, Wolf Bay, Perdido Bay, and the Gulf of Mexico, encompassing approximately 250 miles of shoreline.

Figure 2.34 summarizes population growth in Baldwin County since the first federal census enumeration of 1820 for the State of Alabama. The figure includes population historical data from 1810 after the establishment of the county in 1809 - preceding Alabama statehood in 1819.

The overall historic average growth per decade of the county has been around 28%. As a side note, this historical perspective shows an interesting decline in population (by 20%) during the Civil War period, between the decennial years of 1860 and 1870.

Since 1980 Baldwin County has more than doubled its population, and between the 1990 and 2010 Censuses, population grew by 85% with an addition of 84,000 people. The population of the county has historically been concentrated in its major municipalities which lie in the central portion of the county. Most recently the growth patterns have extended to the southern portions of the county with some of the highest growth rates.

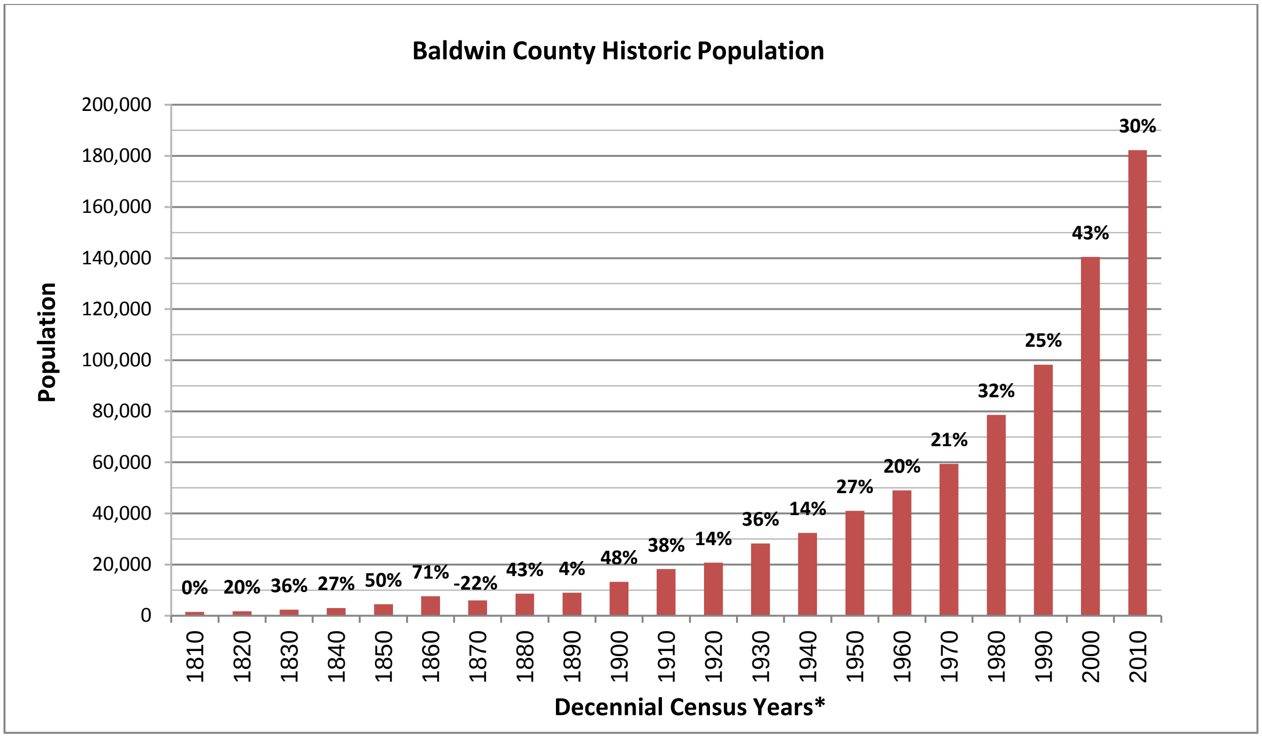


Figure2.34 Baldwin County Historic Population
Source: U.S. Census 2010 and 2015 Population Estimates

Figure 2.35 shows population growth for some of the major municipalities in the county since 1980, including the three largest cities; Daphne, Foley, and Fairhope. Over the time period depicted (1980 -2015), these cities experienced some of the highest percentages in growth along with Gulf Shores.

While the overall growth pattern is high during this time period, between the years of 2000-2015, the sharpest increase in population is most notable for Foley and Gulf Shores, with high increases also for Fairhope, Daphne, Spanish Fort, Robertsdale, and Orange Beach.

As previously noted in Section 2.6, these municipalities have the majority of their incorporated areas lying outside the Watershed boundary. Continued and shifting growth has - and is expected to continue – to add development pressure within the Watershed.

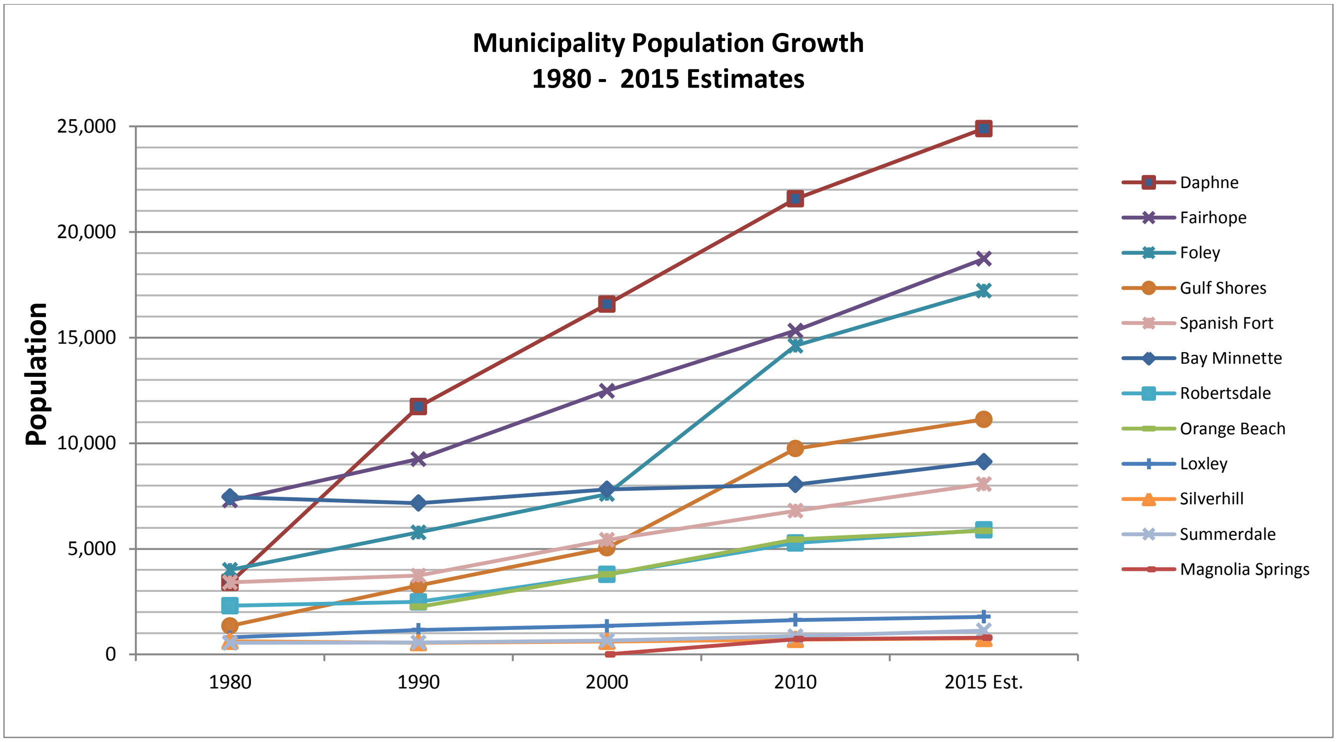


Figure 2.35 Municipality Population Growth 1980 - 2015 Estimates
Source: U.S. Census 2010 and 2015 Population Estimates

2.7.4.2 Projected Future Population Growth

When evaluating population growth and projections for the Watershed, the most current population data from the 2010 Census was used to first estimate the population of each HUC 12 Subwatershed for that year.

The U.S. Census uses various geographic areas (or units) to aggregate and organize the information it collects. Aside from legal/administrative areas (e.g., states, counties, cities), it supplements these by aggregating data for statistical areas that are created in cooperation with state and local agencies. Most notably, counties are divided into census tracts, block groups, and blocks. The block is the smallest and most detailed geographic unit that the Census Bureau uses to tabulate decennial census data.

Blocks usually correspond to city blocks and in rural areas may include many square miles bound by streets, streams, political, or other features. As such they do not coincide with Watershed boundaries. Approximately 20% of census blocks in the Weeks Bay study area fall partially outside the Watershed or in two Subwatersheds. In order to obtain an accurate population number for each HUC 12 Subwatershed, 2011 aerial imagery was used to estimate the number of housing units inside the Subwatersheds for each census block that overlapped. A population number was then derived for these based on the 2010 Census average household size of 2.5 persons. A total population number was then calculated by Subwatershed.

Table 2.12 shows the population results for each of the four HUC 12 Subwatersheds. Upper and Lower Fish River Watersheds each have about 16,000 people, and Middle Fish River and Magnolia River Watersheds have about half of that. The populations for Upper and Lower Fish River are due in part to the municipalities of Fairhope, Daphne, and Loxley. Figure 2.36 shows the distribution of the 2010 population within the Watershed by depicting it in density per square mile by Census block.

Table 2.12 2010 Watershed Population

Watershed	2010 Census Population Estimate	% of Weeks Bay 2010 Total Population	% of County 2010 Total Population
Upper Fish River	16,273	32.77%	8.93%
Middle Fish River	8,186	16.48%	4.49%
Lower Fish River	16,022	32.26%	8.79%
Magnolia River	9,183	18.54%	5.04%
Weeks Bay Watershed	**49,664**	**100%**	**27.25%**

In 2010, the entire Weeks Bay Watershed population was approximately 49,664. This comprised about 27% of the total Baldwin County population of 182,265 for the 2010 Census. As some of these populations lie inside the various city jurisdictions, it is interesting to note that 51% of the County's total 2010 population lived inside an incorporated municipality per the 2010 Census data. Based on general population growth patterns, we can expect that the increase in population for the Watershed will be concentrated in and around the incorporated areas.

For population projections, various sources were evaluated to assist and guide estimates for 2040. For this study, the Eastern Shore Metropolitan Planning Organization "*2040 Long Range Transportation Plan (LRTP)"* was used for population projections through the year 2040 for most of the Weeks Bay Watershed.

The LRTP study was conducted in 2015 for transportation planning for the urban area along the Eastern Shore of Baldwin County. A metropolitan planning organization (MPO) is a federally mandated and funded transportation policy-making organization. The Eastern Shore Metropolitan Planning Organization (ESMPO) was formed in 2012 and includes all or part of the largest municipalities of Baldwin County (Spanish Fort, Daphne, Fairhope, and Loxley) with an approximate area of 311 square miles inside their planning area (ESMPO "*2040 Long Range Transportation Plan"*) - a substantial portion of which encompasses the majority of the Weeks Bay Watershed (Figure 2.37).

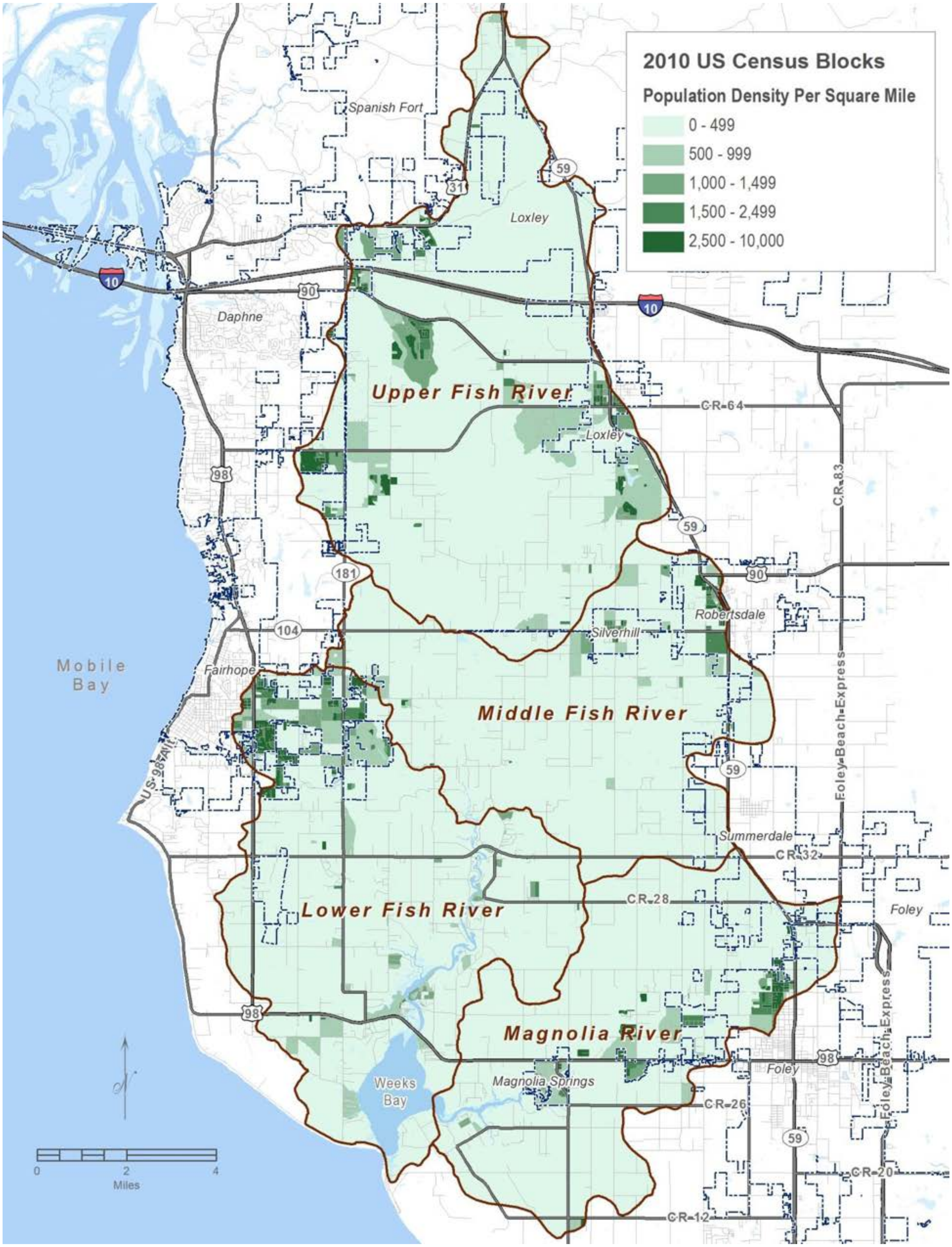
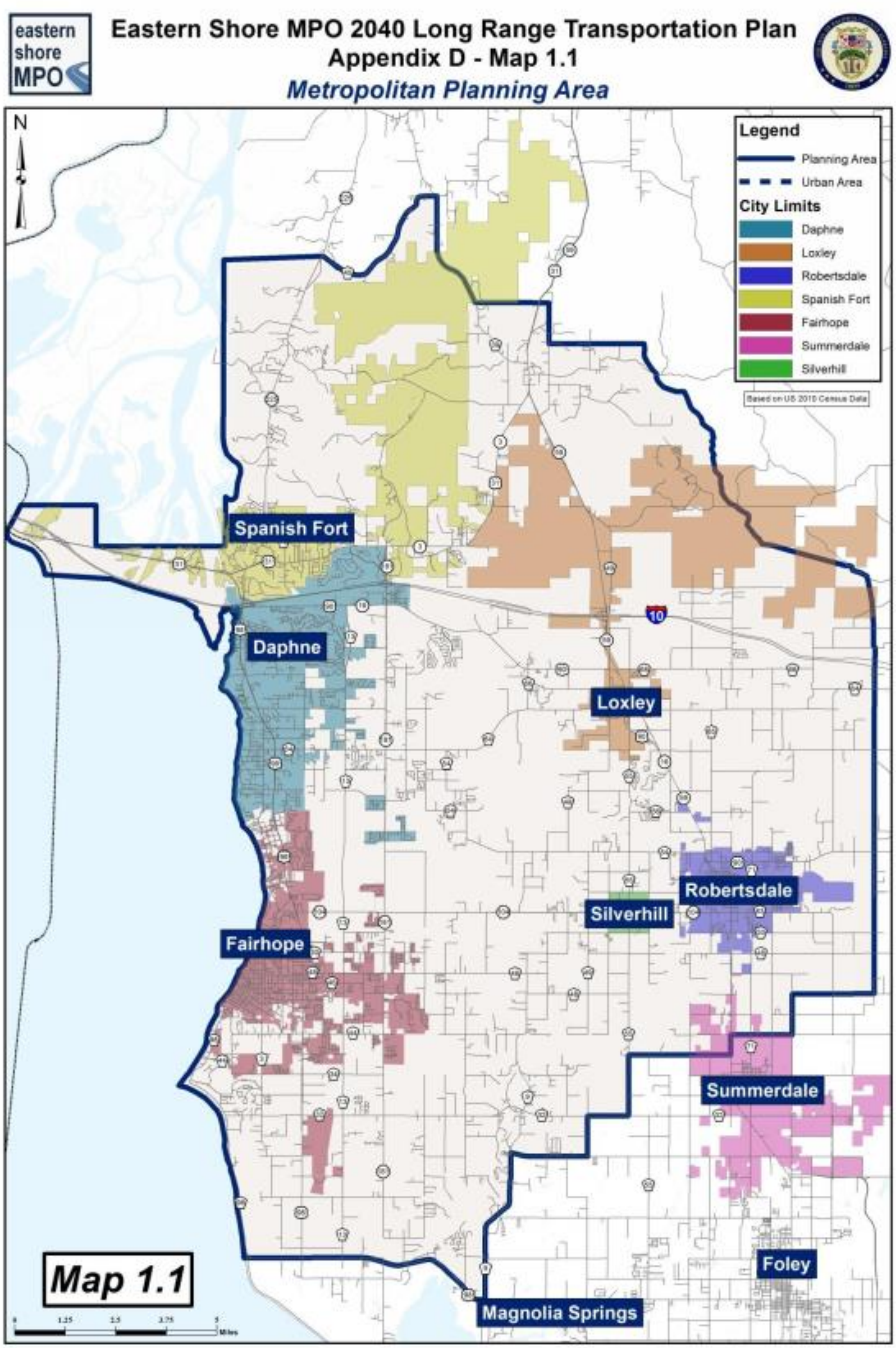


Figure 2.36 2010 Population Density Per Square Mile, US Census Blocks



Source: ESMPO "*2040 Long Range Transportation Plan*"

Figure 2.37 Eastern Shore MPO Planning Area

MPOs use Census Traffic Analysis Zones (TAZ) for their traffic analysis and modeling. TAZs are geographic units comprized of census blocks. Therefore, TAZs can provide sufficient detail for applying the LRTP 2040 projected growth numbers to areas within the Watershed.

Figure 2.38 shows the ESMPO 2040 LRTP's population density per square mile for the Eastern Shore in relation to the Weeks Bay Watershed study area and its four Subwatersheds (HUC 12s). Portions of the Lower Fish River Watershed, and nearly all of the Magnolia River Watershed, are outside the LRTP population projection study area (about 28% of the Weeks Bay Watershed). Population projections for these areas were therefore developed at the block level using the 2010 base population data estimates noted earlier in this section.

The LRTP projects a total of 112,020 new residents for Baldwin County for 2040; a 62% increase from the 2010 population of 182,265, or an overall 2.04% growth rate per year. Of these, 66,084 residents were forecasted to reside within the MPO Planning Area. The apportionment of this estimated growth was not applied to all TAZs equally across the MPO's planning area (i.e. a 2.04% increase was not applied to all 2010 TAZ population numbers). Rather, distribution of the forecast population was done through the distribution of housing units (based on average household size of 2.5 people per household per the 2010 Census) and the evaluation of various factors including properties ready for or under development at the time (*ESMPO 2040 LRTP)*.

In terms of population density, the LRTP shows population concentrations around the major municipal cores and stretching outward where the jurisdictions of Spanish Fort, Daphne, Loxley, Fairhope and Robertsdale reach into the Watershed. Respectively, the apportioned projected households of the LRTP fall outside these urban area cores and toward the margins of their incorporated areas. Urban areas and cores currently developed are unlikely to see further development or infill unless these are re-developed at higher densities – something usually experienced only in larger metropolitan areas. Rather, it is more likely that these urban areas will continue to sprawl outward and into the Watershed for the next 30 years before growth patterns change and any infill is experienced. The City of Fairhope has seen some infill and high-density redevelopment within its core, however, the city continues to grow outwards.

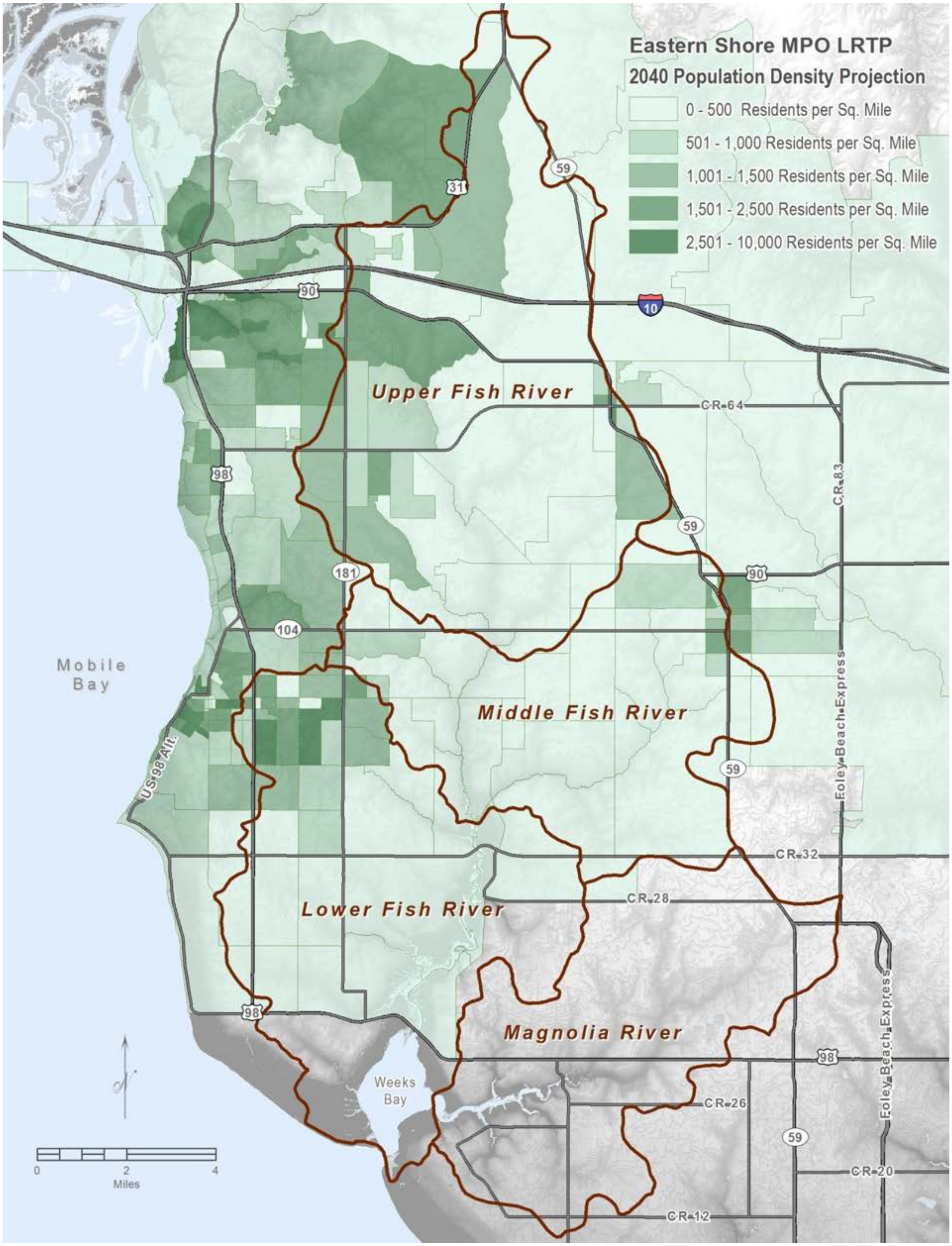


Figure 2.38 Eastern Shore MPO LRTP 2040 Population Density Projection, TAZ

For Weeks Bay Watershed population projections, the LRTP 2040 projections were applied to the Watershed in all those areas where the TAZs fell completely inside the Watershed. For TAZs located partially outside the Watershed, or overlapping the HUC 12 Subwatersheds, the percent population change between 2010 and 2040 was calculated for the TAZ and applied to the 2010 Census block base population (as noted, TAZ are comprised of blocks).

For population projections of the Weeks Bay Watershed area outside the LRTP study area, two methods were used to forecast growth for 2040. First, 12 current and future subdivision sites were inventoried and assessed for number of lots using parcel data and aerial photography. A household size of 2.5 persons per lot (estimated lot size of 0.3 acre) was applied to the 2010 population, and a 2040 population calculated per census block. Second, an overall annual population growth of 1% per year for the 30 year period from 2010 to 2040 was applied to the census blocks outside of the 12 identified subdivisions in the non-LRTP study area. This rate was derived based on historic growth of these areas, geographic location, transportation corridors, and existing land uses and zoning.

Table 2.13 shows the projected 2040 populations for the Weeks Bay Watershed and each of the HUC 12 Subwatersheds. The Weeks Bay Watershed is projected to have a 99% increase in population from 49,996 people to 99,069 people for this 30 year period. Figure 2.39 shows the projected population density per square mile within the Watershed using TAZ in the LRTP study area, and census blocks outside the ESMPO study area.

Table 2.13 Weeks Bay Watershed Population Projections

WATERSHED	2010 Census Population Estimate	2040 Population Estimate	Estimated Population Change (%)	% of County 2010 Total Population	% of County 2040 ESMPO Population Estimate
Upper Fish River	16,273	49,984	207.16%	8.93%	16.98%
Middle Fish River	8,186	11,063	35.15%	4.49%	3.76%
Lower Fish River	16,022	23,101	44.18%	8.79%	7.85%
Magnolia River	9,183	14,921	62.49%	5.04%	5.07%
Weeks Bay Watershed	**49,664**	**99,069**	**99.48%**	**27.25%**	**33.66%**

2010 Total Baldwin County Population	**182,265**
2040 ESMPO Baldwin County Population Projection	**294,285**

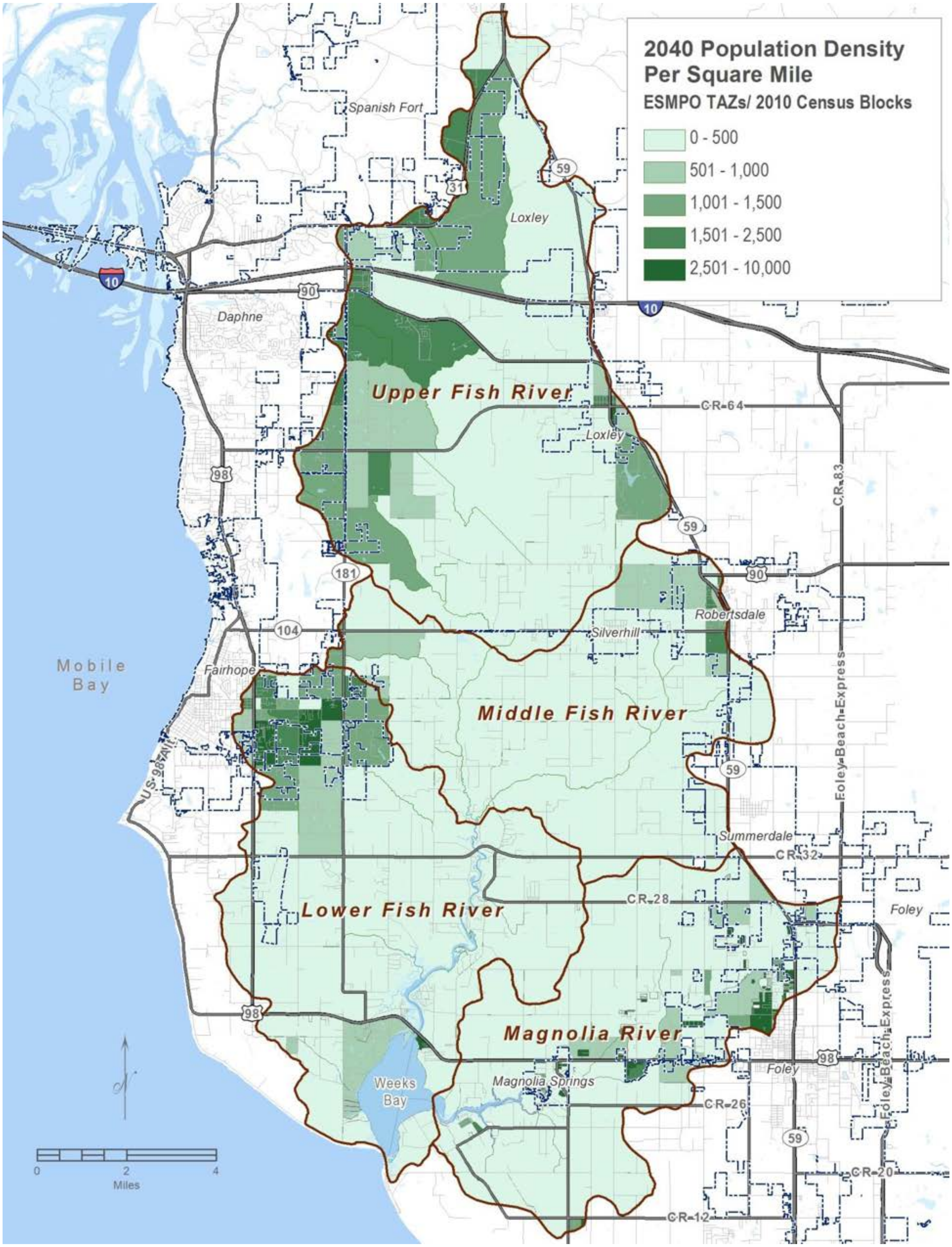


Figure 2.39 2040 Population Density Projections Per Square Mile, TAZ and US Census Blocks

The highest estimated percent change in population is in the Upper Fish River Subwatershed with a population increase estimated at 207%. The major influence for this Subwatershed's high projection is the town of Loxley which has 40% of its incorporated area inside the Subwatershed (see Table 2.8). The entirety of this area is part of the Loxley's Planned Unit Development, which encompasses most of the area north of Interstate 10 and bounded by U.S. Highway 31 and Alabama Highway 59 (see Figure 7.1, located in Section 7). Population projections also show high percentage growth along the Highway 181 corridor that runs south along the west side of the Subwatershed. Many agricultural use areas along this corridor have already transitioned into subdivisions over the last twenty years, with projections and zoning showing the continuation of this trend.

The Middle Fish River Subwatershed is estimated to increase in population by 35% through 2040. This Subwatershed is primarily influenced by growth in Robertsdale and Summerdale, which lie partially within the east side of the Subwatershed, and to a lesser extent, the Town of Silverhill. The Middle Fish River Subwatershed has less development pressures than Upper and Lower Fish River Subwatersheds with slower growing jurisdictions and major corridors just skirting its boundaries (such as Highway 181, Highway 59, and Highway 104). However, the entire Subwatershed area west of Fish River is within the City of Fairhope's planning jurisdiction for which LRTP projections show continued growth through 2040.

The Lower Fish River Subwatershed is estimated to increase in population by 44% through 2040 from 16,022 to 23,101 people. This Subwatershed encompasses 45% of the City of Fairhope's incorporated area along its northern end. The City of Fairhope had the second largest growth rate in the county between 2010 and 2015 and is the largest growth influence for this Subwatershed. The City's planning jurisdiction encompasses the entire Subwatershed west of Fish River and is expected to continue growing over the next decades as the City expands east and south. U.S. Highway 98, Alabama Highway 181, and CR 32 pass through the middle of the Subwatershed increasing development pressures along their corridors.

The Magnolia River Subwatershed shows the second largest growth projection within the Weeks Bay Watershed at 62%. The largest growth influences are the municipalities of Summerdale and Foley. While these only have 12% and 19% of their incorporated areas inside the Watershed, the influence from municipalities is high - particularly from the City of Foley that has shown an estimated 18% increase in population between 2010 and 2015. The general proximity of the beaches, Highways 59 and Foley Beach Express (the primary corridors along the east side of the Watershed linking Interstate 10 and Loxley, Robertsdale, Summerdale, Foley, Gulf Shores, and Orange Beach), and nearby retail hubs provide development pressures for the area with 12 subdivisions currently under some state of construction.

2.8 Land Use and Land Cover

Land use/land cover (LU/LC) significantly influences stormwater runoff velocities, volumes, and timing within Watersheds. The following summarizes historic, existing and projected land uses for the Weeks Bay Watershed through 2040.

2.8.1 Roads and Their Influence on Development Patterns

Highways greatly influence the location, type, and pattern of land use. Major roads and arterials become traffic routes next to which high intensity development such as residential areas, shopping areas, businesses, and the like emerge. The major roads influencing development in the Weeks Bay Watershed are Interstate 10, U.S. Highways 31, 98, and 90; Alabama Highways 181, 104, and 59, and numerous County Roads (see Figure 2.40).

For the early part of the 20th Century, U.S. Highway 31, U.S. Highway 90, and U.S. Highway 98 traversed the Watershed area and crossed the lower Mobile-Tensaw Delta by way of the low elevation, two-lane "Causeway" that was completed in 1927. Before the "Causeway" was built, boats were the only means of travel between Mobile and Baldwin County's Eastern Shore. In February 1941, opening of the two-lane Bankhead Tunnel underneath the Mobile River enhanced the travel corridor between the two counties.

The "Causeway" was subject to periodic flooding. That situation, combined with the general tendency for most people to live near their jobs, discouraged extensive development of the Eastern Shore of Baldwin County prior to the 1960s. The small unincorporated community of Spanish Fort was essentially associated with U.S. Highway 31, while Daphne and Fairhope demonstrated a similar affiliation for U.S. 98 that traversed the area near the Mobile Bay shoreline. The land along U.S. Highway 90, which now extends through the north-central portion of the Upper Fish River Watershed, was essentially undeveloped.

The completion of Interstate 10 in the late 1960s terminated at Alabama Highway 59; and in the late 1970's the I-10 "Bayway" bridge and twin tunnels were completed. The improved transportation links made it easier for people to live in Baldwin County and work in Mobile County. In the 1980s people began to move to the Eastern Shore for quality of life and other reasons. Being the closest Eastern Shore communities to Mobile, Spanish Fort and Daphne began to experience increasing demands for housing to accommodate the needs of their rapidly expanding populations (see Figure 2.35).

What originally began as the development and expansion of a large bedroom community to serve individuals who worked in Mobile has gradually transformed the Baldwin County communities into an area where people now people work, reside, shop, and recreate without having to go to Mobile. This was facilitated in part by some major developments on the Eastern Shore such as Jubilee Square, Spanish Fort Town Center, and the Eastern Shore Centre which were developed around these principal highways. This development has produced additional increased traffic and development of county roads and along other arterials.

Interstate-10 runs through the northern section of the Upper Fish River Watershed which, since the completion of the Bayway, has promoted easier movement of people, goods, and jobs between Mobile and Baldwin Counties. This increased traffic flow also provided increased

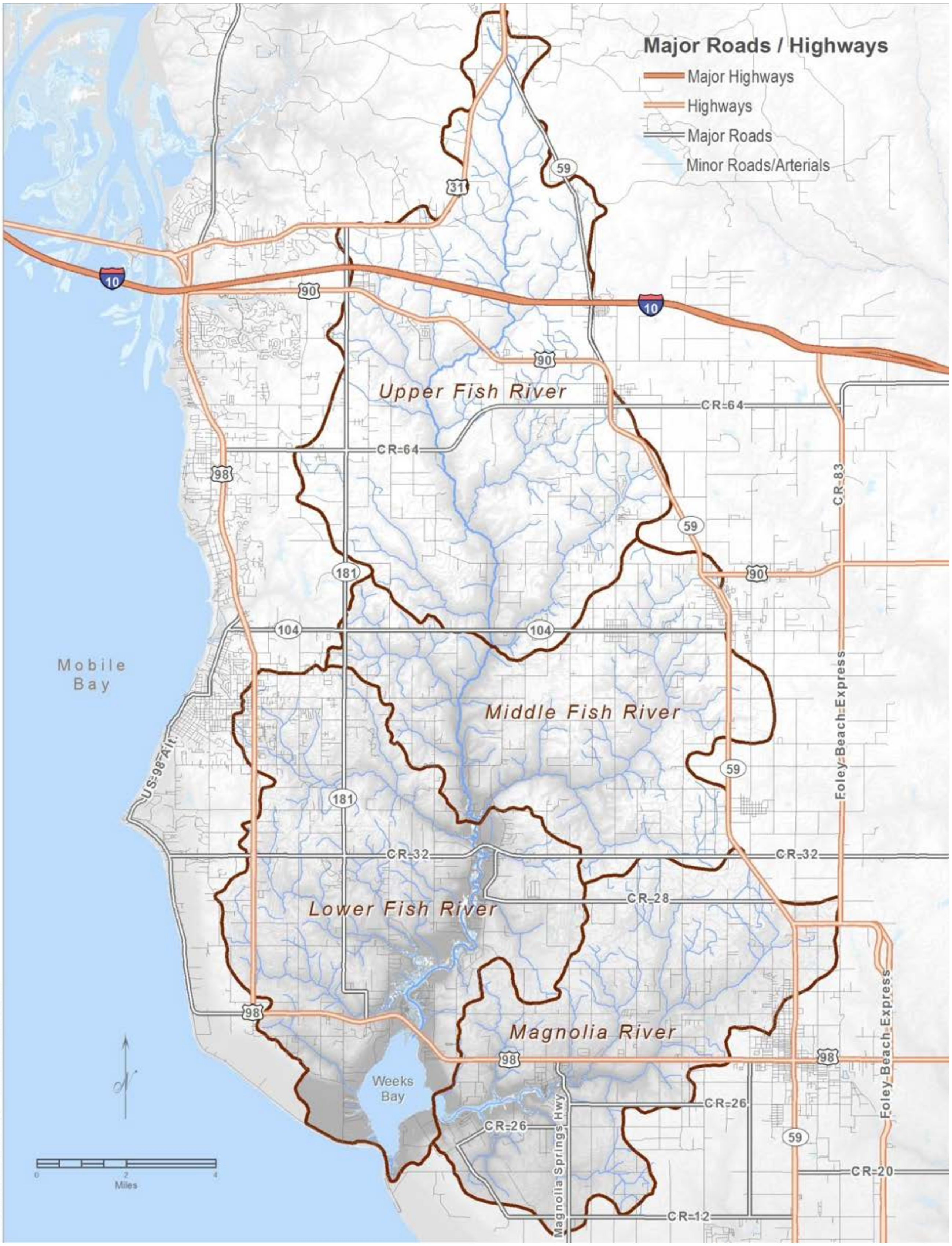


Figure 2.40 Major Roads of Weeks Bay Watershed

development pressures along the Interstate exits at the intersections of Alabama Highways 181 and 59. These intersections are at the west and east edge of Upper Fish River Watershed, respectively (Figure 2.40). As an example of the growth in the Upper Fish River Watershed, the Malbis area typifies the urbanization of this formerly forest and farmland area. Subdivisions were developed along U.S. Highways 31 and 90, and Alabama 181, followed by retail development such as the Eastern Shore Centre at the intersection of I-10 and Alabama 181. This large mall complex with retail, restaurants, and movie theatres seemed to solidify the Eastern Shore as an urban center, thus generating a magnet for the locations of additional urban services in the area.

2.8.2 Historic Land Use Trends

Historic land use within the Weeks Bay Watershed area has been evaluated by various means to assess land uses by remote sensing data. One such effort was performed by NASA for the MBNEP for various watersheds within Mobile and Baldwin Counties (Ellis et al., 2008). This analysis, however, only covers the Fish River Watershed portion of the Weeks Bay Watershed from 1974-2008. A second dataset that addresses the entire Weeks Bay Watershed is the USGS National Land Cover Dataset (NLCD), and covers the period from 1992-2011 (https://www.mrlc.gov/). Both land use/land cover datasets utilize Landsat derived land cover with a 60- meter and 30-meter resolution and are discussed in the following paragraphs.

2.8.2.1 NASA Land Use/Land Cover

Under the direction of the Mobile Bay National Estuary Program, NASA (Ellis et al., 2008) used remote sensing imagery to investigate historic LU/LC changes in selected areas bordering Mobile Bay. This study focused on a regional analysis of urban expansion at the watershed level using Landsat data for the following years: 1974, 1979, 1984, 1988, 1991, 1996, 2001, 2005, and 2008. A 60-meter resolution was used for 1974 through 1984, and a 30-meter resolution for subsequent years. The LU/LC change analysis considered upland herbaceous, barren, open water, urban, upland forest, woody wetland, and non-woody wetland-dominated land cover types. In order to represent approximate decadal changes, the analysis was presented for the years 1974, 1984, 1996, and 2008 for several watersheds in Mobile and Baldwin Counties that drain into Mobile Bay. The Fish River Watershed was included as one of the six watershed-scale analyses; however, the Magnolia River Watershed was not. The results of the analysis are summarized in Table 2.14 and graphically depicted in Figure 2.41.

Table 2.14 NASA Comparison of Land Use/Land Cover Changes in the Fish River Watershed for 1974, 1984, 1996, and 2008

LULC Category	1974		1984		1996		2008	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Open Water	1,757	1.7	2,192	2.2	2,124	2.0	2,183	2.1
Barren	38	0	29	0	468	0.5	503	0.5
Upland Herbaceous	44,699	43.1	40,630	40.5	54,792	52.9	42,603	41.1
Non-woody Wetland	925	0.9	669	0.7	1,160	1.1	966	0.9
Upland Forest	37,027	35.7	37,105	37.0	22,876	22.1	33,641	32.5
Woody Wetland	13,440	13.0	13,875	13.8	14,615	14.1	14,348	13.8
Urban	5,758	5.6	5,875	5.9	7,613	7.3	9,404	9.1
Total	103,643	100.0	100,373	100.0	103,649	100.0	103,649	100.0

Source: Ellis *et al*, 2008

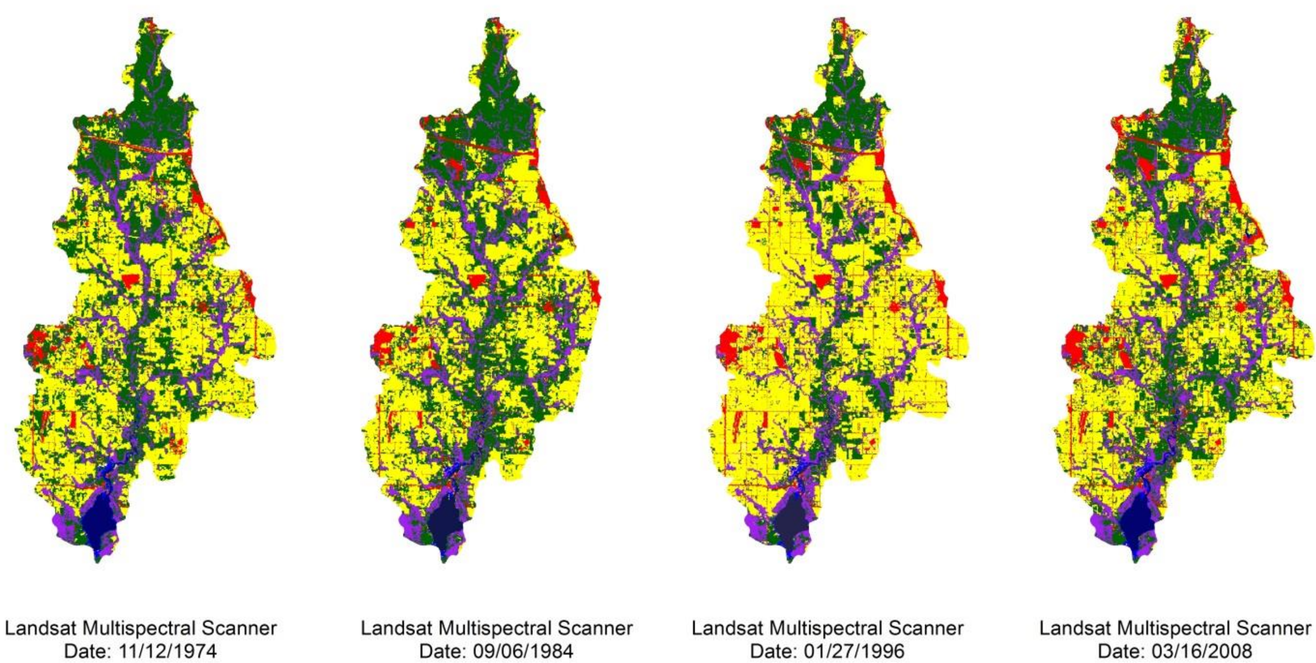


Figure 2.41 Fish River Watershed Land Use and Cover Decadal Change
Source: Ellis *et al*, 2008

Interestingly, the total Upland Herbaceous (agricultural) acreage varied up and down, but the total amount was estimated to be approximately the same in 1974 and 2008 (44,699 acres / 42,603 acres). Upland Forest acreages also varied up and down, somewhat inversely to Upland Herbaceous, but again the 1974 and 2008 estimates were similar (37,027 acres / 33,641 acres). The estimates for Urban acreage showed only a minor increase from 1974 to 1984, but much more dramatic increases for the 1984 – 1996 and 1996 – 2008 periods. In total, Urban acreage from 1974 to 2008 increased from 5,758 to 9,404 (an increase of 63%). Nevertheless, the percentage of Urban land cover proportionate to the total Fish River Watershed acreage remains low (5.6% in 1974 and 9.1% in 2008).

This data suggests that urbanization effects on the Fish River Watershed have (to date) been less adverse compared to some of the other watersheds draining to Mobile Bay. For comparison, the 2008 NASA study showed the Urban land cover in the D'Olive Watershed to increase from 16% to 35% between 1974 and 2008. Dog River Watershed showed an Urban acreage change from 23.2% to 37.5%, and Three Mile Creek Watershed from 49.5% to 70.2%. The Fowl River Watershed compared favorably to Fish River Watershed with Urban land use estimates of 7.5% in 1974 and 12.1% in 2008.

2.8.2.2 USGS NLCD Land Use/Land Cover Analysis

An analysis of the USGS National Land Cover (NLCD) Land Use/Land Cover datasets was conducted to evaluate previous growth and urbanization of the Watershed, and to estimate future growth and urbanization patterns within the entire Weeks Bay Watershed. While current land uses provide for the evaluation of existing conditions in the Watershed, future growth estimates and land use change projections are necessary and provide direction for future management methods and strategies within the Watershed.

Various factors influence growth and make exact land use and growth predictions difficult. Therefore, two future growth predictions were made for the year 2040; a "Medium Growth Prediction" and a "High Growth Prediction" as will be discussed.

2.8.2.2.1 **General Land Cover**

The NLCD analysis covers the 1992, 2001, 2006, and 2011 LU/LC datasets. The land cover classification system changed from the 1992 NLCD dataset to the consistent system used for 2001, 2006, and 2011 (2016 dataset not yet released at the time of this writing). Therefore, care should be taken in making statistical comparisons between the 1992 NLCD and the more recent datasets. A summary comparison of the past land cover data for these years, as well as the projected 2040 medium and high growth scenarios is presented in Table 2.15. A more detailed land cover comparison spreadsheet is found in Appendix D.

All land use percentages within the Weeks Bay Watershed have remained about the same between 2001 and 2011, except for increases in developed areas and small declines in wetlands and agriculture. Agriculture remains a large portion of the land use within the Watershed since 2001 comprising almost 50% of the Watershed, with forest cover being second (22%), wetland cover third (14%), and developed cover fourth (13%). Figure 2.42 shows a graph of the historic NLCD and future projected land cover changes for the 2040 medium and high growth scenarios.

Table 2.15 National Land Cover Dataset, Weeks Bay Watershed, 1992-2040

Upper Fish River	1992		2001		2006		2011		2040 Medium		2040 High	
Land Cover	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Water	59	0%	43	0%	44	0%	41	0%	41	0%	14	0%
Developed	963	2%	4,504	11%	5,442	13%	6,127	14%	13,624	32%	18,637	44%
Forest	16,867	40%	15,255	36%	14,997	35%	14,624	35%	10,233	24%	8,641	20%
Agriculture	19,483	46%	17,366	41%	16,955	40%	16,664	39%	13,523	32%	9,955	24%
Barren Land	1,210	3%	235	1%	138	0%	138	0%	318	1%	155	0%
Wetlands	3,687	9%	4,866	12%	4,692	11%	4,675	11%	4,530	11%	4,868	12%
Middle Fish River	**1992**		**2001**		**2006**		**2011**		**2040 Medium**		**2040 High**	
Land Cover	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Water	15	0%	14	0%	15	0%	14	0%	14	0%	13	0%
Developed	353	1%	2,133	8%	2,321	9%	2,580	10%	4,042	15%	5,200	19%
Forest	7,225	27%	5,388	20%	5,445	20%	5,403	20%	5,294	20%	5,150	19%
Agriculture	17,866	67%	16,021	60%	15,858	59%	15,654	58%	14,330	54%	13,227	49%
Barren Land	407	2%	50	0%	29	0%	24	0%	23	0%	16	0%
Wetlands	902	3%	3,162	12%	3,100	12%	3,092	12%	3,064	11%	3,160	12%
Lower Fish River	**1992**		**2001**		**2006**		**2011**		**2040 Medium**		**2040 High**	
Land Cover	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Water	1,907	6%	1,738	5%	1,739	5%	1,740	5%	1,738	5%	1,736	5%
Developed	535	2%	4,061	12%	4,467	13%	4,929	14%	7,110	21%	7,810	23%
Forest	9,288	27%	5,240	15%	5,489	16%	5,461	16%	5,207	15%	4,937	14%
Agriculture	19,630	57%	15,690	46%	15,138	44%	14,718	43%	12,925	38%	12,353	36%
Barren Land	754	2%	430	1%	398	1%	431	1%	399	1%	393	1%
Wetlands	2,334	7%	7,290	21%	7,217	21%	7,170	21%	7,069	21%	7,218	21%
Magnolia River	**1992**		**2001**		**2006**		**2011**		**2040 Medium**		**2040 High**	
Land Cover	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Water	206	1%	180	1%	179	1%	186	1%	186	1%	184	1%
Developed	284	1%	2,715	10%	3,174	12%	3,280	13%	5,114	20%	6,424	25%
Forest	5,697	22%	2,536	10%	2,513	10%	2,423	9%	2,170	8%	1,713	7%
Agriculture	18,902	72%	17,016	65%	16,751	64%	16,737	64%	15,263	58%	14,269	55%
Barren Land	443	2%	128	0%	108	0%	112	0%	166	1%	153	1%
Wetlands	581	2%	3,537	14%	3,388	13%	3,375	13%	3,214	12%	3,370	13%
Fish River Combined	**1992**		**2001**		**2006**		**2011**		**2040 Medium**		**2040 High**	
Land Cover	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Water	1,981	2%	1,795	2%	1,798	2%	1,795	2%	1,794	2%	1,764	2%
Developed	1,851	2%	10,698	10%	12,229	12%	13,636	13%	24,775	24%	31,647	31%
Forest	33,381	32%	25,883	25%	25,931	25%	25,487	25%	20,734	20%	18,728	18%
Agriculture	56,979	55%	49,077	47%	47,952	46%	47,036	45%	40,778	39%	35,536	34%
Barren Land	2,371	2%	715	1%	566	1%	594	1%	740	1%	564	1%
Wetlands	6,922	7%	15,318	15%	15,009	15%	14,937	14%	14,663	14%	15,246	15%
Weeks Bay Combined	**1992**		**2001**		**2006**		**2011**		**2040 Medium**		**2040 High**	
Land Cover	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%	Area (ac)	%
Water	2,187	2%	1,975	2%	1,978	2%	1,981	2%	1,979	2%	1,948	2%
Developed	2,135	2%	13,413	10%	15,403	13%	16,916	13%	29,889	23%	38,071	29%
Forest	39,078	30%	28,419	22%	28,444	22%	27,911	22%	22,904	18%	20,441	16%
Barren Land	2,814	2%	842	1%	673	1%	706	1%	906	1%	717	1%
Agriculture	75,881	59%	66,093	51%	64,703	50%	63,772	49%	56,041	43%	49,804	38%
Wetlands	7,503	6%	18,855	15%	18,396	14%	18,311	14%	17,877	14%	18,616	14%

Source: Multi-Resolution Land Characteristics Consortium (MRLC) National Land Cover Database (NLCD)

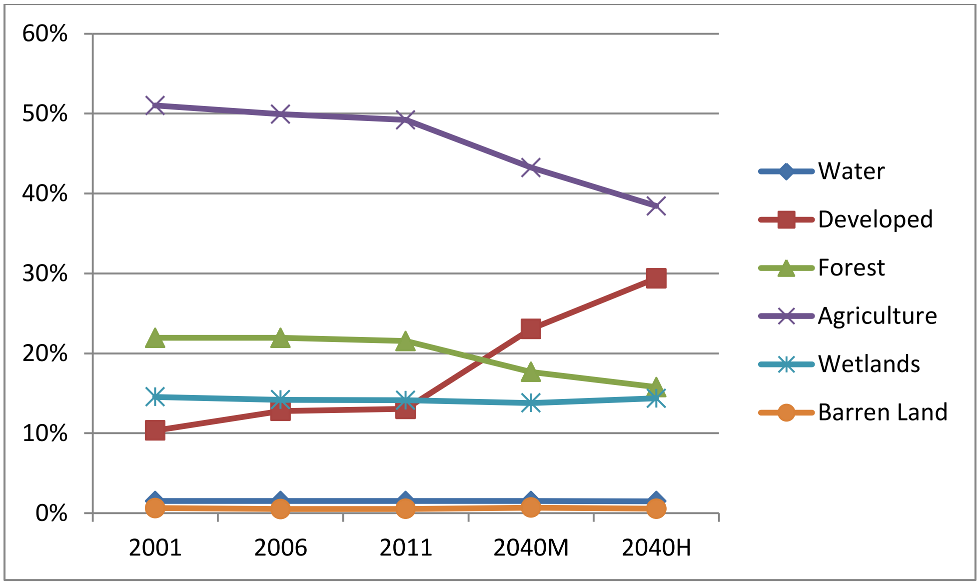


Figure 2.42 Weeks Bay Watershed Historic and Projected Land Cover Changes

Figures 2.43 through 2.46 show the historic Weeks Bay land cover changes from 1992, 2001, 2006, and 2011. The 1992 land cover classification was symbolized to closely match the more recent years' classifications – with the emphasis being in the change of developed and urbanized areas which range in color from pink to red. The change in developed and urbanized areas is quite apparent in the nine years between 1992 to 2001, and in the 10 years between 2001 and 2011.

The methodology for projecting the two 2040 land cover scenarios are described further in the following paragraphs. In general, wetlands and open water areas are anticipated to remain fairly consistent, while agriculture and forest coverage declines, and developed land uses increase. The HUC 12 Watershed anticipated to experience the largest expansion of developed land use is the Upper Fish River Subwatershed, going from about 15% in 2011 to a projected 33% for the 2040 Medium scenario, and 45% for the 2040 High scenario. Figures 2.47 and 2.48 show the land cover changes for the two projected 2040 scenarios.

The future land use/land cover projections for 2040 were developed to show the effects of continual urbanization/development within the Weeks Bay Watershed. The land cover information is an integral part of the watershed model (Soil and Water Assessment Tool – SWAT) that is being used in this watershed management plan to demonstrate long-term effects of land management activities within the Weeks Bay Watershed. The SWAT Model analysis is discussed further in Sections 3.4 and 3.5.

The 2011 NLCD land cover has been utilized to formulate the baseline condition by which to compare the future growth scenarios. The two 2040 growth scenarios were developed in an effort to reasonably bracket the 2040 land cover estimates due to uncertainties that are intrinsic to future population/land cover estimates and projections.

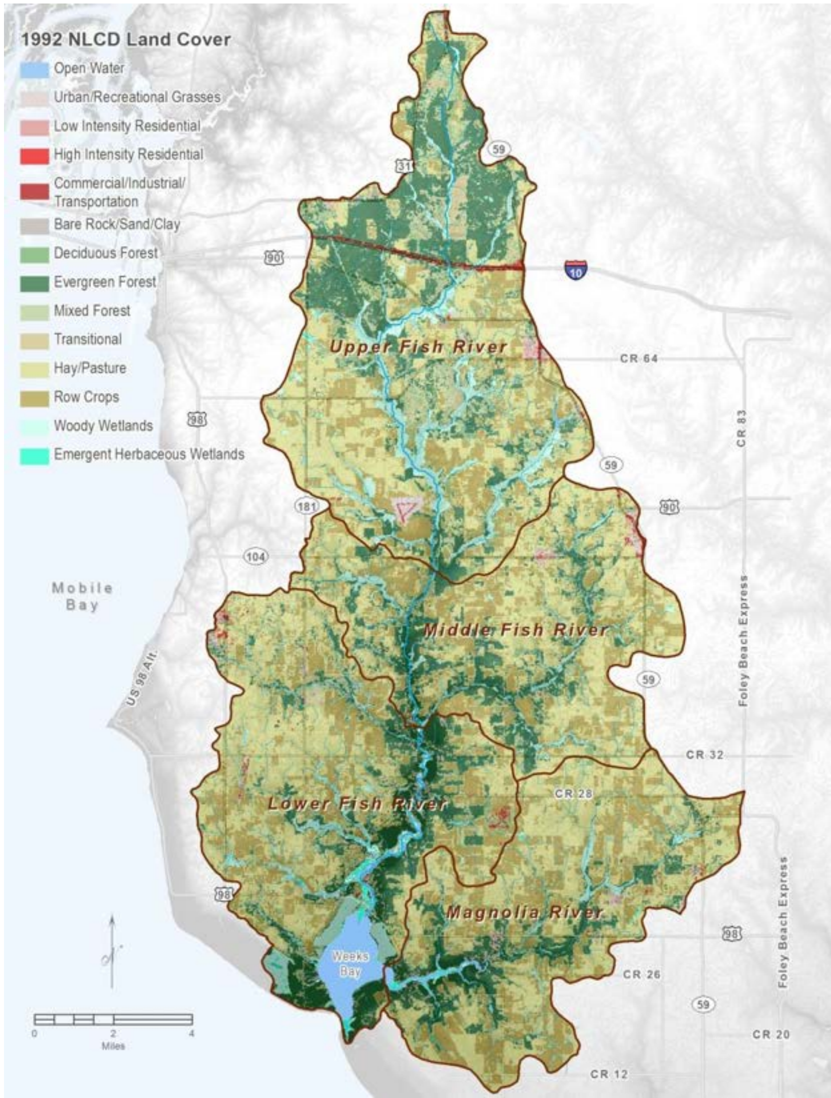


Figure 2.43 1992 Land Cover in Weeks Bay Watershed

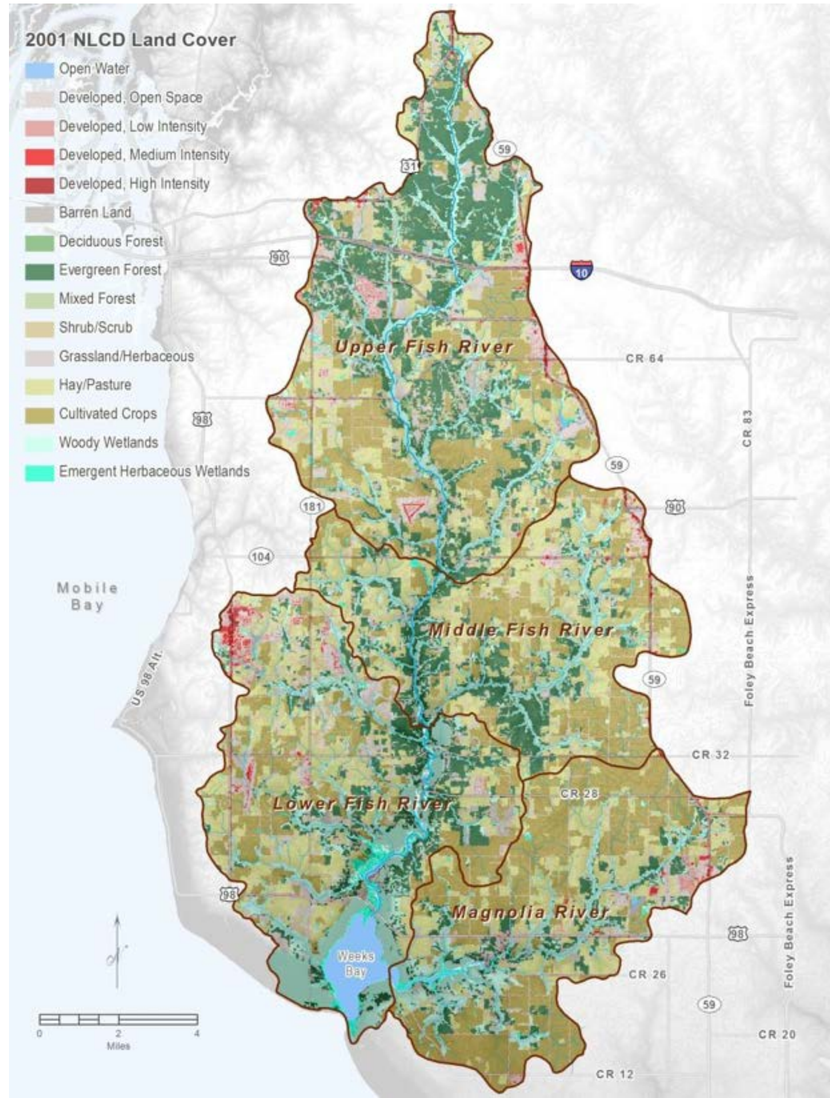


Figure 2.44 2001 Land Cover in Weeks Bay Watershed

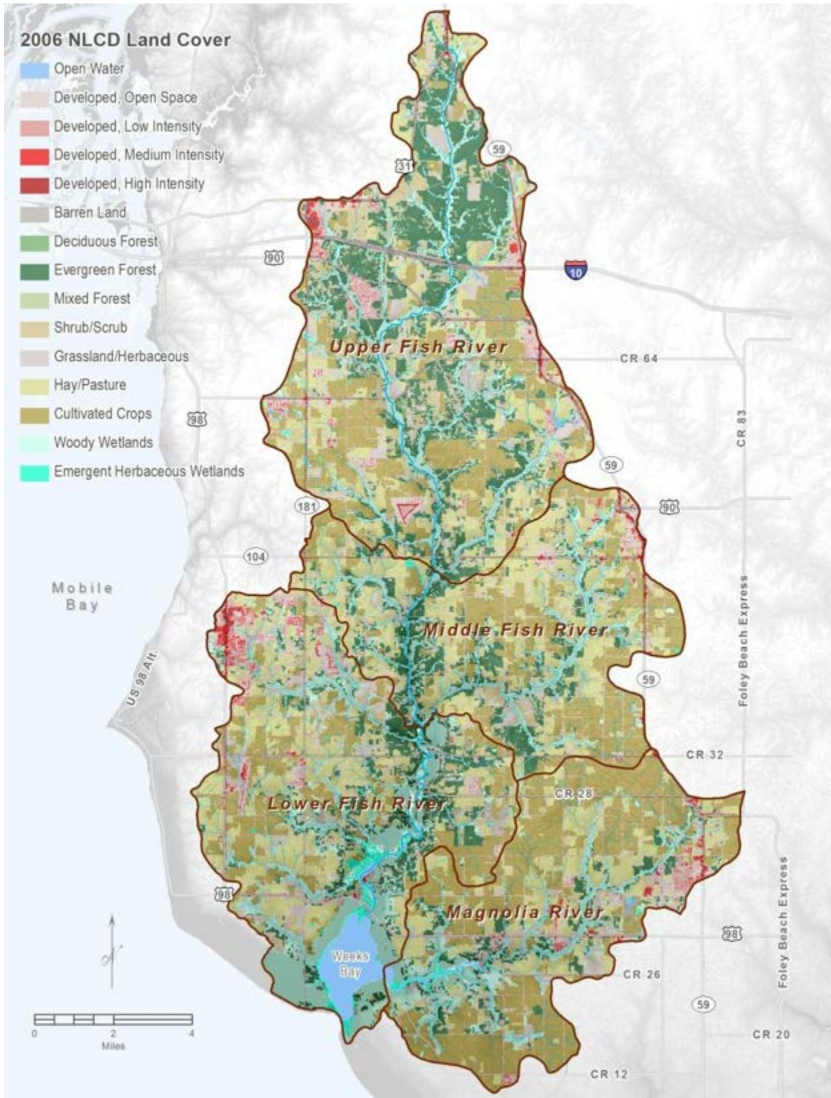


Figure 2.45 2006 Land Cover in Weeks Bay Watershed

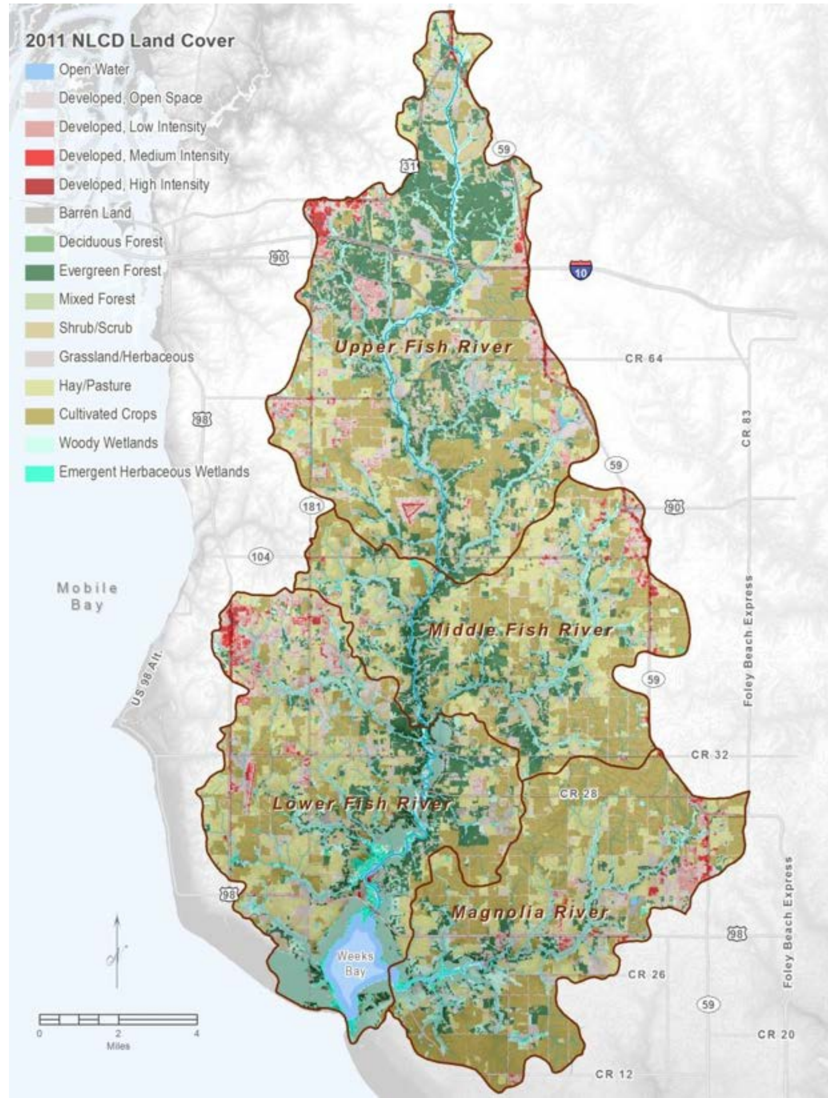
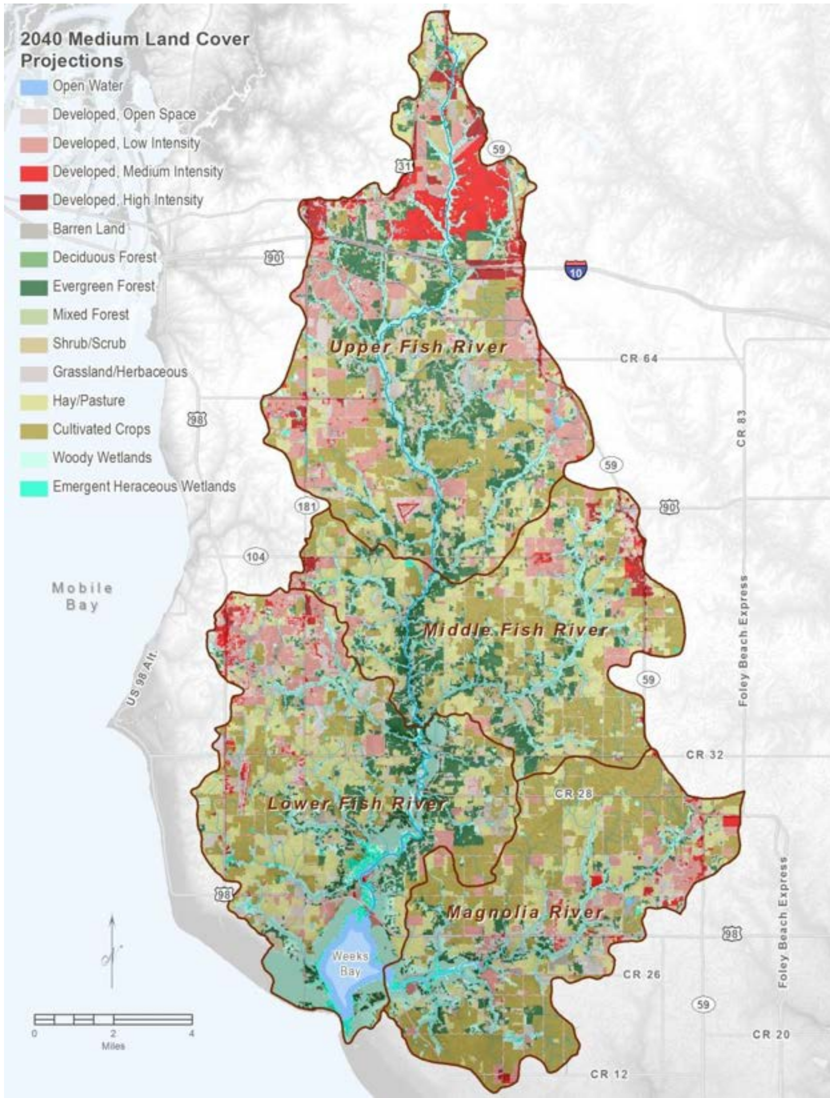


Figure 2.46 2011 Land Cover in Weeks Bay Watershed



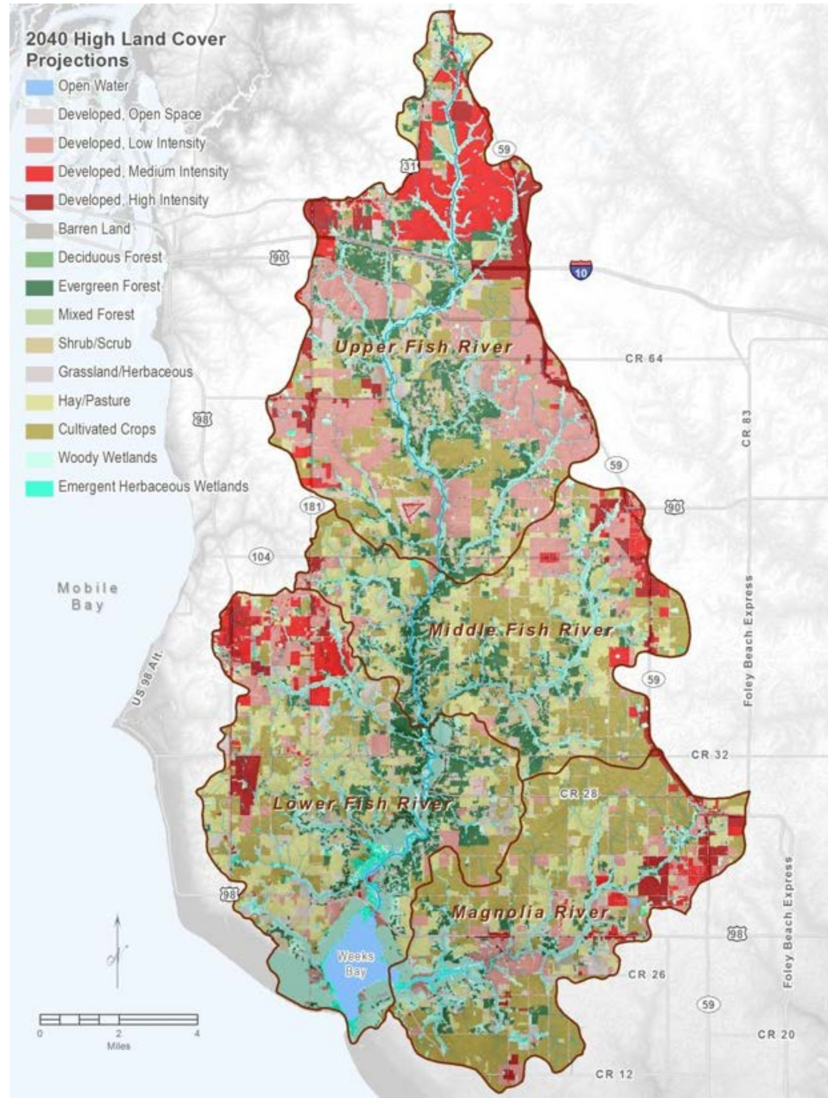


Figure 2.47 2040 Medium Land Cover in Weeks Bay Watershed

Figure 2.48 2040 High Land Cover in Weeks Bay Watershed

2.8.2.2.2 **2040 Medium Growth Scenario**

The 2040 Medium scenario is a population-based estimate that was developed through use of conservative population growth as discussed in Section 2.7. As described in that section, the Eastern Shore MPO's Long Range Transportation Plan was heavily relied upon since their geographic area of responsibility covers the majority of the Weeks Bay Watershed (basically all but the Magnolia River Subwatershed as shown in Figure 2.38). As discussed, the population estimates for 12 existing undeveloped/underdeveloped subdivision sites outside the LRTP study area were applied to census blocks they were in based on general lot size of 0.3 acres for a single family residence, and 2.5 persons per house. For all the other census blocks in this non-LRTP study area, an annual growth rate of 1% per year was applied for the 30-year period from 2010 to 2040, i.e., 30% projected increase for these census blocks. This methodology is consistent with technical basis applied by the Eastern Shore MPO for the population growth within their planning jurisdiction.

In terms of population, the 2040 population density estimates for each of the census-based geographic areas were translated into acreage by applying 2.5 persons per household on a 0.3 acre site to the existing NLCD Developed, Low Intensity classification for single family homes. The "placement" of these populations was guided by analyzing existing zoning, aerial photographs, and parcel data for the identification of new development sites and subdivision plats, and lastly proximity to existing developed areas and major arterials through the use of GIS. No population-based conversions were made to other NLCD Developed classifications. Other NLCD classification conversions made to the 2011 NLCD involved updates to areas that have already undergone a land use change since 2011, e.g., agricultural to commercial. These new land uses were converted to the appropriate NLCD classification of Developed, Low Intensity; Developed, Medium Intensity; or Developed, High Intensity; and Barren Land through the inspection of 2013 and 2015 aerial photographs (barren lands where forest/agricultural land is now dirt pit). Wetlands and water bodies were retained based on their 2011 NLCD classification.

This future growth scenario has its focus on residential housing land use changes as related to the population projections and generally updates the LU/LC to existing conditions. It does not include the peripheral land use changes that follow the associated population growth such as commercial, industrial, schools, recreation, and infrastructure.

2.8.2.2.3 **2040 High Growth Scenario**

The 2040 High Growth Scenario employed a zoning-based approach to land cover change within the Watershed. In other words, all geographic areas that were zoned for development, whether residential, business, commercial, or industrial, were converted to the appropriate NLCD Developed land cover classification with the assumption that they would be fully developed as zoned. No changes were made to "agricultural" zoned areas. The base 2011 LU/LC classification was retained in all remaining areas.

2.8.3 Impervious Cover

Four principal factors influence stormwater runoff (quantity and quality): rainfall, soil characteristics, topography, and land use / land cover (LU/LC). Of these, the most important factor in controlling stormwater is land use / land cover. Land use / land cover (in addition to topographic features and soil characteristics) is the variable most often influenced by man in developing landscapes. The potential for adverse effects on stormwater increases as natural vegetation is replaced with Impervious Cover in a developing watershed.

Impervious Cover (IC) is a collective term used to describe all hard surfaces (i.e., rooftops, driveways, roads, parking lots, patios, compacted soils, etc.) that permit little or no water infiltration into the soil. Impervious cover fundamentally alters the hydrology of urban watersheds by generating increased stormwater runoff and reducing the amount of rainfall that soaks into the ground.

2.8.3.1 Background

Vegetative cover protects the soil from raindrop impact, reduces stormwater runoff velocities, increases infiltration of rainfall, and holds soil in place with root structures. In addition, through the process of evapotranspiration, water present in the soil is “mined” up through the roots of plants and evaporated into the atmosphere. This process helps plants dry soils through evapotranspiration which increases the soil’s capacity to hold water that in turn reduces runoff.

In the natural, undisturbed environment, rain that falls is intercepted by trees and other vegetation and/or infiltrates into the soil. When permeable soils are present, runoff typically occurs only with significant precipitation events (USEPA, 2009).

Urbanization of a watershed results in the removal of the native vegetation. Traditional development practices cover large areas with impervious surfaces such as roads, driveways, sidewalks, and buildings. Land cover changes also increase soil compaction and alter natural drainage patterns. These changes increase the imperviousness of a watershed so that runoff occurs even during small precipitation events that would normally have been absorbed by the soil and vegetation. Multiple studies have identified the negative impacts of poorly managed post-construction stormwater on our nation’s waters. As landscapes become more urbanized, there is a corresponding increase in the amount of impervious surfaces that limit the ability of stormwater to infiltrate into the ground.

In some watersheds, as much as 55% of rainfall runs off an urban landscape and only 15% of rainfall soaks into the ground. In comparison, a more natural landscape will infiltrate 45% of the rainfall with only 10% running off (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf)[1].

Figure 2.49 provides a conceptual comparison of the effects of urbanization on the hydrology of a site.

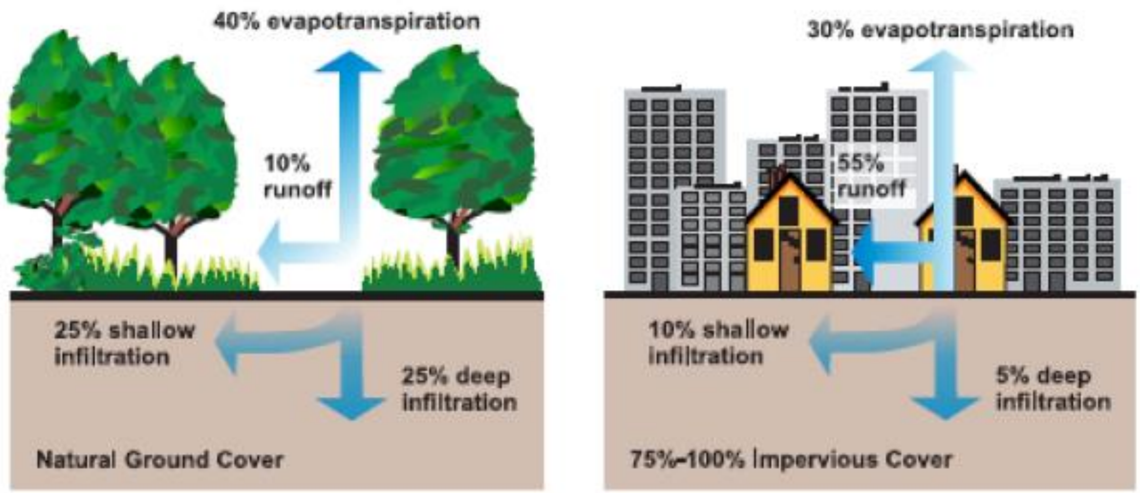


Figure 2.49 Comparison of Pre-Development and Post-Development Hydrology
Source: USEPA, 2009

The cumulative impacts of the land cover changes result in the natural hydrology of a site/watershed being altered, producing increased runoff volumes and peak runoff velocities. Development results in an increase in the impervious surface area, a higher degree of connectivity between impervious areas and the loss of soils and vegetative cover that previously slowed or reduced runoff in the pre-developed condition. Figure 2.50 illustrates the impacts of development on runoff volume and timing of the runoff on the hydrograph of a receiving stream. Changes in the watershed land cover result in greater discharge velocities, greater volumes, and shorter discharge periods. As shown in Figure 2.50, pre-development runoff velocities are lower than those on developed sites and the discharges occur over a longer time period. The pre-development peak discharge rate is also much lower than the post-development peak discharge rate due to attenuation and absorption by soils and vegetation. In addition, development shortens the time before runoff begins.

[1] The document referenced above is undated, and was initially released in late 2013 by the Alabama Department of Environmental Management in cooperation with the Alabama Cooperative Extension Service (ACES) and Auburn University. Another updated version of the handbook, entitled "*Planning for Stormwater: Developing low impact solution*" is published on ACES's website at: http://www.aces.edu/natural-resources/water-resources/watershed-planning/stormwater-management/documents/1467207286_lowimpactdistribution59.pdf .

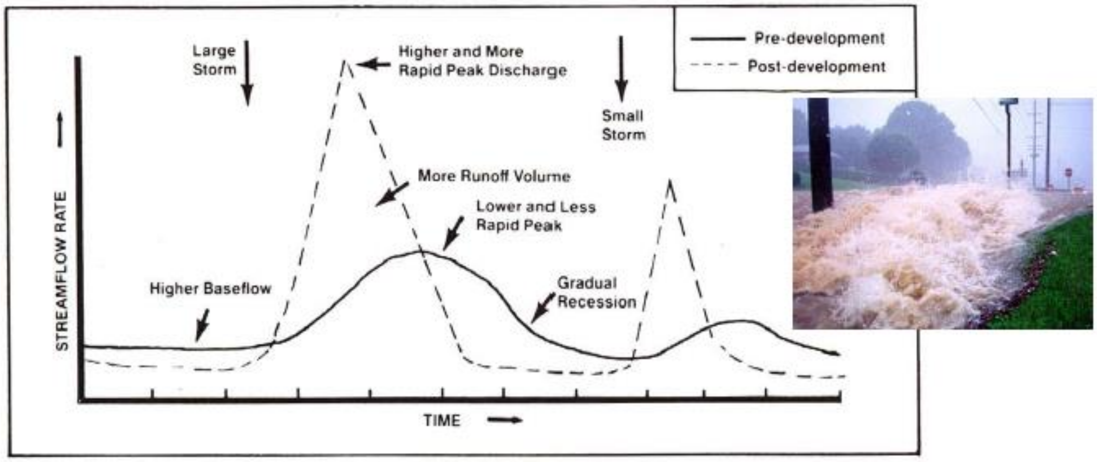


Figure 2.50 Comparison of Pre-Development and Post-Development Hydrographs
Source: Schueler, undated

Degradation of aquatic ecosystems can occur when the hydrology of a watershed is altered by large increases in impervious area. The collective force of the increased runoff scours streambeds, erodes streambanks, and causes large quantities of sediment and associated pollutants to enter streams each time it rains.

Impervious cover is the best indicator to measure the intensity of watershed development and to predict the severity of development impacts on the network of streams within a watershed. The extent of impervious cover in a watershed is closely linked to the specific land cover types that reflect intensive land uses traditionally associated with urban growth. Typically, increases in Impervious Cover result in the fragmentation of natural area remnants; create interruptions in the stream corridor; reflect encroachments into and expansion of developments within floodplains; and increase the density of stormwater hotspots.

2.8.3.2 The Impervious Cover Model (ICM*)*

The Center for Watershed Protection (CWP, 2003 and CWP, 2005) has developed an Impervious Cover Model (ICM) that can be used to predict changes in stream health as a consequence of watershed development and to assess the effectiveness of stream restoration. According to the ICM, when the imperviousness of a watershed begins to exceed 10%, increased nonpoint source pollutant loads begin to appear from urban runoff; stream temperatures become elevated due to reduced canopy cover; and increases in stream scour and channel instability begin which reduces the quality of stream habitat and diminishes biodiversity.

The ICM (CWP, 2005) identifies four classifications of urban streams based on the extent of Impervious Cover (IC) and future restoration potential (see Figure 2.51). The four types of streams are as follows:

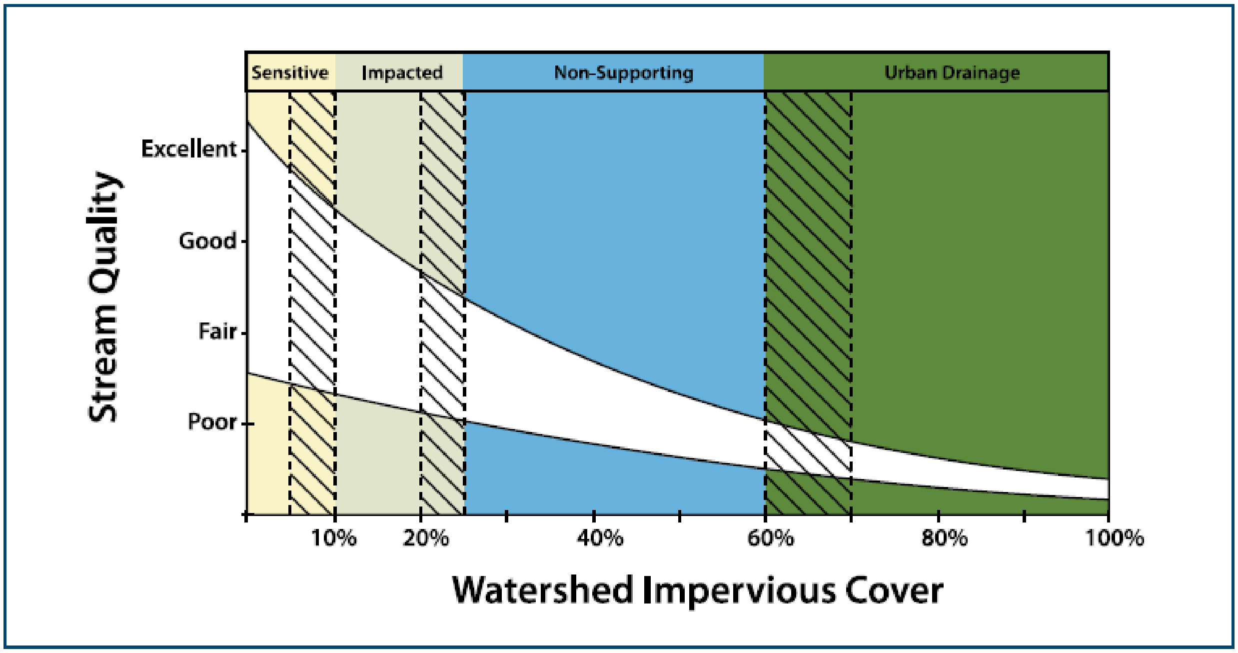


Figure 2.51 Relationship between Watershed Impervious Cover and Stream Quality
Source: Hirschman and Kosco, 2008

- **High Quality Streams** have less than 10% IC in their contributing drainage area and generally retain their hydrologic function. Such streams support good to excellent aquatic diversity.
- **Impacted Streams** have between 10 and 25% IC in their supporting subwatershed, and show clear signs of declining stream health. Most indicators of stream health fall in the fair range, although some reaches may still be rated as being of good quality. These streams often exhibit the greatest restoration potential since they exhibit only moderate degradation, have an intact stream corridor, and usually have enough undeveloped land available in the watershed in which to install restoration practices.
- **Non-Supporting Streams**[2] range between 25 and 60% IC in their supporting subwatershed. These streams no longer support their designated uses as defined by hydrology, channel stability, habitat, water quality and biological indicators. Subwatersheds at the lower end of the IC range (25 to 40%) may show promise for partial restoration, but are so altered that they normally cannot attain pre-development conditions for most indicators. In some circumstances, streams in the upper range of the non-supporting category (40 to 60% IC) may show some potential for stream restoration. In most circumstances, however, the primary restoration goals are to reduce pollutants, improve the stream corridor, or enhance community amenities.
- **Urban Drainage** refers to streams that have subwatersheds with more than 60% IC and where the stream corridor has essentially been eliminated or physically altered to the point that it functions merely as a conduit for flood waters. Water quality indicators are consistently poor, channels are highly unstable, and both stream habitat and aquatic

[2] The "Non Supporting" category used in the ICM is not synonymous with the terminology used in the 303(d) list of impaired streams and should not be confused with the 303(d) program.

> diversity are rated as very poor or are eliminated altogether. Thus, the prospects to restore aquatic diversity in urban drainage are extremely limited, although it may be possible to achieve significant pollutant reductions.

The ICM displayed in Figure 2.51 expresses the IC/stream health relationship as a “cone” that is widest at the lower level s of IC and progressively narrows at higher levels of IC. At lower levels of IC (i.e., less than 10%), stream quality varies widely according to the amount of forest cover, road density, extent of riparian vegetative cover, and other factors that are present in less urban watersheds. At higher levels of IC, the correlation between IC and stream health is stronger. The transition between the four stream health categories is shown in Figure 2-51 as ranges (i.e., 5%-10%, 20%-25%, and 60%-70%) as opposed to sharply defined thresholds because of the variability between streams (Hirschman and Kosco, 2008). According to the Center for Watershed Protection, use of the ICM to classify urban watersheds allows reasonable restoration expectations to be developed. The ICM helps define general thresholds at which current water quality standards or biological conditions cannot be consistently met during wet weather conditions. These predictions help set realistic objectives to protect stream quality based on current and future conditions.

2.8.3.3 Current Impervious Cover in the Weeks Bay Watershed

Impervious cover has unique properties that can be measured, tracked, forecasted, managed, regulated, and mitigated. The extent of impervious cover in a watershed can be accurately measured using either remote sensing or more detailed aerial photography. Impervious cover is usually reported as the percentage of impervious cover occurring within a specific area and at a specific time, which can range in size from an individual lot to an entire watershed. Figure 2.52 illustrates the impervious cover as measured for two individual residential lots.

As previously discussed in Section 2.8.2.2, the USGS leads a group of 10 federal agencies, the Multi-Resolution Land Characteristics (MRLC) consortium, to produce the National Land Cover Database - NLCD (Homer, C.H. et al., 2012). NLCD 2001, and subsequent datasets at 5-year intervals, use Landsat imagery as the primary data source to provide national land cover, percent impervious surface area, and percent tree canopy distribution. The percent developed imperviousness has been recognized as an important data source to quantitatively determine the extent of developed land cover at both regional and national scales. This product with the thematic land cover dataset has been widely used to evaluate urban land cover extent and associated effects on hydrological and ecological systems (Xian, G. et al., 2011). NLCD 2001, 2006, and 2011 are currently available, along with interval changes (2001 to 2006, 2006 to 2011). The NLCD 2016 is still under development.

Figure 2.52 Measured Percent Impervious Cover for Individual Residential Lots

Percent developed imperviousness includes two areal increments: Impervious Surface Area (ISA) which calculates the area of imperviousness proportion in every 30-meter pixel, and Impervious Effect Area (IEA) which totals the number of 30-meter pixels that contain any impervious surface (>0%) (Xian, G. et al., 2011). The ISA and IEA data from NLCD 2001, 2006, and 2011 for the Weeks Bay Watershed are compiled in Appendix E. The areas of ISA and IEA are presented in 10% categories (1 – 10, 11 – 20, etc.) for each HUC 12 watershed. A summary is presented in Table 2.16 below for each of the four HUC 12 Watersheds as well as for the entire Weeks Bay Watershed.

The Percent Developed Imperviousness for the Weeks Bay Watershed is displayed graphically for 2001, 2006, and 2011 on Figures 2.53, 2.54, and 2.55, respectively. The Changes in Percent Developed Imperviousness from 2001 – 2006 and 2006 – 2011 are presented on Figures 2.56 and 2.57.

The Impervious Surface Area (ISA) values in 2011 (see Table 2.16), compared to total areas of each HUC 12 Subwatershed, range from 1.8% to 3.1%, with a composite average of 2.6% for the entire Weeks Bay Watershed. The Impervious Cover Model (ICM) discussed above (see Figure 2.51) suggests that impacts to date (due to urbanization) are minor overall, with High Quality streams remaining that are retaining their hydrologic function. Nevertheless, this should not imply that localized impacts have not occurred. When the imperviousness within developed areas is considered, as represented by the ISA/IEA ratios, impervious values range from 18.2% to 21.7%, with a composite average of 20.4% for the entire Weeks Bay Watershed. The ICM suggests that streams in these developed areas would fall in the Impacted Streams category. The 2011 Percent Developed Imperviousness presented in Figure 2.55 graphically depicts where such stream impacts have likely occurred.

Table 2.16 Summary of IEA and ISA Factors in the Weeks Bay Watershed

Impervious Effect Area (IEA)					
Watershed Name:	**Upper Fish River**	**Middle Fish River**	**Lower Fish River**	**Magnolia River**	**Weeks Bay Watershed**
Total Watershed Area:	**42,269 ac**	**26,767 ac**	**34,448 ac**	**26,113 ac**	**129,598 ac**
2001 IEA Area (acres)	4,481	2,117	4,042	2,702	13,341
2001 IEA (% of total)	10.6%	7.9%	11.7%	10.4%	10.3%
2006 IEA (acres)	5,415	2,297	4,440	3,163	15,314
2006 IEA (% of total)	12.8%	8.6%	12.9%	12.1%	11.8%
2011 IEA (acres)	6,110	2,543	4,915	3,259	16,827
2011 IEA (% of total)	14.4%	9.5%	14.3%	12.5%	13.0%
Impervious Surface Area (ISA)					
Watershed Name:	**Upper Fish River**	**Middle Fish River**	**Lower Fish River**	**Magnolia River**	**Weeks Bay Watershed**
Total Watershed Area:	**42,269 ac**	**26,767 ac**	**34,448 ac**	**26,113 ac**	**129,598 ac**
2001 ISA (acres)	789	332	749	416	2,286
2001 ISA (% of total)	1.9%	1.2%	2.2%	1.6%	1.8%
2006 ISA (acres)	1,069	389	881	546	2,885
2006 ISA (% of total)	2.5%	1.4%	2.6%	2.1%	2.2%
2011 ISA (acres)	1,327	485	1,028	593	3,433
2011 ISA (% of total)	3.1%	1.8%	3.0%	2.3%	2.6%
ISA/IEA Ratio (%)					
Watershed Name:	**Upper Fish River**	**Middle Fish River**	**Lower Fish River**	**Magnolia River**	**Weeks Bay Watershed**
2001 ISA/IEA Ratio	17.6%	15.7%	18.5%	15.4%	17.1%
2006 ISA/IEA Ratio	19.8%	16.9%	19.8%	17.3%	18.8%
2011 ISA/IEA Ratio	21.7%	19.1%	20.9%	18.2%	20.4%

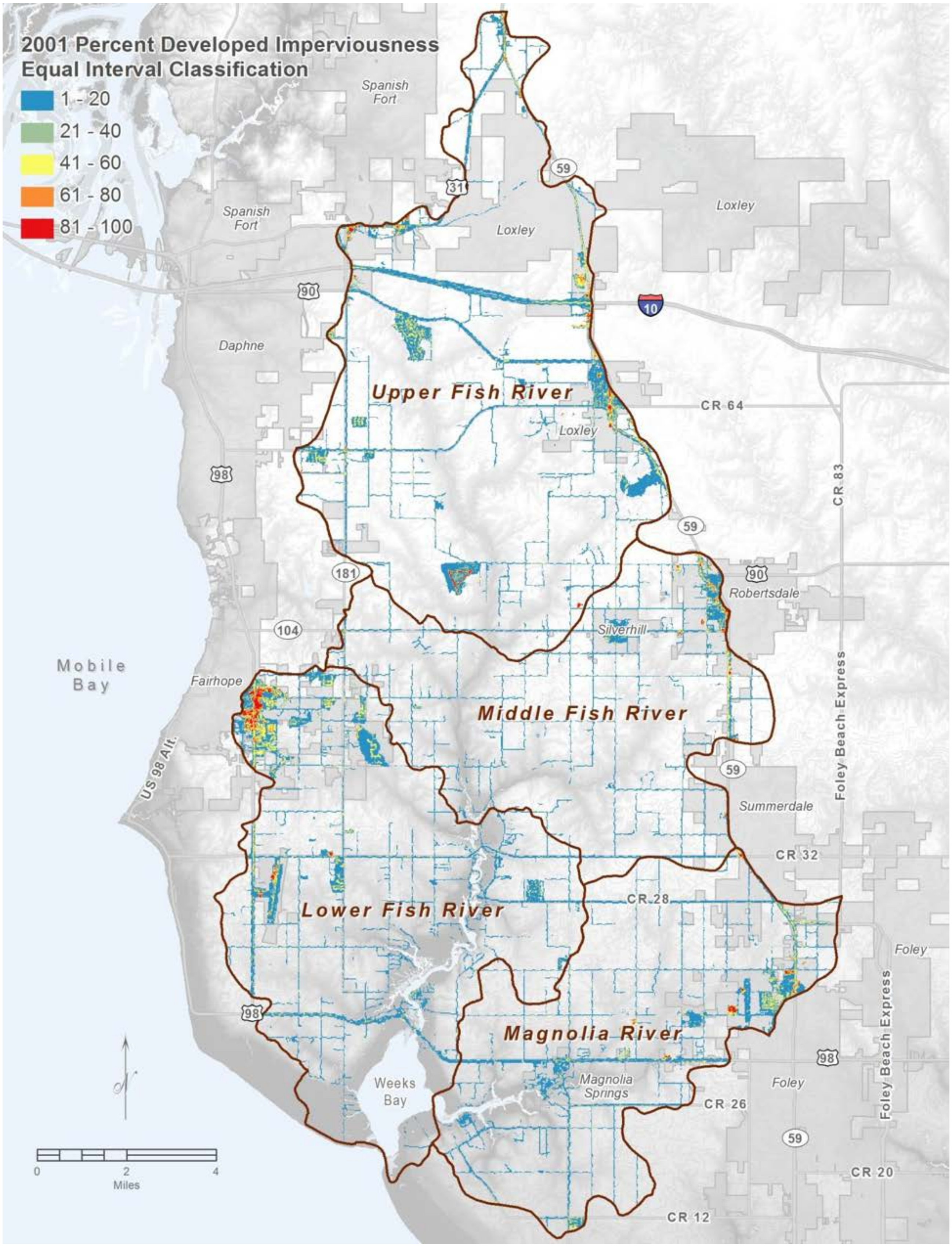


Figure 2.53 2001 Percent Developed Imperviousness

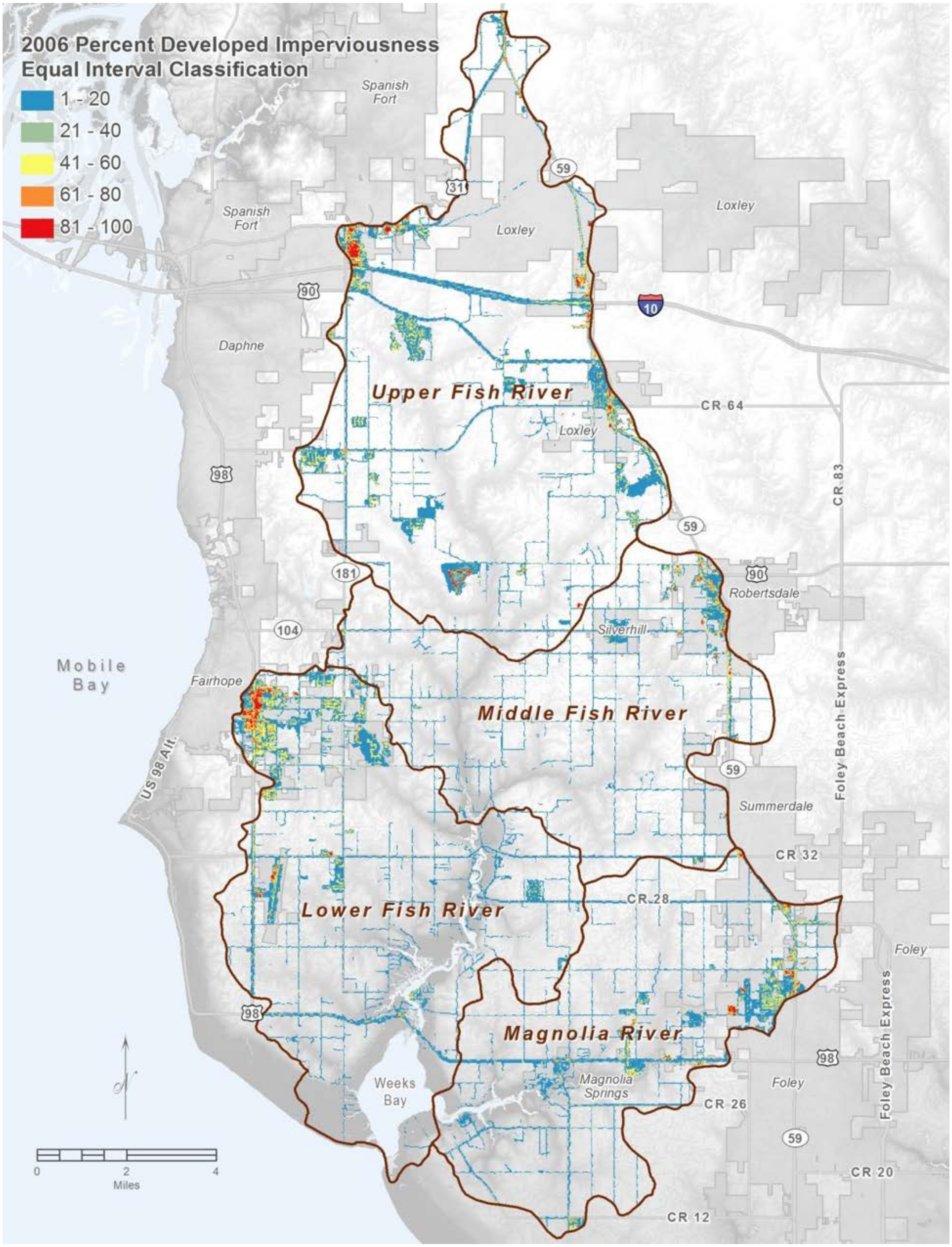


Figure 2.54 2006 Percent Developed Imperviousness

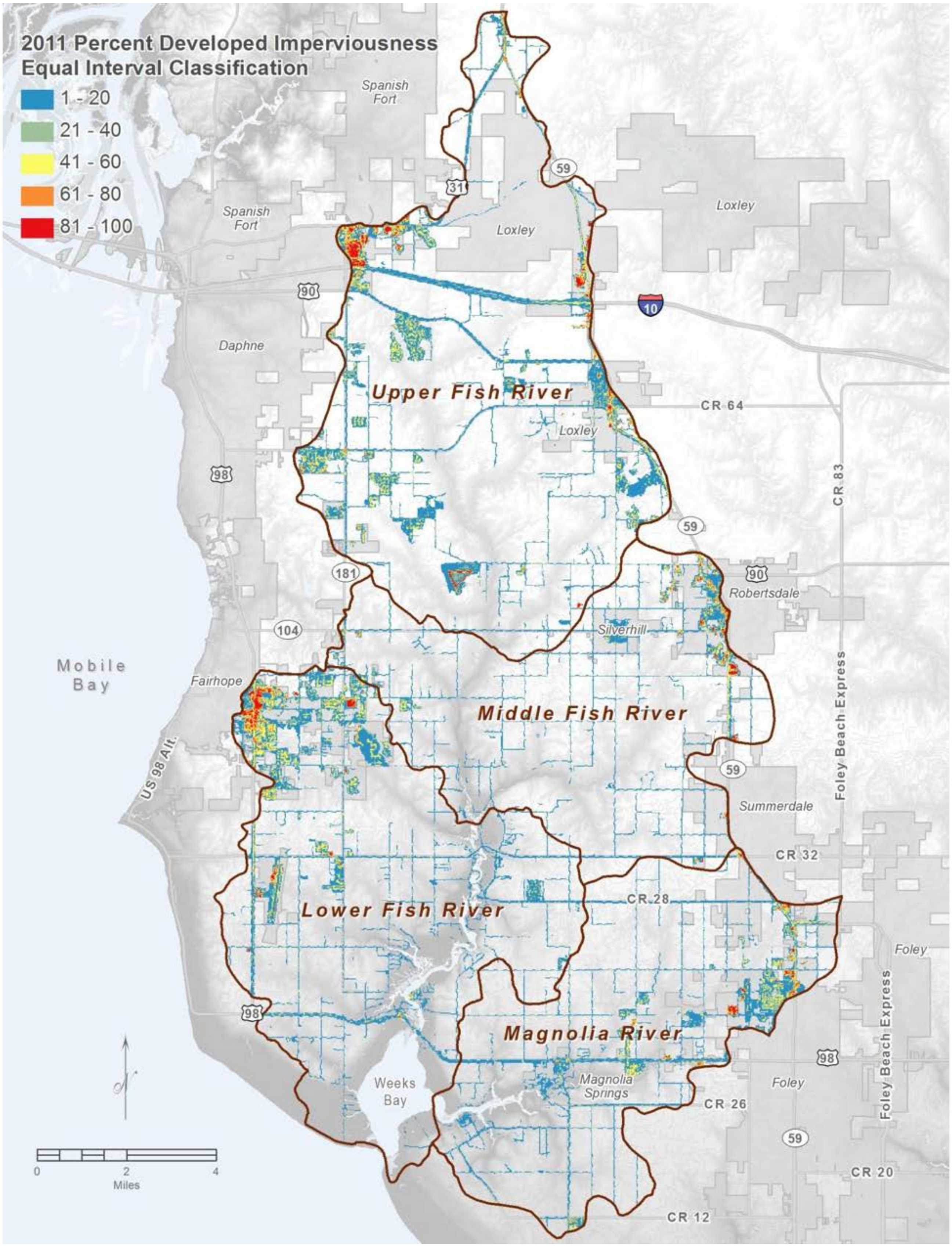


Figure 2.55 2011 Percent Developed Imperviousness

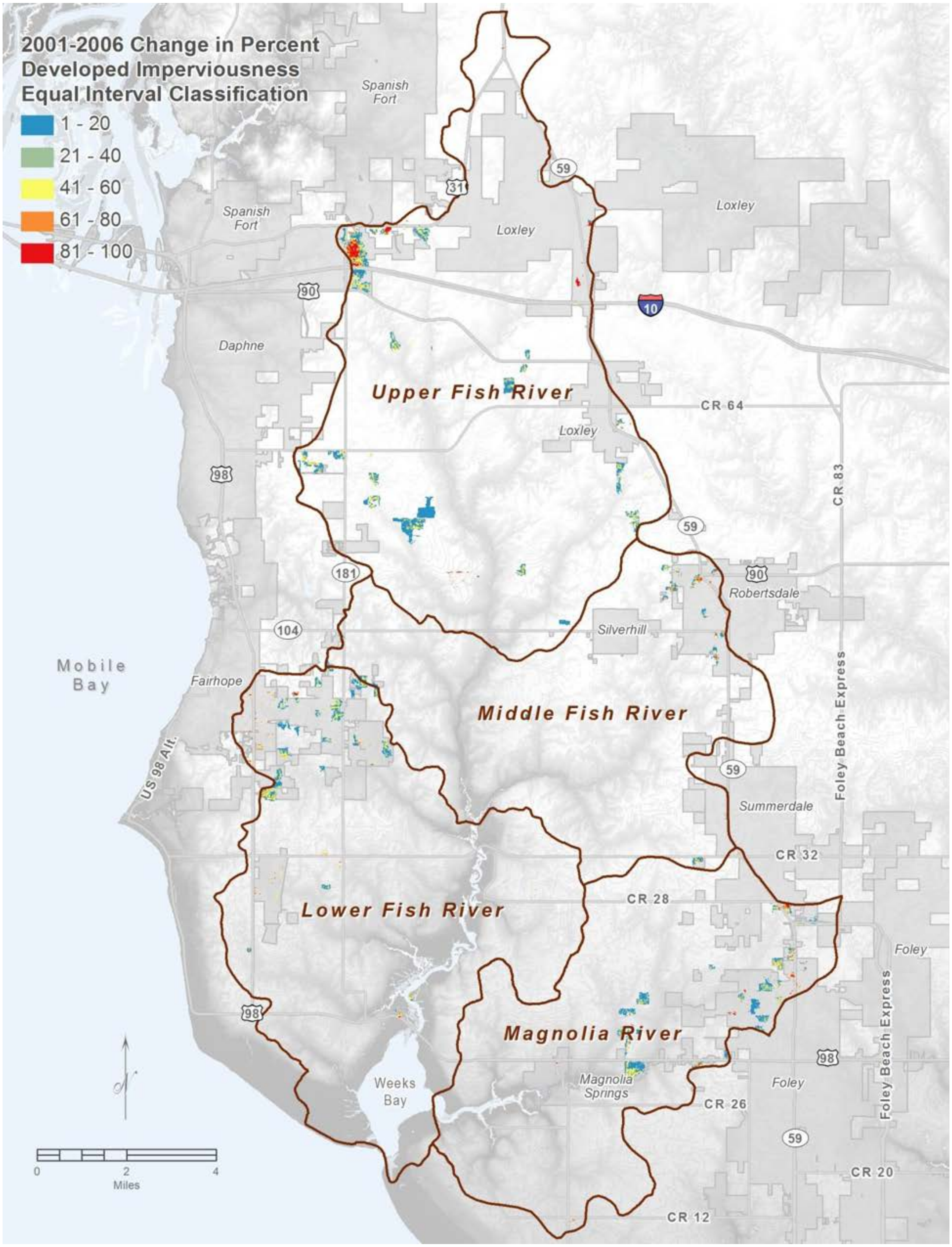


Figure 2.56 2001-2006 Percent Developed Imperviousness Change

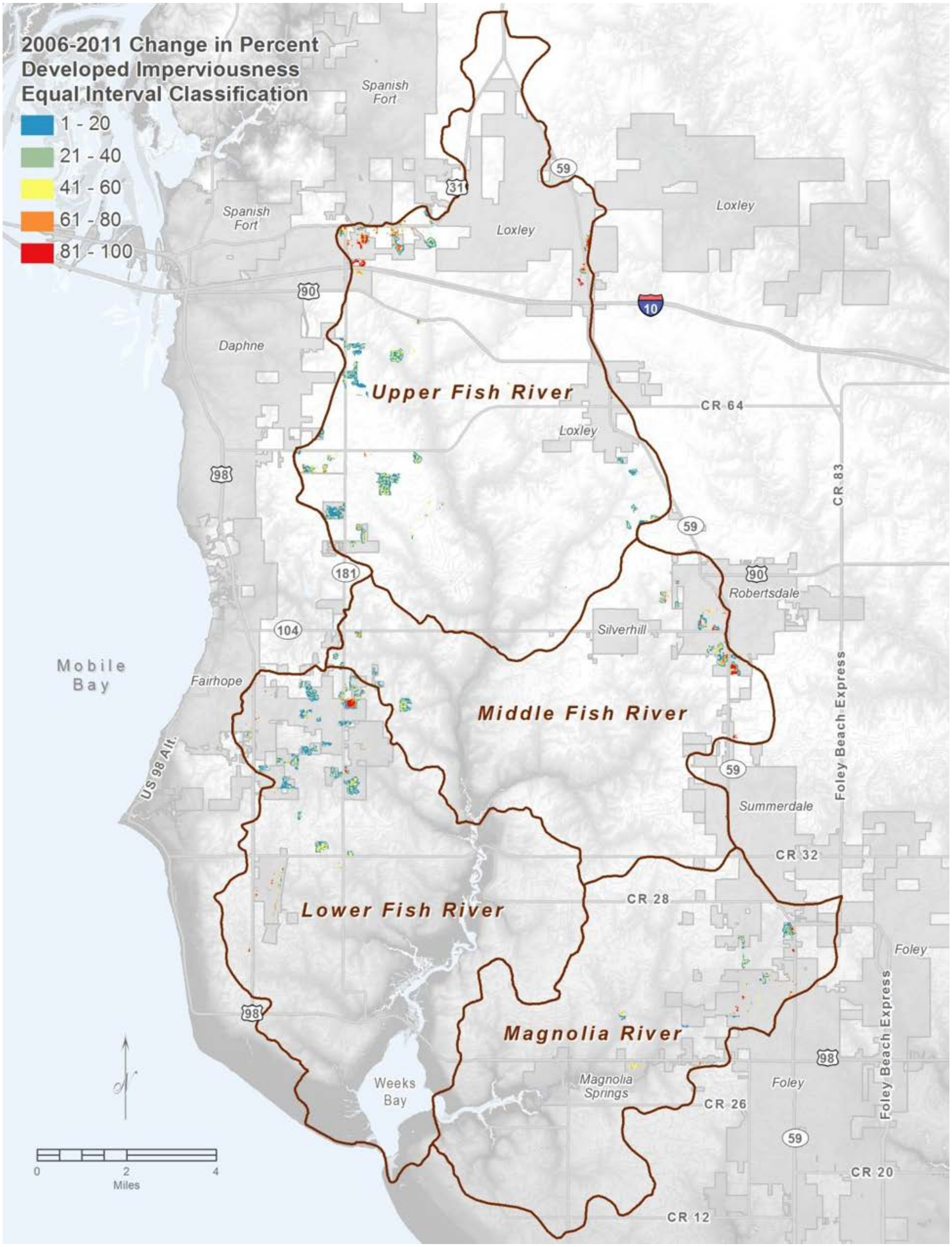


Figure 2.57 2006-2011 Percent Developed Imperviousness Change

This Page Intentionally Left Blank

3.0 Watershed Conditions

3.1 Water Quality Standards and NDPES Permitting

3.1.1 Introduction

The primary "regulatory drivers" governing discharges of pollutants to waterways and stormwater management within the Weeks Bay Watershed are the federal and state programs implemented pursuant to the Federal Water Pollution Control Act or Clean Water Act (CWA). These primarily include the CWA Section 303(d) Impaired Waters and TMDL program and the Section 402 National Pollutant Discharge Elimination System (NPDES). The NPDES permitting program includes point source discharges from industrial and municipal sources (Wastewater Treatment Plants), stormwater discharges from various industrial activities (i.e. manufacturing, construction activities, etc.), and the Municipal Separate Storm Sewer System (MS4) program. The Alabama Water Pollution Control Act (AWPCA) and Environmental Management Act provide the statutory basis for the State of Alabama to be delegated the authority to implement portions of the CWA related to water quality standards and NPDES permitting. A more detailed overview of these existing federal and state regulations is presented in Section 8 of this Plan.

3.1.2 Water-use Classification and Water Quality Criteria

The CWA (Section 303) requires that states develop and describe water quality standards and criteria. Alabama's water quality criteria have been developed by ADEM and are based on a water use classification system for each waterbody. Use classifications and the general and specific narrative and numeric water quality criteria for each classification can be found in ADEM Admin. Code R. 335-6-10 and ADEM Admin. Code R. 335-6-11, respectively. The Use classifications utilized by the State of Alabama are as follows:

Outstanding Alabama Water	**OAW**
Public Water Supply	PWS
Swimming and Other Whole Body Water-Contact Sports	**S**
Shellfish Harvesting	SH
Fish and Wildlife	**F&W**
Limited Warmwater Fishery	LWF
Agricultural and Industrial Water Supply	A&I

The three classifications in bold font are assigned to various waterbodies within the Weeks Bay Watershed. Additionally, ADEM has adopted two special designations that may be applied to high quality waters which allow for added protection. These designations are Treasured Alabama Lake (TAL) and Outstanding National Resource Water (ONRW) (ADEM Admin. Code R. 335-6-10-.10). Weeks Bay currently carries the ONRW designation.

The use classification system applies both narrative and numeric water quality criteria appropriate for the particular uses based on existing utilization, uses reasonably expected in the future, and those uses not now possible because of correctable pollution but which could occur if the effects of pollution were controlled or eliminated. The water quality criteria are primarily used for assessment purposes (CWA Section 305(b)), setting water quality targets for impaired waters (TMDL program), and for the permitting and regulation of discharges of pollutants to waters of the State of Alabama. However, they also provide an indication of expected ambient water quality conditions. Of necessity, the assignment of use classifications must take into consideration the physical capability of waters to meet certain uses. It should also be noted that under certain natural conditions or phenomena values may range outside the criteria for the parameters of pH, dissolved oxygen and turbidity and not be considered a contravention of the standard (ADEM Administrative Code R. 335-6-10-.05(4)). In some instances, a waterbody may be assigned multiple classifications (e.g. S/F&W). A number of waterbodies throughout the state are specifically named in the ADEM regulations and those not named are assigned the classification of F&W.

The primary numeric water quality criteria for the three water use classifications applicable to the Weeks Bay Watershed are provided in Table 3.1.

Table 3.1 ADEM Water Quality Criteria by Use Classification

Water Use Classification	**pH (s.u.)**	**Water Temperature °F**	**Dissolved Oxygen[1] mg/l**	**Bacteria[2] Colonies per 100 ml**	**Turbidity[4] NTU**
Outstanding Alabama Water (OAW)	6.0-8.5(fresh) 6.5-8.5 (salt)	<90	>5.5	126/235 *E. coli* 35/100 *enterococci*	<50
Swimming and Other Whole Body Water-Contact Sports (S)	6.0-8.5 (fresh) 6.5-8.5 (salt)	<90	>5.0	126/235 *E. coli* 35/100 *enterococci*	<50
Fish and Wildlife (F&W)	6.0-8.5 (fresh) 6.5-8.5 (salt)	<90	>5.0	548/2,507 *E. coli* 126/298 *E. coli*[3] 275 *enterococci* 35/158 *enterococci*[3]	<50

Source: ADEM Administrative Code R. 335-6-10, February 3, 2017

[1]Dissolved oxygen criteria applies at surface and at mid-depth or 5 feet whichever is greater (ADEM Administrative Code R. 335-6-10-.09). In estuaries and tidal tributaries, values may be less than 5.5mg/l in dystrophic waters due to natural phenomenon

[2]Bacteria standards are shown as the "geometric mean**/**single sample maximum" concentrations. *E. coli* standards apply to non-coastal waters; *enterococci* standards apply to coastal waters

[3]Seasonal "swimming" standards apply to waters classified as Fish and Wildlife (May – October)

[4]Turbidity criteria apply to discharges which shall not cause or contribute to an increase in the turbidity of the receiving waters by more than 50 NTU (nephelometric turbidity units) above background

Water use classifications assigned to specific waterbodies within the Weeks Bay Watershed are listed in Table 3.2 and depicted in Figure 3.1

Table 3.2 ADEM Water Use Classifications in the Weeks Bay Watershed

Waterbody	From	To	Classification	Subwatershed
Weeks Bay	Bon Secour Bay	Fish River	S/F&W[1]	Lower Fish
Fish River	Weeks Bay	Its source	S/F&W[2]	Lower/Middle/Upper Fish
Turkey Branch	Fish River	Its source	S/F&W[2]	Lower Fish
Waterhole Branch	Fish River	Its source	S/F&W[2]	Lower Fish
Cowpen Creek	Fish River	Its source	S/F&W[2]	Lower Fish
Polecat Creek	Fish River	Its source	S/F&W[2]	Middle Fish
Corn Branch	Fish River	Its source	F&W	Upper Fish
Magnolia River	Weeks Bay	Its source	OAW/S/F&W[2]	Magnolia

Source: ADEM Administrative Code R: 335-6-11, February 3, 2017

[1]Also carries the special designation of **ONRW**

[2]For these streams, the portions below +10 feet MSL are considered “coastal waters” and the portions above +10 feet MSL are considered “non-coastal waters” for the purposes of applying water quality criteria

The fact that Weeks Bay proper has been designated as a National Estuarine Research Reserve since 1986, an ONRW since 1992, and the Magnolia River designated as an OAW since 2009 is testament to the fact that Weeks Bay and its watershed rivers and streams have long been recognized as more than just a local treasure. In fact, considering the percentage of waters classified as swimming and the two special water quality designations, this Watershed is likely one of the highest classified in the state.

Figure 3.1 ADEM Stream Classifications and 303(d) Stream Segments
Note: All smaller blue-colored streams are classified as Fish & Wildlife (F&W)

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

Section 303(d) of the CWA requires that states develop lists of “impaired waters,” those waters that do not meet state water quality standards for their designated uses. These listings must be approved by EPA and are published biannually. The CWA also requires that states establish priority rankings for waters on the 303(d) lists and develop a Total Maximum Daily Load (TMDL) for these waters. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards. The TMDL calculates the maximum amount of a pollutant allowed to enter a waterbody (i.e., also known as the loading capacity) so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. The TMDL then allocates the pollutant load to point sources (Wasteload Allocation or WLA) and nonpoint sources (Load Allocation or LA), which include both anthropogenic and natural background sources of the pollutant. Once a waterbody is placed on the 303(d) list, it can only be removed when the TMDL is completed or if new information indicates that water quality criteria are being met.

Since 1998, a number of stream segments within the Weeks Bay Watershed have been placed on, and taken off, Alabama’s 303(d) list due to a variety of pollutants of concern. By example, the entirety of Fish River proper was first listed in 1998 due to Mercury (Hg), pathogens and low pH. In the 2002 303(d) list, the pH impairment was removed because the low values were considered naturally occurring. On the 2014 303(d) list the pathogen impairment was removed because a TMDL was completed and approved in 2013, but the Hg impairment still appears on the 2016 list.

Another example is the Caney Branch Success Story:

> *Caney Branch, about five miles long, is located in the Upper Fish River Watershed and is classified as F&W. The stream was listed in the 1998 303(d) list due to pathogens (bacteria) impairment with a suspected source of “pasture grazing”. Through the Weeks Bay Watershed Project, working with ADEM, EPA Gulf of Mexico Program, NRCS, stakeholders and landowners, several agricultural Best Management Practices (BMPs) were implemented within the Caney Branch subwatershed. BMPs included livestock exclusion fencing, riparian buffers and protected stream crossings, as well as educational efforts. Subsequent pathogen monitoring indicated that the bacteria standard was met and the stream segment was removed from the 303(d) list in 2002.* Source: https://www.epa.gov/sites/production/files/2015-11/documents/al_caney.pdf)

With the exception of Baker Branch, the 2016 303(d) listings in the Watershed (Table 3.3) are for mercury (Hg) due to the issuance of fish consumption advisories by the Alabama Department of Public Health (ADPH). The source of the mercury is thought to be atmospheric deposition. Baker Branch is listed due to “organic enrichment” with the source indicated as “pasture grazing.”

Table 3.3 ADEM 2016 303(d) Listed Streams in the Weeks Bay Watershed

Waterbody	From	To	Cause	Source
Fish River	Weeks Bay	Its source	Hg	Atmospheric Deposition
Cowpen Creek	Fish River	Its source	Hg	Atmospheric Deposition
Polecat Creek	Fish River	Its source	Hg	Atmospheric Deposition
Baker Branch	Polecat Creek	Its source	Organic Enrichment[1]	Pasture grazing
Magnolia River	Weeks Bay	Its source	Hg	Atmospheric Deposition

[1]Organich Enrichment as indicated by CBOD and NBOD.

In August of 2013 ADEM published their Final Total Maximum Daily Load (TMDL) for Fish River for Pathogens (*E. coli*) (ADEM 2013). The report provided a synopsis of the impairment, the data that had been collected which indicated the impairment, and the technical basis for the TMDL development. The primary sources of the pathogen load to Fish River were attributed to "non-point sources" (NPS), e.g. sources that do not have a defined discharge point and are not required by law to have an NPDES permit (wildlife, agriculture, etc.). The report indicates that a 68% reduction in total pathogen loading was needed to meet and maintain water quality standards, and essentially assigned this reduction rate to NPS and future MS4s. The removal of a stream segment from the 303(d) list because a TMDL has been developed does not necessarily mean that there is no longer any impairment for the particular parameter, only that a loading has been calculated and future NPDES permitting actions will be based on that loading. Figure 3.1 shows the locations of the listed segments within the Weeks Bay Watershed.

3.1.4 CWA Section 402 NPDES Permitting Program

Section 402 of the CWA sets forth the national permitting program for discharges of pollutants to waters of the United States. ADEM is a delegated state, authorized to implement the NPDES permitting program within Alabama. Facilities discharging pollutants are divided into a number of categories based on the type and/or size of the facility (e.g. major industrial, major municipal, minor industrial, etc.) and level of treatment required. Discharge limitations are generally similar within the classifications but may vary where the water quality of the waterbody receiving the discharge is a limiting factor. The larger facilities, such as sewage treatment plants and heavy industrial facilities, usually are authorized to discharge under an "Individual" NPDES permit. Smaller facilities of a similar nature (i.e. concrete plants, construction sites, etc.) are usually grouped under a "General Permit" developed to cover the specific industrial sector.

Based on data from the USEPA ECHO (Environmental Compliance History Online) website (https://echo.epa.gov/?redirect=echo) and the ADEM Mobile Field Office, there were three permitted municipal (sewage) wastewater treatment plants (WWTP) that discharge to the Weeks Bay Watershed operating under Individual NPDES Permits (although one WWTP has not yet been constructed). All three are within the Upper Fish River basin. There are also two industrial dischargers with individual NPDES permits, both in the Upper Fish River basin.

There are 19 large (>five acres) mining sites and one sanitary landfill with Individual NPDES Permit coverage. In addition, there are approximately 181 permitted sites/facilities covered by several different types of General NPDES Permits, the majority (144) being construction sites, of which 105 are active and 39 are inactive but still appear in the ECHO dataset. Figure 3.2 depicts the relative locations of the NPDES permitted facilities.

The individual NPDES permits, and some of the general NPDES permits, will set pollutant discharge limitations for each of the discharges based on either a treatment standard or instream state water quality criteria. These discharge limitations are designed to be protective of the water quality of the receiving stream. Some general permits (e.g. construction) do not set a specific pollutant limit but rather require that certain treatment standards be implemented (i.e. installation and maintenance of Best Management Practices (BMPs)). Under normal operating conditions, these NPDES permitted discharges should be within their permitted limits, however they are obviously a source of pollutants due to the potential for permit excursions and upsets or bypasses that may occur. Of particular concern would be bacteria from waste water treatment plants and sanitary sewer collection system overflows (SSOs), and sediment or turbidity associated with mining and construction sites. The NPDES permits do require that upsets, by-passes and SSOs be reported to ADEM. This information is not readily available for the construction and mining sites, but is available for reported SSOs under the WWTP permit number through the ADEM eFile system. Based on a review of this information, during the past 5 years there have been approximately 52 reported SSO events within the Weeks Bay Watershed, half of which occurred from the portion of Fairhope's collection system within the Fish River Watershed (Figure 3.3).

3.1.5 NPDES MS4 Program

Stormwater runoff in urbanized areas is also subject to NPDES permitting regulations pursuant to the Municipal Separate Storm Sewer Systems (MS4) program, 40 CFR 122.32. Large municipalities and certain other MS4 operators (such as departments of transportation, universities, etc.) must obtain NPDES permit coverage and develop a stormwater management program. Currently the MS4 program is in Phase II, which began in 1999, and requires that cities or certain urban areas and counties with populations of 50,000 or more to obtain NPDES permit coverage for their stormwater discharges. Each regulated MS4 is required to develop and implement a local stormwater management program to reduce the contamination of stormwater runoff and prohibit illicit discharges.

The general requirements of MS4 permits are to develop, implement and enforce a Storm Water Management Program Plan (SWMPP) that addresses the following six minimum control measures:

- Public Education and Outreach on Stormwater Impacts
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination

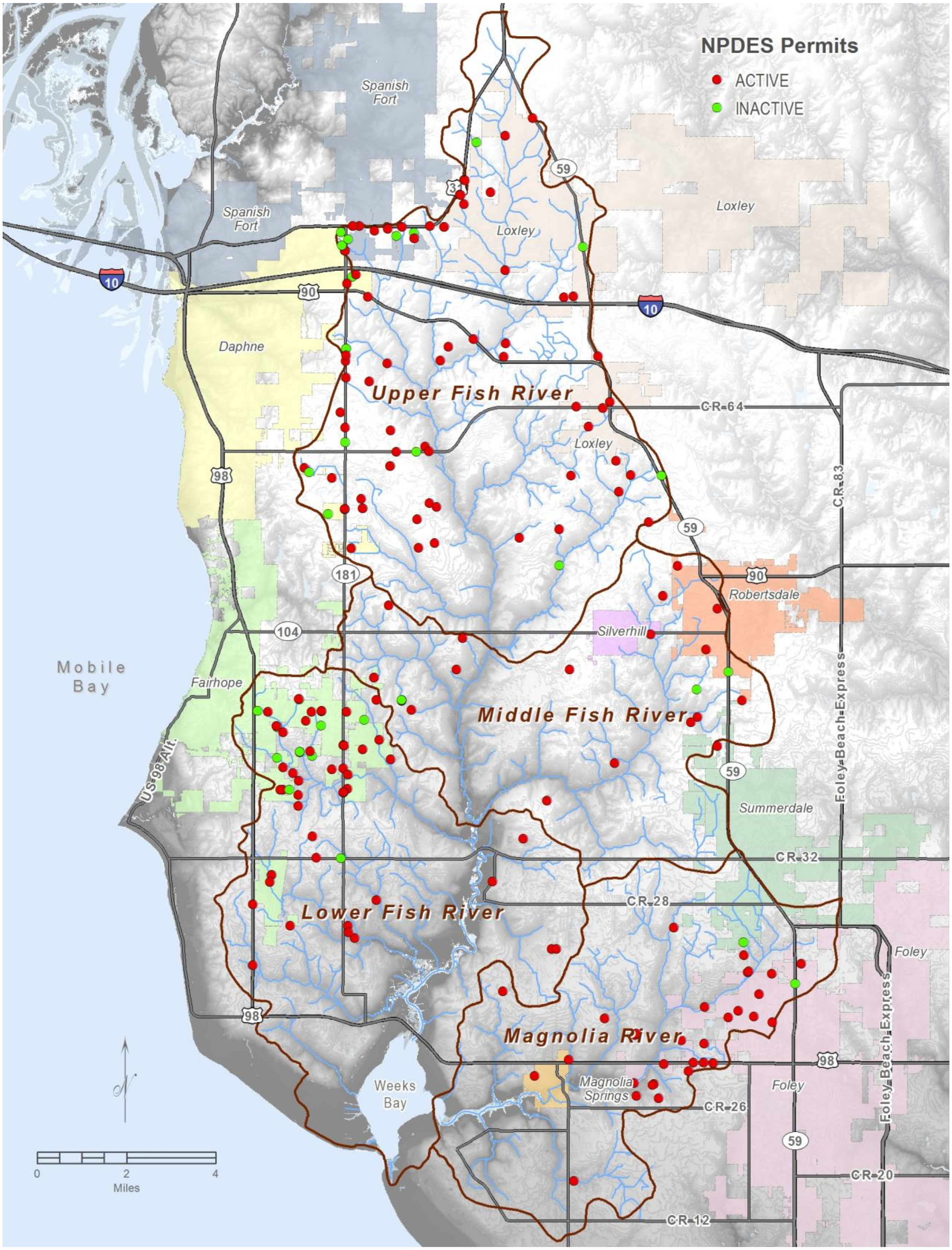


Figure 3.2 NPDES Permits in Weeks Bay Watershed
Source: USEPA ECHO Database and updated by ADEM Mobile Field Office staff

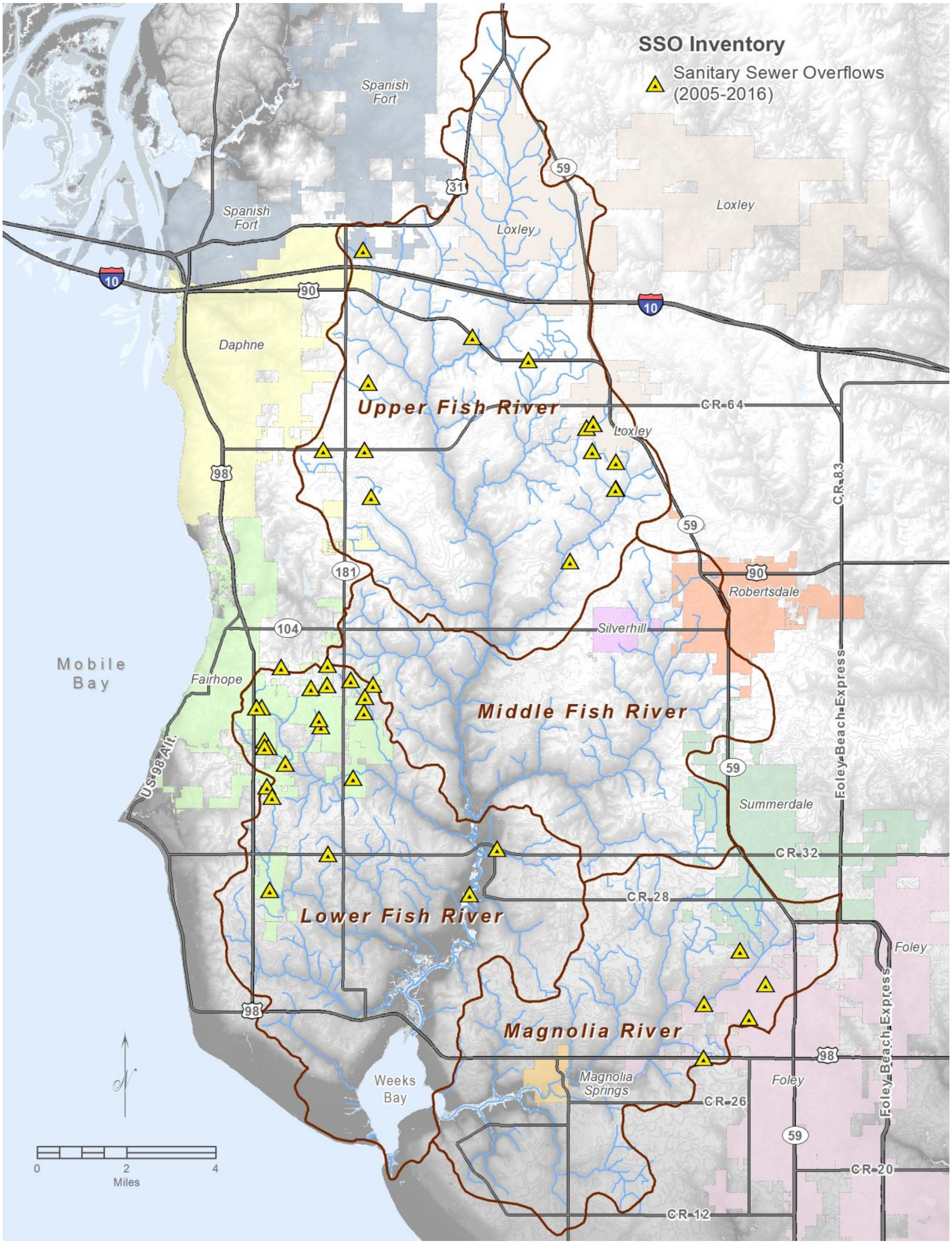


Figure 3.3 Sanitary Sewer Overflow Inventory in Weeks Bay Watershed
Source: ADEM eFile database

- Construction Site Stormwater Runoff Control
- Post-construction Stormwater Management
- Pollution Prevention/Good Housekeeping for Municipal Operations

The MS4 permits also may set forth requirements for actual stormwater or stream monitoring or assessment where stormwater discharges are to a 303(d)-listed stream or to a stream with an approved TMDL, and encourages the implementation of Low Impact Development / Green Infrastructure (LID/GI) practices. The MS4 permits also require that an annual report of activities and accomplishments related to the six control measures be submitted to ADEM. The general NPDES permit for phase II MS4s (ALR04) expired on January 31, 2016 and was administratively continued until the new permit was issued effective October 1, 2016.

Currently the City of Spanish Fort, City of Daphne, City of Fairhope and Baldwin County each have Phase II MS4 permit coverage that extends into some portion the Weeks Bay Watershed. Additionally, the Alabama Department of Transportation (ALDOT) maintains a MS4 permit covering its transportation corridors within the aforementioned urbanized areas. The portion of the Weeks Bay Watershed covered under these five MS4 permits is relatively small, approximately 17.5 square miles (Figure 3.4).

A review of the most recent annual reports (covering reporting year 2015) was performed during the course of preparing this watershed management plan. It is apparent that there have been extensive activities related to public education, outreach, involvement and participation by each of the MS4 permittees and these activities will hopefully translate to a reduction in future water quality issues related to urban stormwater runoff. When considering current water quality concerns, the potential for impacts is greatest with illicit discharges, construction site runoff, and post-construction stormwater controls. Table 3.4 below summarizes the reported 2015 efforts of each of the MS4 permittees.

Table 3.4 MS4 Activities reported by Permittees for 2015

	NPDES Permit	Square miles within Watershed	Illicit Discharges	Construction Stormwater Enforcement	Petroleum Chemical Spills	Major Stormwater Outfalls to Watershed
Spanish Fort	ALR040041	0.83	5	11*	0	NR
Daphne	ALR040039	.094	3	3	6	NR
Fairhope	ALR040040	5.5	2	>150	1	0
Baldwin Co.	ALR040042	14.2	0	0	NR	9
ALDOT	ALS000006	n/a	0	0	0	7**

It should be noted that not all of the reports indicate activities on a Watershed specific basis, these numbers are for the entirety of the permitted MS4 areas, not just the Weeks Bay Watershed. Also, the reporting formats are not consistent so some information was segregated or aggregated based on descriptions provided within each report.

*Spanish Fort refers non-compliant sites to ADEM for enforcement.

**Inventory completed in August 2016. ALDOT J. Bearrentine (Pers. Comm.)

NR = not reported.

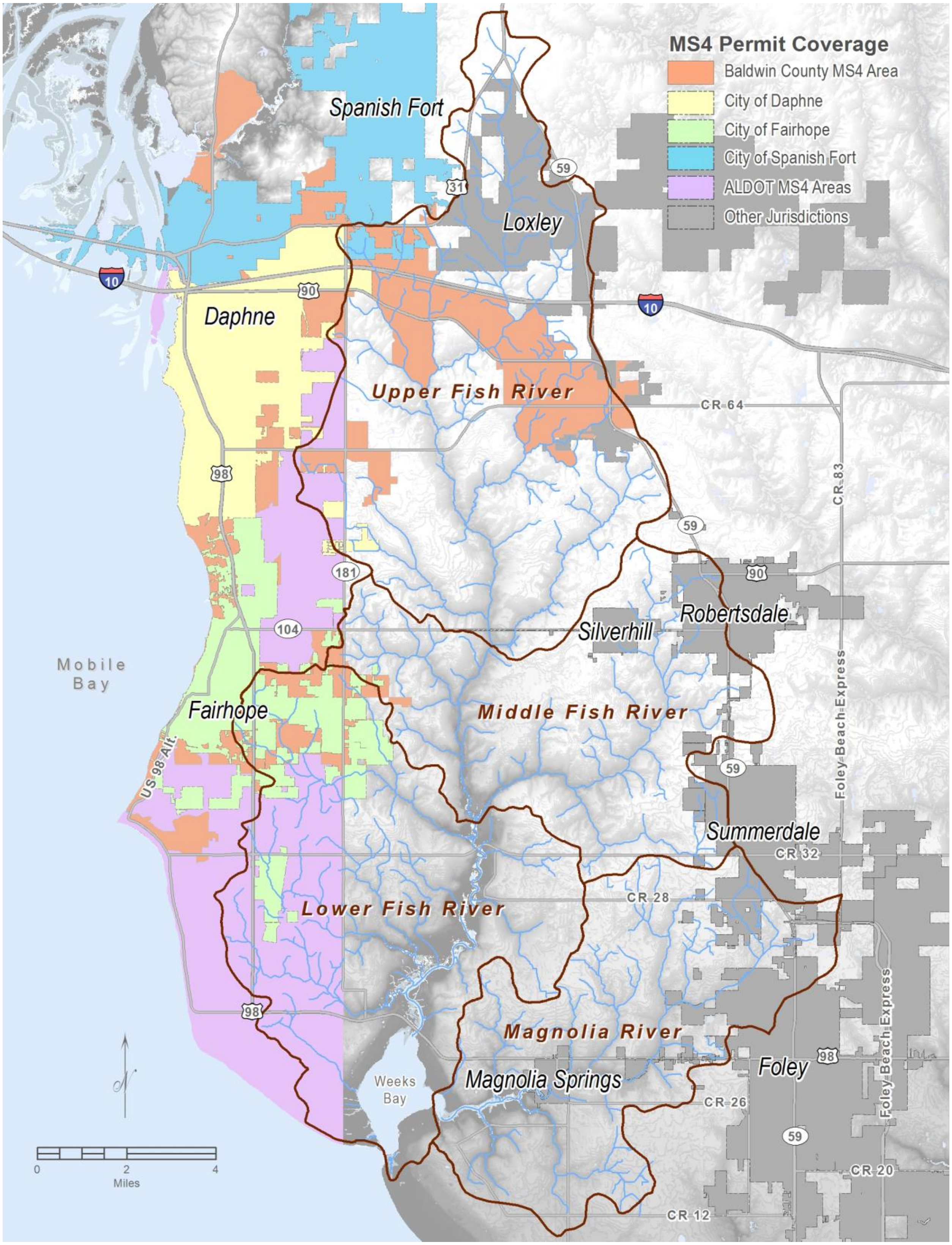


Figure 3.4 MS4 Permit Coverage Areas in Weeks Bay Watershed
Source: Baldwin County 2015 Report, pg. 16/593

Only the City of Daphne and ALDOT are required to conduct water quality sampling under their MS4 permit, but monitoring is for the D'Olive Creek Watershed only. The three municipal permittees have undertaken a number of stormwater management and stream restoration projects, but to date only Fairhope and Baldwin County have had projects within the Weeks Bay Watershed, including: seven "Post-Catastrophic Event Storm Water Activities" in the Cowpen Creek Watershed following the April 29, 2014 rainfall event, and one joint Fairhope-Baldwin County project; three small bio-retention areas, one retention basin and one porous sidewalk project all within the Cowpen Creek Watershed (2013).

3.2 Other Potential Sources of Pollutants

In addition to the permitted discharges of pollutants directly to waterways under the NPDES program, other potential sources of pollution to surface and groundwater may include hazardous waste generators, animal feeding operations, landfills, and various non-point sources (septic tanks, agriculture, etc.). Many of the non-point sources are currently not subject to regulation or permitting requirements.

3.2.1 Regulated Waste Generators

Sites or facilities that generate regulated waste materials (hazardous chemicals, used oil, etc.) are potential sources for surface water or groundwater contamination due to leaks, spills or improper disposal methods. A review of the EPA ECHO data indicates that there are 36 registered generators of regulated waste in the Watershed, most being classified as "categorically exempt" small quantity generators such as automotive repair shops or pharmacies.

3.2.2 Landfills

There are currently two ADEM permitted landfill operations within the Watershed, Magnolia Springs sanitary landfill (ADEM solid waste permit #02-03) and the McBride construction and demolition (C&D) landfill (ADEM solid waste permit #02-11), both operated by Baldwin County.

The Magnolia Springs landfill has a NPDES permit (AL006934) covering stormwater discharges (not including landfill wastes) to an unnamed tributary to Barner Branch and an Undergound Injection Control (UIC) permit (ALSI9902554) for injection of wastewater from the leachate collection and treatment system. Routine monitoring is required under both permits.

The McBride C&D landfill currently does not have a NPDES permit, but held a general permit for stormwater discharges (ALG160077) up to 2011.

3.2.3 Animal Feeding Operations

Although many agricultural activities are not subject to regulation under the Clean Water Act, ADEM does regulate, and require NPDES permit coverage for, certain types animal feeding operations (ADEM Administrative Code R. 335-6-7). Facilities where the equivalent of 300 animal units are concentrated, for a period of 45 days per year, that do not contain crops, are not vegetated or do not produce forage, are considered Animal Feeding Operations (AFOs). Feeding operations with 1,000 animal units are considered Concentrated Animal Feeding Operations (CAFOs). These types of facilities can be a source of nutrient and pathogen pollution from stormwater runoff and inadequate waste management practices. Currently there are no AFO/CAFO operations permitted within the Weeks Bay Watershed.

3.2.4 Non-Point Sources

Other sources of pollution not originating from a discrete discharge location are generally lumped into the category of Non-Point Sources and are generally not regulated under the state or federal water pollution control acts. These include stormwater runoff from non-regulated agricultural activities (crop production, grazing, etc.), silvicultural activities, stormwater runoff from developed areas (outside of designated MS4 areas), bio-solids application sites, septic tanks, and inputs from wildlife. Of these, animal grazing is implicated as a source of organic enrichment in one subwatershed (Baker Branch), fertilizer application is thought to be a source of instream nutrient enrichment, and high runoff rates associated with sod farms is of interest in understanding stream flows. Determining the impacts from non-point sources is difficult due to the diffuse nature of the activities and discharges, and the lack of specific information on when and where they may occur.

3.2.4.1 On-Site Sewage Disposal Systems (OSDS)

On-Site Sewage Disposal Systems (septic tanks) can be a source of pollution when they fail to function properly due to improper siting, lack of maintenance or failure of the disposal system (field lines). In areas where there is no centralized sanitary sewer collection service, septic tanks are the primary option for treatment and disposal of sewage. A permit from the Alabama Department of Public Health (ADPH) is required to install a septic tank and records, although incomplete for systems installed prior to 2001, indicate that there are over 4,300 systems within the Weeks Bay Watershed (Figure 3.5). The majority of the systems are thought to be properly sited and properly functioning. However, many are located in areas that are within a floodplain, close to a waterway, and/or areas with high groundwater or soils having low permeability. There are also septic systems that were installed prior to adoption of the most current siting criteria. Several alternative septic treatment systems, designed to lessen the potential for water quality impacts, have been evaluated and installed within the Watershed. ADEM, through its Coastal Nonpoint Pollution Control Program (ACNPCP) and 319 program, and the Baldwin County Health Department (BDHD) have initiated a number of efforts to help improve OSDS within the Watershed, including: maintenance workshops where pump out vouchers were distributed, and increased OSDS maintenance and inspections (ADEM, 2016).

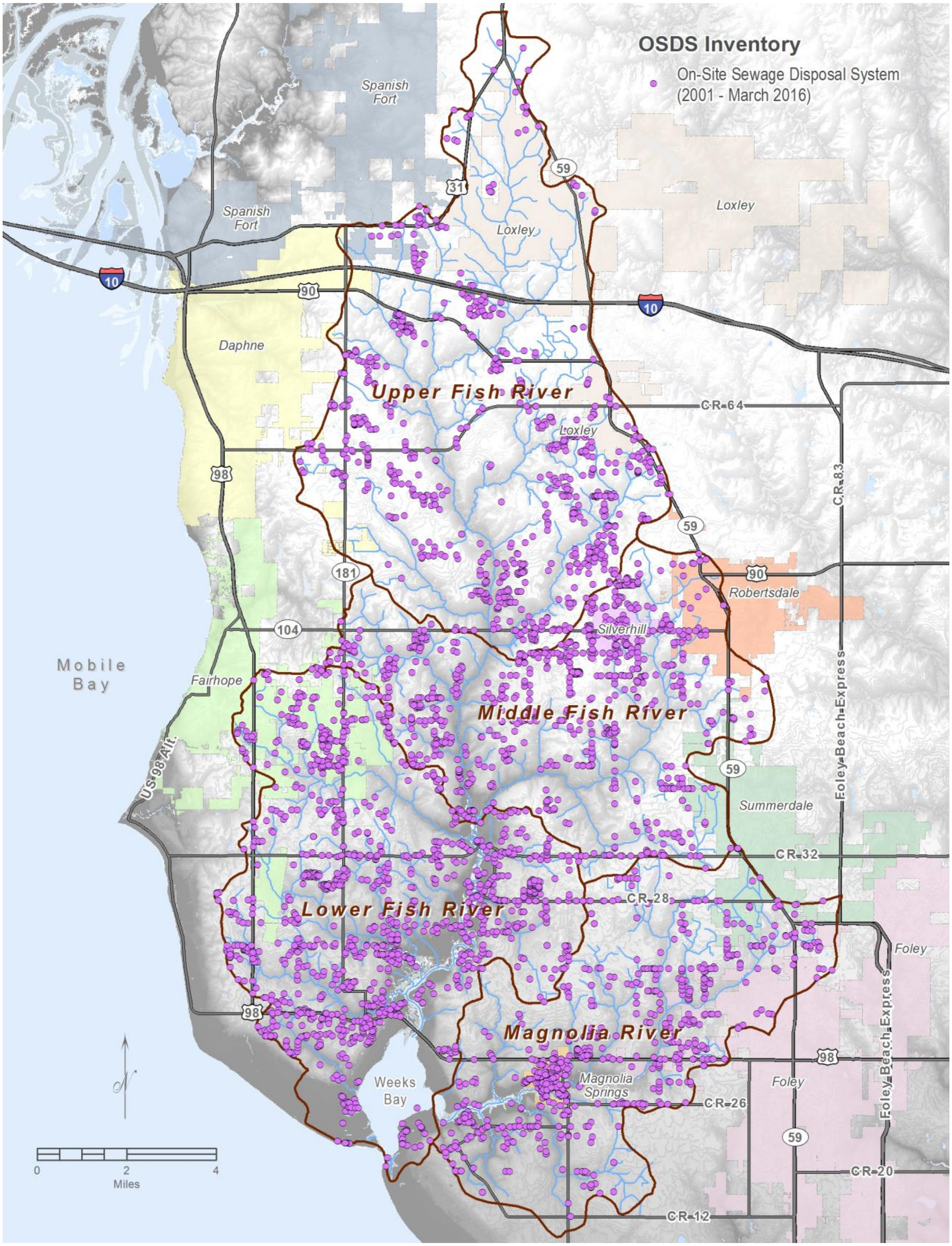


Figure 3.5 On-site Sewage Disposal Systems (Septic Tanks) in Weeks Bay Watershed
Source: Alabama Department of Public Health

Alternative On-site Sewage Disposal Systems, a success story:

The Fish River / Weeks Bay Watershed Management Project recognized early on that improperly sited or malfunctioning OSDS were a potential source of both pathogens and nutrients to the waterbodies feeding Weeks Bay. At that time, it was estimated that 90% of the residents in the Watershed used OSDS. In an effort to test the efficacy of various alternative treatment systems, in 1993 and 1994 two pilot projects were initiated in cooperation with the ADEM, ADPH and EPA Gulf of Mexico Program, both in the lower Fish River Watershed. The first involved the replacement of 20 poorly functioning traditional systems with new Puraflo™ systems which were shown through sampling to achieve an initial reduction of fecal coliform bacteria of 92% (average) that improved to 98% within one year. Follow up sampling two years later indicated similar removal rates were still being achieved. The second project involved the installation of four constructed wetland treatment systems, all in the lower Fish River Watershed. (Gulf of Mexico Program Demonstration Project in Sewage Management – Final Project Report, ADPH. January 13, 1995. Demonstration Project in Onsite Wastewater Management in the Weeks Bay Watershed – Final Report, ADPH September 30, 1996.)

3.2.4.2 Agricultural Activities

With the exception of the aforementioned animal feeding operations, agricultural activities are largely unregulated and are frequently implicated in 303(d) listings, for example "pasture grazing" in Baker Branch. Of particular concern is runoff contaminated with fertilizers, pesticides (insecticides, fungicides and herbicides), and sediment (including turbidity). Certain types of agriculture, particularly turf farms, may also result in increases of stormwater runoff volume and velocity that can result in increased stream and channel erosion. Leaching of the more soluble fertilizers, particularly nitrogen, and chemicals can contaminate shallow groundwater which often is the primary water source for rivers and streams. The environmental impacts from agriculture can be "acute," resulting from a single spill or misapplication of fertilizer or chemical, or "chronic," resulting from normal usage over a long period of time. Sedimentation and turbidity impacts due to erosion of areas in crop production is also of concern, especially where areas with highly erodible soils are in production and or where riparian buffers have been reduced or eliminated. Runoff from areas with higher concentrations of manure, which contains both pathogens and nutrients, and areas where livestock have uncontrolled access to streams are also a concern. Livestock tend to reduce or eliminate riparian areas and "loaf" in and around waterbodies during warm weather. Impacts associated with livestock can also occur in association with large animals kept as "pets," not usually considered an agricultural operation.

A roadside survey of the Watershed was conducted in 2016 by the Thompson Team and several volunteers to locate animal grazing operations and to estimate the number of and type of animals, and to locate current turf farms operations. Estimated livestock, by type, are: Cows: 2,745; Horses/Donkeys: 775; Sheep/Goats: 190; Other: 30 (including oddities such as camels and alpacas). These livestock collectively represent approximately 4,300 animal units (AU). Figure 3.6 shows the relative locations of livestock herd sizes within the Weeks Bay Watershed.

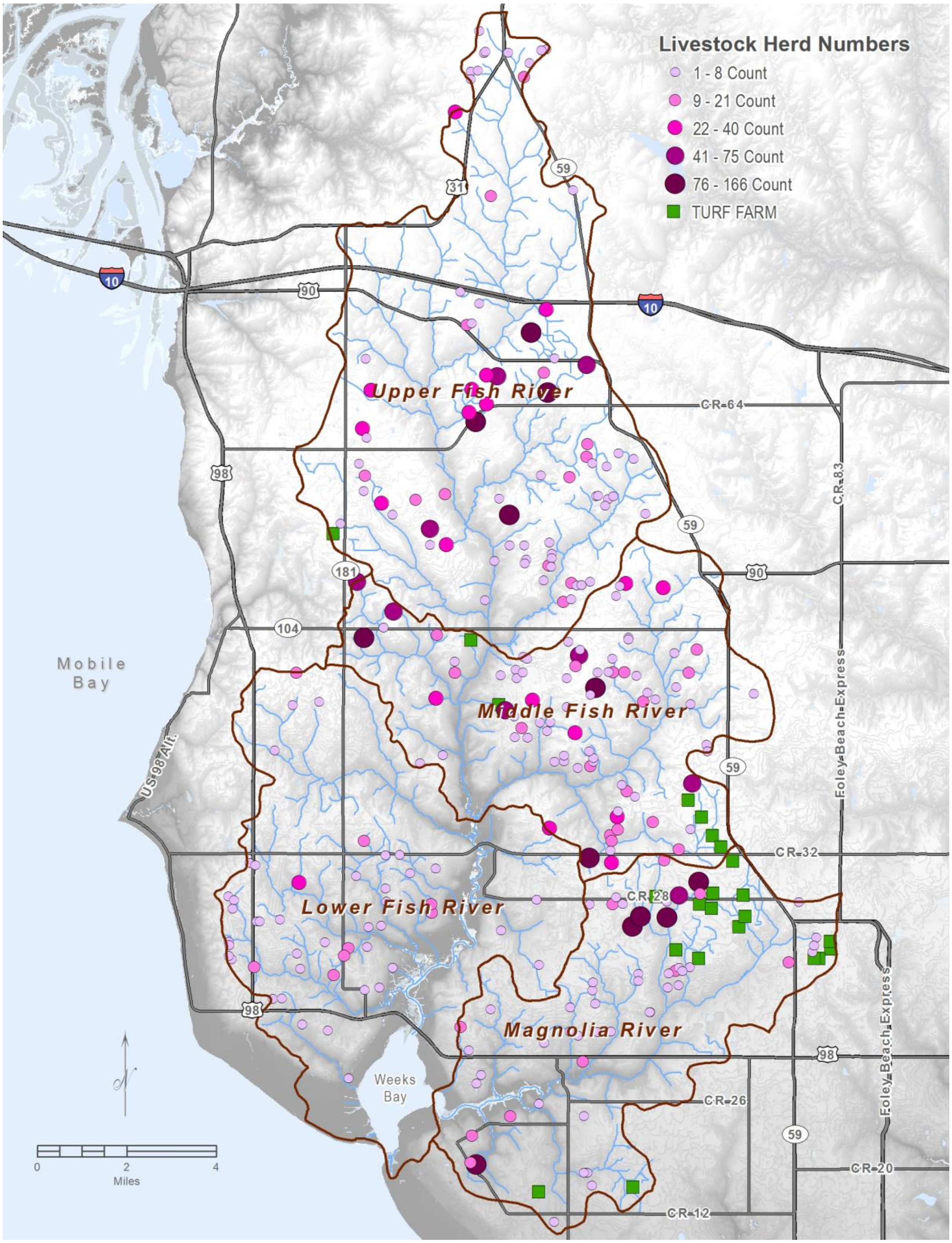


Figure 3.6 Livestock and Turf Farm Inventory in Weeks Bay Watershed

Crop production, both commodity and acreage, vary each year due to normal rotation practices, double cropping and market demand. Each crop will have specific management practices and timing (tillage, fertilization, etc.) that can impact stormwater runoff quantity and quality and the potential for groundwater impacts due to leaching. Data available from the National Agricultural Statistical Service (NASS) (nassgeodata.gmu.edu/cropscape) was referenced to estimate the agricultural landscape of the Weeks Bay Watershed. Data for 2011 (Table 3.5) indicates that approximately 24% of the Weeks Bay Watershed was in cultivated crops and 19% was in pasture/hay production. Although the NASS data for 2011 and 2015 indicated increases of 114%-405% in pasture/hay acreage in the four Subwatersheds, the Thompson Team projected the acreage in pasture/hay production will decrease by approximately 15% in the 2040-High Growth Scenario.

Table 3.5 2011 Agricultural Land Use Summary

Subwatershed	Landcover	Area Acres	% of Subwatershed
Upper Fish River	Pasture/Hay	5,093	12.1
	Cultivated Crops	8,277	19.6
Middle Fish River	Pasture/Hay	7,254	27.1
	Cultivated Crops	7,207	26.9
Lower Fish River	Pasture/Hay	7,266	21.1
	Cultivated Crops	5,400	15.7
Magnolia River	Pasture/Hay	4,838	18.5
	Cultivated Crops	10,663	40.8
Weeks Bay Overall	Pasture/Hay	24,451	18.9
	Cultivated Crops	31,546	24.3

NASS data for 2015 indicates that the primary crops requiring tillage within the Watershed are: peanuts, soybeans, cotton, corn, seed/sod grass (turf), cereal grains (wheat and oats), and potatoes. These primary crops and percent of each Subwatershed (2015) are listed in Table 3.6.

Table 3.6 Percent of Subwatershed Coverage in Various Crops

2015 Crop	Upper Fish 1% = 423ac	Middle Fish 1% = 268ac	Lower Fish 1% = 344ac	Magnolia 1% = 261ac
Corn	1.9	2.4	2.9	2.2
Cotton	4.8	6.7	4.0	3.1
Peanuts	7.1	5.2	6.1	9.8
Soybeans[1]	2.5	7.6	4.6	15.7
Turf Grass	0.4	2.9	2.1	13.0
Sweet Potato	0.9	1.0	0.3	0
Pecans	2.9	2.2	4.4	3.1

Source: NASS

[1]Includes Soybean/Wheat double crop acreage

Turf farms are of particular interest because according to local NRCS authorities turf fields have increased runoff rates, due to cultivation practices, as compared to normal cropping activities or home lawns (personal communication, Joey Koptis, NRCS, Baldwin County). Based on Table 3.6, approximately 5,061 acres of turf farming was located within the Weeks Bay Watershed during 2015. Turf farming represents a higher proportion of land use in the Magnolia River Watershed than in the Fish River Watershed.

Comparing the NASS data for 2015 to the data from 2011 provides some insight into the variability of row crop coverage in the Watershed. For example: in Middle Fish River Subwatershed soybean acreage shows a 568% increase over 2011 acreage, with a similar increase noted in the Magnolia River Subwatershed; turf grass acreage increased in all but the Upper Fish River Subwatershed and now covers 13% of the Magnolia River Subwatershed. The NASS data also indicates that almost all areas classified as fallow cropland in 2011 have been returned to tillage or converted to uses other than agriculture.

There are a number of conservation programs available for both public and private landowners through the NRCS and Farm Service Agency (FSA). A brief description of each appears below (Source: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/).

- Conservation Stewardship Program provides financial and technical assistance to agricultural producers to implement enhanced conservation practices to improve plants for wildlife, grazing management to reduce soil compaction and improve riparian function.
- Environmental Quality Improvement 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 and non-industrial forestland. Within EQIP, the Air Quality Initiative provides financial ass stance to implement conservation practices that address air resource issues (greenhouse gas emissions, ozone precursors, volatile organic compounds, airborne particulate matter, and some odor-related volatile compounds) for designated locations.
- Emergency Watershed Protection Program (EWP) provides financial assistance for recovery efforts in response to natural disasters and is designed to help people conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, drought, windstorms and other natural occurrences.
- Regional Conservation Partnership Program (RCPP) provides for public-private partnerships focused on improving water quality, combating drought, enhancing soil health, supporting wildlife and protecting agricultural viability.
- The Watershed and Flood Prevention Operations Program (WFPO) provides technical and financial assistance to state and local governments for planning and installing watershed projects.

- The Agricultural Water Enhancement Program (AWEP) and the Wildlife Habitat Incentive Program (WHIP) were repealed on February 7, 2014 and new enrollments are no longer accepted. Conservation practices previously covered under the two programs are usually eligible under EQIP.

Through these various programs, there are a number of conservation practices promoted by the Natural Resources Conservation Service (NRCS) that are on-going throughout the Weeks Bay Watershed for various agricultural activities including:

- Cropland: Contour farming, crop residue management, cover crop, crop rotation, field borders, terraces, tile outlet terraces, sod waterways, gully structures, conservation tillage, and sediment retention structures.
- Grassland: Pasture management, controlled grazing, weed control, stream crossing, gully structures, livestock exclusion, and cropland conversion.
- Forestland: Tree planting, planting desirable species, control burning, control undesirable invasive species, water breaks, gully structures, and access roads.

Appendix F contains a copy of the NRCS Conservation Catalog (October 2016) with complete descriptions of the various agricultural practices.

Information from NRCS related to the number of conservation practices and acreages enrolled within the Weeks Bay Watershed for fiscal year 2015 (October 2014 – September 2015) is presented in Table 3.7.

Table 3.7 Conservation Practice Acreages in the Weeks Bay Watershed

Watershed	**Cover Crop**	**Residue/Tillage**	**Nutrient Mngt.**	**Other**
Upper Fish River	1,461	857	1,584	341
Middle Fish River	1,576	0	1,192	68
Lower Fish River	37	0	0	30
Magnolia River	1,560	0	0	94
TOTAL	4,974	857	3,366	533

Source: Joey Koptis, pers. comm., NRCS, Baldwin County, 2017)

Of these practices, the use of cover crops, residue tillage management, and nutrient management appear to be the most prevalent practices enrolled in 2015 (J. Koptis, pers. comm. 2017). ADEM (2016) reported that the increased use of a newly purchased No-Till Grain Drill within the Fish River Watershed on 235 acres resulted in an erosion reduction of approximately 3,943 tons per year (based on Revised Universal Soil Loss Equation calculations). Sediment and nutrient loadings within each subwatershed are discussed in the Sediment Transport and Water Quality sections that follow.

3.2.4.3 Forestry Activities

The land use analysis indicates that approximately 28,000 acres, or 22%, of the Weeks Bay Watershed is forested. The vast majority (approximately 90%) of the forests are classified as evergreen, consisting primarily of longleaf pine and loblolly pine stands. There are also approximately 1,500 acres of mixed forests and 450 acres of deciduous forests within the Watershed. As noted in Section 2.0, forestry and forestry products have long been an economic staple in Baldwin County and the primary driving force for early development.

Potential impacts associated with forestry operations can include habitat alteration or elimination for various endangered species and wetland or water quality impacts from harvest activities or erosion due to land disturbance. Normal forestry operations are not subject to permitting under the Clean Water Act unless they involve the permanent placement of dredged or fill material. In Alabama, the Alabama Forestry Commission (AFC) provides educational and technical assistance to landowners, loggers, foresters, vendors and the general public on forest stewardship and implementation of good forestry best management practices. The AFC has established non-regulatory guidelines for the implementation of best management practices as published in *Alabama's Best Management Practices for Forestry*, 2007 (copy provided in Appendix F). These practices include stream-side management zones, forest road construction, fire break stabilization, harvesting techniques, and stream crossings.

Although Watershed specific information is not available, annual state-wide surveys in 2016 at 253 sites indicate a very high rate of forestry BMP implementation (95%-98%) with very few (23) silvicultural water quality complaints being investigated (AFC, 2017). AFC annual reports may be viewed at: http://www.forestry.alabama.gov/bmpmon.aspx.

The forested subwatersheds within the Watershed usually represent the least environmentally impacted areas, as evidenced by the findings of Cook (2016) and the SWAT model results.

3.2.4.4 Bio-Solids Application

Bio-solids (sewage sludge or animal wastes) application sites, although under the purview of 40 CFR 503, appear mostly unregulated. When permitting is required, the USEPA is the regulatory authority and operators must certify that they comply with the various pathogen and vector reduction requirements of 40 CFR 503. Records of application sites in Alabama, application rates and origin of bio-solids are not readily available. Historically, there have been several application sites throughout the Weeks Bay Watershed and one is currently in operation that applies ~290 metric tons of bio-solids per year on approximately 100 acres of agricultural land south of Highway 90 in the Upper Fish River Subwatershed. Other application sites that have been used (and may still be in use) include: acreage on Highway 104 that received 1,057 dry metric tons (dmt) in 2015 (Middle Fish River); acreage south of CR 32 that received 44 dmt in 2015 (Lower Fish River); 200 acres on CR 24 (Lower Fish River); and 400 acres off Underwood Road (Lower Fish River and Magnolia River) (source: Annual 503 Sludge Reports for 2014 and 2015 available at www.adem.alabama.gov/efile). The Magnolia Springs landfill also has accepted bio-solids and septage (Lower Fish River). Bio-solids are used as soil conditioners and generally have high nutrient value. Depending on the class of bio-solids and the effectiveness of treatment, bacteria are usually low, however several of the analytical reports reviewed indicated fecal coliform values ranging up to 18,000 mpn. Often the application rates are based solely on nitrogen concentration and nitrogen uptake rates for specific plants and can result of over application of other nutrients, particularly phosphorous.

Animal manure, particularly poultry litter, is also often used as a soil conditioner and/or for its nutrient value. This practice was popular throughout Baldwin County for several years around 2008, and early application rates were based solely on nitrogen until tests revealed excessive phosphorus build up in the soil. Application rates were then calculated based on phosphorous, which greatly reduced the amount of nitrogen being applied and has led to the decline in use of poultry litter in recent years (Northcutt, Morris, pers. comm. 2016).

3.2.4.5 Mercury

As previously mentioned, the presence of mercury (Hg) and other pollutants in fish tissue at certain levels triggers the issuance of a consumption advisory by the Alabama Department of Public Health (ADPH) and subsequent inclusion on the 303(d) list. These advisories are intended to provide information and guidance on the consumption of fish and shellfish to the public. The advisories apply mainly to “at-risk” groups, e.g. babies, children under the age of 14, and women who are nursing, pregnant or who plan on becoming pregnant.

Table 3.8 Waterbodies with Mercury Fish Consumption Advisories

Waterbody	Sample Location	Species	Advisory
Cowpen Creek	Upstream of confluence with Fish River	All Species	Do Not Eat Any
Fish River	~1 mile above Hwy 32 bridge	Black Crappie Largemouth Bass Striped Mullet	1 meal/month Do Not Eat Any No Restriction
Fish River	~2 miles above US 98 bridge	Largemouth Bass Striped Mullet	Do Not Eat Any No Restriction
Magnolia River	~2.5 miles above Weeks Bay	Largemouth Bass Striped Mullet	Do Not Eat Any No Restriction
Polecat Creek	Upstream of Fish River	All Species	Do Not Eat Any
Weeks Bay	Main channel between boat ramp and US 98 bridge	All Species	No Restriction

Source: ADPH, 2017. ADPH Fish Consumption Advisory Website http://adph.org/tox/index.asp?id=1360

Fish samples are routinely collected and analyzed by ADEM and the results, along with information on the type and size of fish and sampling locations are provided to ADPH. Based on this information, ADPH may issue a consumption advisory for fishes caught from all or portions of a waterway. These advisories can include: “no consumption,” “1 meal per week,” “1 meal per month,” or “no restriction” and may relate to one or more species of fishes. A meal is considered one 8-ounce serving. Once issued these advisories remain in effect until rescinded by ADPH. There is no evidence that incidental ingestion or full body contact with any waters of the Weeks Bay Watershed is a health concern due to mercury. To learn more about fish consumption advisories, visit Food and Drug Administration's (FDA) Website at http://www.fda.gov/Food/ResourcesForYou/Consumers/ucm110591.htm. or go to the USEPA Website at www.epa.gov/ost/fish.

There are a number of water bodies that currently have ADPH fish consumption advisories within the Weeks Bay Watershed (see Table 3.8). Each waterbody included in Table 3.8, in its entirety, is also included on ADEM's 2016 303(d) list for mercury impairment. Section 303(d) listings based on consumption advisories only occur on streams where there are routine fish tissue monitoring sites, however due to the pervasive nature of the suspected source (atmospheric deposition) and similar water chemistry, it is likely that Hg levels are elevated in the same and similar fish species throughout the Watershed.

The source of mercury included in the 303(d) list is atmospheric deposition, although Hg occurs both naturally in the environment (i.e. cinnabar, etc.) and from various anthropogenic sources (i.e. industrial processes, waste incineration, coal burning, etc.), both present and historical. Mercury, once vaporized, may persist in the atmosphere for days up to a year (depending on species) and can be transported for great distances. Transport and deposition of atmospheric mercury is monitored nationally via the National Atmospheric Deposition Program (NADP) - Mercury Deposition Network (MDN) and up until 2009 there were two MDN sites operated by ADEM in close proximity to Weeks Bay (AL02 - Delta Elementary School Baldwin County and AL024 – Bay Road Mobile County). There is currently a site near Pensacola, FL (FL96) that is the closest actively monitored NADP site. A cursory review of the historical Alabama MDN data (2008-2009) indicates that wet Hg deposition rates ranged from 6 to 2,498 ng/m^2, which is generally consistent with the values from 2004 as reported by Monrreal (2007). The more recent data from the Pensacola site (2015-2016) indicates wet deposition rates ranging from 6 to 734 ng/m^2. No dry deposition of mercury was reported at any of the three sites for the time period reviewed (source: http://nadp.sws.uiuc.edu/mdn/).

Mercury persists in the environment and under certain conditions will transform to methyl-mercury which is the form that is readily taken up by organisms and bio-accumulates. The natural water quality conditions present in coastal streams, primarily the amount of dissolved organic matter, higher temperature, low pH and, to a lesser degree, fluctuations in salinity (chlorides) and low dissolved oxygen, are thought to be particularly conducive to the methylation process. Bays and estuaries are thought to be "sinks" or "traps" for mercury and most coastal streams in the United States have mercury related fish consumption advisories, as does the Gulf of Mexico, for long-lived top predator species.

3.3 Surface Water Flow

Surface water flows, both volume and velocity, are naturally influenced by geology, topography, soils, hydrology, land use and rainfall. Anthropogenic influences primarily involve manipulations of land cover (converting forest to agriculture or urban uses, increasing impervious surfaces, creation of impoundments, etc.). (Note: See sections 2.8.3 and 3.7 for further discussion of Impervious Cover impacts.) Increased urbanization and an increase in impervious surfaces may also contribute to higher "flashiness" in a watershed (Morrison, 2011). Morrison further opined that estimates by Singh (2010) indicating a decrease in average monthly flows between two study periods, 1994-1998 and 2008-2010, at Pensacola Branch and Green Branch, were probably due to shifts in land use changes.

Base flow, or low flow rates, for the streams within the Weeks Bay Watershed are driven by groundwater. O'Neil and Chandler (2003) reported that the Miocene-Pliocene and alluvial aquifers are the primary sources of water for springs and seeps, and that 7-day low flows greater than 0.5 cfs per square mile, as reported within the Watershed, are above average for the state. The SWAT model estimates that, on average, >50% of the water yield within each Subwatershed is from groundwater. Stream discharge rates usually correlate to pollutant loadings (sediment, nutrients, bacteria, etc.). Long-term surface water flow data are available from the USGS at two locations within the Weeks Bay Watershed: Fish River at U.S. Highway 104 (USGS 02378500) and Magnolia River at U.S. Highway 98 (USGS 02378300); and is available on the internet (https://nwis.waterdata.usgs.gov/al/nwis/).

In 2011, Hydro Engineering Solutions (HES) completed a hydrologic analysis on the Fish River and Magnolia River Watersheds for various rainfall events under varying development scenarios to assess the impact of regional detention on flooding along the lower reaches of Fish River. The study concluded that, in both basins, undetained development in the headwaters cause a greater impact to the peak discharges on the river than those in the lower part of the basin. In the Fish River basin, development in more northern areas, particularly Belforest and Spanish Fort, have the greatest impact to the discharges on Fish River, with Belforest being the most sensitive Subwatershed. Fish River peak discharges (100-year storm) at Alabama Highway 104, CR 48 and U.S. Highway 98 were estimated to increase under the developed conditions modeled by 8%, 10% and 3%, respectively.

3.3.1 Upper Fish River Subwatershed Flow (HUC 031602050201)

The primary source of information on stream flow on Fish River is the USGS gauging station located at U.S. Highway 104 within the lower reaches of the Upper Fish River Subwatershed. Figure 3.7 shows the mean daily discharge for Fish River at Highway 104 measured by the USGS from November 2011 to November 2016. Figure 3.8 shows stream flow in Fish River measured during the dry period in October and November 2016, which indicates a baseline low flow well above the lowest mean daily flow of 35 cfs recorded in 2011.

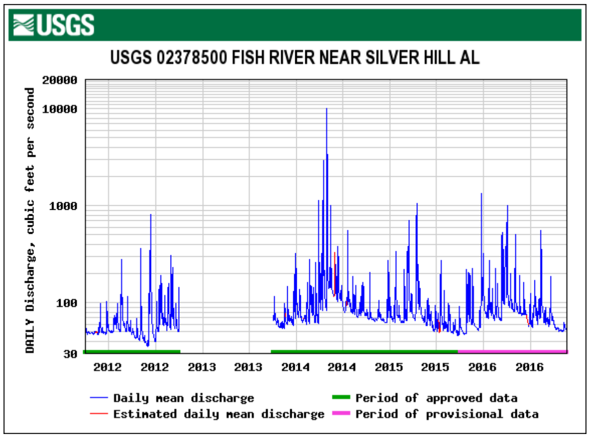


Figure 3.7 Fish River Mean Daily Discharge

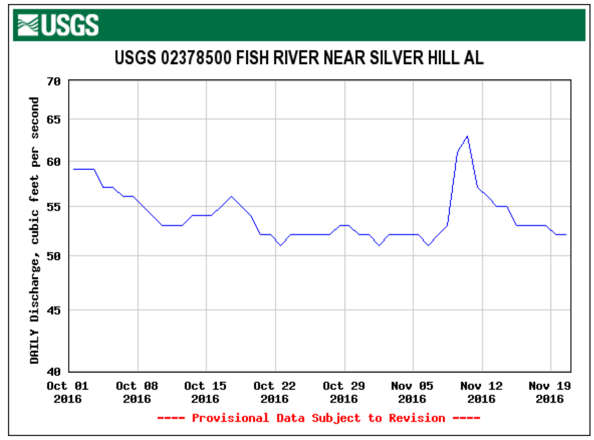


Figure 3.8 Fish River Dry Period Flow

Annual summary statistics for the USGS site from 1953-2015 indicate an average annual (calendar year) discharge of 113 cfs, the minimum annual flow of 52.7 cfs (1968) and the maximum annual flow of 191.1 cfs (1998).

Also, a number of tributaries within the upper portion of the basin have been measured directly or the flow estimated by various models. O'Neil and Chandler (2003) measured flow on Fish River at U.S. Highway 90 during 1994-1998, reporting values ranging from 10.6 cfs to 1,320 cfs (median of 25.9 cfs). Additional measurements were reported for Corn Branch, Caney Branch, and Perone Branch ranging from 2.1 cfs to 480 cfs. Morrison (2011) reports median daily flows for: Fish River at U.S. Highway 90 of 15.5 cfs; Corn Branch at CR 64 of 0.14 cfs; Perone Branch at Alabama Highway 104 of 16.9 cfs; and 77.7 cfs on Fish River at Alabama Highway 104. ADEM (2013) measured stream flow on Fish River at Alabama Highway 104 on several occasions in 2011 and 2012 and selected 179 cfs for TMDL development. Cook (2016) monitored flow at 7 sites in the Upper Fish River Subwatershed with main stem flows ranging from 83 cfs to 764 cfs. Tributary flows ranged from 54 (Bay Branch at U.S. Highway 90) to 150 cfs (Perone Branch at Alabama Highway 104). Most other investigators (Lehrter, 2006; Singh, 2010, etc.) estimate river and tributary flows based on various models, relying on the USGS gauging station at Alabama Highway 104 for calibration data.

3.3.2 Middle Fish River Subwatershed Flow (HUC 031602050202)

O'Neil and Chandler (2003) measured flow at 4 sites within the Middle Fish River Subwatershed and reported: Fish River (at CR 48) with a range of 79.7 cfs to 10,000 cfs with a median of 108 cfs; Polecat Creek (at CR 9) with a range of 29.1 cfs to 220 cfs with a median of 34.5 cfs; Baker Branch (at CR 55) with a range of 1.3 cfs to 48.7 cfs with a median of 2.22 cfs; and Pensacola Branch (at CR 48) with a range of 2.63 cfs to 31.4 cfs with a median of 4.52 cfs. Morrison (2011) reports median daily flow values of: 5.3 cfs in Pensacola Branch at CR 48; 21.2 cfs in Polecat Creek at CR 55; and 3.2 cfs in Baker Branch at CR 55. Cook (2016) monitored the same 4 sites plus one additional site on Polecat Creek at CR 9, reporting an average flow of: 723 cfs for Fish River at CR48; 298 cfs at Polecat Creek at CR 9; 293 cfs at Polecat Creek at CR 55; 105 cfs at

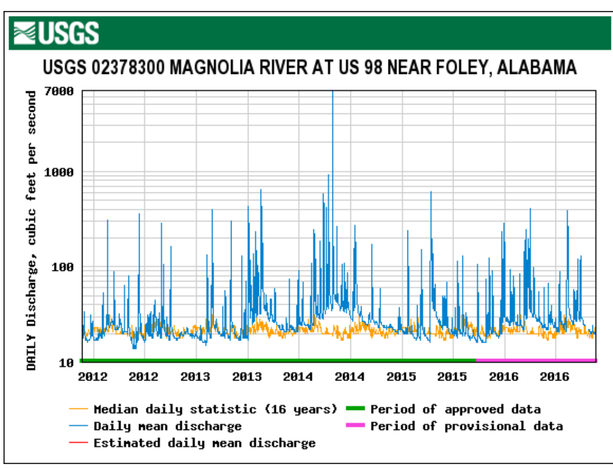
Baker Branch; and 136 cfs at Pensacola Branch. Flows for other tributaries within the Middle Fish River basin have been estimated based on models.

3.3.3 Lower Fish River Subwatershed Flow (HUC 031602050204)

Stream flows in the Lower Fish River Subwatershed have been measured by O'Neil and Chandler (2003) in Turkey Branch at Alabama Highway 181 (0 cfs to 41 cfs) with a median of 0.25 cfs; Cowpen Creek at CR 33 (5.4 cfs to 59.9 cfs) with a median of 8.2 cfs; and Fish River at U.S. Highway 98 (182 cfs to 23,000 cfs) with a median of 255 cfs. Morrison (2011) reports median daily flows of: 6.0 cfs in Cowpen Creek at CR 33; 0 cfs in Green Branch at Danne Road; and 0.11 cfs in Turkey Branch at Alabama Highway 181. Cook (2016) monitored flow at 5 sites and reports average discharges of: 168 cfs for Cowpen Creek at CR 33; 86 cfs for Green Branch at Danne Road; 152 cfs for Waterhole Branch at Highway 181; 174 cfs for Turkey Branch at Alabama Highway 181; and 764 cfs for Fish River at CR 32.

3.3.4 Magnolia River Subwatershed Flow (HUC 031602050203)

The primary source of information on stream flow on Magnolia River is the USGS gauging station located at U.S. Highway 98 near Foley Alabama. Data from this location has been utilized by a number of investigators and represents the only available long term flow history for the Magnolia River Watershed. Figure 3.9 shows the mean daily discharge measured by the USGS from November 2011 to November 2016. Figure 3.10 shows stream flow measured in Magnolia River during the dry period in October and November 2016, which indicates a base low flow above the long-term mean daily flow and well above the lowest mean daily flow of 8.5 cfs recorded in 2002.



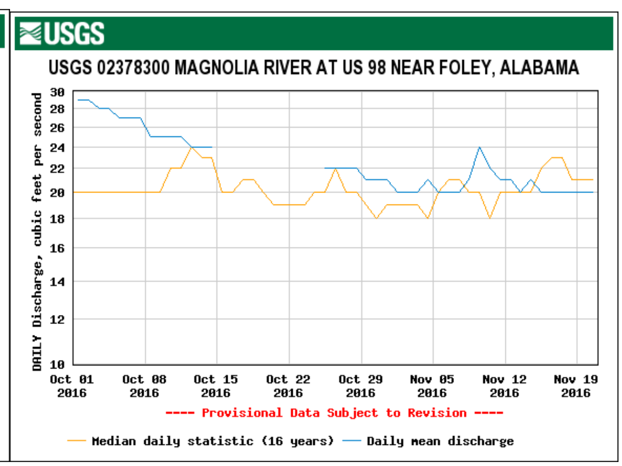


Figure: 3.9 Magnolia River Historical Flow **Figure: 3.10 Magnolia River Dry Period Flow**

Annual summary statistics for the USGS site from 1999-2015 indicate an average annual (calendar year) discharge of 38.2 cfs, the minimum annual flow of 23.6 cfs (2007) and the maximum annual flow of 101.7 cfs (2005).

O'Neil and Chandler (2003) measured flow at six sites in the Magnolia River Watershed and reported values of: 2 cfs to 25.8 cfs in Magnolia River at CR 24 with a median of 5.4 cfs; 18.8 cfs to 140 cfs in Magnolia River at CR 49 with a median of 39.5 cfs; 0.03 cfs to 26 cfs in Eslava Branch at U.S. Highway 98 with a median of 0.05 cfs; 0.1 cfs to 59 cfs in Weeks Creek at CR 26 with a median of 0.53 cfs; 0.04 cfs to 33.6 cfs in Schoolhouse Branch at U.S. Highway 98 with a median of 0.77 cfs; and 1 cfs to 14.6 cfs in Brantley Branch at CR 24 with a median of 2.8 cfs.

ADEM (2006) in their Monitoring Summary reported a range of flow measurements on Magnolia River at CR 65 (upper 7 mi^2 of the basin) between 2.1 cfs and 27.2 cfs. By comparison, Lehrter (2006) reported the median annual discharge for the Magnolia River in 2000 and 2001 as 16.9 cfs and 20.5 cfs, respectively.

The Geological Survey of Alabama (Cook et.al., 2009) measured stream flow characteristics at 8 of 10 sites within the Magnolia River Watershed, reporting flow ranges of 0.1 cfs to 16 cfs on the smallest tributary, up to a range of 14.0 cfs to 1,380 cfs on Magnolia River at U.S. Highway 98. Stream gradients varied from 5 ft/mi up to 30 ft/mi and stream velocities ranged from 0.02 ft/s to 1.9 ft/s on Weeks Creek at CR 49 to 0.3 ft/s to 7.0 ft/s on Weeks Creek at Bay Road. The average discharge for the Magnolia River (at U.S. Highway 98) reported by Cook et al. (2009) was 33.4 cfs.

As evidenced in the narrative above, flows within Fish and Magnolia Rivers and their tributaries are highly variable, in many instances fluctuating by orders of magnitude over relatively short time periods. The "flashiness" of the tributary streams is due to topography, with stream gradients ranging from 5-38 ft/mi (Cook 2016), rainfall intensity, and land use changes. Reasonable and accurate flow estimates are obviously critical to estimating pollutant loadings generated within the various Subwatersheds.

3.4 Sediment Transport

The impact of sediment on aquatic systems is one of the leading causes of stream impairment in the United States. Excessive sediment delivery can cause a number of biological (disruption of the food web, smothering of benthic organisms, irritating or clogging fish gills, impairing spawning of fish, screening out sunlight, etc.) and physical impacts (reducing hydraulic capacity, increased flooding, loss of navigation, increased maintenance costs for stormwater management systems, etc.). Sediment can be generated from upland sources in the form of sheet, rill or gully erosion and transported to nearby waterbodies during stormwater runoff events. Sediment can also be generated from stream and channel erosion due to stream scour and bank erosion due to increases in stream flow (velocity and/or volume) resulting from increases in stormwater runoff associated with development or agricultural practices. Erosion is the process whereby soil particles are detached from the land surface and sedimentation is the process where eroded soil particles are transported from areas of higher elevation and deposited in areas of lower elevation. These processes are influenced by a number of factors, including topography, climate (precipitation), soil types, and land use and land cover (LULC).

Sediment is usually characterized as suspended sediment or suspended solids (particles suspended in the water column) or as bed load. Sediment or soils with a high percentage of "fines" (clay, muck, fine silts) are the primary contributors to turbidity in waterbodies. There currently are no state or federal water quality standards for sediment or sedimentation, however there are standards associated with turbidity as a result of stormwater or point source discharges (Section 3.1.2). Since there are no formal sediment loading criteria, assessment efforts usually will use only relative comparisons (e.g. "this subwatershed has a higher sediment yield than another") or will compare to yields or loadings to some generally accepted "natural" or "acceptable" projection.

Sediment yields or loading are often related to land use and land cover within a watershed and several sediment related studies have been conducted within the Weeks Bay Watershed (Singh, 2010; Cook, 2016; Cook, et al., 2009; Niraula et al., 2012). There are a number of various watershed models that have been used to assess water quantity and quality relative to LULC changes, one of the most common being the USDA's Soil and Water Assessment Tool (SWAT) (Niraula et al., 2012; Singh, 2010; Morrison, 2011; Kalin, 2017). The SWAT model was developed in 1990 by merging two earlier water quality models (Gassman et al., 2007) and is particularly suited to watersheds having a high percentage of agricultural land use. This model was employed to assess relative sediment and nutrient delivery rates from various Subwatersheds of the Fish and Magnolia River Watersheds over time (2011 to 2040) using both a moderate and a high population growth/development rate. Earlier SWAT modelling efforts estimated that, at the Subwatershed level, ~27% of the Watershed area was contributing half of the total sediment yield in the Fish River Watershed (Singh, 2010); and that about 10% of the area was responsible for 36% of the sediment yield in the Magnolia River Watershed (Niraula et al., 2012). Generally speaking yield and load can be defined as:

- Yield is the quantity (water, sediment, etc.) leaving the watershed or subwatershed over a certain time period (usually a year or longer). It is usually given per unit area.
- Load is used with water quality and is flow*concentration, thus has a unit of mass per unit time (e.g., kg/s, ton/day). When you talk about total load over a certain period then it becomes similar to yield.

The SWAT model created specifically for this Watershed planning effort (Kalin, 2017 – Appendix G) estimates that, at the subwatershed level, 20% of the area yields 50% of the sediment in the Fish River Watershed, and 34% of the area yields 50% of the sediment in the Magnolia River Watershed. At a finer scale (Hydrological Response Unit (HRU)), the model estimates that 11% of the total Watershed is responsible for 50% of the sediment load in Fish River and that 50% of the area is contributing 99% of the entire sediment load. In the Magnolia River Watershed, 23% of the total Watershed area is responsible for 50% of the sediment load and 50% of the area generates 79% of the total load. These model estimates are indicative of very concentrated or localized sources within these Watersheds. Documentation of the Weeks Bay Watershed SWAT modelling effort is in Appendix G. The results of the SWAT model sediment yield and other pertinent sediment studies are summarized in the sections below and Figures 3.11 and 3.12 graphically represents the SWAT model predictions for sediment yield vs area in

Fish River and Magnolia River Watersheds, respectively. Figure 3.13 represents the SWAT subwatershed level loading estimates for the 2011 baseline and two future 2040 growth (medium and high) scenarios. The lowest numeric category (lightest shading) represents sediment yields that roughly correspond to ADEM's (2010) ecoregion reference reach Total Suspended Sediment (TSS) value. The subwatersheds depicted in darker shading have higher than the ADEM ecoregion reference values and generally correspond to areas with high agricultural use. These subwatersheds also correspond well with those identified as having only fair or poor wetland and riparian buffer habitats. It is recommended that efforts to implement sediment loading reduction management measures (BMPs, restoration, etc.) be focused in those subwatersheds with the highest sediment yield (darkest shading).

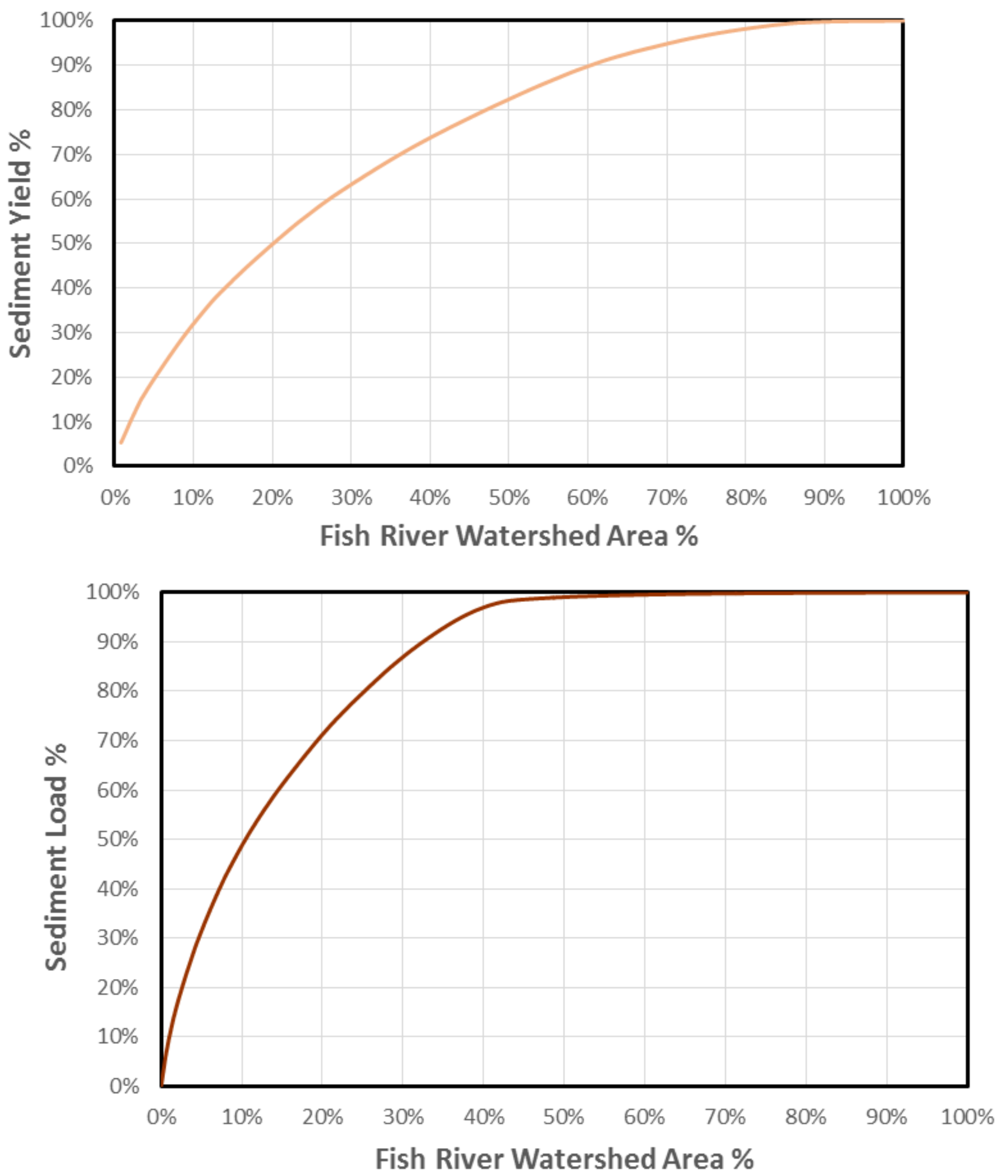
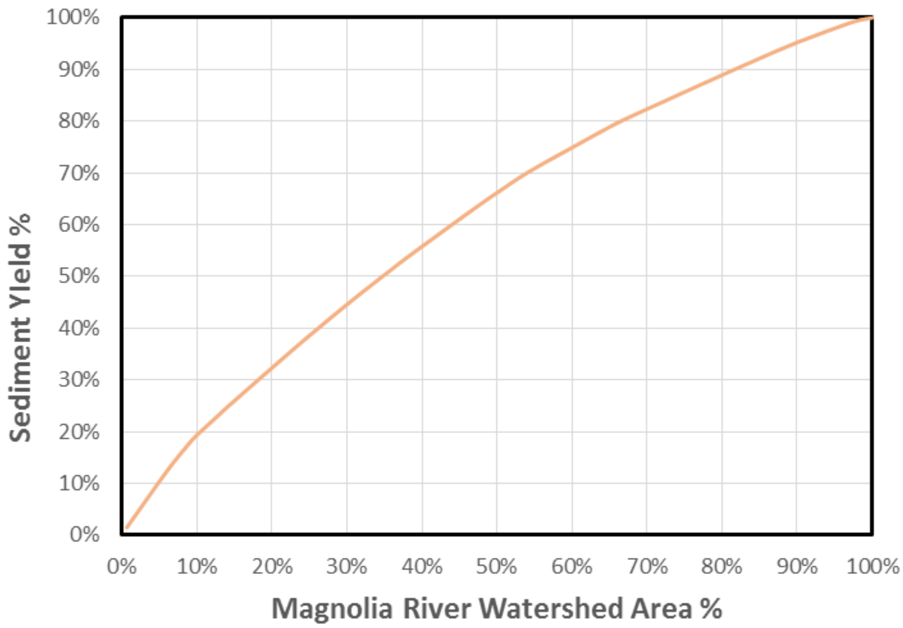


Figure 3.11 SWAT Subwatershed Level Sediment Yield (Top) and Hydrologic Response Unit Loading (Bottom) vs Area in the Fish River Watershed
Source: Kalin, 2017



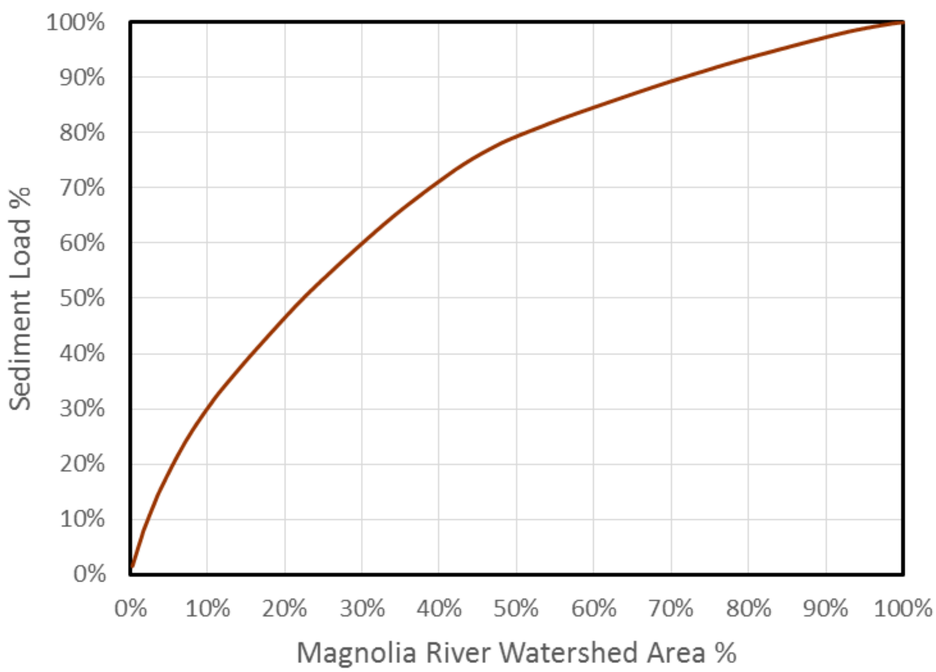


Figure 3.12 SWAT Subwatershed Level Sediment Yield (Top) and Hydrologic Response Unit Sediment Loading (Bottom) vs Area in the Magnolia River Watershed
Source: Kalin, 2017

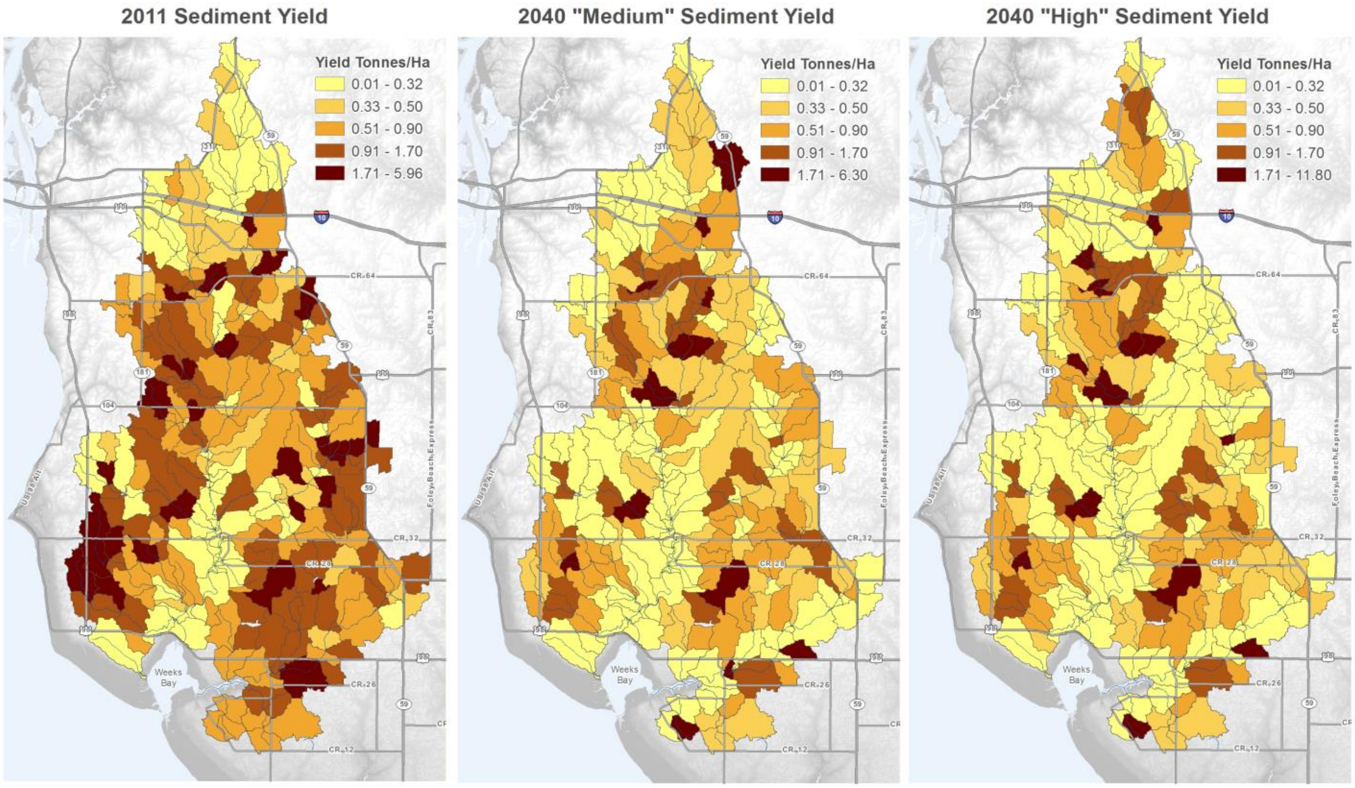


Figure 3.13 SWAT Model Sediment Yields for 2011, 2040med, & 2040high Scenarios
Source: Kalin, 2017

Although the SWAT predicts that subwatershed level sediment yield may actually decrease by 2040, overall sediment loadings and instream TSS concentrations are predicted to increase up to 50%. Erosion and sediment transport are extremely complex processes. Once the eroded sediment from the subwatersheds (net erosion=total erosion – deposition) are transported to the streams, other processes take place: channel bed erosion, channel bank erosion, channel bed deposition, and floodplain deposition. Any of these processes can happen on any day depending on the supply/demand in the stream. If the sediment supply is less than the sediment transport capacity of the stream (which is a function of flow velocity and discharge) then the deficit could come from the stream bed and bank. The stream bed and bank erodibility is important; for example consider a concrete channel, which cannot supply the extra sediment to meet the deficit. On the contrary, if supply exceeds the transport capacity, then the excess sediment will be deposited to the stream bed or during larger storms sediment can deposit into the floodplain also.

The SWAT model considers all these mechanisms. When looking at the more detailed SWAT outputs, channel bed erosion and deposition play a significant role in these Watersheds. Below is summarized the annual average sediment load (in metric tons) transported to reaches from the SUBWATERSHED and the sediment load leaving the outlet for the Fish River Watershed REACH into Weeks Bay:

	SUBWATERSHED	REACH
2040High	21,010	25,896
2040Med	22,045	21,903
2011	36,786	19,361

In 2011 there is a lot of sediment deposition. There is actually a good amount of stream bed erosion too, but deposition exceeds erosion (thus net deposition). When looking at the projected more urbanized 2040 future scenarios, especially 2040High, there is additional sediment coming from the stream bed/bank erosion. This is likely because of the flashier hydrology expected in the future due to increased urban land uses, which increases the sediment transport capacity of the streams and thus leads to stream bed/bank erosion. An interesting side note is that according to local NRCS staff, turf farms are reported to have runoff rates more similar to urban areas due to the soil compaction associated with this land use (personal communication, Joey Koptis, NRCS, Baldwin County). Projected sediment loadings to Weeks Bay for the 2040High scenario are predicted by the SWAT models to increase by 34% and 12%, respectively, from the Fish and Magnolia Rivers.

3.4.1 Upper Fish River Subwatershed Sediment

Currently, LULC in the Upper Fish River basin is primarily forest with small areas of agricultural and urban development encroaching primarily from the west side of the Watershed in the Spanish Fort and Belforest areas. (Note: See Section 2.8 for discussion of LULC changes in the Watershed.) The current SWAT model for existing conditions seems to validate earlier work by Singh (2010), and more recent work by Cook (2016), indicating that the mainstem Fish River Watershed above Interstate 10 has low sediment delivery rates. This is generally consistent with the findings of Cook (2016) indicating that Fish River at I-10, Threemile Creek and Bay Branch all have sediment loadings at or below the natural geologic erosion rate of 64 t/mi^2/yr. The upper-most portion of this subwatershed, known locally as the "Golden Triangle," was recently incorporated into the Town of Loxley and is projected to have among the highest projected growth rates over the next several decades.

Also within the Upper Fish River portion of the Watershed, upper Corn Branch was observed to have the highest normalized annual total sediment load at 689 t/mi^2/yr, indicative of excessive erosion (Cook 2016). The intermittent streams that drain the upper reaches of Corn Branch have severely eroded channels and little or no riparian buffer as evidenced on aerial imagery (Google Earth™). Perone Branch, which drains the southeastern portion of the Upper Fish River Watershed, has annual total sediment loading similar to Corn Branch but, when normalized based on drainage area (196 t/mi^2/yr), is high but only about 1/3rd that of Corn Branch. This is likely due to the fact that the very upper reach of Perone Branch is impounded and the lower portions of the main channel, and most secondary tributaries, have substantial riparian buffers.

The SWAT model estimates that the total sediment loading from the Upper Fish River is 0.52 t/ha/yr (148 t/mi^2/yr) which equates to annual loading of approximately 8,737 metric tons. The model also predicts that by 2040 the total annual loading will increase by 26-50% (compared to 2011) due primarily to the conversion of forested area to residential or commercial development.

3.4.2 Middle Fish River Subwatershed Sediment

The Middle Fish River Subwatershed is significantly smaller and has more agriculture (east side) and a significant amount of urban development (west side), particularly at the headwaters of Pensacola Branch. These differences are reflected in the sediment yields and loadings estimates of the SWAT model and were noted by Cook (2016) who reports that Pensacola Branch has the highest normalized suspended sediment (778 t/mi^2/yr), elevated levels of bed load sediment (1,253 t/mi^2/yr), and high total sediment loadings (9,744 t/yr). This is accompanied by one of the highest average runoff rates per unit area reported by Cook (2016) of 28 cfs/mi^2. Morrison (2011) and Singh (2010) also report changes in hydrology and relatively high TSS, attributed to increased urbanization, in the Pensacola Branch basin.

Polecat Creek and its tributaries drain the east side of the Watershed and is the largest tributary to the middle Fish River segment. The extreme headwaters of Polecat Branch, east of Highway 59 and immediately west of Highway 59, drain agricultural areas and appear to have little to no riparian buffer and show signs of severe erosion. However, the remainder of the main stem and secondary tributaries appear to have good riparian buffers that, coupled with a number of small impoundments, seem to mitigate overall total sediment loadings. Total sediment loadings (normalized) on Polecat Creek proper are among the lowest in the Fish River Watershed at 107 t/mi^2/yr (Cook 2016).

Baker Branch, a tributary to Polecat Creek, has slightly higher total sediment loadings (116 t/mi^2/yr) and a relatively high average discharge per unit area at 26 cfs/mi^2 (Cook 2016), about twice that of Polecat Creek. The higher flow rate is indicative of sod farms throughout the upper reaches of the sub-basin.

The SWAT model predicts that total annual sediment loading from the middle Fish River Subwatershed is 15,564 metric tons or 0.56 t/ha/yr (160 t/mi^2/yr) and that total annual sediment loading within the Middle Fish River Subwatershed will increase 5-15% by 2040.

3.4.3 Lower Fish River Subwatershed Sediment

The Lower Fish River Watershed receives only minor drainage from the east side, the majority of inflow being from the west, the major tributary being Cowpen Creek that drains a portion of the City of Fairhope and surrounding urbanized area. The suspended sediment load, bed load sediment and total sediment loadings were all among the highest reported by Cook (2016), second only to Pensacola Branch, and when normalized by unit area, Cowpen ranked third highest for total sediment loading at 546 t/mi^2/yr (Cook 2016). The relatively high sediment contributions are consistent with the SWAT model loading estimates within the Cowpen Creek basin. Currently, the upper reaches of the basin are highly urbanized, particularly east of Highway 181 and north of Red Barn Road, with a high concentration of detention ponds. Similar loadings and aquatic impacts were not noted in earlier studies (O'Neil and Chandler, 2003), but elevated total suspended solids were noted by Morrison (2010).

Other tributaries on the west side of Fish River that were monitored by Cook (2016) include Green Branch, Waterhole Branch and Turkey Branch. All three tributaries appear flashy and have high reported average discharge rate per unit area (27 - 31 cfs/mi^2) and similar total sediment loads (normalized) ranging from 119-158t/mi^2/yr. Total suspended sediment concentrations reported by Morrison (2010) in both Green Branch and Turkey Branch from the period 2008-2010 are consistently lower than those recorded by Cook (2016) in the winter and spring of 2016. The SWAT model estimates for sediment loading in these sub-basins (Green Branch, Waterhole Branch and Turkey Branch are generally consistent with the aforementioned studies. Aerial imagery (Google Earth™) indicates that agricultural activity (row cropping), particularly on land with steep slopes immediately upstream of Cook's (2016) sampling location on Turkey Branch, is likely to have influenced the reported sediment loadings.

The SWAT average annual sediment loading from the Lower Fish River are estimated at 0.48 t/ha/yr (137 t/mi^2/yr) for a total load of 19,361 metric tons, and are predicted to increase by 13-34% in 2040.

3.4.4 Magnolia River Subwatershed Sediment

The Magnolia River Subwatershed is mostly agricultural with only the upper-most reaches impacted by urban development around the City of Foley, and a small area in the Town of Magnolia Springs. Sediment transport in the Magnolia River Subwatershed is less studied than in Fish River, with the primary source of data being provided by the Geological Survey of Alabama (GSA/Cook et al.) study published in 2009, a SWAT study in 2011 (Niraula et al., 2012) and the current SWAT model predictions. With the exception of one unnamed tributary (GSA site 6), stream gradients are generally less than those of the Fish River Subwatersheds, ranging from ~5 to 19 ft/mi. The unnamed tributary has a gradient of 30 ft/mi but had the lowest average discharge (0.2 cfs) and lowest reported sediment loadings (Cook et al., 2009). Six of the 10 sites monitored by GSA (Cook et al., 2009) had total annual sediment loads less than the geologic erosion rated of 64 t/mi^2/yr, including the most upstream site that drains the area immediately north of Foley city limits. The other tributaries with low sediment loadings are: Schoolhouse Branch, Weeks Creek, and Eslava Branch. Main stem loadings were only estimated at and above Highway 98 and show an increase in sediment loading moving downstream. Weeks Creek and an unnamed tributary at CR 24 (GSA site 9) had the highest tributary total sediment loadings (normalized) at 168 t/mi^2/yr and 161 t/mi^2/yr, respectively (Cook et al., 2009). A SWAT model calibration study in 2012 (Niraula et al., 2012) included the

Magnolia River, and a number of Critical Source Areas (CSA) were identified in an unnamed tributary (GSA site 9) and along the mainstem of the river, above GSA site 2. This study also predicted that 10% of the Watershed area was responsible for 36% of the sediment.

The SWAT model estimates that average annual sediment loading in the Magnolia River Watershed is 0.14 t/ha/yr (40 t/mi^2/yr) for a total annual loading of 1,371 metric tons, and predicted to increase by ~12% in 2040 based on the high growth scenario. The total suspended sediment (TSS) concentrations are predicted to decrease by 9% under the medium growth scenario and increase by 10% under the high growth scenario. The model also estimates that roughly 23% of the land area is responsible for 50% for the sediment loading.

3.4.5 Unpaved Roads and Other Sediment Hotspots

Due to the large size of the Weeks Bay Watershed, a special aerial imagery evaluation and review of available literature were utilized to identify sediment source hotspots. In particular unpaved roads, dirt pits, and other erosion sites identified on publicly available aerial imagery and are described in the following paragraphs.

3.4.5.1 Unpaved Road Sediment Sources

Studies were conducted in 1998 and in 2010 outlining the 25 most environmentally damaging dirt roads in Baldwin County, Alabama, Knaebel (1998) and Carlton et al., (2010), respectively. All unpaved roads erode to some degree during the many rain events experienced in Baldwin County, as well as wind-generated erosion during dry periods in the form of dust suspended by winds and vehicles. Sediment and dust particles are moved offsite onto nearby lands and waters creating problems clogging drainage ways, filling wetlands and streams, in addition to causing maintenance and repairs by the responsible entities. These studies showed the danger of allowing the dirt roads to be unmaintained or even partially maintained. Without full maintenance conducted regularly on the dirt roads, they are a detriment to the wetlands, water bodies, and water quality. The above studies showed that the most environmentally damaging on these unpaved roads are where the dirt road directly crossed a stream or wetland. In these areas there would be increased turbidity and sediments causing degradation of these important resources. The four roads listed in the 1998 report that are located within the Weeks Bay Watershed (Langford Road, Sherwood Highland Road, portion of Miller Pit Road, and Beasley Road) that were among the “25 most environmentally damaging roads in Baldwin County” are now paved. In the 2010 report, eight of the “25 most environmentally damaging roads in Baldwin County” are located within the Weeks Bay Watershed. To date two of these roads are paved (Spring Creek Drive and Nolte Creek Drive), while six remain unpaved (Lipscomb Road, Norris Lane, Mannich Lane [S2], Mannich Lane [S4], Paul Cleverdon Road, and Sherman Road).

In addition to these studies of the “most environmentally damaging dirt roads,” there are many more miles of unpaved roads within the Watershed. Based on GIS data from the County Highway Department, supplemented by recent Google Earth™ imagery (December 2016) there are 63 total unpaved roads located in the Weeks Bay Watershed. These roads account for

225,555 linear feet (42.7 miles) of erodible dirt roads. Approximately 45,343 linear feet on 14 unpaved roads are found in the Upper Fish River Subwatershed, approximately 63,238 linear feet on 19 unpaved roads in the Middle Fish River, approximately 14,484 linear feet on 7 unpaved roads from the Lower Fish River Subwatershed, and 102,489 linear feet on 23 unpaved roads from the Magnolia River Subwatershed. These roads are listed in Tables 3.9 through 3.12 by Subwatershed, and are shown on Figure 3.14.

Table 3.9 Upper Fish River Subwatershed Unpaved Roads

Road ID Number	Road Name	Length (ft)
0	Harris Lane	437
4	Burris Road	1,003
6	Corte Road	5,489
8	Woodpecker Road	5,247
56	Peturis Road	5,242
80	Oak Street	690
98	Devine Road	1,295
99	Hinote Glass Road	1,585
100	Cabinet Shop Road	2,886
120	Dixon Road	2,549
134	Flowerwood Road	1,824
162	Unpaved Road	4,081
163	Unpaved Road	4,194
166	Dick Higbee Road	8,822
Total		45,343

Table 3.10 Middle Fish River Subwatershed Unpaved Roads

Road ID Number	Road Name	Length (ft)
20	South Boulevard	5,328
27	Harris Lane	2,665
29	Davis Road	7,744
32	Blueberry Lane	5,300
33	Paul Cleverdon Road	7,933
34	Ted Lysek Road	6,683
53	Dry Branch Road	2,588
84	Snarr Road	2,661
91	McCarron Lane	1,297
93	Newman Road	2,072
95	Holston Lane South	2,649
96	Bohemian Hall Road	3,309
115	Baughman Road	2,638
117	Sedlack Road	2,701
129	Dick Higbee Road	436
139	Barnard Rd.	2,463
159	Undeveloped Subdivision	2,377
165	Woodhaven Dairy Road East	1,648
167	Woodpecker Road	752
Total		63,238

Table 3.11 Lower Fish River Subwatershed Unpaved Roads

Road ID Number	Road Name	Length (ft)
41	King Road	1,186
73	Miller Lane	2,485
124	Etta Smith Road	1,142
140	Magnolia Landfill	6,836
164	Pierce Road	908
169	Mannich Lane	910
170	Dry Branch Road	1,377
Total		14,484

Table 3.12 Magnolia River Subwatershed Unpaved Roads

Road ID Number	Road Name	Length (ft)
94	Sherman Road	2,660
127	Mannich Lane	7,060
135	Bay Road	11,290
136	Charolais Road	2,619
137	Davis Road	4,232
138	John Bauer Road.	5,267
141	Undeveloped Subdivision	4,511
142	Norris Lane North	6,704
143	Mannich Lane	3,927
144	Lipscomb Road	4,511
145	Irene Drive	6,138
146	Eslava Drive	2,533
147	Norris Lane	10,643
148	Sherman Road	3,821
149	Undeveloped Subdivision	5,050
150	Hartung Road	2,655
151	Magnolia Creek Drive	3,604
152	George Younce Road	3,153
153	Junniper Street North	6,823
154	Woerner Road	1,325
155	Lauber Lane	1,201
156	Sellers Lane	1,332
168	Barnard Road	1,431
Total		102,489

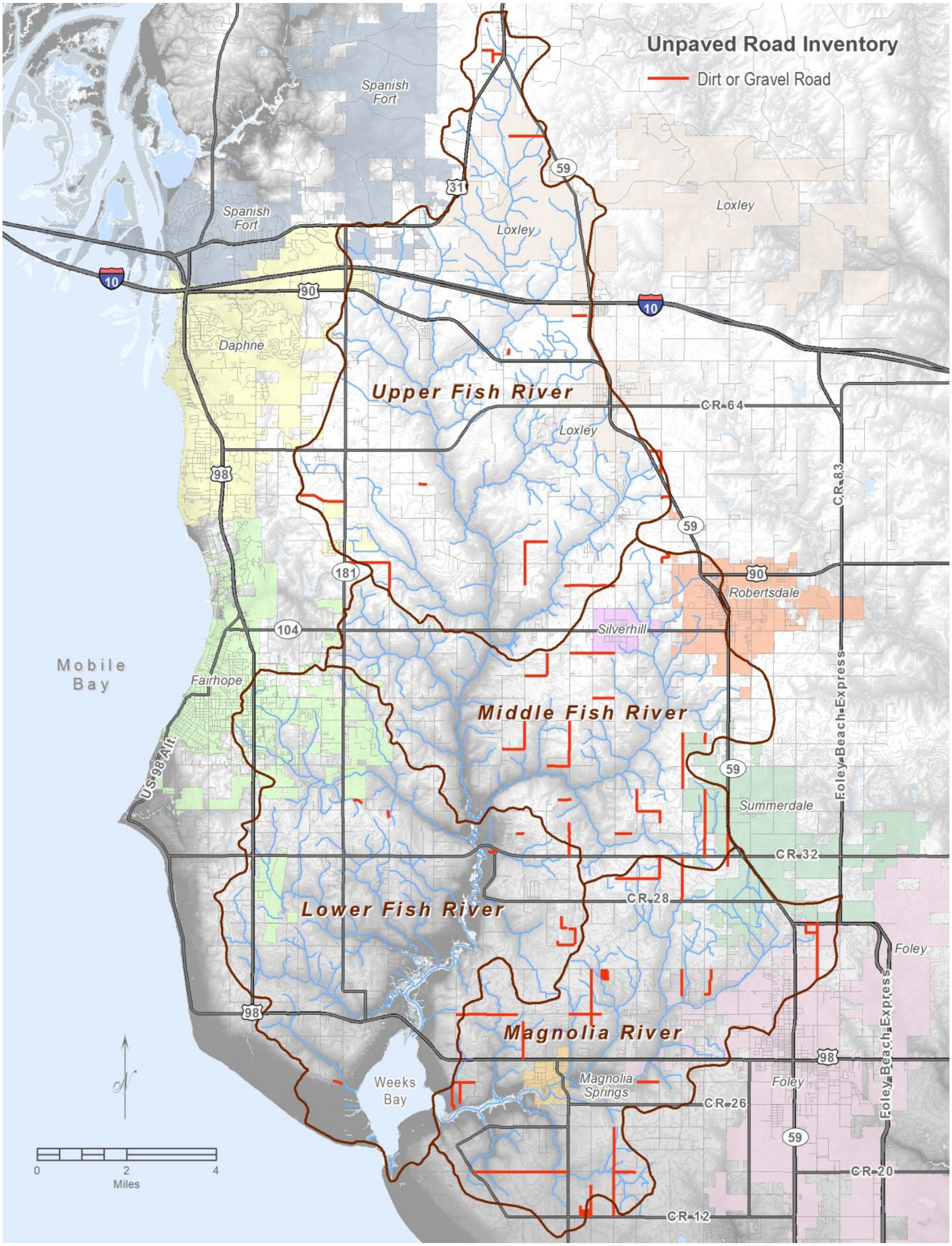


Figure 3.14 Major Unpaved Roads in the Weeks Bay Watershed

3.4.5.2 Dirt Pits and Other Erosion Sediment Sources

Based on an analysis of Google Earth™ imagery, there are an estimated 61 dirt pits located within the Weeks Bay Watershed. Many of these are incised, therefore are contained and do not have a surface discharge or serve as a sediment source for drainway/streams in the Weeks Bay Watershed. In the Upper Fish River Subwatershed there are 20 pits, in the Middle Fish River Subwatershed there are 7 pits, in the Lower Fish River Subwatershed there are 23 pits, and in the Magnolia River Subwatershed there are 11 pits. The spatial distribution of these dirt pits within the Weeks Bay Watershed is shown on Figure 3.15.

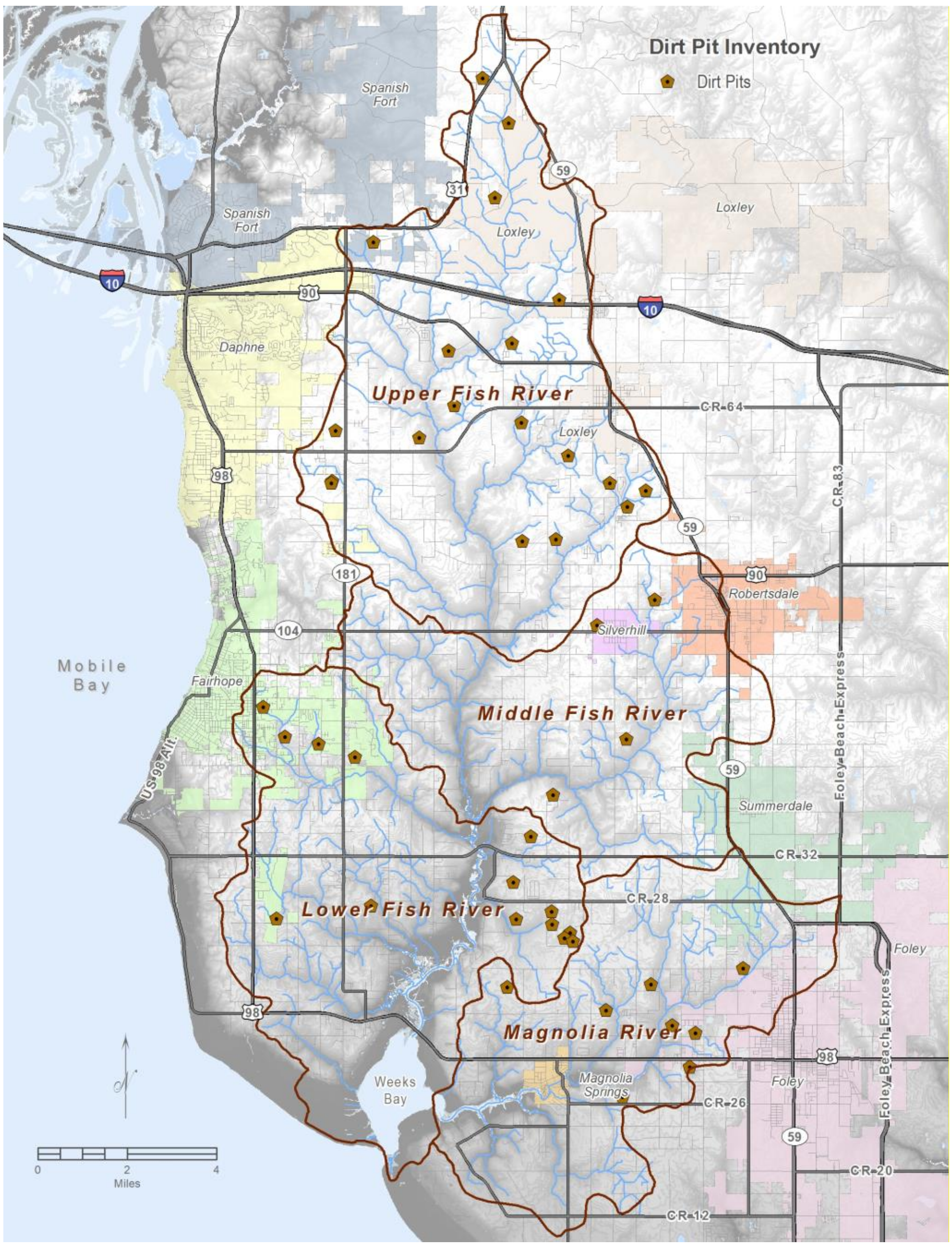


Figure 3.15 Dirt Pits in the Weeks Bay Watershed

3.5 Water Quality

The FWPCA and AWPCA both provide definitions of “waters of the U.S.” and “waters of the state,” respectively, each recognizing that our waters are a shared natural resource. Protecting and restoring water quality is the underlying intent and ultimate goal of the federal and state water pollution control laws and the watershed management planning process is one avenue to help achieve the “fishable and swimmable” goals of those statutes. Good water quality is essential to the maintenance of healthy ecosystems as well as the various human uses identified in the water quality criteria. Measures of water quality often take the form of various chemical analyses or measurements for dissolved oxygen (DO), temperature, pH, salinity, nutrients, metals, bacteria and the like. In some instances, water quality is inferred from biological parameters or indices, using aquatic organisms as indicators. This data can then be compared to “standards” or “criteria,” where they exist, to assess the relative quality of the water.

Unlike most of the watershed management planning projects in coastal Alabama, there is no shortage of general water quality information for the Weeks Bay Watershed, thanks in big part to the Weeks Bay National Estuarine Research Reserve which has attracted both researchers and funding to the Watershed. The Thompson Team identified 40 scientific efforts that either focused directly on water quality or collected water quality information ancillary to the primary investigation. Due to differences in collection methods, analytical methods, timing and locations, and budgetary constraints it was not practical to utilize all the information. Although several research projects and studies were reviewed and are cited, the primary sources of water quality information are from various WBNERR and ADEM efforts, as well as the GSA and Cook studies. Volunteer citizen generated water quality data within the Weeks Bay Watershed, particularly that generated through recognized monitoring programs, has been shown to have good accuracy (AWW, 2001) and, in many cases, the sampling efforts are wider spread and longer lived than the shorter term scientific studies; but they are usually dated and can have significant temporal gaps. Some of these data, available at: https://web.auburn.edu/gww/aww/maps/06.html have also been utilized in the characterization of water quality conditions. Many of the published reports reviewed for this project only contain data summaries (ranges, annual averages, median values, etc.).

The following sections will focus on the primary water quality parameters of concern (i.e. those where an impairment has already been documented, is suspected, or the parameter is considered of importance) and will summarize the primary sources of available information.

3.5.1 Geochemical and Physiochemical Parameters

The geochemical and physiochemical parameters, often referred to as “classical water quality parameters” are measures of the physical and chemical properties of the water and the geologic inputs. They include: dissolved oxygen (D.O.), pH, temperature, salinity, conductivity, turbidity, suspended and dissolved solids and chlorophyll *a*. These water quality parameters are usually the most often reported because they are easily measured, are fairly well understood environmental indicators, often complimentary or interrelated and, for the most part, have well established standards or threshold values. Dissolved oxygen is obviously important to the wellbeing of aquatic organisms, as is pH and temperature. Very high or low pH or temperatures, or large swings in pH or temperature, are often unconducive to a productive aquatic ecosystem. Both temperature and salinity dictate the waters ability to absorb and hold oxygen. Conductivity (aka. specific conductance) is related to the concentration of dissolved solids in the water. The concentration of total suspended solids (TSS) may be associated with sediment transport, and can impact water clarity as measured by turbidity. Chlorophyll and D.O. are often used is as an indicator of nutrient over-enrichment or eutrophication.

Water quality standards or threshold values for freshwater systems and coastal (marine) systems will vary for each parameter and are listed in Table 3.1 and/or the Tables that follow. The ADEM recently revised its water quality standards to add clarification to the “coastal” and “non-coastal” waters definitions. Although no changes in water quality standards or classifications were made for streams in the Weeks Bay Watershed, the boundary for coastal waters moved slightly upstream, to the point where the stream reaches 10’ above MSL, on many of the tributaries to Fish River and on the Magnolia River proper.

3.5.2 Nutrient Over-enrichment

Nutrients, by definition, furnish nourishment to plants and animals and are a necessary and essential part of our ecosystem, fueling the primary biological productivity necessary to sustain the various food webs. A lack of nutrients results in a sterile, non-productive system, while an over-abundance of nutrients results in over nourished conditions commonly referred to as eutrophic. The input of excess nutrients often results in “blooms” of naturally occurring algae and phytoplankton (e.g. red tide) that can make waterbodies unsuitable for other organisms and for various human uses (water contact sports, etc.). These blooms often result in high oxygen demands and anoxic or hypoxic conditions (e.g. the dead zone in the Gulf of Mexico). Eutrophication is generally considered one of the most detrimental problems in waterbodies, particularly estuaries. Where water quality impairments have been documented, EPA estimates that nutrients contribute to 25-50% of the impairments nationally (EPA 822-B-00-019, Dec. 2000). Nutrient inputs can be from point source discharges (WWTPs), non-point sources (agriculture, residential and commercial use of fertilizers, septic tanks, etc.), groundwater, and atmospheric deposition.

The primary nutrients of interest in most coastal systems are nitrogen and phosphorus. Also of interest is the form that these nutrients are in (dissolved or particulate, organic or inorganic), which greatly effects their ability to be utilized in primary production. Although knowing the concentrations of the various forms of nutrients are useful in understanding potential sources and ecosystem responses, most efforts at developing nutrient criteria are focused on Total Nitrogen (TN), Total Phosphorus (TP) and Chlorophyll α. Also of interest is how the nutrients are used or cycled within the waterbody and often measures of dissolved oxygen, chlorophyll *a*, turbidity and other parameters are made to assess the impacts of nutrient enrichment. By example, increased nutrients are expected to result in increased levels of chlorophyll *a*, lower dissolved oxygen concentrations and reduced light transmission (increased turbidity). Nutrients are assimilated differently in estuarine systems compared to rivers and streams or lakes and recommended levels, or standards, for nutrient concentrations can vary widely.

Recognizing that nutrient enrichment is a significant problem nationwide, EPA launched the *National Strategy for the Development of Regional Nutrient Criteria* in 1998, and published several guidance documents and suggested numeric criteria (see Table 3.13), by waterbody type, in 2000-2001. The nutrient concentrations expressed in those documents were based on broad "aggregate ecoregions" and the documents clearly encourage states to develop more local, waterbody class criteria where possible. By example, the entire coastal zone of Alabama (including Weeks Bay and the lower portions of Fish and Magnolia Rivers) is in Aggregate Ecoregion XII and Level III Sub-ecoregion 75a which also includes most all of central Florida where, coincidentally, most all of the river and stream nutrient monitoring stations used in developing the EPA recommendations are located (EPA 822-B-00-021, Dec. 2000). The upper reaches of Fish River and Magnolia Rivers are considered to be in Aggregate Ecoregion IX and Level III Sub-ecoregion 65f (EPA 822-B-00-019, Dec. 2000). All of the EPA recommended reference values are based on the median seasonal upper 25th percentile (i.e. 75th percentile) of all data reviewed. The natural conditions of Alabama's coastal streams are most likely different than those represented by the statistical values calculated by the EPA to develop their recommendations. As recommended by EPA, ADEM has undertaken efforts to establish Alabama specific ecoregion nutrient criteria by establishing and sampling a number of "Reference Reach" streams in 17 of the recognized ecoregions within the state (ADEM, 2010), including ecoregion 65f, but not ecoregion 75a.

Table 3.13 Various Reference Nutrient Concentrations for Rivers and Streams

Parameter	**EPA Ecoregion IX[1] Sub-ecoregion 65f**	**EPA Ecoregion XII[2] Sub-ecoregion 75**	**State of Florida[3]**	**State of Alabama[4] Sub-ecoregion 65f**
Total Nitrogen (mg/L)	0.62	0.90	0.67	0.64
Nitrate+Nitrite (mg/L)	0.095	0.02	0.35[5]	0.33
TKN (mg/L)	0.30	0.56	n/a	0.42
Total Phosphorus (mg/L)	0.023	0.04	0.06	0.04
Chlorophyll α (µg/L) (s)	0.05	0.40	n/a	1.76
Turbidity (NTU)	6.2	1.9	n/a	9.7

[1] USEPA-822-B-00-019, December 2000. Applicable to Rivers and Streams in Ecoregion65f (Table 3H)
[2]USEPA-822-B-00-021, December 2000. Applicable to Rivers and Streams in Ecoregion 75 (Table 2)
[3]State of Florida, 62-302.531 F.A.C., February 2016. Nutrient Thresholds for Panhandle (West)
[4]State of Alabama, Ecoregional Reference Guidelines for Ecoregion 65f. ADEM 2010
[5]Applicable to "spring vents."
(s)-spectrophotometric method

Several research efforts have been undertaken within the Weeks Bay Watershed to study nutrient cycling (Mortazavi et al., 2012), nutrient concentration variations (Lehrter, 2003, 2006), the impacts of land use and land cover on nutrient inputs (Basynat et al., 1999; Lehrter, 2006; Morrison, 2011; Singh, 2010). Additionally, the Gulf of Mexico Alliance (GOMA) sponsored pilot studies in several Gulf coast estuaries, including Weeks Bay, to provide the technical foundation for nutrient criteria development. This "Sources, Fate, Transport and Effects" pilot study (GOMA, 2013) used various regression analyses and empirical models to analyze various nutrient inputs and system response scenarios and generated "annual geometric mean threshold values" for TN, TP and chlorophyll α for Weeks Bay proper (see Table 3.19).

In addition to these studies, there have been several water quality monitoring efforts, some still on-going, throughout the Watershed that measured the concentrations of one or more nutrients or nutrient surrogates, either as a focus of the monitoring effort or coincidental to the primary monitoring objective (WBNERR/NERRS, on-going; ADEM (2006, 2011 [3 reports], 2014, and ongoing; USGS, on-going; Monrreal, 2007; Chandler et al., 1998, O'Neil and Chandler, 2003; Cook, 2016). Although there is an abundance of nutrient data, because of legitimate differences in collection timing and technique, analytical methods, reporting units, nutrient species sampled, etc., there are inherent difficulties in comparing these data to each other or to "standards" that may have been developed using data generated by different protocols or methods.

The SWAT model prepared in conjunction with this plan was also used to assess nutrient yield and loadings within the Watershed. Figure 3.16 represents the SWAT estimated nitrogen and phosphorous yields, at the subwatershed level, for a baseline condition (2011) and the two future (2040) growth scenarios. The lowest numeric category (lightest shading) represents nutrient yields that roughly correspond to ADEM's (2010) ecoregion reference reach values for Total Nitrogen (TN) and Total Phosphorous (TP). The subwatersheds depicted in darker shading have higher than the ADEM ecoregion reference values and generally correspond to areas with high agricultural use. These subwatersheds also correspond well with those identified as having only fair or poor wetland and riparian buffer habitats. It is recommended that efforts to implement nutrient loading reduction management measures (BMPs, restoration, etc.) be focused in those subwatersheds with the highest nutrient yield (darkest shading).

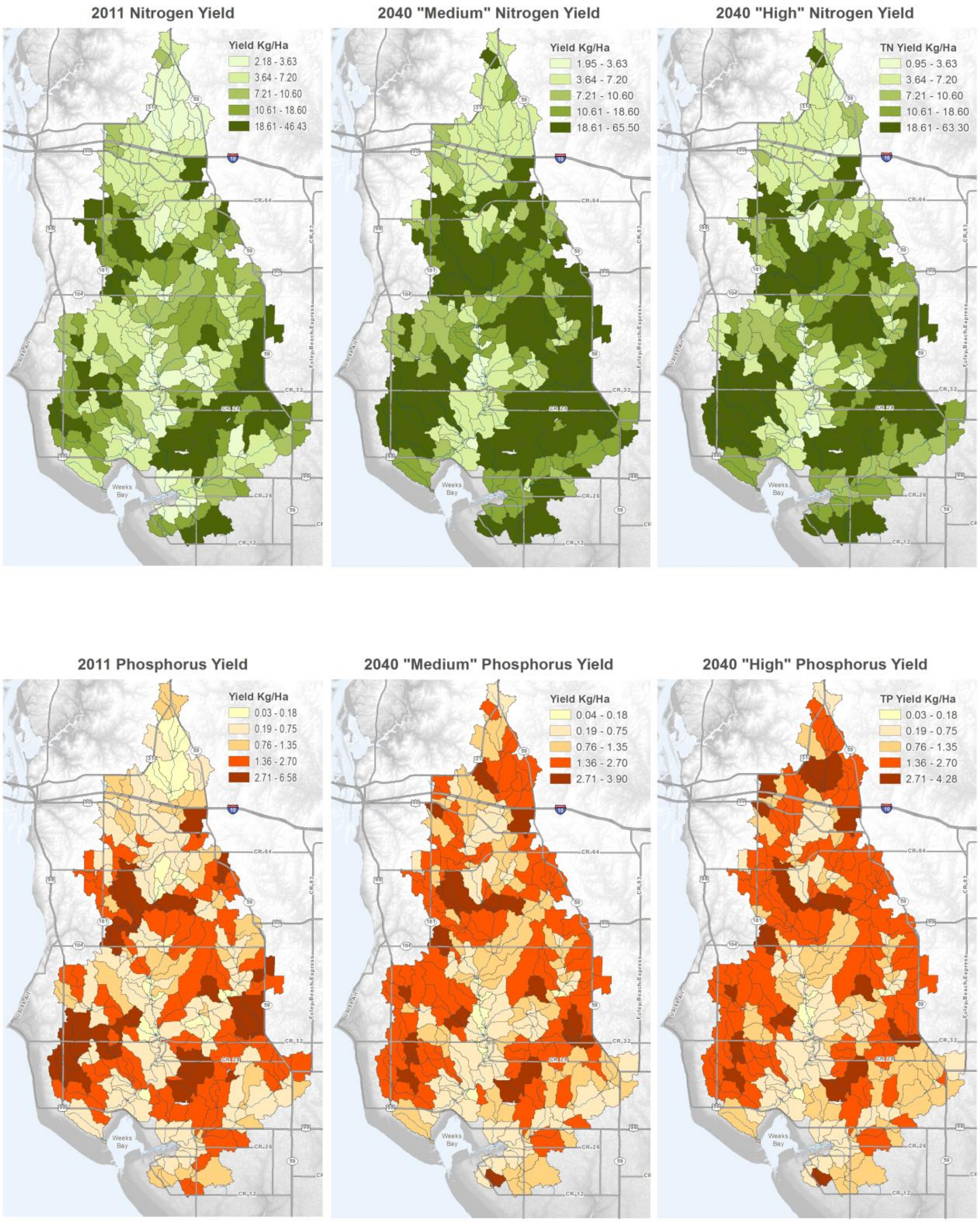


Figure 3.16 SWAT Model Total Nitrogen & Phosphorus Yields for 2011, 2040med, & 2040high Scenarios
Source: Kalin, 2017

The SWAT model results were also reviewed to estimate the nutrient yield and loading per unit area (Figures 3.17 and 3.18, respectively). This review indicates that, at the subwatershed level, approximately 31% and 29% of the land area of the Magnolia River Watershed is generating about 50% of the TN and TP load, respectively. Approximately 23% and 18% of the Fish River Watershed is generating 50% the TN and TP load, respectively. At the HRU level (Figure 3.4.3.3), 14% and 10% of the total Watershed area is responsible for 50% of the TN and TP load in the Fish River, while 50% of the land area is responsible for 86% and 98% of the load, respectively. In the Magnolia River Watershed 24% and 19% of the land area is responsible for 50% of the TN and TP loading, while 50% of the area is producing 90% and 88% of the TN and TP, respectively. The nutrient loadings appear to track the sediment loadings more closely in the Fish River Watershed than in the Magnolia River Watershed. These data are consistent with earlier studies (Niraula et al., 2012) and reflect the apparent geographical concentration of the potential sources and the need to target management measure implementation geographically.

3.5.3 Pathogens

The presence of pathogens in waterbodies is a primary public health concern, particularly in waterbodies used for whole body contact recreation and fishing. Since the detection of the myriad of potential human pathogens (protozoans, viruses, bacteria, etc.) is often difficult in environmental samples, certain strains of bacteria, especially the coliform bacteria, *Escherichia coli,* and coccoid bacteria, *Enterococcus*, are often used by environmental and health agencies as surrogates and indicators of fecal pollution. Although considered better indicators of human pathogens than fecal coliform, neither indicator is actually human specific and the measured values can be influenced by the presence of bacteria originating from non-human, warm-blooded sources, primarily wildlife, pets and livestock. ADEM has adopted water quality standards for *Enterococcus* in coastal waters and *E. coli* in freshwaters based on both the geometric mean of a series of samples and a single sample maximum. The standards vary according the classification of the waterbody (swimming, fish and wildlife, etc.) (see Table 3.1) and ADEM recently revised the dividing line between fresh and coastal waters within the Weeks Bay Watershed and extended also the “summer swimming season” timeframe.

3.5.4 Contaminants

Contaminants include water quality constituents not covered in the previous sections for which there are known or suspected issues within the Watershed. Mercury (Hg) is the only contaminant for which there is a documented issue within the Weeks Bay Watershed. Both Fish River and Magnolia River, and several of their tributaries, are listed on ADEM’s 303(d) list because of fish consumption advisories due to elevated Hg levels in edible tissue (See Section 3.2.4.4 for additional details related to fish consumption advisories). ADEM has promulgated water quality standards for a number of chemical contaminants and a complete listing can be found in ADEM Administrative Code R: 335-6-10-.07. ADEM (2010) has also developed ecoregion reference guideline values for a number of metals.

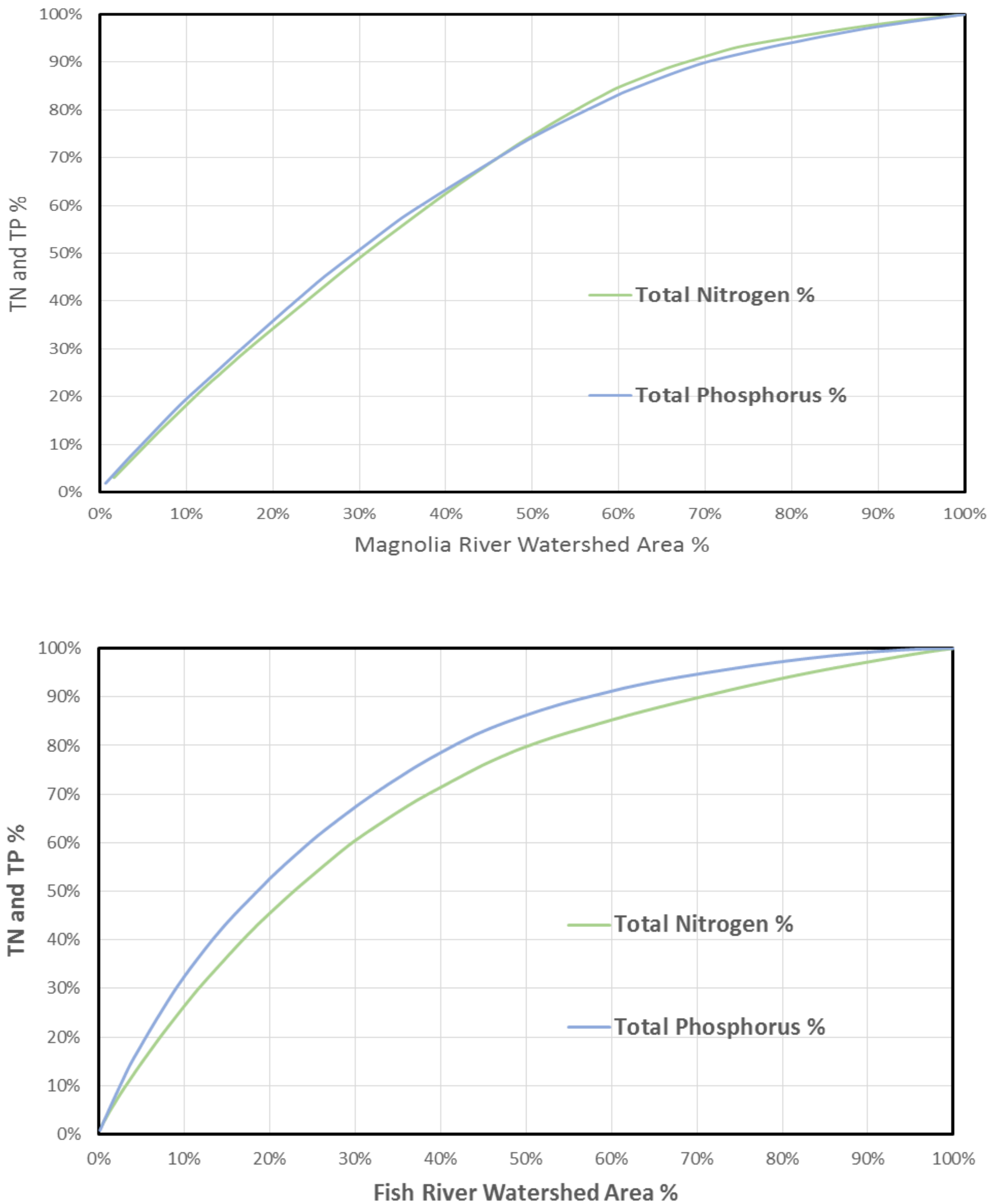


Figure 3.17 SWAT Subwatershed Level Total Nitrogen (TN) and Total Phosphorus (TP) Yield by Percent Area for Magnolia River (Top) and Fish River (Bottom)
Source: Kalin, 2017

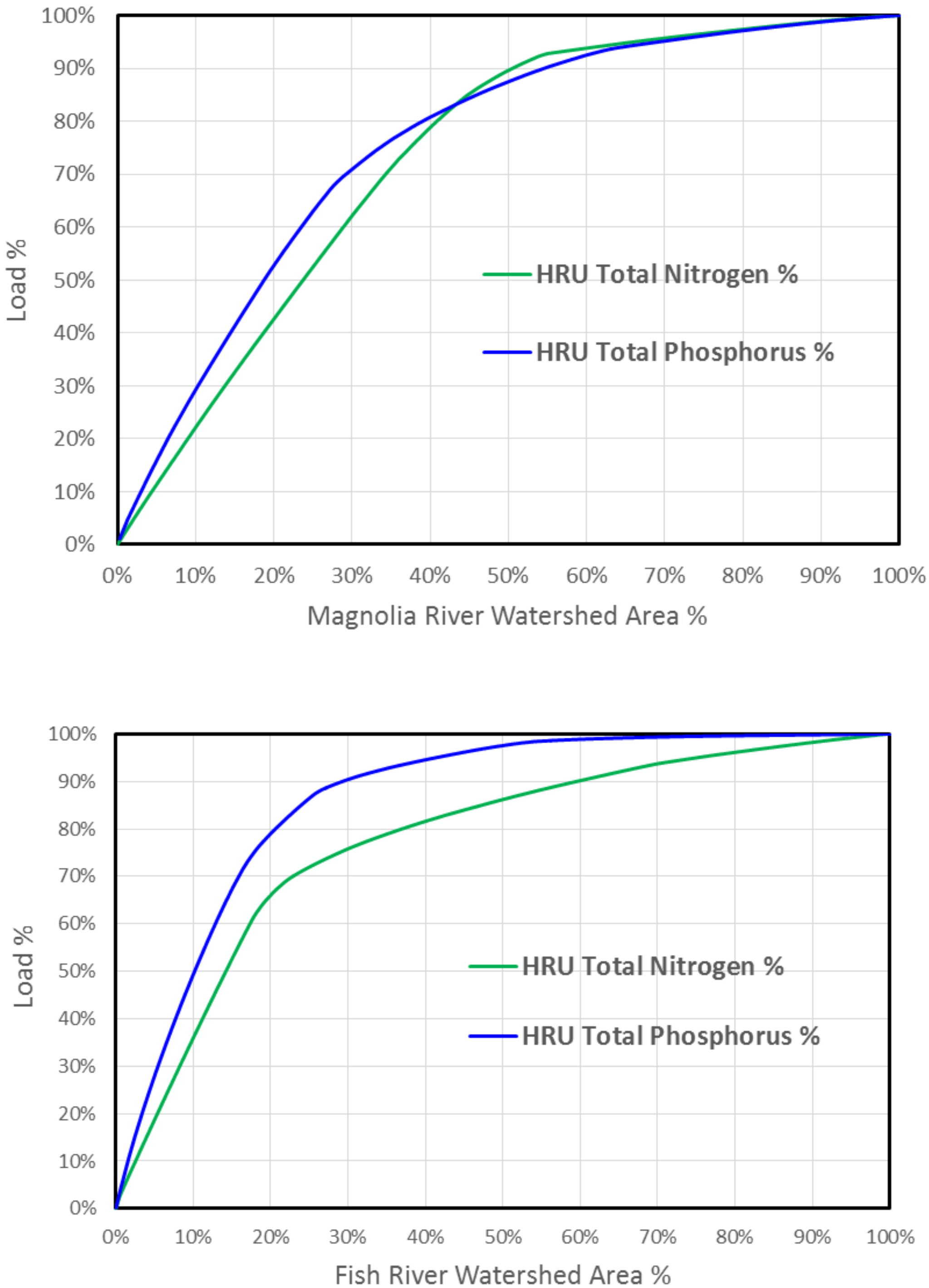


Figure 3.18 SWAT Hydrological Response Unit Level Total Nitrogen (TN) and Total Phosphorus (TP) Loading by Percent Area for Magnolia River (Top) and Fish River (Bottom)
Source: Kalin, 2017

3.5.5 Upper Fish River Subwatershed Water Quality

The Upper Fish River Subwatershed has areas that are distinctly forested (mainstem above Interstate 10), distinctly urban (along Highway181, U.S. 90 and Highway 31) and areas that are largely agricultural. The HUC 12 Subwatershed extends from Stapleton southward to just below Highway 104 at the confluence of Perone Branch. The primary tributaries are Threemile Creek, Bay Branch, Turkey Branch (Upper), Corn Branch, Caney Branch and Perone Branch.

3.5.5.1 Geochemical and Physiochemical Parameters

Geochemical and physiochemical data from the uppermost reaches of the Fish River Subwatershed (above Highway 90) is limited. Cook (2016) gathered information on D.O., pH, water temperature, conductivity and turbidity during his sediment loading study and reports no anomalies in Fish River, Bay Branch and Threemile Creek. Dissolved oxygen readings averaged ~8.0 ppm, well above the water quality standard (5.0 ppm); turbidity levels were generally low and increased slightly with flow; and pH and conductivity were within normal ranges. O'Neil and Chandler (2003) report similar results from the samples collected in Fish River at Highway 90 during 1994-1998. Available Alabama Water Watch (AWW) data from Fish River at Highway 90 collected in 1993-2003 indicate D.O. averaging around 7 ppm, with rare excursions below 5.0 ppm, and low (<10 ntu) turbidity. Similar results were reported by AWW volunteer monitors for Bay Branch at Highway 90 during the period from October 2001 to October 2003.

Further downstream, on the main stem of Fish River, data generated by Cook (2016) indicates that the D.O remains good, generally above 7 ppm, conductivity and pH are within expected ranges and turbidity is slightly higher (but generally less than 50 ntu) at low flow and strongly associated with flow, with values exceeding 100 ntu during high discharge. AWW data from the mainstem of the river at CR 64 (September 2001- September 2003) and CR 54 (January 1997 to January 2002) are similar to Cook's findings, the CR 54 station indicating the high variability of turbidity, possibly due to the influence of Corn Branch.

Corn Branch has been sampled by the AWW at CR 64 (April 2002 – October 2003) and indicates D.O consistently less than 5 ppm and relatively low, but highly variable, turbidity values. Cook (2016) found higher D.O. (no reading below 5.0 ppm), turbidity values consistently above 100 ntu, and specific conductance readings 2-5 times the ADEM reference reach value (20.4 µmhos). O'Neil and Chandler (2003) report similar findings (D.O. above 5.0 ppm and elevated turbidity).

Near the bottom of this Subwatershed, Caney Branch enters the river just above Alabama Highway 104 and Perone Branch enters just below Alabama Highway 104. Caney Branch was sampled near the confluence with Fish River and a median D.O. of 7.6 ppm, median turbidity of 9 ntu (but ranging up to 360 ntu), and conductance of 52 µmho were reported (O'Neil and Chandler, 2003). The upper most reach of Perone Branch is impounded within the Lakeland subdivision (Lake Raynagua). AWW volunteer monitoring in 2006-2009 indicated D.O. averaging over 7 ppm (no readings below 5.0 ppm) and generally good turbidity values (<50 ntu) within the lake. Downstream of the lake (~0.25 miles), volunteer monitoring data from 2003-2006 indicate extended periods of low D.O. (<5.0 ppm) during the summer and generally low turbidity values. Further downstream on Perone Branch, at CR 54, volunteer monitoring data from 1997-2002 indicate good D.O. with few readings at or below 5.0 ppm during the summer and generally low but variable turbidity. Perone Branch at Alabama Highway 104 had good D.O. (median of 8.4 ppm), relatively low conductance and low median turbidity (7 ntu) but ranging up to 180 ntu in 1994-1998 (O'Neil and Chandler, 2003). At the same location in 2016, Cook reports D.O. values above 6.9 ppm, conductance readings of 31-57 µmho and highly variable, discharge dependent, turbidity ranging from 5-198 ntu.

Fish River at Alabama Highway 104 has been monitored on a number of occasions and is the location of one of ADEM's long term water quality trend stations. Figures 3.19 and 3.20 graphically represents the yearly median of the ADEM trend station data. Monthly sampling from January through November 2011 by ADEM is consistent with the long term yearly median data (ADEM, 2011), as is AWW data collected 2000-2010.

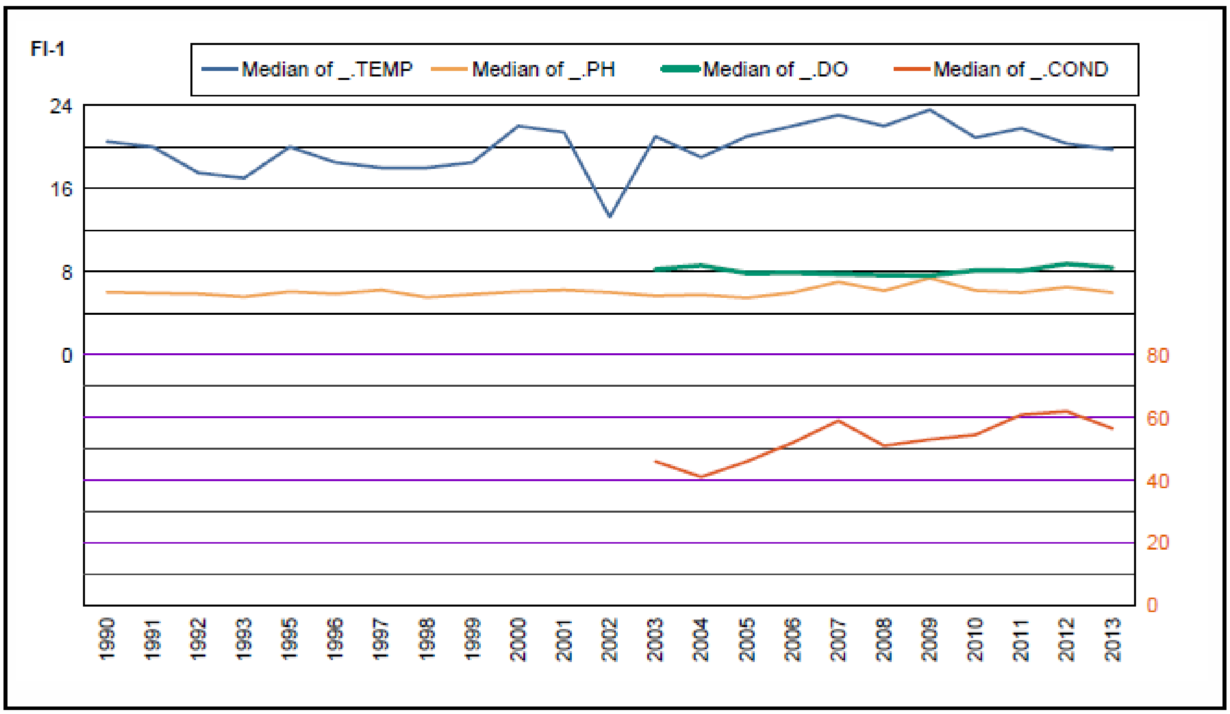


Figure 3.19 Temperature, pH, D.O. and Conductance in Fish River at Alabama Highway 104
Source: ADEM, April 2014 (all of the ADEM 2014 graphs were taken from App E, ~ p.662)

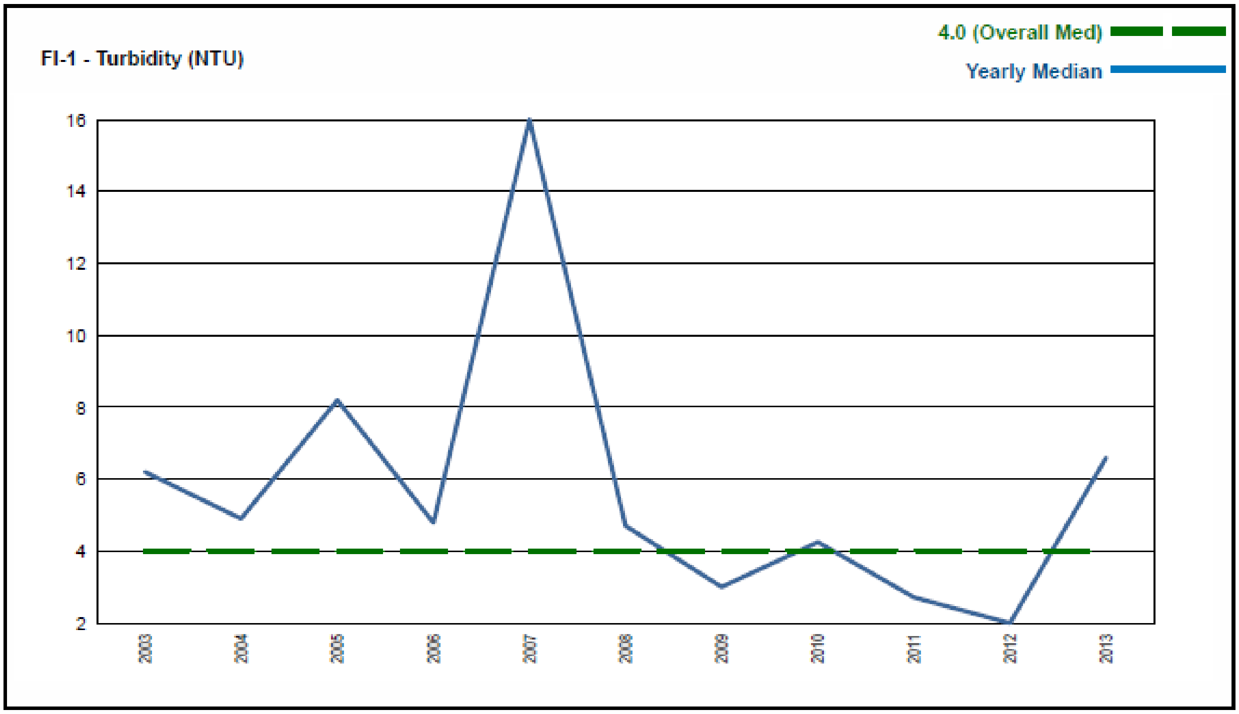


Figure 3.20 Turbidity in Fish River at Alabama Highway 104
Source: ADEM, April 2014

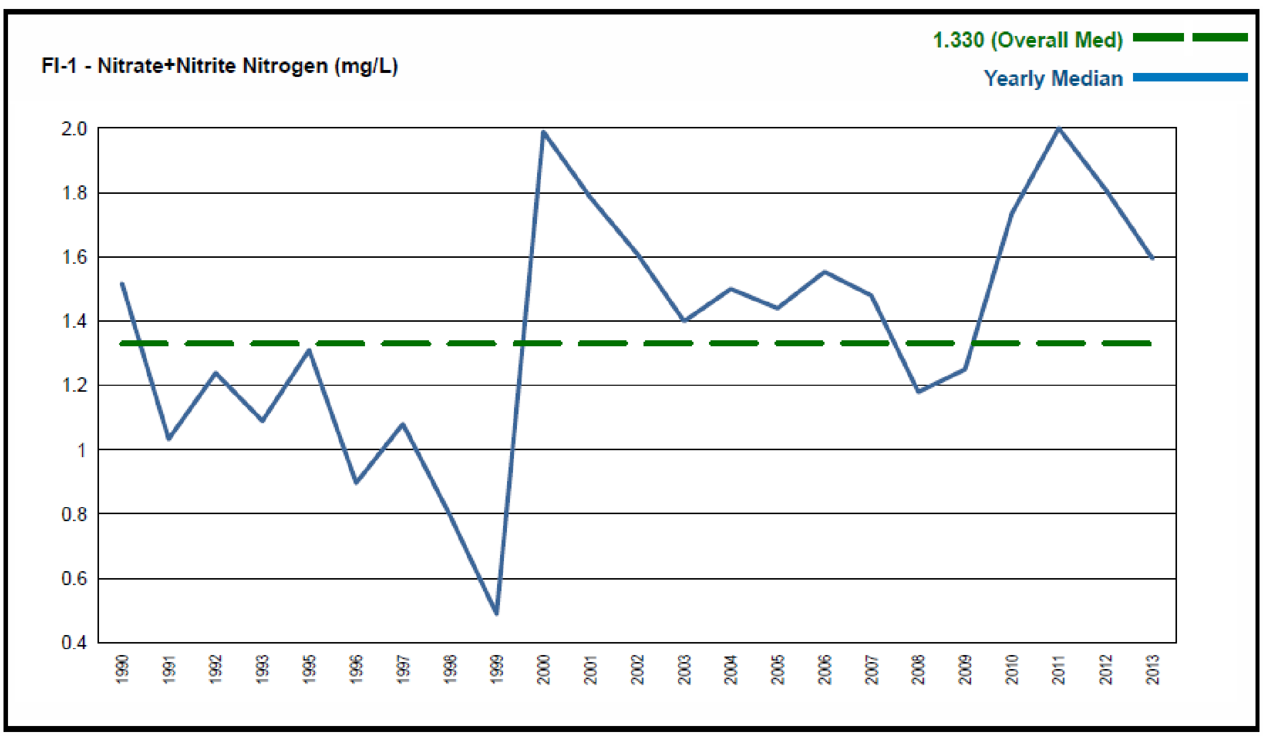
3.5.5.2 Nutrient Over-enrichment

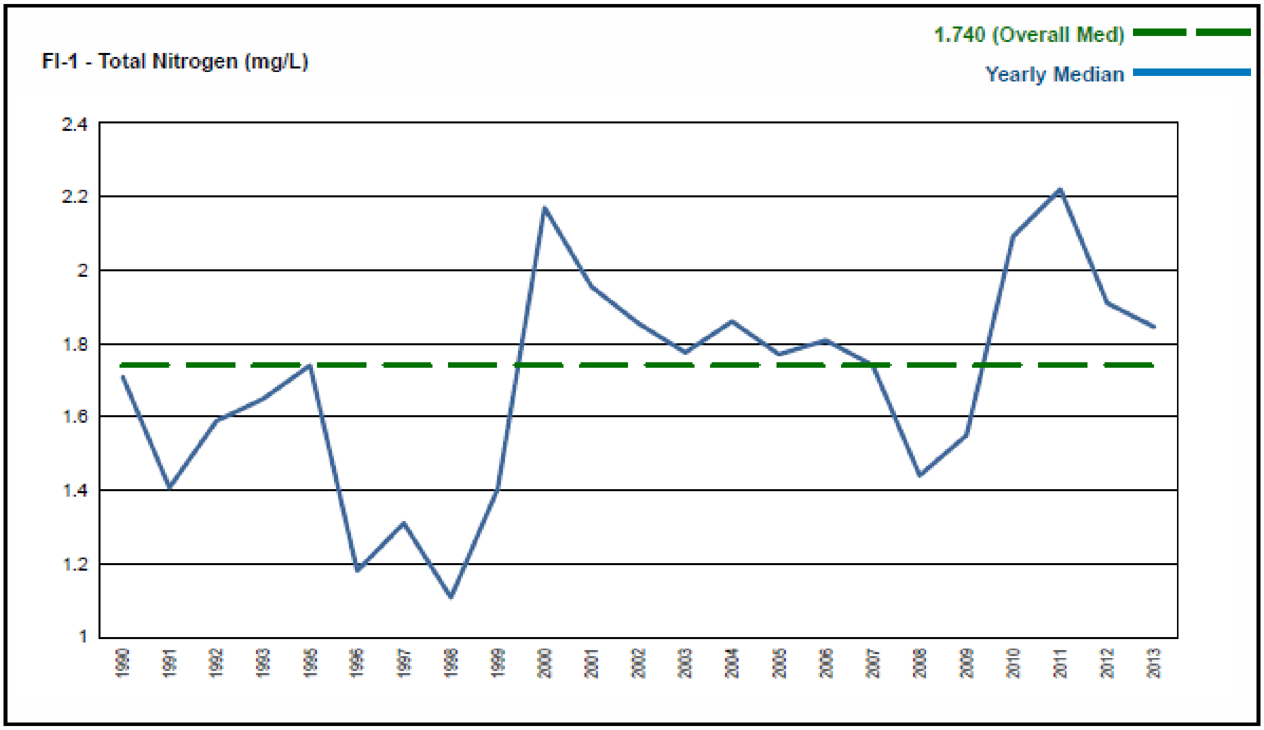
Nitrate (NO3-N) samples collected by Cook (2016) indicate that, of the three upper most study locations (above Interstate 10 and U.S. 90), only Three Mile Creek had concentrations above detection limits (0.3 ppm) in half of the samples. Cook also reports that total phosphorus was only detected (>0.05 ppm) in half of the samples from Fish River at Interstate 10. Combining the nitrogen values reported in O'Neil and Chandler (2003) give a range for total nitrogen of 0.12 ppm to 3.1 ppm, with a median of 0.63 ppm on the main stem of Fish River at U.S. Highway 90; while total phosphorus was reported ranging from <0.01 ppm to 0.38 ppm with a median of <0.01. These values are generally consistent with ADEM reference reach values for total nitrogen at 0.64 ppm and total phosphorus at 0.04 ppm (Table 3.13).

Further downstream in the Upper Fish River Subwatershed, the river is influenced primarily by inputs from Corn Branch, Caney Branch and Perone Branch. Cook (2016) reports elevated total phosphorus levels in Corn Branch and consistently high nitrate values in Perone Branch; which are reflected in the highly variable (0.0 ppm to 4.46 ppm nitrate; 0.05 ppm to 1.02 ppm total phosphorus) and elevated nutrient concentrations reported for the main stem of Fish River at CR 64 and at CR 54 (0.0 ppm to 7.6 ppm nitrate; 0.07 ppm to 1.1 ppm total phosphorus). Morrison (2011) also reports that Perone Branch and Fish River at Alabama Highway 104 have elevated nitrate levels. O'Neil and Chandler (2003) report average total nitrogen ranging from 1.15 ppm (Corn Branch) to 1.69 ppm (Perone Branch); while median total phosphorus was reported to be low at 0.02 ppm for both Corn Branch and Caney Branch, and <0.01 ppm for Perone Branch.

ADEM's long term water quality monitoring site (FI-1) is located on Fish River at Alabama Highway 104, just above its confluence with Perone Branch, and just above the outlet for the hydrologic unit. ADEM's *Monitoring Summary* (2006) for FI-1 indicates a median total nitrogen concentration of 1.81 ppm and a median total phosphorous concentration of 0.086 ppm, both above their reference reach values. In ADEM's 2011 *Monitoring Summary* reports that the median levels of total nitrogen and total phosphorus (2.22 mg/L and 0.120 mg/L, respectively) and were again noted as being "greater than 90% of all verified ecoregions reference reach data collected in sub-ecoregion 65f." The ADEM's long term nutrient data (2014) seem to indicate a six to eight-year cycle in nutrient concentrations, with an overall increasing trend in both nitrogen and phosphorus (Figure 3.21). This trend also appears when comparing the ADEM 2006 and 2011 *Monitoring Summary* reports for FI-1. Ammonia nitrogen is reported as low throughout the Weeks Bay Watershed (Morrison 2011), and total nitrogen concentrations generally track with nitrate-nitrite concentrations indicating that organic nitrogen is also probably low.

SWAT model results predicting total nitrogen and total phosphorus concentrations from the Upper Fish River Subwatershed (2011) are 1.34 ppm and 0.18 ppm, respectively, and generally consistent with the ADEM long term trend data. These concentrations are expected to increase 43-76% (TN) and 33-56% (TP) by 2040. Also, the SWAT model subwatershed level nutrient loading results are generally consistent with the tributary nutrient concentrations referenced above and have been used to illustrate the drainage areas predicted to have the highest TN and TP yields (Figure 3.16).





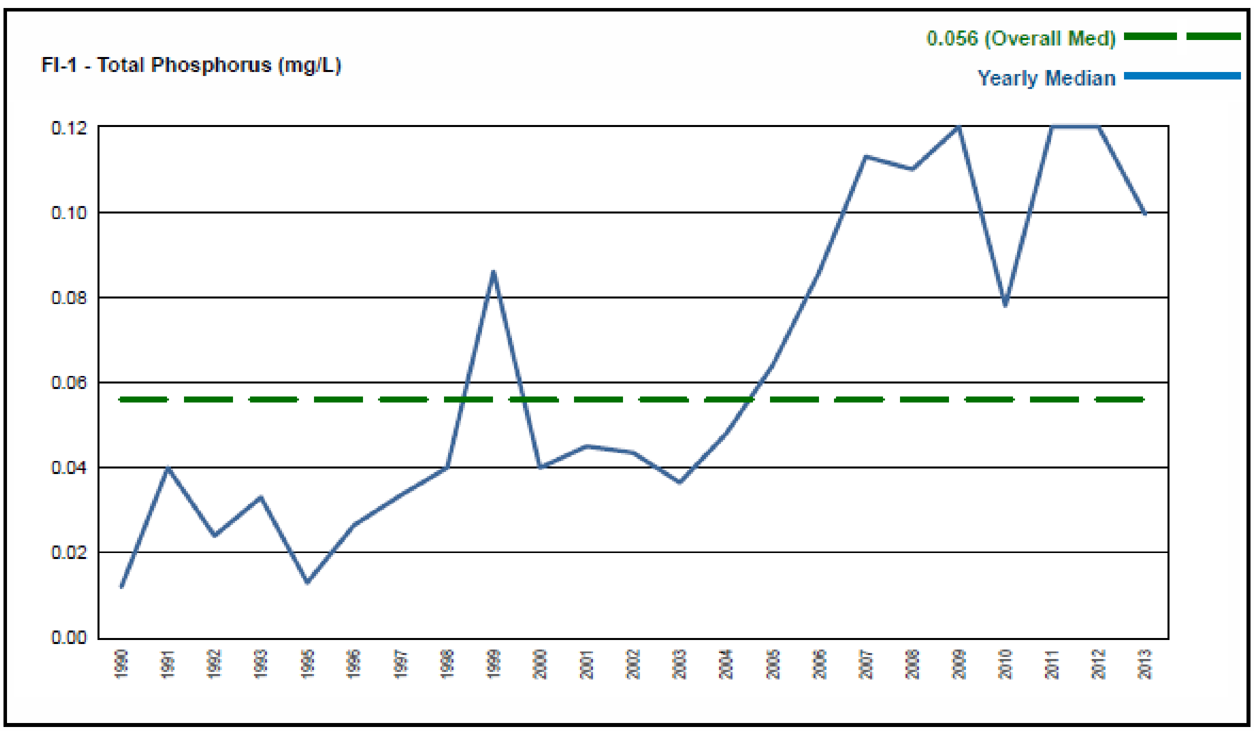


Figure 3.21 Nitrate-Nitrite (Top), Total Nitrogen (Middle) and Phosphorous (Bottom) Concentrations in Fish River at Alabama Highway 104 (FI-1)
Source: ADEM Ambient Trend Stations – Sampled 1977-2014, ADEM, 2014.

3.5.5.3 Pathogens

Information on pathogens was collected from six locations in the Upper Fish River Watershed in 1994-1998 by O'Neil and Chandler (2003), who sampled for both fecal coliform and fecal streptococcus. Cook (2016) collected data on E. coli from 7 locations and AWW has collected data from ~25 sites. Additionally, ADEM monitors Fish River at Alabama Highway 104 as part of its water quality trend station program and the WBNERR undertook a "Bacterial Source Tracking" (BST) project in 2009 that included several locations within the Upper Fish River.

The ranges of the available bacteria data from the aforementioned efforts are presented in Table 3.14. Some efforts, particularly the recent study by Cook (2016) and the earlier WBNERR BST study (WBNERR, 2011), intentionally timed sample collections to correspond with rainfall or high or low stream flow conditions. Both efforts clearly indicate that bacteria increase to levels exceeding the ADEM water quality standards for the Fish & Wildlife classification during high flow conditions. During normal or low flow conditions the standards for the Swimming classification appear to be routinely met. Notable exceptions are Bay Branch at U.S. Highway 90 and Corn Branch at CR 64, that appear to stay elevated even during low flow conditions, and Lake Raynagua that consistently appears to stay within the Swimming standard during varying rainfall/flow conditions.

3.5.5.4 Contaminants

ADEM (2011) analyzed water samples from Fish River at Alabama Highway 104 for a variety of metals, including mercury, and reported no samples above the ecoregion reference values. The Town of Loxley WWTP has begun, as part of its NPDES permit, an effort to identify and quantify Mercury sources to the treatment facility. No other information is currently available on contaminant loadings to the Upper Fish River Subwatershed.

3.5.6 Middle Fish River Subwatershed Water Quality

Middle Fish River Subwatershed extends from just below Alabama Highway 104 southward to just below it confluence with Polecat Creek. The primary tributaries to the Middle Fish River Subwatershed are Pensacola Branch, which drains the urbanizing west side of the river, and Polecat Creek, and its primary tributary Baker Branch, which drains the predominantly agricultural east side of the river.

3.5.6.1 Geochemical and Physiochemical Parameters

Water quality within this section of the mainstem of Fish River, as represented by geochemical and physiochemical parameters, is generally considered good. O'Neil and Chandler (2003) sampled the mainstem at CR 48 and report a median D.O. value of 8.2 ppm, with no reading below 5 ppm, median conductance value of 41 µmho, pH within expected ranges and generally low turbidity (median of 9 ntu). Cook (2016) reports average D.O. of 8.0 ppm, a slightly higher conductance (71 µmho) and higher average turbidity (75 ntu) that appears strongly correlated

Table 3.14 Bacteriological Data Upper Fish River Subwatershed

Waterbody	Location	Fecal coliform	Fecal strep.	E. coli
Fish River	I-10			>2,420[2]
Fish River	I-10			0-1,450[3]
Fish River	I-10			0-33[5]
Fish River	Hwy 90	9-9,000[1]	27-22,000[1]	0-5,850[3]
Fish River	Hwy 90			0-1,117[5]
Fish River	CR 64			178->2,420[2]
Fish River	CR 64			0-3,150[3]
Fish River	CR 64			11-125[5]
Fish River	CR54			114->2,420[2]
Fish River	CR54			0-4,100[5]
Fish River	CR54			20-5,750[3]
Fish River	Hwy 104			4-270[4]
Fish River	Hwy 104			67-867[5]
Bay Branch	Hwy 90			344-1,011[2]
Bay Branch	Fish River			0-67[5]
Turkey Branch	Fish River			0-33[5]
Threemile Creek	I-10			68-1,011[2]
Corn Branch	CR 64	7-86,000[1]	20-74,000[1]	272-1,011[2]
Corn Branch	CR 64			0-25,000[5]
Caney Branch		30-83,000[1]	80-93,000[1]	
Perone Branch	CR 54			0-5133[5]
Lake Raynagua	Near dam			0-78[5]
Perone Branch	¼ mile below Lake Raynagua			0-433[5]
Perone Branch	Hwy 104	30-20,000[1]	50-31,000[1]	60->2420[2]

[1] O'Neil and Chandler (2003) reported in colonies/100 ml
[2] Cook (2016) reported as MPN (Most Probable Number)
[3] Fish River Bacterial Source Tracking Project (2009) reported in colonies/100 ml
[4] ADEM (2011) reported as colonies/100 ml
[5] Alabama Water Watch (dates vary by station) reported as colonies/100 ml

to discharge with most samples being less than 50 ntu. AWW data from 1998-2016 for D.O. and turbidity are consistent with the aforementioned values, although a few D.O. excursions below 5 ppm were observed in 2003 and 2004.

Pensacola Branch at CR 48 was reported to have good D.O, with a median value of 8.5 ppm, a median conductance of 46 µmho and median turbidity of 10 ntu (O'Neil and Chandler, 2003). Cook (2016) reports an average D.O. of 8.0 ppm, similar level of conductance and higher average turbidity of 145 ntu, with more than half of the samples exceeding 100 ntu, ranking as the highest in the Fish River Watershed. AWW data at this location for D.O. indicate frequent excursions below 5 ppm in 1999-2004 with low but variable turbidity.

The upper reaches of Polecat Creek (CR 55) are reported to have an average D.O. of 7.6 ppm, average conductance of 51 µmho and average turbidity of 61 ntu (Cook, 2016). Further downstream on Polecat Creek, near the mouth (CR 9), O'Neil and Chandler (2003) report a median D.O. of 7.2 ppm, median conductance of 49 µmhos and median turbidity of 9ntu. At the same location, Cook (2016) reports an average D.O. of 7.7 ppm, average conductance of 50 µmho, and average turbidity of 47 ntu with few readings above 50 ntu. AWW data at this location from 2006-2011 also indicates good D.O. concentrations and variable turbidity, usually less than 50 ntu.

Baker Branch, a tributary to Polecat Creek, is currently listed on ADEM's 303(d) list as impaired due to "organic enrichment" as represented by low D.O. and/or elevated BOD. O'Neil and Chandler (2003) reported D.O. values for Baker Branch at CR 55 ranging from 3.0-10.1 ppm with a median of 6.3 ppm (data for this study was collected from 1994-1998). AWW data indicates a period from March of 2002 through October of 2002 with no readings above 5.0ppm. More recent sampling (Cook, 2016) indicates an average D.O. of 6.7 ppm, with only two readings slightly below 5.0 ppm. The above sources of data indicate relatively good specific conductance and turbidity values that may have increased in recent years, Cook (2016) reporting over half of his readings above 50 ntu that appear strongly correlated to discharge.

3.5.6.2 Nutrient Over-enrichment

Cook (2016) reports nitrate values consistently above 1 ppm in both Pensacola Branch and Polecat Creek during the January through March sampling period, but significantly lower values in April and May samples. This seasonal difference in nitrate values is even more evident in the data from Baker Branch that varies from 0.96 ppm to 1.45 ppm in the January and February samples but was less than detectable (<0.03 ppm) for March and April. Pensacola Branch and Polecat Creek have the highest estimated nitrate loading (normalized) in the Weeks Bay Watershed at 0.46 t/mi^2/yr and 0.36 t/mi^2/yr, respectively. Cook (2016) also reports total phosphorus concentrations frequently above 0.1 ppm for Pensacola Branch (0.09 - 0.197 ppm), lower Polecat Creek (CR 9) normally under 0.1 ppm (.056 - .127 ppm) and Baker Branch extremely high (0.254 ppm to 2.00 ppm). Pensacola Branch and Polecat Creek also had high estimated total phosphorus loads (normalized) at 4.0 and 3.3 t/mi^2/yr. Morrison (2011) also reports extremely high concentrations of total phosphorus in Baker Branch and high concentrations of nitrate in Polecat Creek.

Summing the median nitrogen values reported by O'Neil and Chandler (2003) to obtain a total nitrogen value, Polecat Creek would be ~1.4 ppm and Pensacola Branch ~1.1 ppm; median total phosphorus was reported as 0.02 ppm and 0.01 ppm for Polecat Creek and Pensacola Branch, respectively. The difference between the Cook and the O'Neil and Chandler data is likely due to the land use / land cover changes that have taken place between studies, 1994-1998 (O'Neil and Chandler) and 2016 (Cook).

SWAT model results predict total nitrogen and total phosphorus concentrations from the Middle Fish River Subwatershed (2011) are 1.47 ppm and 0.20 ppm, respectively, which are generally consistent with the concentrations referenced above. These concentrations are expected to increase 52-82% (TN) and 15-25% (TP) by 2040. Also, the SWAT model subwatershed level nutrient loading results are generally consistent with the tributary nutrient concentrations referenced above and used to illustrate the drainage areas predicted to have the highest TN and TP yields (Figure 3.16).

3.5.6.3 Pathogens

Bacteriological data from Middle Fish River Subwatershed (Table 3.15) is limited spatially and temporally, and generally dated. The available data indicates the variability in pathogen levels is associated with stream discharge and that the ADEM water quality standards are occasionally exceeded during periods of high flow, particularly in the mainstem of Fish River. A notable exception is Baker Branch that maintains relatively low bacteria levels even during high flow events.

Table 3.15 Pathogen Sampling Data Middle Fish River Subwatershed

Waterbody	Location	Fecal coliform	Fecal strep.	E. coli
Fish River	CR 48	50-32,000[1]	96-96,000[1]	91-1,011[2]
Fish River	CR 48			0-6,200[3]
Fish River	Above Polecat Ck			0-12,167[5]
Fish River	Woodhaven Dairy			0-2,600[3]
Pensacola Br.	CR 48	30-5,000[1]	57-6,800[1]	120->2,420[2]
Baker Branch	CR 55	37-9,700[1]	27-16,400[1]	148-317[2]
Baker Branch	CR 55			0-200[5]
Polecat Creek	CR 9	30-1,040[1]	118-2,500[1]	99-961[2]
Polecat Creek	CR 9			0-489[5]

[1] O'Neil and Chandler (2003) reported in colonies/100 ml
[2] Cook (2016) reported as MPN (Most Probable Number)
[3] Fish River Bacterial Source Tracking Project (2009) reported in colonies/100 ml
[4] ADEM (2011) reported as colonies/100 ml
[5] Alabama Water Watch (dates vary by station) reported as colonies/100 ml

3.5.6.4 Contaminants

No information is currently available on other contaminant loadings to the Middle Fish River Subwatershed.

3.5.7 Lower Fish River Subwatershed Water Quality

The Lower Fish River Subwatershed extends from the Fish River-Polecat Creek confluence southward to Weeks Bay and is considered for water quality purposes by ADEM as coastal waters. Although this 12 digit USGS Hydrologic Unit encompasses Weeks Bay proper, for purposes of water quality discussions and modeling, only Fish River proper is included, Weeks Bay water quality is discussed separately. The Lower Fish River Subwatershed receives drainage primarily from Cowpen Creek, Waterhole Branch and its tributary Green Branch, and Turkey

Branch from the west and Barner Branch and other small tributaries from the east. Cowpen Creek receives a large portion of its drainage from the City of Fairhope and the surrounding urban area.

3.5.7.1 Geochemical and Physiochemical Parameters

The mainstem of Fish River has been sampled at CR 32 by Cook (2016) who reports an average D.O. of 7.4 ppm, and an average turbidity of 65 ntu, with 60% of the readings below 50 ntu. Specific conductance readings were unremarkable, although normally 2-3 times above the ADEM reference reach value (20.4 µmho) and, on one occasion, document tidal influence. AWW data from 1997-2012 indicate relatively low turbidity but D.O. frequently less than 5.0 ppm, with readings occasionally ranging below 4.0 ppm (Figure 3.21).

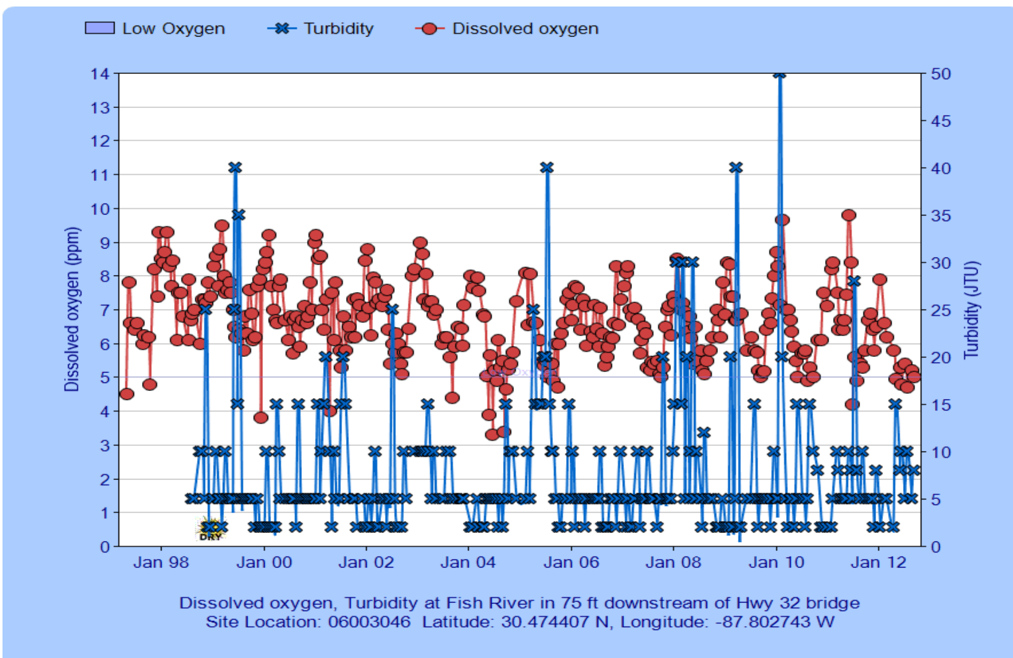


Figure 3.21 AWW Turbidity and D.O. in Fish River near CR 32
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

Cowpen Creek at CR 33 was reported as having good D.O. (median of 7.5 ppm) and a specific conductance ranging from 21-52 µmho with low turbidity and pH within normal range (O'Neil and Chandler, 2003). Cook (2016) reports slightly higher D.O. (average of 7.98 ppm) and conductance (range of 30-57 µmho) and much higher turbidity levels with readings consistently >100 ntu during high discharge. ADEM (2011) reports similar D.O. and specific conductance, but significantly lower turbidity, with no readings above 7.0 ntu. AWW data from 1999-2003 at this location show good D.O. and relatively low turbidity. However, further upstream on Cowpen Creek, at Highway 181, D.O. was consistently <5.0 ppm and turbidity was frequently elevated during 1998-2003 (Figure 3.22).

Cook (2016) found good D.O. (average of 7.9 ppm), specific conductance of 34-73 µmho and normal pH in Green Branch (at Danne Road), a tributary to Waterhole Branch. Green Branch drains a developing area near the intersection of Alabama Highway 181 and CR 32, and turbidity readings reported by Cook are all over the ADEM reference reach value of 9.7 ntu and exceed 100ntu during high discharge. The upper reaches of Waterhole Branch drain the southern portions of the City of Fairhope, including the airport, and developing areas west of Alabama Highway 181. O'Neil and Chandler (2003) report a depressed D.O. ranging from 0.5ppm to 9.6ppm (median of 3.5 ppm), specific conductance of 51 µmho (median) and a median turbidity of 22 ntu in Waterhole Branch at Alabama Highway 181. At the same location, Cook (2016) reported D.O. values <5.0 ppm in 2 of 7 samples and slightly higher specific conductance and turbidity values. Further downstream along Waterhole Branch, AWW data from 1999-2003 indicates low turbidity and D.O. readings consistently below 5.0 ppm.

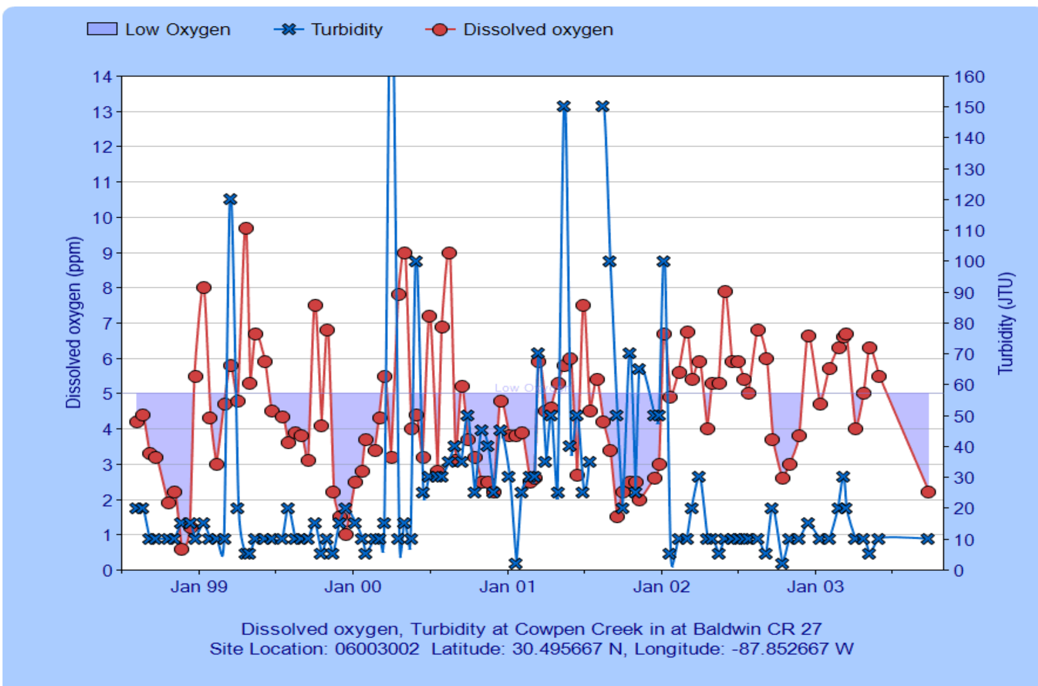


Figure 3.22 Turbidity and D.O in Cowpen Creek at Alabama Highway 181
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

Turkey Branch also drains portions of the City of Fairhope, as well as the agricultural lands in the southwestern portion of the Watershed. On Turkey Branch at Highway 181 O'Neil and Chandler (2003) report a median D.O. of 7.9 ppm, ranging down to 4.2 ppm, turbidity ranging from 29 ntu to 118 ntu and a wide range of specific conductance, indicative of tidal influence. AWW data from 2001 and 2002 indicate low turbidity and consistently low D.O., with 88% of the readings <5.0 ppm. Cook (2016) reports D.O. readings of 5.2-9.0 ppm, specific conductance of 41-67 µmho, and turbidity values ranging from 11-164 ntu, depending on discharge.

The small tributaries draining the east side of the Lower Fish River Subwatershed have been less well studied. In 1994-1998 Barner Branch was sampled at CR 9 by O'Neil and Chandler

(2003) and found to have D.O. ranging from 4.0 to 9.4 ppm, a median specific conductance of 50 µmho, and median turbidity of 6ntu. AWW data from this location collected in 2001-2003 indicate low turbidity and frequently low (<5.0 ppm) D.O. Further downstream on Barner Branch, in the small basin near the mouth, AWW data from 1999-2008 indicate generally low turbidity and D.O. frequently below 5.0 ppm and occasionally less than 3.0 ppm (Figure 3.23).

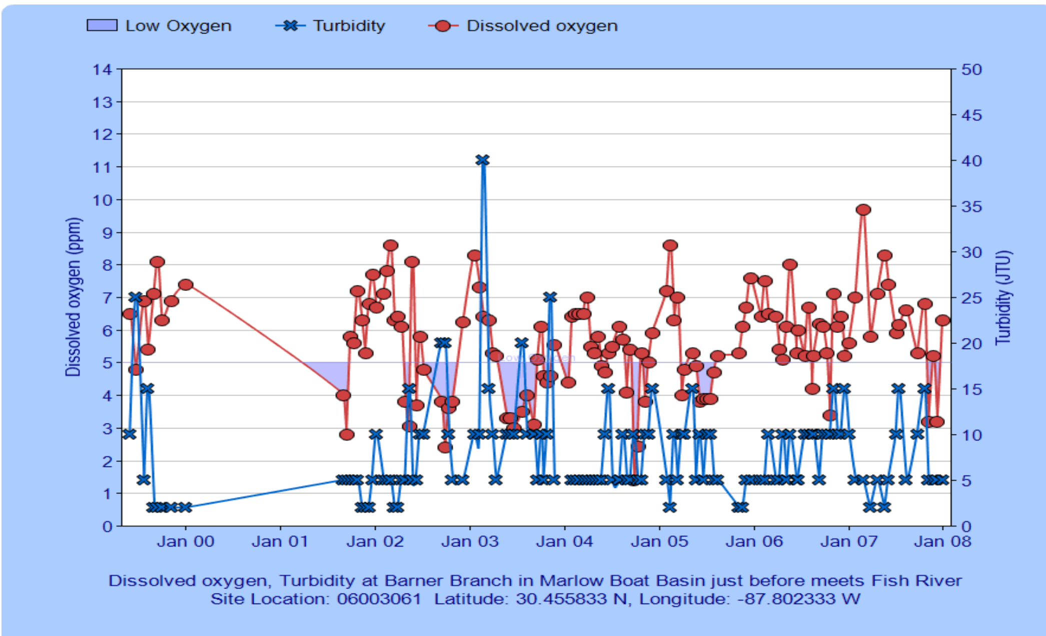


Figure 3.23 Turbidity and D.O in Barner Branch at Marlow
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

The main stem of Fish River discharges into Weeks Bay at U.S. Highway 98 and represents the majority of freshwater flow into the Bay. This location has been sampled as part of a number of studies, is an ADEM long term water quality trend station (WB-1), an AWW monitoring site, and there is a continuous water quality monitoring site through the NERRS. Most all data reviewed for this location indicate low turbidity (<20 ntu) that increases during high river flow, and variable D.O. concentrations, occasionally dipping below 5.0 ppm. Figures 3.24 – 3.27 graphically represent the AWW data, ADEM trend station data and NERRS data for D.O. and turbidity.

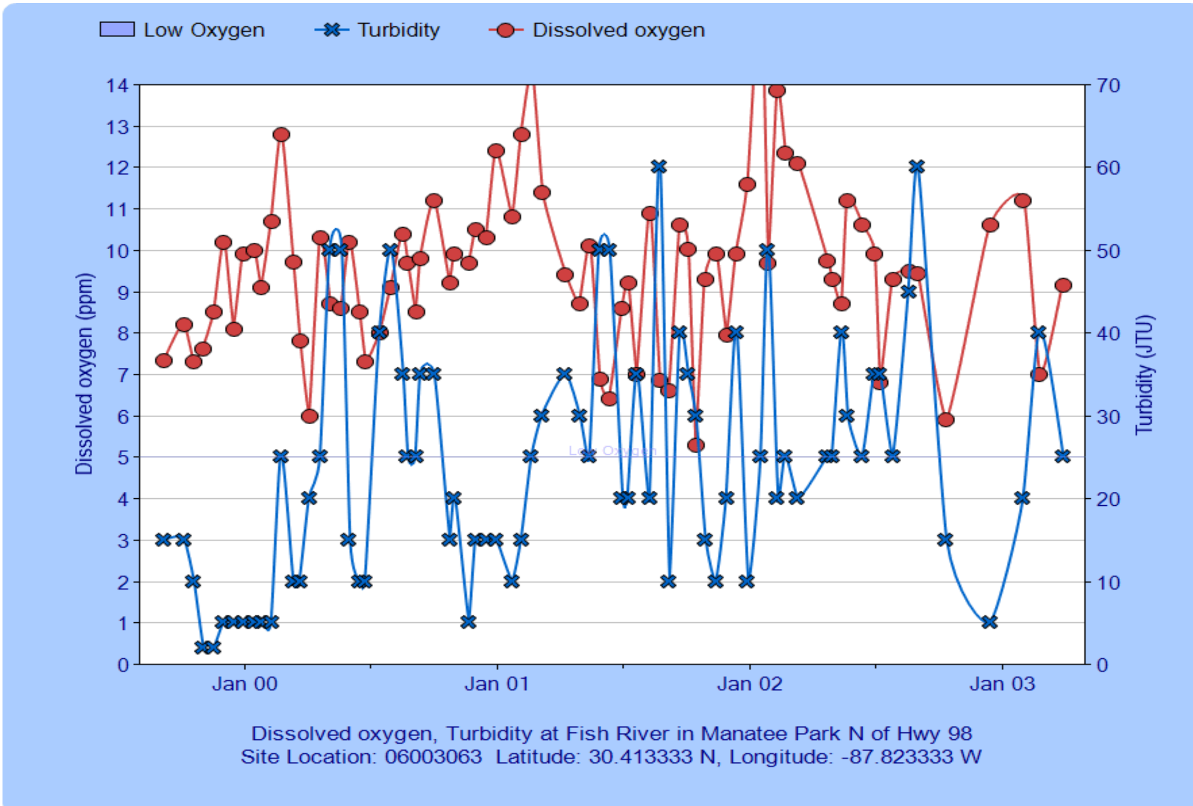


Figure 3.24 AWW Turbidity and D.O. in Fish River near U.S. Highway 98
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

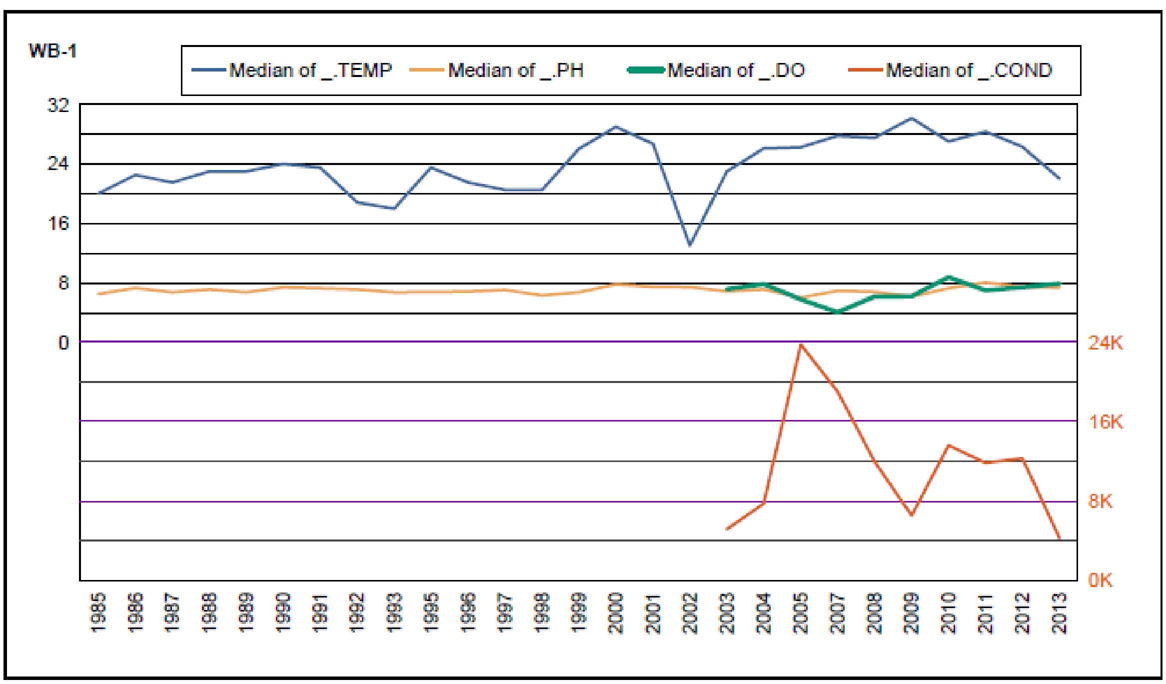


Figure 3.25 ADEM Temperature, pH, D.O. and Conductance in Fish River near U.S. Highway 98
Source: ADEM (2014)

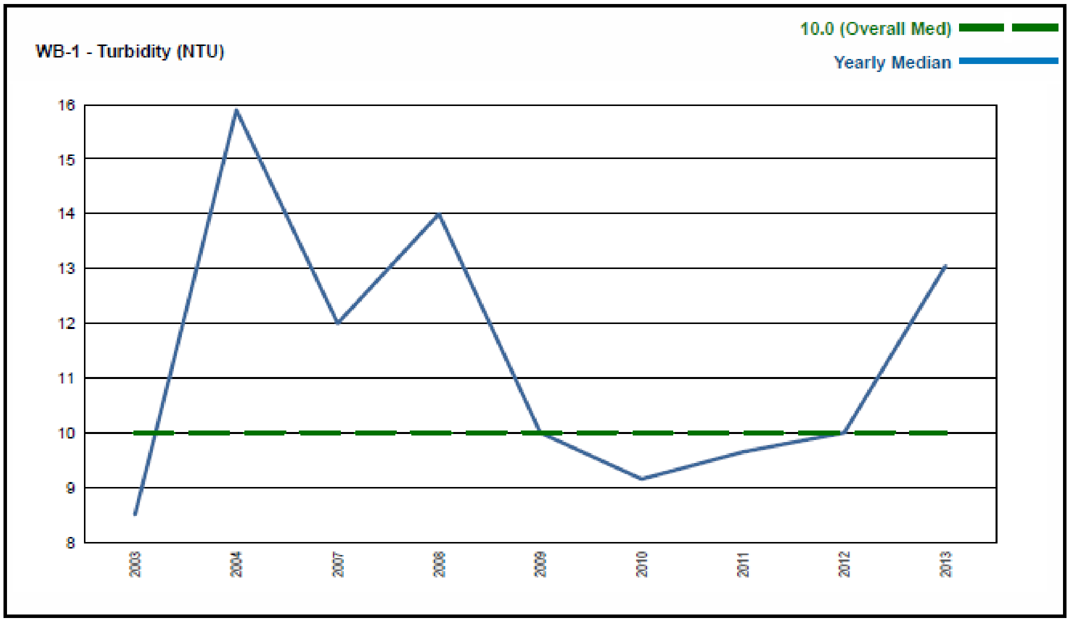


Figure 3.26 ADEM Turbidity in Fish River near U.S. Highway 98
Source: ADEM (2014)

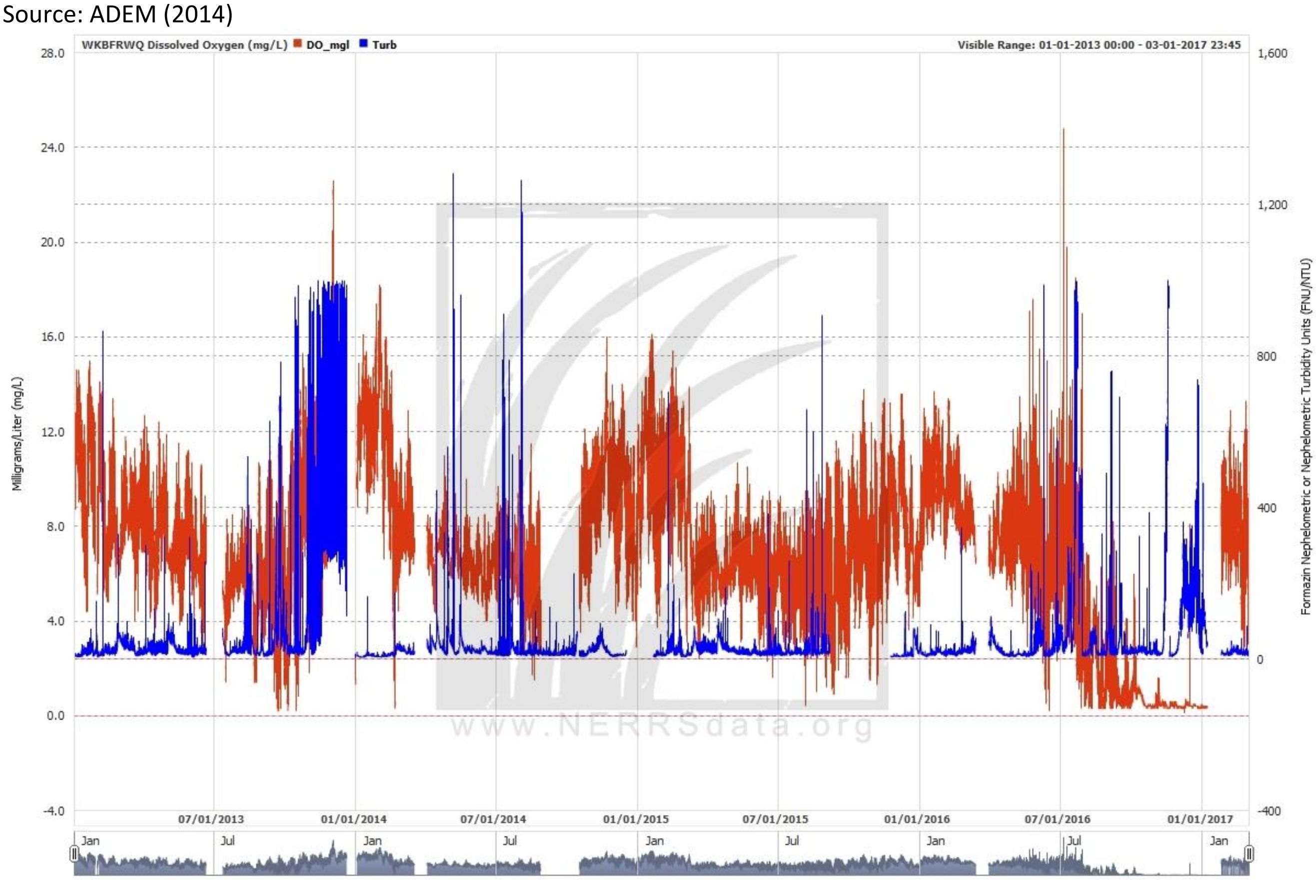


Figure 3.27 NERRS Dissolved Oxygen and Turbidity in Fish River near U.S. Highway 98
Source: NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed January 23, 2017*.

3.5.7.2 Nutrient Over-enrichment

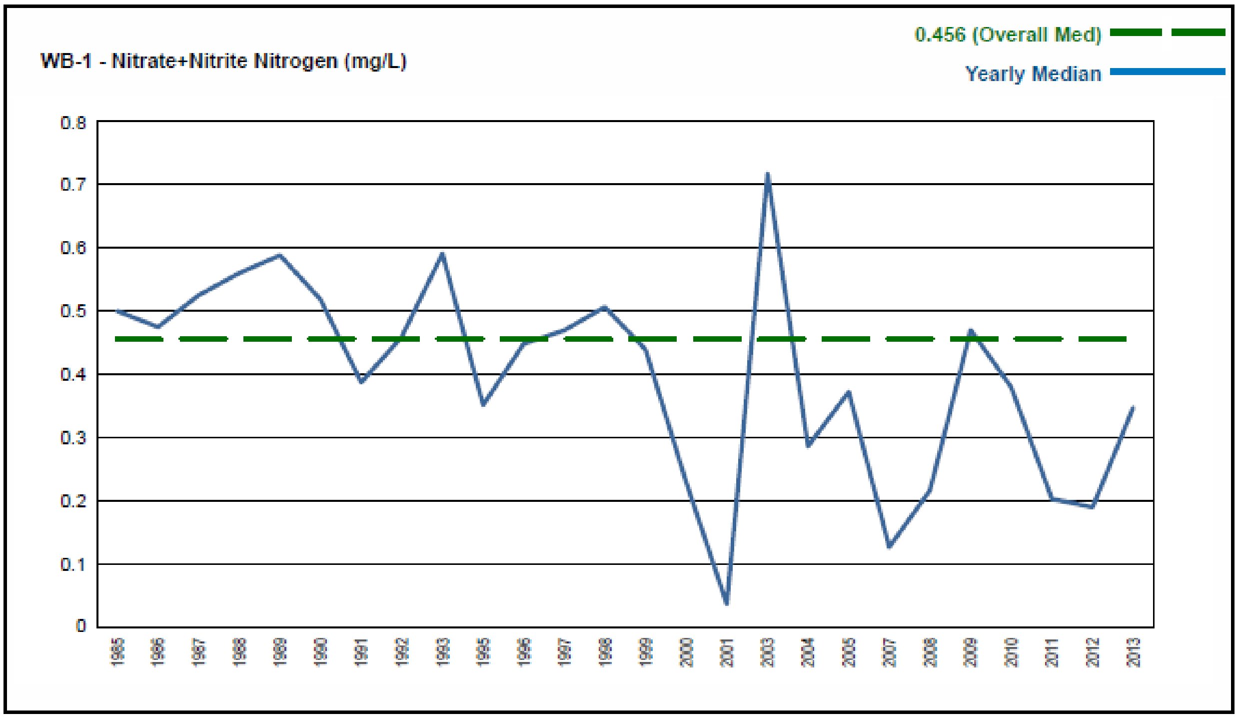
Nitrate levels in Cowpen Creek at CR 33 were observed by Cook (2016) to range from 0 ppm to 1.37 ppm, with higher concentrations observed at lower flow conditions, indicative of groundwater sources. Total phosphorus levels ranged from 0 ppm to 0.31 ppm and increased with increasing flow, indicative of surface runoff sources. Although these concentrations are above the ADEM ecoregion reference values, when loadings (t/mi^2/yr) are calculated and normalized based on drainage area, Cowpen Creek has among the lowest estimated nitrate and total phosphorus loads of all sampling sites visited by Cook (2016). ADEM (2011) reported a median total nitrogen concentration of 1.37 ppm and a median total phosphorus concentration of 0.01 ppm for Cowpen Creek. O'Neil and Chandler (2003) report median nitrogen species concentrations that, when summed, indicate a total nitrogen concentration of 1.45 ppm and they report a median total phosphorus concentration of <0.01 ppm.

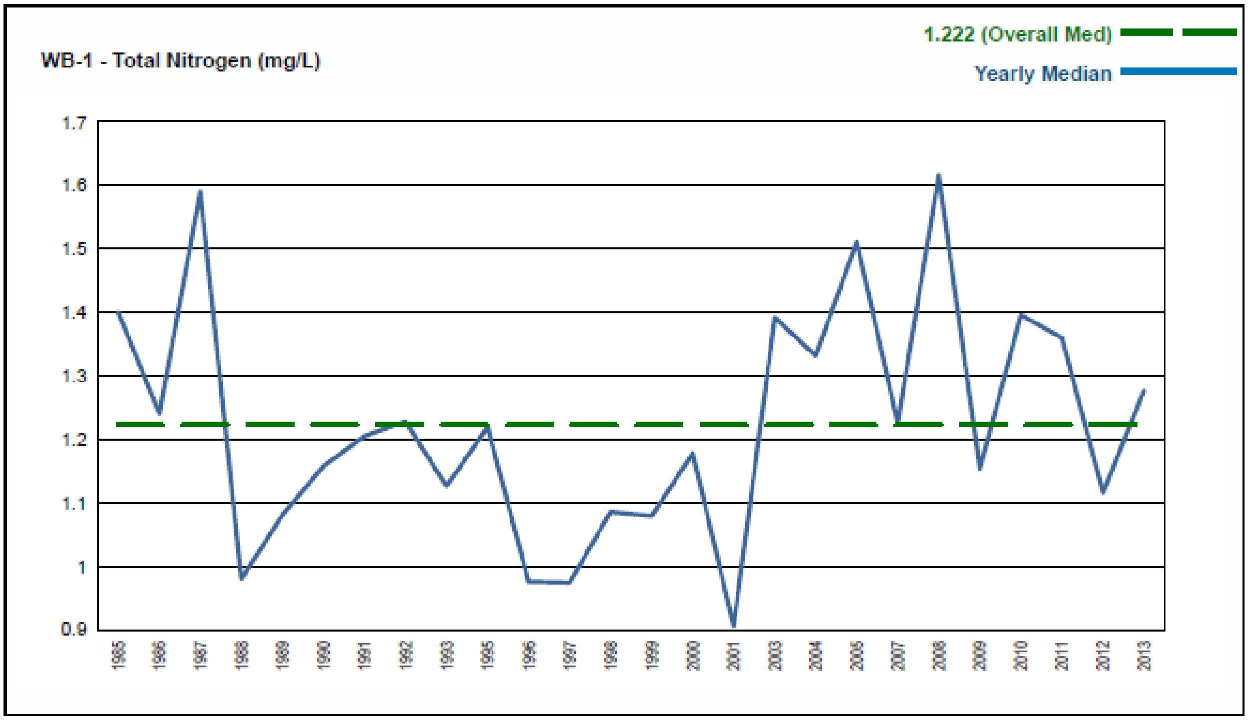
Waterhole Branch and its tributary Green Branch drain the central west side of the Lower Fish River Subwatershed. Nitrate levels are reportedly low in both Waterhole Branch and Green Branch while total phosphorus ranges from 0.05 ppm to 1.68 ppm in Waterhole Branch and <0.05 ppm to 0.248 ppm in Green Branch (Cook, 2016). Morrison (2011) reports a mean nitrate concentration of 0.06 ppm and a mean total phosphorous level of ~0.8 ppm in Green Branch. O'Neil and Chandler (2003) report median nitrogen concentrations that, when summed, give a total nitrogen concentration of 0.74 ppm (the majority being organic), and a median total phosphorous concentration of 0.04 ppm in Waterhole Branch. Turkey Branch (lower) mean nitrate concentrations are reported as 0.21 ppm (Morrison, 2011), 0.33 ppm (Cook, 2016), while total nitrogen concentrations are reported as 0.70 ppm (O'Neil and Chandler, 2003). Reported mean total phosphorous concentrations in Turkey Branch (lower) range from 0.04 ppm (O'Neil and Chandler, 2003) to 1.05 ppm (Morrison, 2011), with Cook (2016) reporting an average total phosphorous concentration of 0.204 ppm and estimated normalized loading of 1.8 t/mi^2/yr, the highest recorded in the Fish River Watershed.

Barner Branch is the largest tributary draining the east side of the Lower Fish River Subwatershed and receives the discharge from the Magnolia Landfill. O'Neil and Chandler (2003) report a high median total nitrogen concentration of 2.04 ppm, but a low median total phosphorous (<0.01 ppm).

Nutrient levels in the mainstem of Fish River at CR 32 were found by Cook (2016) to vary with flow, high nitrate concentrations (~1.56 ppm) and low total phosphorous (<0.05 ppm) were reported during the January-February sampling, while lower nitrate concentrations (~0.533 ppm) and slightly higher total phosphate concentrations (~0.07 ppm) were reported during the higher flow sampling period of March-April.

The outlet of Fish River at U.S. Highway 98 has been monitored by ADEM as part of their long-term trend station program, station WB-1, since 1985. A summary of data (yearly median concentrations) was presented in graphic form in ADEM's *2014 Integrated Water Quality Monitoring and Assessment Report* (Figure 3.28). These graphs indicate that nitrate-nitrite nitrogen is showing a slight decreasing trend and higher variability; total nitrogen concentrations, although higher in more recent years, also appear to show a recent downward trend. Nitrate-nitrite does not track as strongly with total nitrogen at this sampling location, perhaps indicating that organic nitrogen makes up a higher percentage of total nitrogen. Instream phosphorus concentrations also appear to have a high annual variation with a definite increasing trend since 1995. Additional nutrient information for this location, indicating a similar range of concentrations, is available through the NERRS (Figure 3.29).





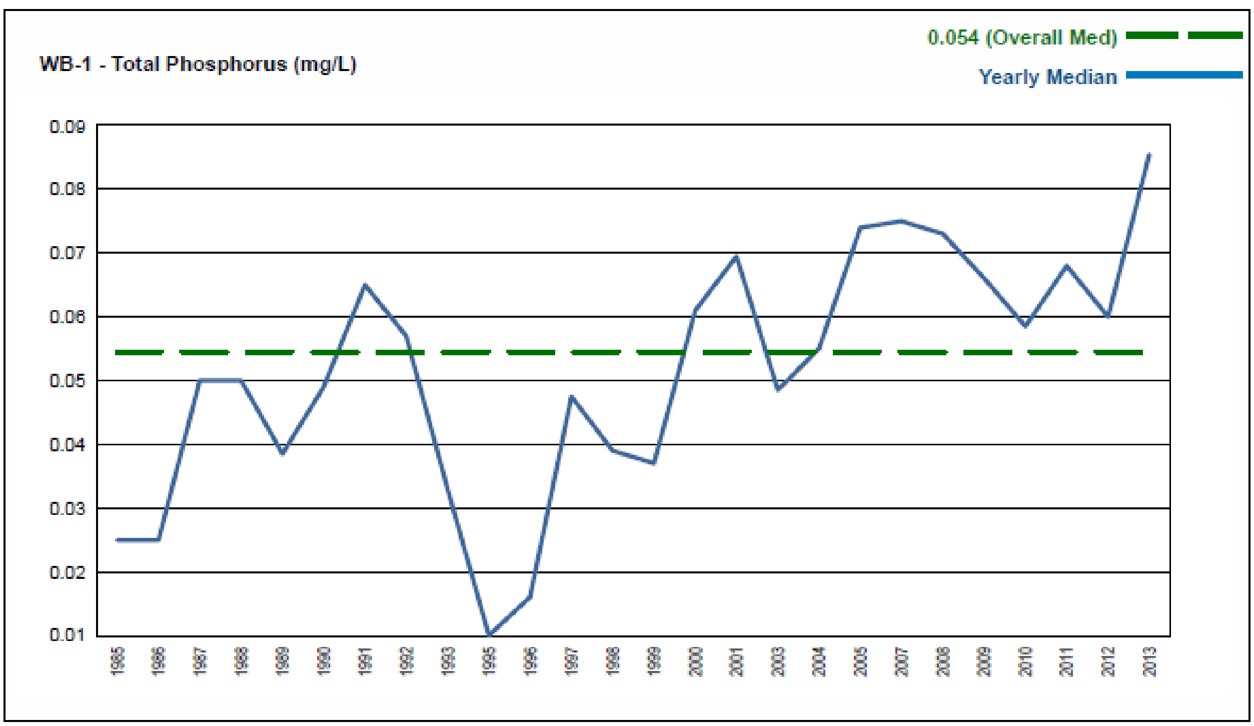


Figure 3.28 Nitrogen and Phosphorous Concentrations in Fish River at U.S. Highway 98
Source: ADEM Ambient Trend Stations – Sampled 1977-2014, ADEM, 2014.

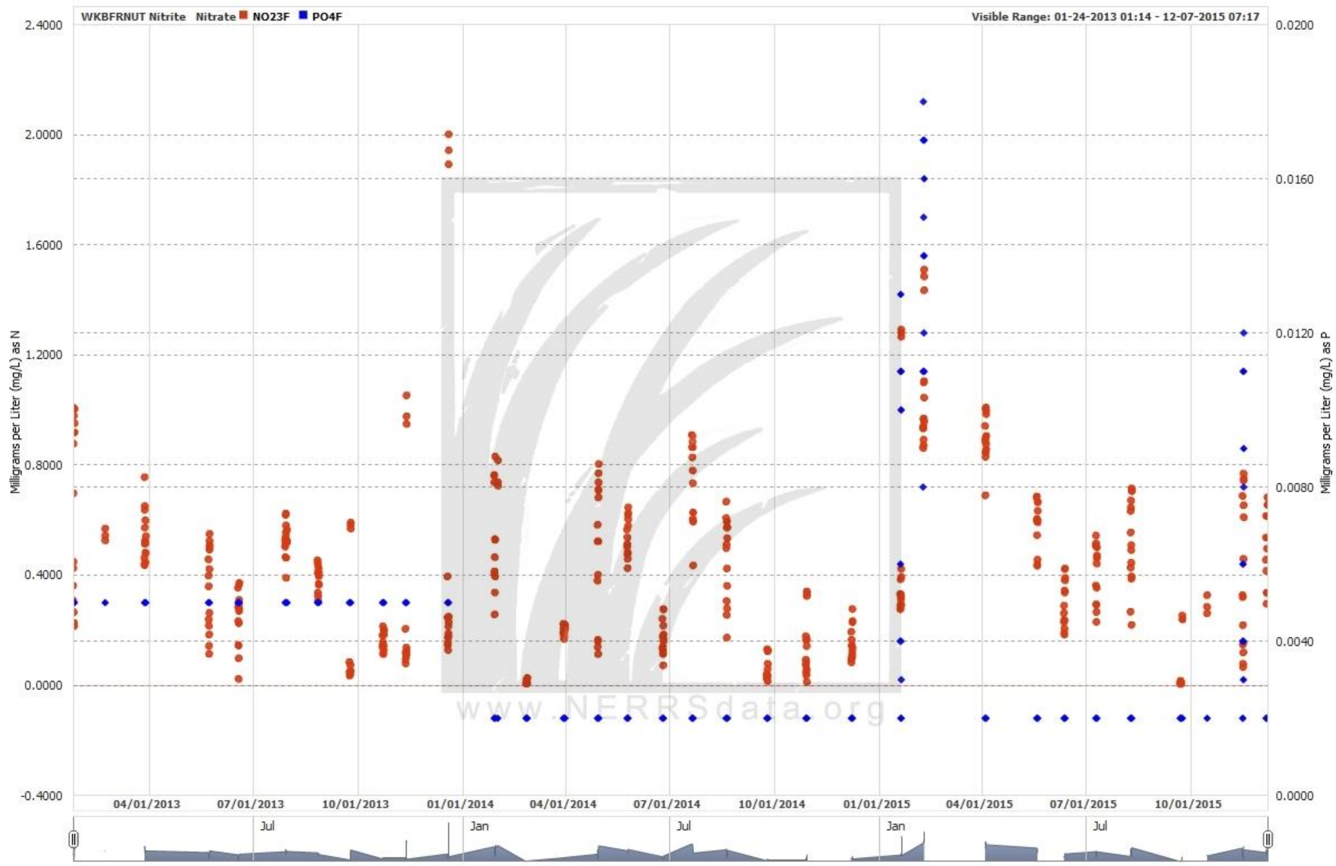


Figure 3.29 Nitrate-Nitrite and Phosphorus in Fish River near U.S. Highway 98
Source: NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed March 13, 2017*.

SWAT model results predicting total nitrogen and total phosphorus concentrations from the Lower Fish River Subwatershed (2011) are 1.54 ppm and 0.22 ppm, respectively, and generally higher than the ADEM long term trend median. The TN concentrations are expected to increase 47-74% (TN) by 2040; however, TP is expected to remain constant or only slightly increase (9%). Also, the SWAT model subwatershed level nutrient loading results are generally consistent with the range of tributary nutrient concentrations referenced above and illustrate the drainage areas predicted to have the highest TN and TP yields (Figure 3.16).

3.5.7.3 Pathogens

Data from the mainstem of Lower Fish River Subwatershed (Table 3.16) indicate that the bacteria levels in the more developed segments occasionally exceed the ADEM water quality standards during high flow. The AWW data from near Marlow Park off Honey Road (Figure 3.30) are fairly typical. More recent and area specific data is needed to assess potential bacteriological contributions from septic tanks located near the River and tributaries.

Table 3.16 Pathogen Data for Lower Fish River Subwatershed

Waterbody	Location	Fecal coliform	Fecal strep.	E. coli
Fish River	CR 32			156[2]
Fish River	River Park			0-325[4]
Fish River	Marlow Park			0-2,500[4]
Fish River	Marlow Basin			0-7,500[4]
Fish River	Hwy 98	3-10,600[1]	2-6,000[1]	0-278[4]
Cowpen Creek	CR 33	23-2,800[1]	60-3,400[1]	152->2,420[2]
Cowpen Creek	CR 33			0-100[5]
Cowpen Creek	CR 33			3-150[3]
Cowpen Creek	Hwy 181			0-283[4]
Green Branch	Danne Rd			71->2,420[2]
Waterhole Br.	Hwy 181	7-24,000[1]	27-31,000[1]	16-1,011[2]
Waterhole Br.	Near mouth			0-392[4]
Turkey Branch	Hwy 181			162->2,420[2]
Turkey Branch	Hwy 181			0-333[4]
Turkey Branch	Moore Dock			0-1611[4]
Barner Branch	CR 9	30-1,540[1]	17-9,800[1]	17-367[4]

[1] O'Neil and Chandler (2003) reported in colonies/100 ml
[2] Cook (2016) reported as MPN (Most Probable Number)
[3] ADEM (2011) reported as colonies/100 ml
[4] Alabama Water Watch (dates vary by station) reported as colonies/100 ml

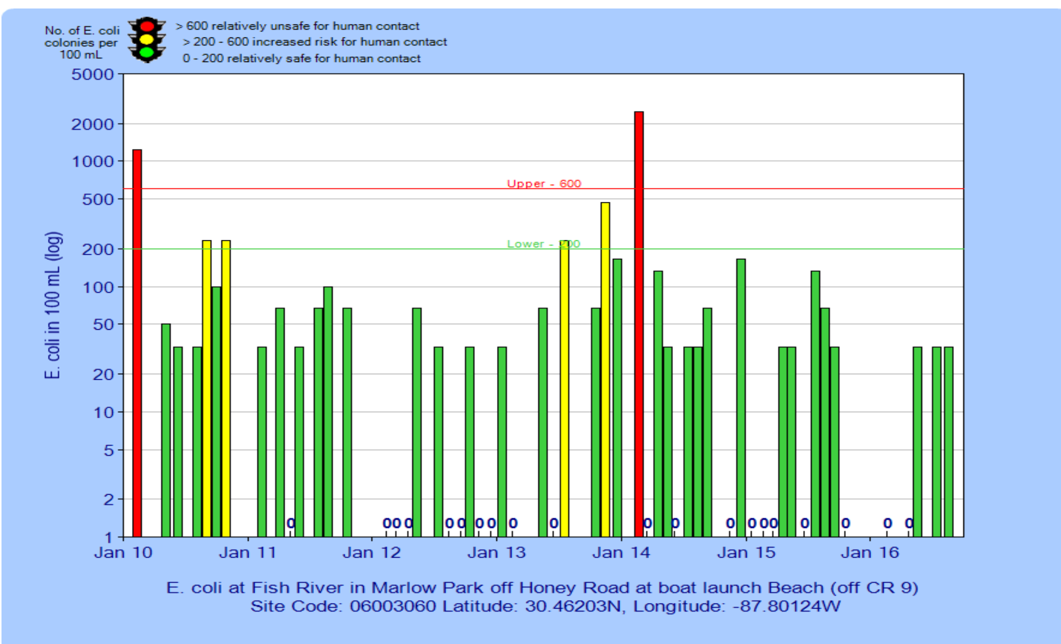


Figure 3.30 AWW E. coli Data for Fish River near Honey Road
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

3.5.7.4 Contaminants

No information is currently available on other contaminant loadings to the Lower Fish River Subwatershed.

3.5.8 Magnolia River Subwatershed

The Magnolia River and its tributaries drain the southeastern portion of the Weeks Bay Watershed that includes portions of the Town of Summerdale, City of Foley and the Town of Magnolia Springs. Major tributaries include: Eslava Branch, Weeks Creek, Schoolhouse Branch, Brantley Branch, and Nolte Creek.

3.5.8.1 Geochemical and Physiochemical Parameters

The upper reaches of Magnolia River proper were sampled at CR 24 in 1994-1998 by O'Neil and Chandler (2003) and found to have low turbidity (median of 5 ntu), highly variable D.O (3.7-10.2 ppm), a median specific conductance of 66µmho, and pH values were observed ranging down to 5.0 s.u. AWW data from this location from 1997-2005 indicate frequent D.O. values less than 5.0 ppm and generally low turbidity (Figure 3.31). Brantley Branch at CR 24 was also sampled by O'Neil and Chandler (2003) who reported generally low turbidity (median of 10 ntu), highly variable D.O. ranging from <1.0-9.4 ppm, and specific conductance ranging from 42-103 µmho. AWW data from Brantley Branch at this location from 2001-2003 indicates consistently low D.O. (Figure 3.32).

Schoolhouse Branch was also found to have highly variable D.O., ranging from 1.0-9.7ppm, slightly lower specific conductance and highly variable turbidity (4-250ntu) (O'Neil and Chandler, 2003). The same study reports that Eslava Branch (at U.S. Highway 98), which also drains primarily agricultural lands in the northern portion of the Watershed, has better D.O. concentrations of 5.7-6.9ppm, turbidities ranging from 20-180ntu and a median specific conductance of 43µmho. AWW data (ca. 1997-1998 and 2003) from Eslava Branch at its mouth indicate relative good D.O. and low turbidity.

Weeks Creek and Nolte Creek are the primary tributaries draining the southern portion of the Watershed. Weeks Creek was sampled at CR 26 in 1994-1998 by O'Neil and Chandler (2003) who report consistently depressed D.O. (median of 1.9ppm), highly variable turbidity (3.5-500ntu) and a median specific conductance of 62µmho. These conditions are also evident in the AWW data collected from 1997-2015 (Figure 3.33). These poor water quality conditions are likely due to the extensive stream alterations and lack of riparian buffer in the upper reaches, upstream of Bay Road.

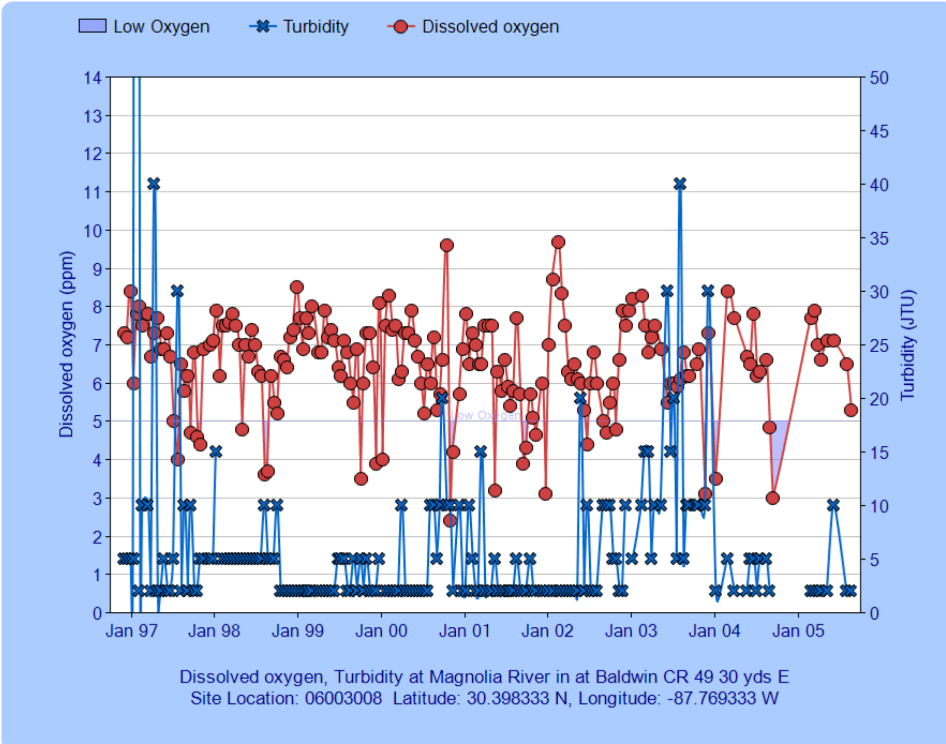


Figure 3.31 Turbidity and D.O. in Magnolia River near CR 49
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

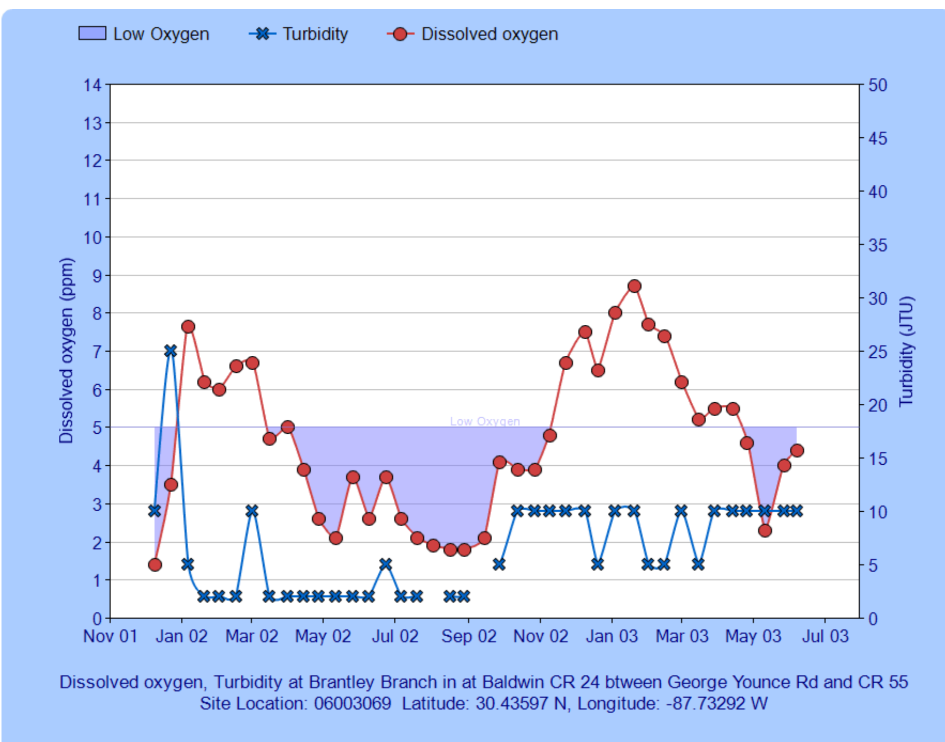


Figure 3.32 Turbidity and D.O in Brantley Branch at CR 24
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

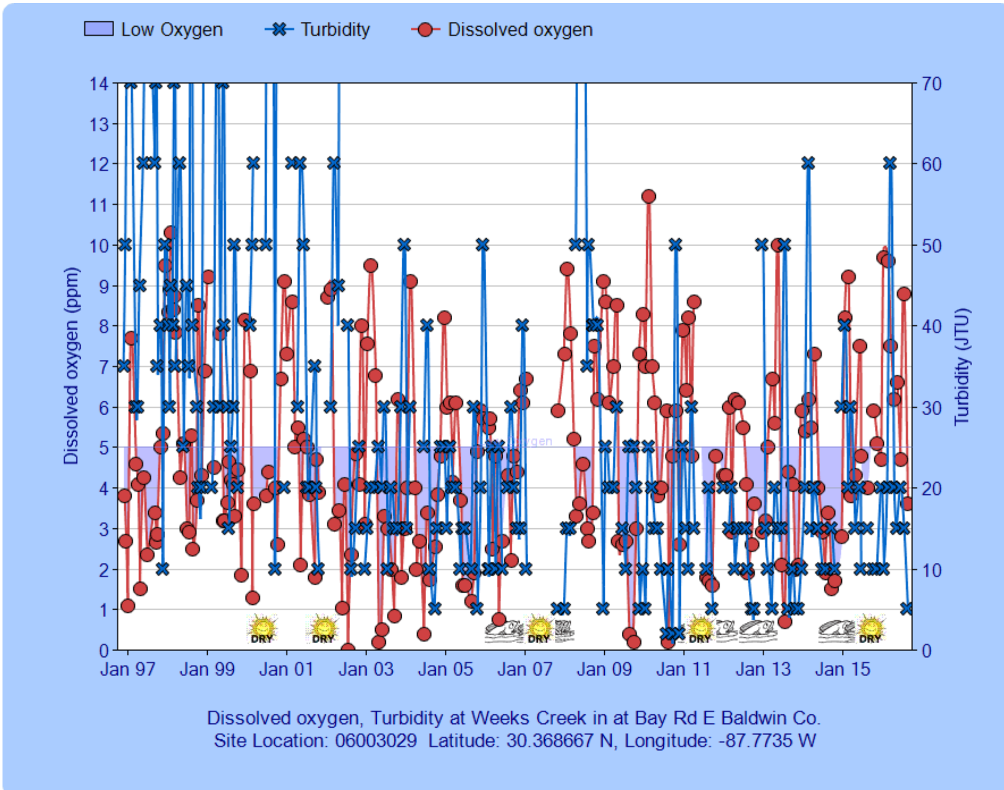


Figure 3.33 Turbidity and D.O. in Weeks Creek at Bay Road East
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

AWW data collected from Nolte creek at CR 26 (ca. 1997-1998, 2001, 2009) indicates higher D.O. (normally >5.0 ppm) and generally lower turbidity.

The main stem of the Magnolia River has been monitored at several locations below the headwaters location (CR 24). AWW monitoring on the Magnolia River occurred from 1997-2007 at CR 65, indicating good D.O. levels and low turbidity.

In 2011, ADEM published a water quality monitoring summary and reported D.O. values ranging from 6.9-8.7 ppm in Magnolia River at U.S. Highway 98. A median specific conductance of 71 µmho and turbidity values less than 7 ntu were also reported. O'Neil and Chandler (2003) reported highly variable D.O. (0.2-8.9 ppm), turbidity (1-500 ntu), and specific conductance (34-16,400 µmho) at CR 49. The depressed D.O. conditions are also evident in the AWW data from this location and another location approximately 300 yards downstream, with levels frequently dipping below 5.0 ppm (Figure 3.34).

The Weeks Bay NERR has maintained a continuous water quality monitor near the mouth of Magnolia River and real-time data are available at: https://coast.noaa.gov/nerrs/reserves/weeks-bay.html; and the historical data is available online at: http://cdmo.baruch.sc.edu/. These data (Figure 3.35) confirm the variability in both D.O. and turbidity in the Magnolia River.

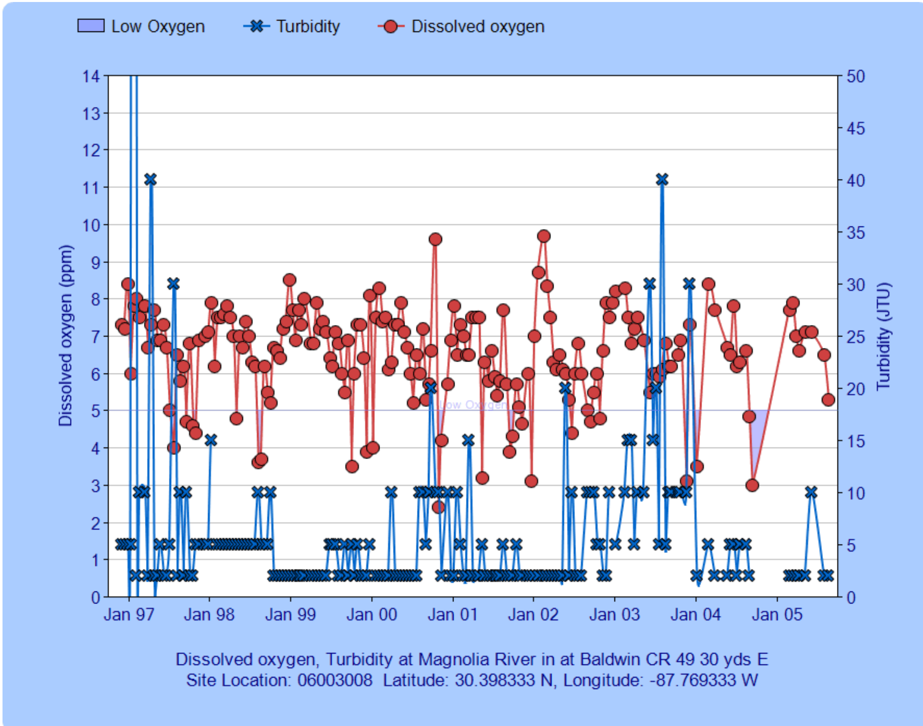


Figure 3.34 Turbidity and D.O. in Magnolia River at CR 49
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

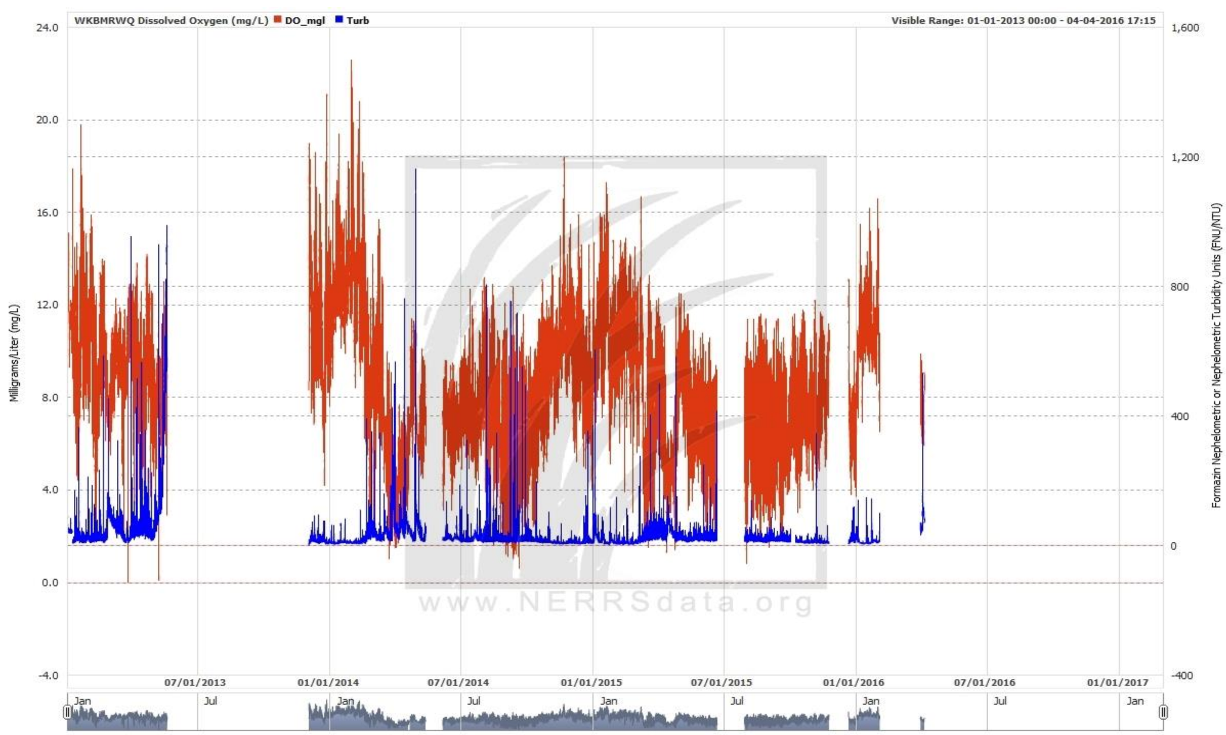


Figure 3.35 Magnolia River NERRS Dissolved Oxygen Data 2013-2016
Source: NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed March 13, 2017*.

3.5.8.2 Nutrient Over-enrichment

The Magnolia River Subwatershed is less well studied than the Fish River, particularly so for nutrient concentrations or loadings. The headwaters of Magnolia River were sampled at CR 24 in 1994-1998 and a very high median total nitrogen concentration of 3.17 ppm was reported, of which 2.95 ppm was nitrate-nitrite (O'Neil and Chandler, 2003). During the same study, total phosphorous concentrations were reported as low (median <0.01 ppm). Further down the Magnolia River, at CR 49, O'Neil and Chandler (2003) reported a median total nitrogen concentration of 2.44 ppm and a median total phosphorous concentration of 0.1 ppm. They also sampled several tributaries within the Magnolia River Watershed with the concentrations shown in Table 3.17 being reported:

Table 3.17 Nutrient Data for Magnolia River Tributaries

Tributary	Location	Median Total Nitrogen[1]	Median Total Phosphorous
Eslava Creek	US Hwy 98	0.03 ppm	0.04 ppm
Schoolhouse Branch	US Hwy 98	0.08 ppm	0.02 ppm
Weeks Creek	CR 26	0.96 ppm	0.07 ppm
Brantley Branch	CR 24	2.04 ppm	0.02 ppm

[1] Reported nitrogen values were summed to represent total nitrogen.

ADEM reports in its 2011 Monitoring Summary for Magnolia River at U.S. Highway 98 a median total nitrogen concentration of 2.198 ppm and median total phosphorous concentration of 0.014 ppm.

SWAT model results predicting total nitrogen and total phosphorus concentrations from the Magnolia River Subwatershed (2011) are 1.74 ppm and 0.17 ppm, respectively, and generally indicate lower TN and higher TP concentrations than the ADEM long term trend data. These concentrations are expected to increase by 59-74% for TN by 2040, and predicted to decrease by -12% for TP by 2040. Also, the SWAT model subwatershed level nutrient loading results are generally consistent with the tributary nutrient concentrations referenced above and were used to illustrate the drainage areas predicted to have the highest TN and TP yields (Figure 3.16).

3.5.8.3 Pathogens

Bacteriological information from the Magnolia River Watershed (Table 3.18) is mostly outdated, the most recent available being the AWW data that seem to indicate that water quality standards for bacteria are generally being met (Figures 3.36 and 3.37).

Table 3.18 Bacteriological Sampling Data in Magnolia River and Tributaries

Waterbody	Location	Fecal coliform	Fecal strep.	E. coli
Magnolia River	CR 24	27-15,000[1]	90-15,600[1]	0-4,633[2]
Magnolia River	CR 65	17->3,000[3]		0-11,417[2]
Magnolia River	Hwy 98			0-12,933[2]
Magnolia River	CR 49	57-38,000[1]	27-94,000[1]	0-5,900[2]
Magnolia River	near mouth			0-700[2]
Brantley Branch	CR 24	50-2,000[1]	50-12,400[1]	
Schoolhouse Br.	Hwy 98	40-23,000[1]	37-75,000[1]	
Eslava Branch	Hwy 98	170-17,300[1]	200-54,000[1]	
Weeks Creek	Bay Road			0-16,833[2]
Weeks Creek	CR 26	17-50,000[1]	53-106,000[1]	
Weeks Creek	near mouth			11-508[2]
Nolte Creek	CR 26			0-5,033[2]

[1] O'Neil and Chandler (2003) reported as colonies/100 ml

[2] Alabama Water Watch (dates vary by station) reported as colonies/100 ml

[3] ADEM (2006) reported as colonies/100 ml

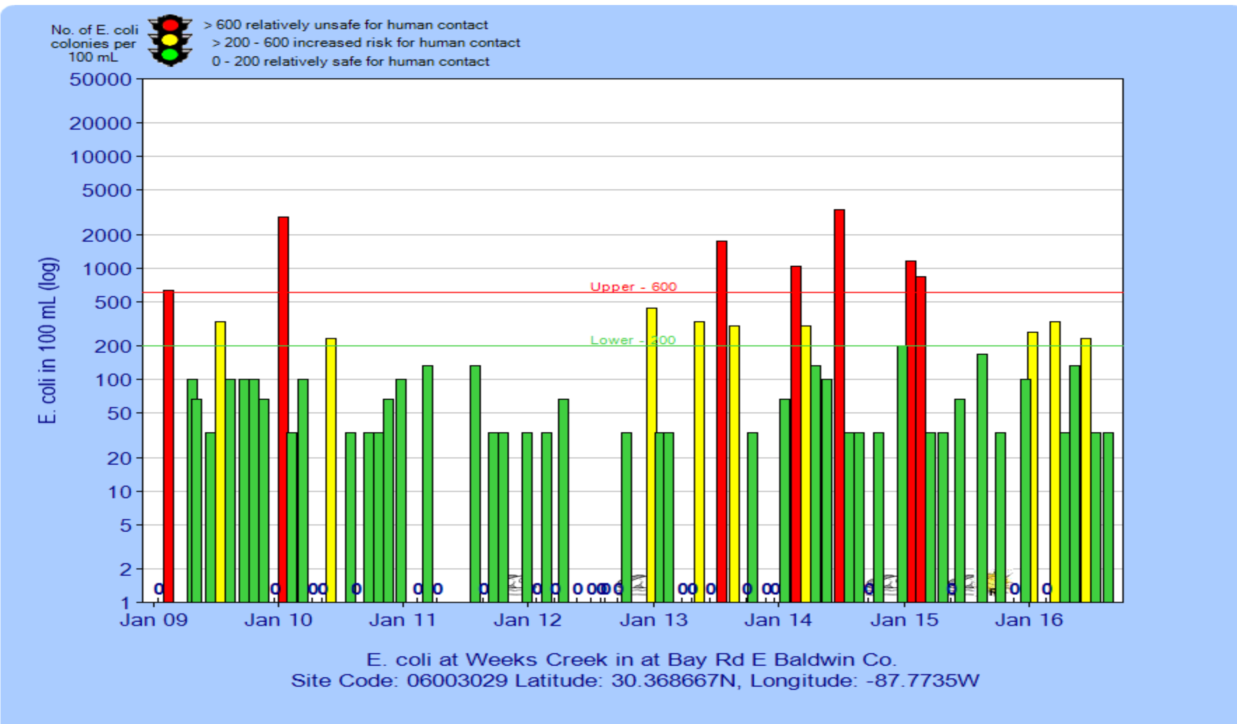


Figure 3.36 E. coli in Weeks Creek at Bay Road East

Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

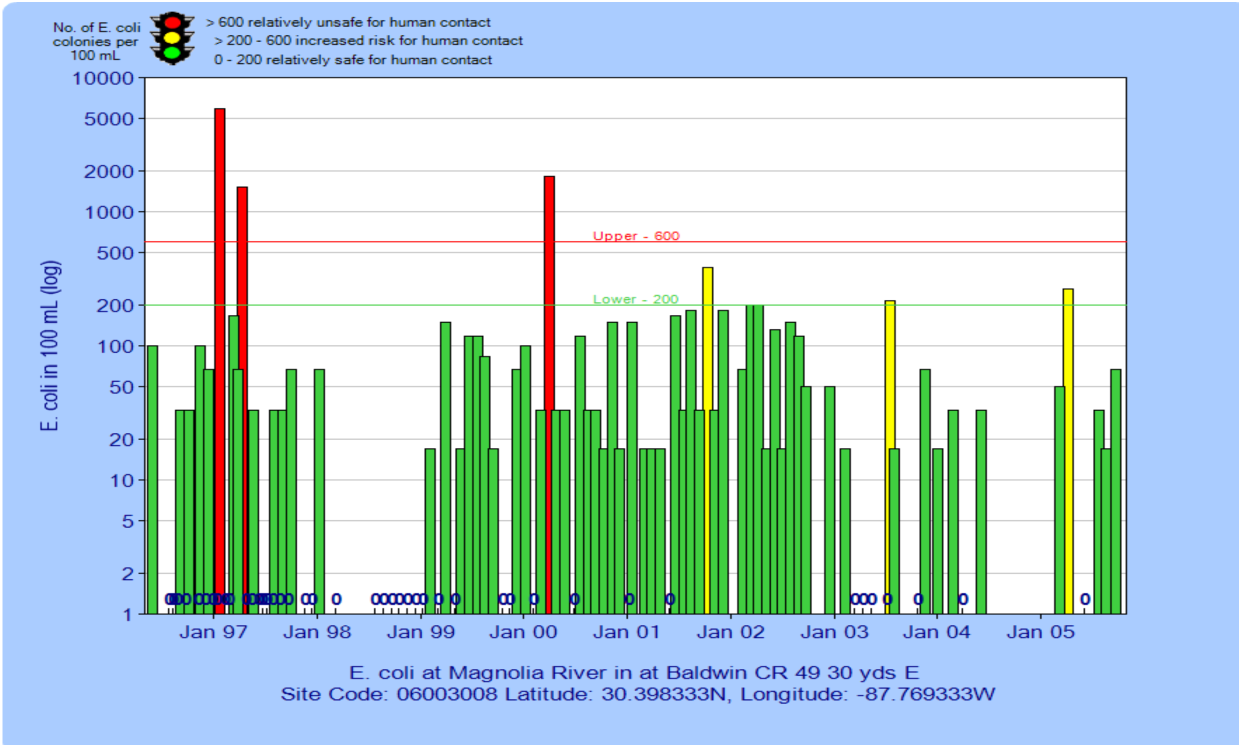


Figure 3.37 E. coli in Magnolia River near CR 49
Source: Alabama Water Watch at http://www.alabamawaterwatch.org/water-data/

3.5.8.4 Contaminants

ADEM (2011) analyzed water samples from Magnolia River at U.S. Highway 98 for a variety of metals, including mercury, and reported a median value for manganese of 0.34ppm which exceeds the ecoregion reference values. No other anomalies were reported. No other information is currently available on contaminant loadings to the Magnolia River Watershed.

3.5.9 Weeks Bay Estuary

Weeks Bay proper is a classic small, shallow tidal sub-estuary that receives its freshwater input from Fish River (approximately 75%) and Magnolia River (approximately 25%) with marine water influence through its connection with Bon Secour Bay. The bay currently enjoys an ADEM water use classification of Outstanding National Resource Water. The Weeks Bay National Estuarine Research Reserve operates several water quality monitoring sondes within the Weeks Bay system as part of a national water quality monitoring network. Data are available online at: http://cdmo.baruch.sc.edu/. Readers are also encouraged to explore the online real time water quality data at: https://coast.noaa.gov/nerrs/reserves/weeks-bay.html and explore the bibliography for additional information on a variety of monitoring and research topics related to Weeks Bay.

3.5.9.1 Geochemical and Physiochemical Parameters

A myriad of classical water quality data is available on Weeks Bay, having been the subject of numerous scientific studies and monitoring efforts. Of these, the WBNERR operation of continuous monitoring sondes as part of the NERRS monitoring program provides the most current and long term data set. Although the bay generally supports its water use classification standards for classical water quality parameters, most researchers, EPA Gulf Ecology Division (Jim Hagy, pers. comm., 2017) and ADEM (2013) consider the bay to be eutrophic, with high chlorophyll *a* levels (~9 ppb) frequently associated with low dissolved oxygen (<5.0 ppm). Episodic hypoxic and anoxic conditions have also been observed by ADEM (2013) and others. Near surface waters generally have good D.O (>5.0 ppm) but D.O. decreases with increased depth and salinity. Vertical stratification of the bay is common, but due to its shallowness, easily overcome by wind action that mixes the water column. This wind action also commonly results in increased turbidity by suspending bottom sediment. Figure 3.38, generated from the NERRS on-line water quality data system, clearly shows the variability of both D.O. and turbidity in Weeks Bay.

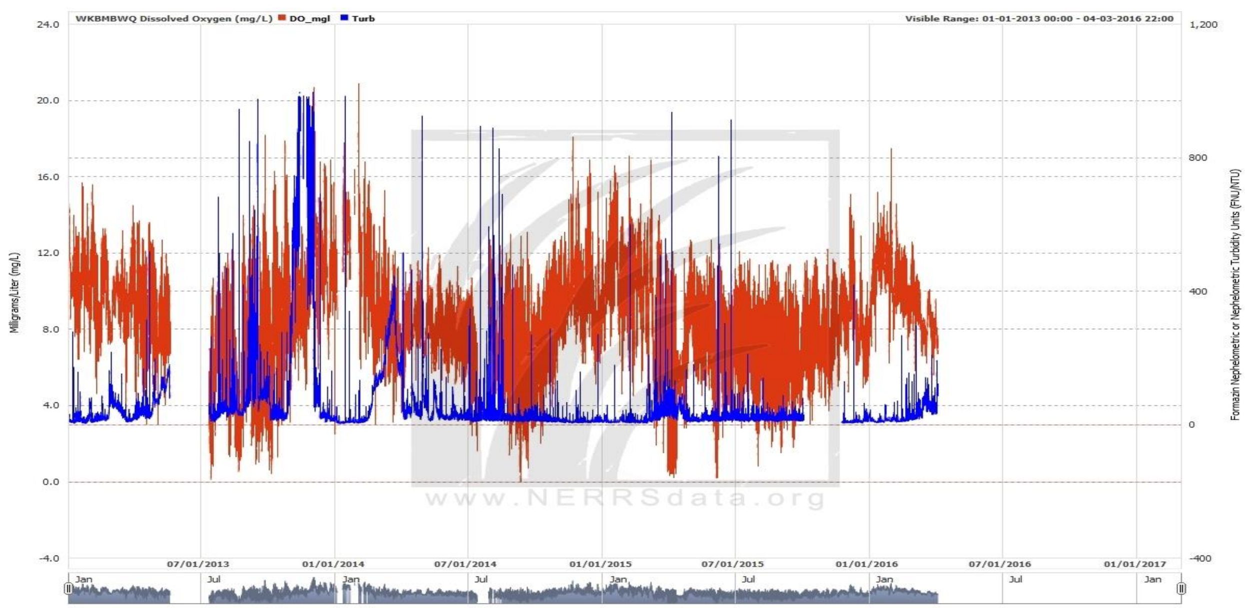


Figure 3.38 NERRS Weeks Bay D.O. and Turbidity (Mid-Bay Station)
Source: NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed: March 13, 2017*.

3.5.9.2 Nutrient Over-enrichment

Currently ADEM has not formally promulgated numeric water quality criteria for nutrients in rivers and streams or estuaries that would be applicable within the Weeks Bay Watershed. However, ADEM does use the aforementioned ecoregion reference reach approach to evaluate water quality conditions and has participated in a pilot study in Weeks Bay to gather and analyze information that may be used in development of nutrient criteria for estuaries (GOMA, 2013). Various nutrient reference values for estuaries are presented in Table 3.19.

The studies and data reviewed indicate that nutrient input into Weeks Bay is primarily from riverine discharge associated with Fish River and, to a lesser degree, Magnolia River and minor contributions from Bon Secour Bay during incoming tides. These inputs vary seasonally and in response to freshets and water residence time is estimated at 11 days (Tetra Tech, 2016). The nutrient contribution from benthic regeneration is reportedly less than expected for a shallow estuary (Mortazavi et al., 2012). There is also a general "bayward" (fresh to marine) increase in TP and turbidity and "bayward" decreases in TN, NO_2-NO_3 (GOMA, 2013). The range of nutrient concentrations observed are generally considered by most investigators as being elevated (eutrophic) for estuaries and episodic high chlorophyll *a* and depressed dissolved oxygen concentrations associated with periods of increased nutrient input are common. It is implied that approximately 27% of the nutrient load to Weeks Bay may be anthropogenic (GOMA, 2013) and that nutrient inputs have been found to be highly correlated to land use and land cover within the Watershed (Basynat et al., 1999; Lehrter, 2006; Singh, 2010). Based on discharge vs. concentration comparisons and the species of nutrients observed, the primary source in agricultural sub-basins appears to be related to high nitrogen levels in groundwater (Lehrter, 2006; Cook, 2016), likely associated with long term fertilizer use, and/or from continuous inputs (WWTP, septic tanks, groundwater, etc.). In the more developed urban sub-basins, nutrient input pathways are predominately associated with surface runoff associated with rainfall events.

Table 3.19 Various Reference Nutrient Concentrations for Estuaries

Parameter	ADEM SFTE Study[1] Weeks Bay	State of Florida[2] Upper Perdido Bay	State of Florida[2] Upper Pensacola Bay
Total Nitrogen (mg/L)	1.5 - 1.7	1.27	0.77
Nitrate+Nitrite (mg/L)	n/a	n/a	n/a
TKN (mg/L)	n/a	n/a	n/a
Total Phosphorus (mg/L)	0.08 - 0.10	0.102	0.084
Chlorophyll α (µg/L) (s)	9.0	11.5	6.0
Turbidity (NTU)	n/a	n/a	n/a

[1]GOMA, March 2013. Applicable to the estuarine portions of Weeks Bay.
[2]State of Florida, 62-302.532 F.A.C., February 2016.

The current nutrient concentrations in Weeks Bay, Fish River and Magnolia River are generally considered elevated and Weeks Bay proper is noted as being eutrophic. The SWAT model developed for the Watershed indicates that average annual loadings of nitrogen and phosphorus to the bay from Fish River are 440 metric tons per year (485 t/yr) and 64 metric tons (71 t/yr), respectively. Annual average loadings of nitrogen and phosphorus from the Magnolia River are estimated at 136 metric tons (150 t/yr) and 13 metric tons (15 t/yr), respectively. By 2040, the SWAT predicts the TN loadings from the Fish River to increase by 45%-71% and 62%-79% from the Magnolia River. Total phosphorus loading from the Fish River is expected to decrease slightly (-3%) under the medium growth scenario or increase by 5%

under the high growth scenario, while TP loading from the Magnolia River is expected to decrease by ~11%.

Modelling done as part of the ADEM SFTE study suggests that total nutrient reductions in the Watershed may not result in a significant corresponding reduction of adverse responses (i.e. lower primary production and/or higher dissolved oxygen concentrations) (GOMA, 2013), and Lehrter (2003, 2006) surmised that reforestation of agricultural or developed areas may not drastically reduce the total nitrogen load, however the form of nitrogen would be different. These assumptions notwithstanding, ADEM encourages nutrient loading reduction efforts in the Watershed.

3.5.9.3 Pathogens

Earlier bacteriological data reviews by Valentine and Lynn, in Miller-Way et al. (1996), indicate that fecal coliform density is usually higher nearest the riverine inputs and lower toward the mouth of the bay. ADEM and ADPH maintain a sampling site at Camp Beckwith beach as part of the Coastal Alabama Beach Monitoring Program. The program is designed to provide recreational users information regarding the bacteriological quality of the waters. During the 11-year monitoring period, 41 excursions above the EPA/ADEM swimming criteria have been documented at Camp Beckwith beach (Figure 3.39).

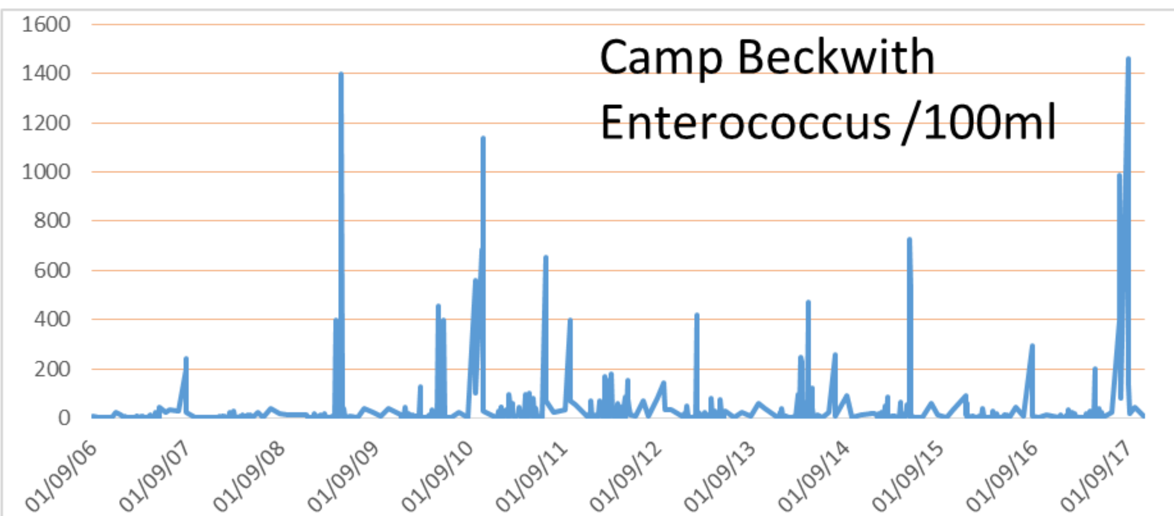


Figure 3.39 Enterococcus Sampling Data in Weeks Bay at Camp Beckwith
Source: ADEM, http://www.adem.state.al.us/programs/coastal/beachMonitoring.cnt

3.5.9.4 Contaminants

Based primarily on the studies reviewed and summarized by Valentine and Lynn, in Miller-Way, et.al, (1996), with the exception of slightly elevated barium concentration noted in sediment samples, no other contaminant (metals or chlorinated compounds) issues are evident in Weeks Bay. Haywick et al. (2004) indicated that sediment concentrations of mercury, cadmium and zinc levels were all within expected ranges from 5 representative core samples.

3.5.9.5 Water Quality Summary

Summarizing the review of available water quality data and the SWAT model results, Table 3.20 indicates stream segments where water quality impacts have been most frequently documented and are considered the most threatened stream segments and where recommended management measures should be focused. The majority of these segments will require additional study to identify specific sources, i.e. targeted reconnaissance, modelling and/or sampling to confirm water quality issue and to develop a detailed plan of action to address the specific source(s).

These notwithstanding, there are relatively isolated areas of concerned, for example the SWAT indicates a potentially high sediment delivery to the Magnolia River from the area surrounding and just upstream of the confluence with Schoolhouse Branch. Field reconnaissance of the area revealed significant bank erosion and sediment deposition along a portion of the Magnolia River proper. Another example is the severe gully erosion and sediment deposition identified along a stretch of an unnamed tributary to Fish River in Marlow. These impacted areas have been identified and are prime candidates for immediate restoration action.

Table 3.20 Summary Water Quality Areas of Concern in Weeks Bay Watershed

Stream	D.O.	Sediment/Turbidity	Nutrients	Bacteria
Fish River			X	X
Corn Branch	X	X	X	
Pensacola Br.		X	X	
Cowpen Creek		X		
Polecat Creek			X	X
Baker Branch	X		X	
Waterhole Br.	X		X	X
Turkey Branch		X	X	
Magnolia River			X	X
Weeks Creek	X	X	X	X
Schoolhouse Br.				X
Eslava Creek				X
Brantley Br.			X	
UT to Magnolia River		X		
Weeks Bay	X		X	

3.6 Flora and Fauna

3.6.1 Introduction

Major environmental alterations of the Alabama coastal area have occurred historically, and continue as natural lands increasingly accommodate human uses. In its Alabama Comprehensive Wildlife Conservation Strategy, ADCNR (2015) identified past and ongoing threats to conservation priority habitats in the study area. Coastal Alabama habitats have been altered and fragmented by agriculture and development. Ditching and draining have changed the natural flood regime of many floodplains, swamps, marshes, and bogs. The direct effects of land conversion often cause significant downstream effects through non-point source pollution, erosion and sedimentation, reduced flood attenuation, and altered biological habitat.

Land use change, habitat fragmentation, dredging and filling, and sedimentation have been identified by the MBNEP as the stressors having the largest present-day impact on the natural condition of Alabama's estuaries, including Weeks Bay (Barry A. Vittor & Associates, Inc., 2014). In its 2017-2022 Draft Management Plan, the Weeks Bay NERR cites changes in land use and pollutant loading as among the most critical stressors affecting Weeks Bay.

3.6.2 Assessment of Wetland and Riparian Corridor Quality

A tiered approach was used to assess the ecological condition of wetlands and riparian buffers in the study area, primarily using a landscape scale assessment (Level 1). Level 1 assessments consider linkages among landscape components, such as land cover type and proximity to locations of interest. Field data collection provides information for Level 2 (qualitative) and Level 3 (quantitative) assessments.

Land use and hydrologic alteration can negatively affect the ecological quality of nearby wetland and riparian buffer habitats (Gergel et al., 2002; Mack, 2007; Falcone et al., 2010; Rooney et al., 2012). Undisturbed riparian zones and wetland buffers with natural vegetation help maintain highly diverse and functional aquatic communities while narrow and impaired riparian zones, such as those associated with roads, pasture, crop land, lawns, and impervious surfaces often result in poor biological conditions. Castelle et al. (1994) determined that, depending on site-specific conditions, buffer widths ranging from 10 to 656 ft (3 to 200 m) were found to be effective at protecting wetlands and streams, and that a buffer of at least 50 ft (15 m) was necessary under most conditions.

For Weeks Bay wetlands, land cover within a 300-ft (91.5 m) upland buffer was used to predict habitat quality. The 300-ft buffer is used by the U.S. Army Corps of Engineers, Mobile District in the Wetland Rapid Assessment Procedure (WRAP), as part of the determination of the relative quality of jurisdictional wetlands. For riparian buffers a 100-ft-wide (30.5 m) corridor bordering each side of study area ditches, streams, and rivers was analyzed.

The metric used in the landscape-scale buffer analysis is the proportion of natural land, using cover categories in the 2011 NLCD dataset. For the wetland buffers, upland forest land (mixed, deciduous, evergreen) is considered natural cover. For riparian buffers, wetlands and adjacent upland forest are considered natural cover. Unnatural cover categories include pasture and crop land, barren land, and developed areas, including roads, buildings, parks, and other areas where concentrations of human activity occur.

For both wetland and riparian buffers, the predicted habitat condition corresponds to the score ranges for wetland quality used in the WRAP. The WRAP protocol scores wetland condition in a range from 0.0 to 1.0, with a score of 0.50 or less considered to be low-quality (poor), 0.51 to 0.74 as medium-quality (fair), and 0.75 to 1.0 as high-quality (good). Wetland and riparian buffers were assessed for each of the 169 NHD catchments in the study area.

Figure 3.40 shows the condition of wetland buffers for each catchment within the four HUC 12 Subwatersheds. Overall, these upland buffers in the Upper Fish River area are mostly in good condition, including 76% of the catchments and 84% of the total buffer acreage (Table 3.21). In the Middle Fish River HUC 12, 43% of the catchments are in fair condition, with around one third in good condition and nearly 25% in poor condition. Total buffer acreage in Middle Fish River is mostly in fair condition (63%). The Lower Fish River HUC 12 has a majority of catchments in good condition, but most of the total upland buffer acreage is only in fair condition, and compared to Upper Fish River there is a greater proportion of acreage in poor condition. Wetland buffers in the Magnolia River HUC 12 area are mostly in poor condition, including 51% of the catchments and 58% of the total buffer acreage (Table 3.21).

Table 3.21 Wetland Buffer Condition in Catchments in the Four HUC 12 Subwatersheds

HUC 12	No. of Catchments (% of total)			Total Buffer Acres (% of total)		
	Good	Fair	Poor	Good	Fair	Poor
Upper Fish R	39 (76%)	8 (16%)	4 (8%)	7,875 (84%)	1,060 (11%)	445 (5%)
Middle Fish R	12 (34%)	15 (43%)	8 (23%)	1,252 (23%)	3,392 (63%)	771 (14%)
Lower Fish R	26 (51%)	20 (39%)	5 (10%)	1,548 (24%)	3,777 (59%)	1,081 (17%)
Magnolia R	10 (26%)	9 (23%)	20 (51%)	551 (12%)	1,420 (30%)	2,685 (58%)

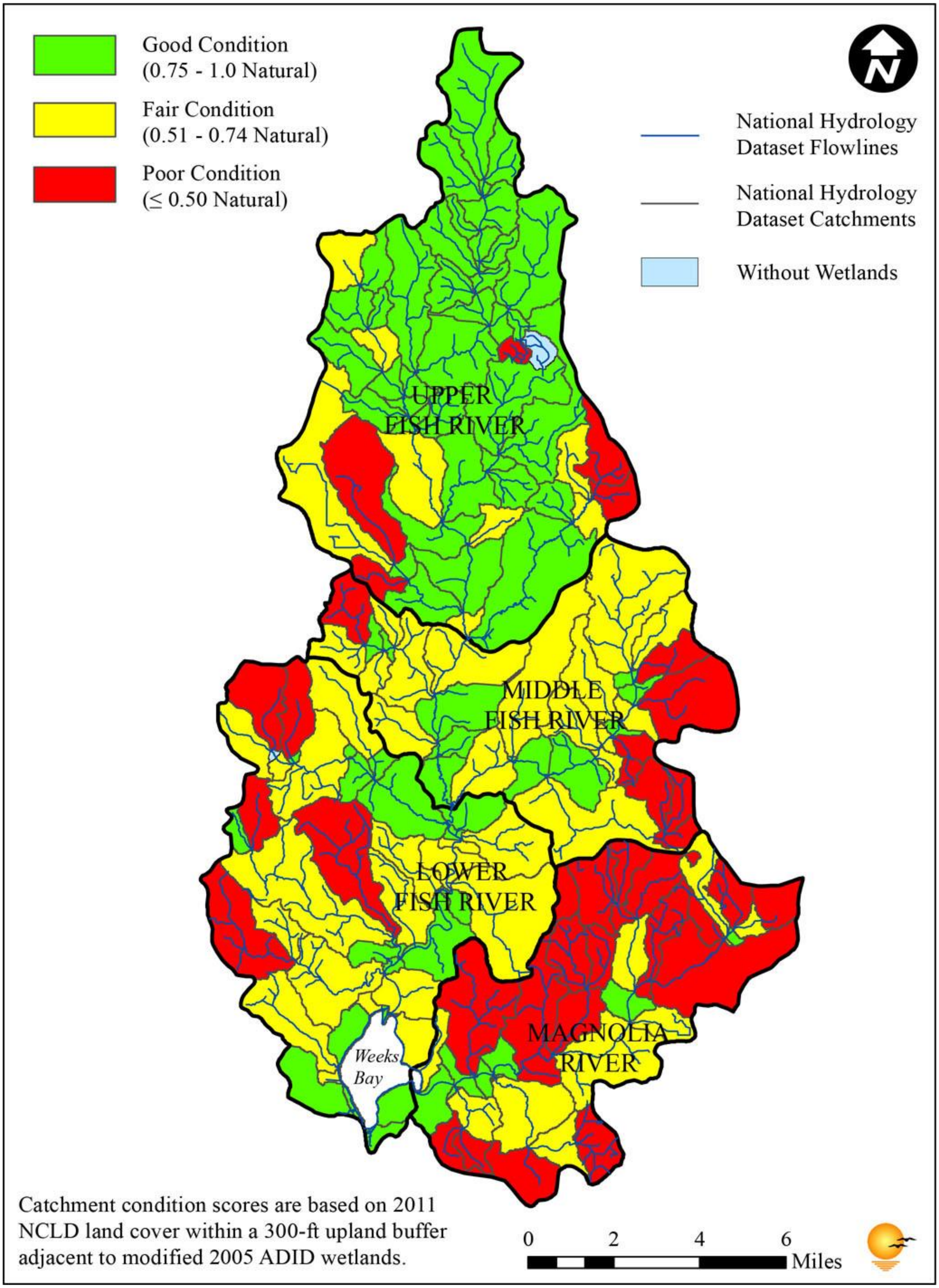


Figure 3.40 Predicted Wetland Condition by NHD Catchment

Table 3.22 presents percentages of land in natural and unnatural cover categories comprising the wetland buffers scored as having good, fair or poor condition. Upland buffers in good condition have natural land cover ranging from 86.8% in the Upper Fish River HUC 12 to 83% in the Magnolia River HUC 12. Compared to upland buffers in good condition, which have combined categories of developed, crop, and pasture lands comprising 13 to 15% of the total acreage, buffers with fair condition have proportions of unnatural land cover ranging from approximately 36 to 38% of the total acreage. In poor condition catchments in the Middle Fish River and Magnolia River HUC 12s, crop land makes up the largest portion of buffers, whereas pasture land comprises a greater proportion of the upland buffers in the Upper and Lower Fish River HUC 12s. Barren land makes up a small percentage of the cover in all of the wetland buffers.

Table 3.22 Percentage of Land in Natural and Unnatural Cover Categories Comprising Wetland Buffers within the Catchments

HUC 12	Natural	Developed	Crop Land	Pasture Land	Barren Land
Good Condition (0.75 – 1.0 Natural)					
Upper Fish R	86.8%	5.2%	3.4%	4.4%	0.2%
Middle Fish R	85.8%	4.1%	3.0%	7.1%	0%
Lower Fish R	85.7%	4.2%	6.3%	2.0%	1.7%
Magnolia R	83.0%	5.8%	4.6%	4.7%	1.9%
Fair Condition (0.51 – 0.74 Natural)					
Upper Fish R	62.6%	13.2%	12.9%	11.3%	0%
Middle Fish R	64.3%	6.0%	8.0%	21.7%	0%
Lower Fish R	62.0%	11.0%	8.6%	17.4%	1.0%
Magnolia R	61.6%	8.8%	17.2%	12.2%	0.2%
Poor Condition (≤ 0.50 Natural)					
Upper Fish R	40.2%	15.3%	20.6%	23.5%	0.3%
Middle Fish R	32.2%	7.1%	36.1%	23.9%	0.8%
Lower Fish R	36.5%	10.7%	19.7%	31.9%	1.2%
Magnolia R	35.5%	8.6%	36.1%	19.6%	0.2%

Figure 3.41 shows the landscape-scale condition of riparian buffers for each catchment within the four HUC 12 Subwatersheds. In general, buffers are mostly in good condition in the northern portion of the study area, and grade to poorer conditions to the south (Table 3.23).

Riparian buffers in the Upper Fish River HUC 12 area have the highest proportion of catchments in good condition (76%), followed by Middle Fish River (66%), Lower Fish River (55%), and Magnolia River (50%) (Table 3.23). Compared to the northern portion of the study area, the Lower Fish River and Magnolia River HUC 12s have a greater proportion of catchments with poor buffer quality, at 25% and 37%, respectively. Of the total acreage, Upper Fish River has the most intact riparian buffers, with 69% in good condition and 17% in fair condition. Middle Fish River also has most of its buffer acreage in good condition (51%), with a greater proportion of buffer acreage in fair condition (37%) compared to Upper Fish River. Lower Fish River has as much of its total buffer acreage in good condition as in poor condition (29%), and 42% in fair condition. Most of the total buffer acreage in the Magnolia River HUC 12 is in poor condition (Table 3.23), largely due to drainage ways and ditches that traverse agricultural land.

Table 3.23 Riparian Buffer Condition in Catchments within the Four HUC 12 Subwatersheds

HUC 12	No. of Catchments (% of total)			Total Buffer Acres (% of total)		
	Good	Fair	Poor	Good	Fair	Poor
Upper Fish R	40 (76%)	7 (13%)	6 (11%)	2,008 (69%)	490 (17%)	400 (14%)
Middle Fish R	23 (66%)	7 (20%)	5 (14%)	897 (51%)	643 (37%)	211 (12%)
Lower Fish R	22 (55%)	8 (20%)	10 (25%)	624 (29%)	921 (42%)	628 (29%)
Magnolia R	19 (50%)	5 (13%)	14 (37%)	526 (29%)	279 (16%)	987 (55%)

Table 3.24 presents percentages of land in natural and unnatural cover categories comprising riparian buffers scored as having good, fair or poor conditions. Riparian buffers in good condition have natural land cover ranging from 92.1% in the Upper Fish River HUC 12 to 86.6% in the Middle Fish River HUC 12. Compared to buffers in good condition, which have combined categories of developed, crop, and pasture lands comprising approximately 7 to 13%, fair condition buffers have altered lands ranging from approximately 31 to 38% of the total acreage, comprised mostly of pasture and crop lands. In poor condition catchments, crop land makes up majority of the riparian buffer cover type in the Middle Fish River and Magnolia River HUC 12s, and comprises the largest proportion of altered land categories in Upper Fish River. Pasture land comprises the greatest proportion of the unnatural land cover within riparian buffers in the Lower Fish River HUC 12. Barren land makes up only a small percentage of the cover in study area riparian buffers.

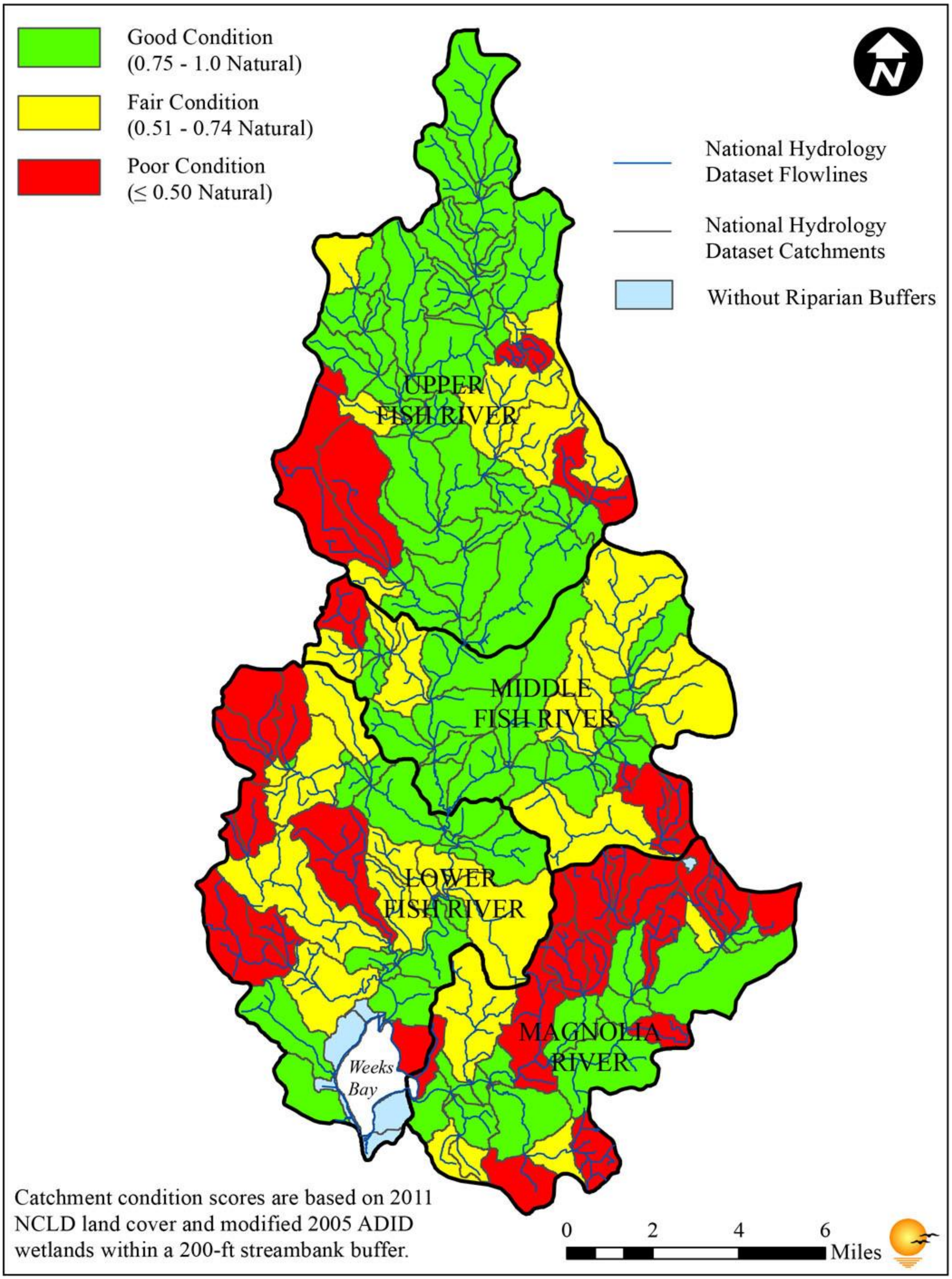


Figure 3.41 Predicted Riparian Buffer Condition by NHD Catchment

Table 3.24 Percentage of Land in Natural and Unnatural Cover Categories Comprising Riparian Buffers within Catchments

HUC 12	Natural	Developed	Crop Land	Pasture Land	Barren Land
Good Condition (0.75 – 1.0 Natural)					
Upper Fish R	92.1%	3.4%	1.4%	2.7%	0.4%
Middle Fish R	86.6%	2.3%	2.5%	8.5%	0%
Lower Fish R	88.0%	3.0%	2.8%	3.2%	3.0%
Magnolia R	91.9%	3.1%	2.3%	1.8%	1.0%
Fair Condition (0.51 – 0.74 Natural)					
Upper Fish R	61.2%	10.9%	15.4%	11.2%	1.2%
Middle Fish R	68.8%	6.9%	10.9%	12.9%	0.1%
Lower Fish R	63.6%	5.8%	10.0%	20.4%	0.1%
Magnolia R	64.0%	3.4%	17.6%	14.8%	0%
Poor Condition (≤0.50 Natural)					
Upper Fish R	35.1%	17.3%	34.5%	13.0%	0%
Middle Fish R	15.4%	7.5%	51.5%	25.7%	0%
Lower Fish R	41.1%	14.5%	9.7%	28.4%	6.3%
Magnolia R	18.6%	6.3%	59.6%	15.4%	0.6%

3.6.3 Field Data

Incidental observations made in January 2017 during field spot checks along roadways found numerous locations across the Watershed with degraded stream reaches and associated wetlands. Degradation was typically due to siltation, sometimes with visible streambank erosion. Some degree of degradation was found to occur at 38 of the 278 field check locations (Figure 3.42). The extent of reduced habitat quality in adjacent, inaccessible areas is unknown.

Some field observations corroborated wetland and riparian buffer conditions predicted by the landscape-scale analysis. In the upper Eslava Branch drainage (Magnolia River HUC 12), wetlands were assessed as in poor condition, and observed in the field to be highly degraded at multiple locations. Hydrology has been severely altered in these areas due to heavily siltation, with exotic invasive Chinese privet commonly occurring (Figure 3.43).

In the Lower Fish River HUC 12, at the southeast corner of the intersection of CR 32 and CR 9, a drainageway and associated wetland is heavily impacted by siltation, probably due to its proximity to the roads and human activity generally (Figure 3.44). The Level 1 condition of wetlands in this catchment is predicted to be fair, and it is probable that wetlands at other locations more removed from the roadways are better quality, particularly given the overall riparian buffer condition of the catchment has mostly intact buffers.

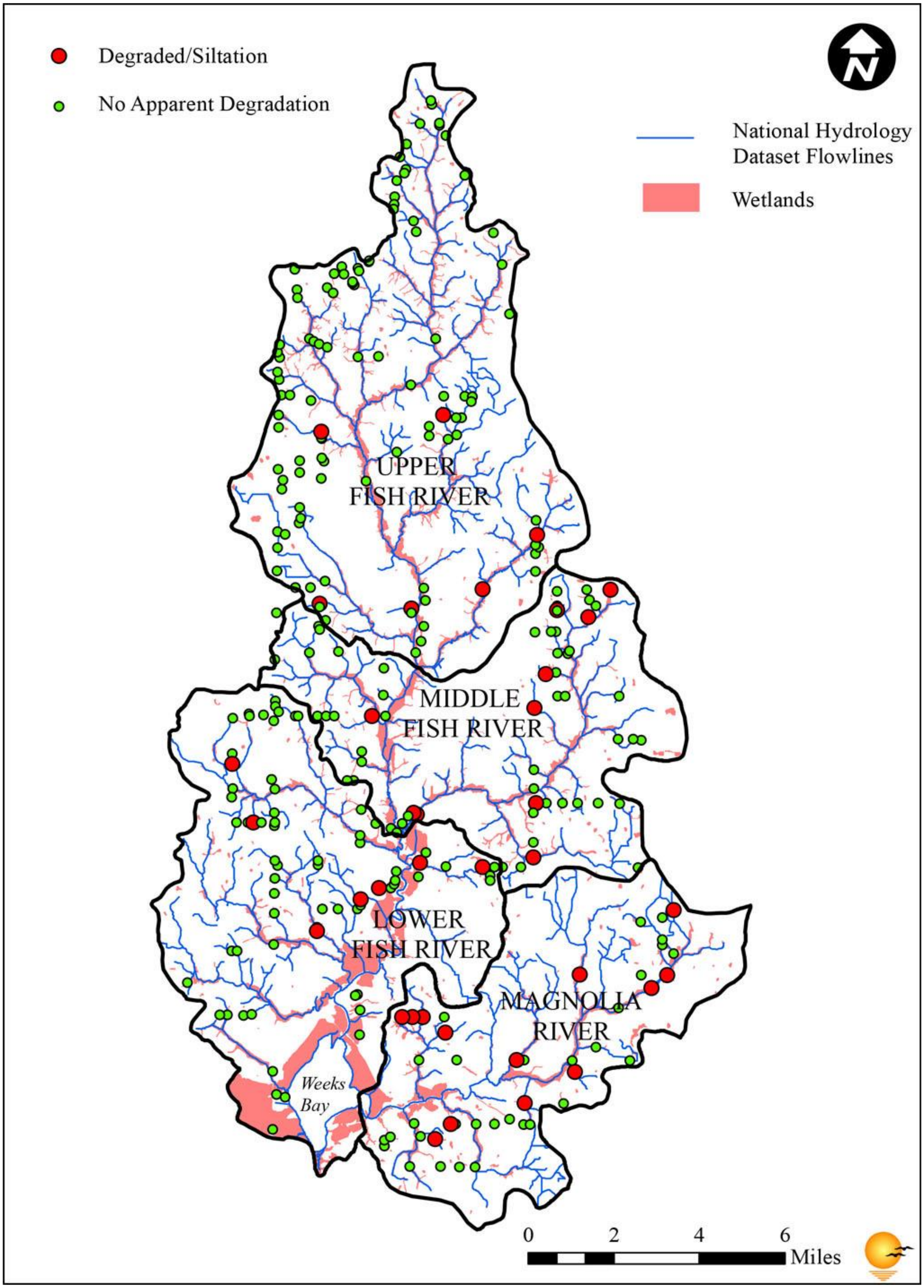


Figure 3.42 Field Check Points for Ecological Assessment

Note: Includes locations where wetland and stream degradation was observed, January 2017

Figure 3.43 Heavily degraded drainageway in upper Eslava Branch.
(Note: The green shrubs are mostly invasive Chinese privet)

On the north side of CR 48, Pensacola Branch has nearly vertical banks and no apparent stream channel, characteristics often indicative of bank erosion and siltation. Wetlands and riparian buffers in this area as assessed as being in fair condition, though the uppermost tributary draining into Pensacola Branch is classified as having poor condition, with its buffers consisting of 60% pasture and 20% crop land.

Degraded waters and wetlands were observed along Silver Creek drainage, located between Silverhill and Robertsdale, which drains into Polecat Creek. Catchments along the uppermost reaches of Polecat Creek are predicted to have poor quality wetlands and fair quality riparian buffers.

Figure 3.44 Degraded and Silted Drainageway Wetlands near the Intersection of CR 32 and CR 9

In the Upper Fish River HUC 12, Perone Branch was stagnant and had heavy siltation at CR 54, and siltation and general degradation upstream at CR 55. The Level 1 assessment of wetlands and riparian buffers in the upper reaches of Perone Branch are assessed as being in fair to poor condition.

Vittor & Associates mapped wetlands in 2005 on the 3,844-acre Golden Triangle Tract, located north of Interstate-10 in the Upper Fish River HUC 12 Watershed. Wetlands on the site are associated primarily with the upper reaches of Fish River and its tributaries, including Bay Branch, Bull Branch, and Threemile Creek. These wetlands were characterized as baygall drainage ways, dominated by a healthy canopy of swamp tupelo gum, sweetbay, poplar, bald cypress slash pine and loblolly pine. The wetland understory in these areas mostly has royal fern and chain fern. Drainageways in much of the Golden Triangle have relatively abrupt side slopes that transition into mixed pine/hardwood forest and managed pine forest.

The field-level assessment in the Golden Triangle has broad agreement with the landscape-scale assessment. Poor condition catchments are located on the southern margins of the Upper Fish River HUC 12, and the majority of catchments having buffers in good condition are concentrated along Fish River and its major tributaries. Most of the wetlands in the Golden Triangle constitute high-quality habitat, based upon surrounding land use, abundant hydrology, and the vegetative communities present (WRAP score = 0.85).

The upper reaches of the Golden Triangle area tributaries adjacent to the larger streams have been significantly altered and are of lower habitat value (WRAP score = 0.55) than the riparian areas of the larger streams at the site. These low-quality habitats are adjacent to roads, logging trails, and at the upper-reaches of the seepage drains, exhibiting signs of silt accumulation and degradation. The degraded areas exhibit intrusion by species more common to uplands, a thick layer of non-hydric soil, and altered hydrology. The species common to these portions of the property are water oak, American holly, southern magnolia, yaupon, and woody vines (*Smilax glauca*, *Rubus* sp., and *Vitis rotundifolia*).

A 68-acre property located on the north and south sides of CR 64, on the western edge of Fish River in the Upper Fish River Subwatershed, was found in November 2012 to have high-quality baygall and bayhead system wetlands, characterized by dense evergreen forests and shrub thickets with a spongy understory of sphagnum moss and ferns. The canopy is composed of tall, evergreen hardwoods dominated by sweetbay, swamp bay, red bay, and loblolly bay. There is typically a more or less open understory of shrubs and ferns and a ground surface of sphagnum mats interlaced with convoluted tree roots in these high-quality wetlands. Level 1 assessment of the site indicates that the local wetland and riparian buffers are in good condition.

3.6.4 Threatened and Endangered Species

Evergreen forest is the most widespread of the natural upland cover types in the Watershed, and along with forested wetlands, including pine flatwoods, represent potential habitat for certain protected species known to occur or potentially occur in the study area. The longleaf pine forests that were once dominant in much of the Weeks Bay Watershed provided habitat for now rare or endangered species such as the gopher tortoise, red-cockaded woodpecker, and eastern indigo snake. Today loblolly and slash pine plantations cover wide areas that are managed for industrial timber production. Pine plantations tend to be heavily fire suppressed; the resulting hardwood encroachment has significantly altered community structure. The understory of the pine plantation areas possesses very little herbaceous groundcover and often contains relatively dense thickets of yaupon, and other low growing shrubs. These degraded areas of pine uplands generally provide poor habitat for federal protected species that occur or potentially occur in the study area.

There are numerous records of gopher tortoise occurrence throughout the study area, including in the Lower and Middle Fish River HUC 12 areas. During 2014 surveys of two parallel Alabama Power Company utility easements in the Upper Fish River HUC 12, Thompson Engineering documented 317 active and inactive tortoise burrows. On the Golden Triangle Tract in 2005, in the Upper Fish River HUC 12, Vittor & Associates found 18 active gopher tortoise burrows during a protected species survey. A majority of the tortoise burrows were scoped using an infrared camera in an effort to locate the eastern indigo snake, which uses the burrows for refuge; however, no indigo snakes were found. It is possible that the study area could potentially support a previously undetected breeding population of indigo snake given the Watershed's large size and number of inaccessible, non-surveyed private lands.

A large portion of the study area, approximately 60% of developed lands, exists as pasture and row crops (NLCD, 2011). No federally protected species are anticipated to occur in these areas, though wood storks could infrequently occupy associated Grady ponds or other isolated waterbodies.

Wood stork utilizes a wide variety of habitats for foraging including ponds, marshes, swamps, depression wetlands, oxbow sloughs, ditches, and flooded fields (Natureserve, 2015). During times of drought, draw-down areas with shallow water constitute an important foraging source, allowing easy access to aquatic prey. In Alabama, inland freshwater habitats are typically favored for foraging, but brackish marshes near the coast are occasionally visited. Individuals can also be infrequently found utilizing farm ponds in coastal Alabama. A single wood stork was seen at a man-made pond on September 14, 2011 near the intersection of Rigsby Road and CR 64, east of Daphne (Craig Litteken personal observation, 2011). eBird (Sullivan et al., 2009) records of Wood Stork include a July 19, 2013 sighting of an individual near Benton Road within the study area (Brinkley, 2013). Wood storks are likely uncommon visitors to the Weeks Bay Watershed region.

Sightings of West Indian manatees are increasing in Alabama, with numerous observations being reported, including in Weeks Bay and the lower portions of Fish River and Magnolia River. Table 3.25 lists manatee sightings in the study area recorded in the last six years (Dauphin Island Sea Lab's Manatee Sighting Network, 2017). Most of the sightings and individuals seen during this time were in the Magnolia River, where the densest SAV in the project area occurs.

Table 3.25 Manatee Sightings Recorded from 2011 to 2016 in the Weeks Bay Area

Year	Total No. of Individuals	No. of Sightings	Month	Location(s)
2016	3	3	June, Dec.	Weeks Bay, Magnolia R., Nolte Cr.
2015	14	10	Jan., June, Sept., Oct.	Weeks Bay, Magnolia R., Fish R.
2014	6	4	Aug., Oct., Dec.	Weeks Bay, Magnolia R.
2013	5	5	Nov., Dec.	Magnolia R., Fish R.
2012	0	0	N/A	N/A
2011	4	4	July, Aug.	Magnolia R.

Source: Dauphin Island Sea Lab's Manatee Sighting Network, 2017

Alabama red-bellied cooter is mostly restricted to the lower Mobile-Tensaw Delta, though the species has also been documented from salt marsh habitats near the mouth of the West Pascagoula River and from Horn Island in Mississippi Sound (Leary et al., 2008). There are at least two records of these turtles occurring in the study area, and they are probably infrequent visitors to Weeks Bay and surrounding waters.

3.6.5 Invasive and Exotic Species

The Southeast Early Detection Network's Early Detection and Distribution Mapping System (EDDMapS) is a web-based system for documenting invasive species distribution. In the study area, EDDMapS contains records for several exotic invasive plants, mostly Chinese privet, Chinese tallowtree, Japanese honeysuckle (*Lonicera japonica*), Japanese climbing fern (*Lygodium japonicum*), torpedograss (*Panicum repens*), and camphortree (*Cinnamomum camphora*).

In 2004, Vittor & Associates participated in surveys for invasive non-native vascular plant species across Baldwin County, in cooperation with the University of South Alabama (USA). A grid system covering the county was established based on United States Geological Survey (USGS) 7.5-minute topographic quadrangle maps. Each quad was subdivided into 6 equal blocks representing approximately 10 square miles, and block-level inventories of exotic plant species were conducted through roadside surveys. A total of 17 survey blocks were surveyed in the Watershed, with five blocks each in the Upper Fish River HUC 12 and Middle Fish River HUC 12, four blocks in the Lower Fish River HUC 12, and three blocks in the Magnolia River HUC 12.

The USA surveys found high concentrations of non-native plants in the Watershed. Eighty non-native species were identified, with most of these comprised of herbaceous, weedy plants. The invasive plants most commonly encountered during the surveys of the 17 blocks are listed in Table 3.26.

Table 3.26 Frequently Encountered Invasive Exotic Plants in the Weeks Bay Watershed

Species	**Occurrence**	
	Number of Survey Blocks	**HUC 12[1]**
Chinese privet (*Ligustrum sinense*)	14	MR LF MF UF
Chinese tallowtree (*Triadica sebifera*)	14	MR LF MF UF
Cogongrass (*Imperata cylindrica*)	14	MR LF MF UF
Japanese honeysuckle (*Lonicera japonica*)	14	MR LF MF UF
Japanese climbing fern (*Lygodium japonicum*)	14	MR LF MF UF
Mimosa (*Albizia julibrissin*)	14	MR LF MF UF
Torpedograss (*Panicum repens*)	8	MR LF MF UF
Camphortree (*Cinnamomum camphora*)	8	MR LF MF UF
Alligator weed (*Alternanthera philoxeroides*)	5	LF MF UF
Golden bamboo (*Phyllostachys aurea*)	5	MR LF MF UF

[1]Key: MR=Magnolia River; LF=Lower Fish River; MF=Middle Fish River; UF=Upper Fish River

Incidental observations made in January 2017 during field spot checks along roadways found that, in particular, Chinese privet, Japanese climbing fern, Chinese tallowtree and camphor tree were common in and near wetlands and streams across the Watershed. One or more of these species were found to occur at over 95% of the 278 field check locations.

3.7 Future Impervious Cover in Watershed

As discussed in Section 2.8.3, Impervious Cover (IC) is the best indicator to measure the intensity of watershed development and to predict the severity of development impacts on the health of the network of streams within a watershed. The extent of IC in a watershed is closely linked to specific land cover types usually associated with urban growth, and is one of the most important factors influencing water quality. For example, an increase in the amount of impervious surface typically results in an increase in stormwater runoff which causes streambank and streambed erosion that in turn degrades water quality and habitat. The relationship between watershed IC and stream quality, as characterized in the Impervious Cover Model (Schueler, undated), has been discussed in Section 2.8.3.2. Generalizing, Impacted Streams (IC between 10 – 25%) usually will have higher restoration potential; whereas stream restoration becomes less practicable for Non-Supporting Streams (25 to 60% IC) especially at the upper IC range. It should also be noted that some scientific studies have shown that less than 10% IC may be critical for some watersheds. The ICM helps define general thresholds where current water quality standards or biological conditions cannot be consistently met during wet weather conditions. These predictions help set realistic objectives to protect stream quality based on both current and projected future conditions.

As presented earlier in Section 2.8.2.2, land use/land cover (LU/LC) projections have been estimated for two future growth scenarios, termed 2040-Medium and 2040-High. The changed acreages within each HUC 12 Subwatershed for all land cover class codes (for the two growth scenarios) are included in Appendix D.

The growth scenario changes in the “developed” land cover class codes can be used to estimate the correlated changes in Impervious Cover (IC) that would result from future development. Review of the land cover class codes for developed categories is provided in Table 3.27 below. Also shown is an “Assigned IC Factor” which is the mid-range impervious surface value for each respective category. The IC factors are then used to compute the impervious surface acreage resulting from the two 2040 growth scenarios (Tables 3.28 and 3.29). As a cross-check of the procedure, the same IC calculation method was used for the 2011 LU/LC developed area dataset. The ratio of calculated “IC/Tot. Dev. Area” compared to the “ISA/IEA ratio” compiled from the dataset (previously discussed in Section 2.8.3.3, Table 2.16) were in good agreement, with the calculated IC percentage approximately 2% higher than the ISA/IEA ratio,

Table 3.27 NLCD Land Cover Class Codes for Developed Categories

Class Code Value	Definition	Assigned IC Factor
21	**Developed, Open Space** - areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.	**10%**
22	**Developed, Low Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.	**35%**
23	**Developed, Medium Intensity** - areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.	**65%**
24	**Developed High Intensity** -highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover.	**90%**

Table 3.28 Impervious Cover Estimate for 2040 Medium

2040 Medium Growth Scenario				
	Lower Fish River	*Watershed Area, Acres:*		*34,448*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	3,209	9.3%	321
35%	Developed, Low Intensity	3,190	9.3%	1,117
65%	Developed, Medium Intensity	554	1.6%	360
90%	Developed, High Intensity	156	0.5%	141
	Subtotals:	***7,110***	***20.6%***	***1,939***
			IC/Tot Dev Area, %	27.3%
			IC/Watershed Area, %	5.6%
	Middle Fish River	*Watershed Area, Acres:*		*26,767*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	1,612	6.0%	161
35%	Developed, Low Intensity	1,802	6.7%	631
65%	Developed, Medium Intensity	98	0.4%	64
90%	Developed, High Intensity	529	2.0%	476
	Subtotals:	***4,042***	***15.1%***	***1,332***
			IC/Tot Dev Area, %	33.0%
			IC/Watershed Area, %	5.0%
	Upper Fish River	*Watershed Area, Acres:*		*42,269*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	3,225	7.6%	322
35%	Developed, Low Intensity	6,373	15.1%	2,231
65%	Developed, Medium Intensity	2,827	6.7%	1,837
90%	Developed, High Intensity	1,199	2.8%	1,079
	Subtotals:	***13,624***	***32.2%***	***5,470***
			IC/Tot Dev Area, %	40.1%
			IC/Watershed Area, %	12.9%

Table 3.28 Impervious Cover Estimate for 2040 Medium (continued)

2040 Medium Growth Scenario				
	Fish River, Combined	*Watershed Area, Acres:*		*103,485*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	8,046	7.8%	805
35%	Developed, Low Intensity	11,366	11.0%	3,978
65%	Developed, Medium Intensity	3,479	3.4%	2,261
90%	Developed, High Intensity	1,885	1.8%	1,697
	Subtotals:	***24,775***	***23.9%***	***8,740***
			IC/Tot Dev Area, %	35.3%
			IC/Watershed Area, %	8.4%
	Magnolia River	*Watershed Area, Acres:*		*26,113*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	2,187	8.4%	219
35%	Developed, Low Intensity	2,479	9.5%	868
65%	Developed, Medium Intensity	372	1.4%	242
90%	Developed, High Intensity	76	0.3%	69
	Subtotals:	***5,114***	***19.6%***	***1,397***
			IC/Tot Dev Area, %	27.3%
			IC/Watershed Area, %	5.3%
	Weeks Bay, Combined	*Watershed Area, Acres:*		*129,598*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	10,232	7.9%	1,023
35%	Developed, Low Intensity	13,845	10.7%	4,846
65%	Developed, Medium Intensity	3,850	3.0%	2,503
90%	Developed, High Intensity	1,962	1.5%	1,765
	Subtotals:	***29,889***	***23.1%***	***10,137***
			IC/Tot Dev Area, %	33.9%
			IC/Watershed Area, %	7.8%

Table 3.29 Impervious Cover Estimate for 2040 High

2040 High Growth Scenario				
	Lower Fish River	*Watershed Area, Acres:*		*34,448*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	2,438	7.1%	244
35%	Developed, Low Intensity	2,630	7.6%	920
65%	Developed, Medium Intensity	1,687	4.9%	1,096
90%	Developed, High Intensity	1,055	3.1%	950
	Subtotals:	***7,810***	***22.7%***	***3,210***
			IC/Tot Dev Area, %	41.1%
			IC/Watershed Area, %	9.3%
	Middle Fish River	*Watershed Area, Acres:*		*26,767*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	1,264	4.7%	126
35%	Developed, Low Intensity	2,339	8.7%	819
65%	Developed, Medium Intensity	633	2.4%	411
90%	Developed, High Intensity	935	3.5%	841
	Subtotals:	***5,171***	***19.3%***	***2,198***
			IC/Tot Dev Area, %	42.5%
			IC/Watershed Area, %	8.2%
	Upper Fish River	*Watershed Area, Acres:*		*42,269*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	2,017	4.8%	202
35%	Developed, Low Intensity	9,780	23.1%	3,423
65%	Developed, Medium Intensity	4,313	10.2%	2,804
90%	Developed, High Intensity	2,526	6.0%	2,274
	Subtotals:	***18,637***	***44.1%***	***8,702***
			IC/Tot Dev Area, %	46.7%
			IC/Watershed Area, %	20.6%

Table 3.29 Impervious Cover Estimate for 2040 High (continued)

2040 High Growth Scenario				
	Fish River, Combined	*Watershed Area, Acres:*		*103,485*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	5,720	5.5%	572
35%	Developed, Low Intensity	14,748	14.3%	5,162
65%	Developed, Medium Intensity	6,633	6.4%	4,311
90%	Developed, High Intensity	4,517	4.4%	4,065
	Subtotals:	***31,618***	***30.6%***	***14,110***
			IC/Tot Dev Area, %	44.6%
			IC/Watershed Area, %	13.6%
	Magnolia River	*Watershed Area, Acres:*		*26,113*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	1,668	6.4%	167
35%	Developed, Low Intensity	2,973	11.4%	1,041
65%	Developed, Medium Intensity	587	2.2%	381
90%	Developed, High Intensity	1,196	4.6%	1,076
	Subtotals:	***6,424***	***24.6%***	***2,665***
			IC/Tot Dev Area, %	41.5%
			IC/Watershed Area, %	10.2%
	Weeks Bay, Combined	*Watershed Area, Acres:*		*129,598*
IC Factor		Area, ac	Area, %	IC calc., ac
10%	Developed, Open Space	7,388	5.7%	739
35%	Developed, Low Intensity	17,721	13.7%	6,202
65%	Developed, Medium Intensity	7,220	5.6%	4,693
90%	Developed, High Intensity	5,712	4.4%	5,141
	Subtotals:	***38,042***	***29.4%***	***16,775***
			IC/Tot Dev Area, %	44.1%
			IC/Watershed Area, %	12.9%

Review of the calculated impervious cover areas for both 2040 growth scenarios indicates significant increases are to be expected for the Weeks Bay Watershed. For the combined Weeks Bay Watershed, the Total Developed Area is projected to be from 23.1% (2040 Medium) to 29.4% (2040 High) of the total Watershed area. This compares to 13.1% for the 2011 LU/LC. The projected Impervious Cover surface area compared to Total Developed Area is from 33.9% (2040 Medium) to 44.1% (2040 High). These compare to an estimated 22.5% for 2011. Similarly, the Impervious Cover expressed as a percentage of total Watershed area is projected to be from 7.8% (2040 Medium) to 12.9% (2040 High). These compare to an estimated 2.9% for 2011.

For the Magnolia River Watershed, the Total Developed Area is projected to be from 19.6% (2040 Medium) to 24.6% (2040 High) of the total Watershed area. This compares to 12.6% for the 2011 LU/LC. The projected Impervious Cover surface area compared to Total Developed Area is from 27.3% (2040 Medium) to 41.5% (2040 High). These compare to an estimated 20.2% for 2011. Similarly, the Impervious Cover expressed as a percentage of total Watershed area is projected to be from 5.3% (2040 Medium) to 10.2% (2040 High). These compare to an estimated 2.5% for 2011.

For the combined Fish River Watershed, the Total Developed Area is projected to be from 23.9% (2040 Medium) to 30.6% (2040 High) of the total Watershed area. This compares to 12.6% for the 2011 LU/LC. The projected Impervious Cover surface area compared to Total Developed Area is from 35.3% (2040 Medium) to 44.6% (2040 High). These compare to an estimated 23.0% for 2011. Similarly, the Impervious Cover expressed as a percentage of total Watershed area is projected to be from 8.4% (2040 Medium) to 13.6% (2040 High). These compare to an estimated 3.0% for 2011.

Impervious cover changes are projected for all three HUC-12 Subwatersheds comprising the Fish River Watershed; however, projected changes for Upper Fish River are substantially higher than the other two. For the Upper Fish River Watershed, the Total Developed Area is projected to be from 32.2% (2040 Medium) to 44.1% (2040 High) of the total Watershed area. This compares to 14.5% for the 2011 LU/LC. The projected Impervious Cover surface area compared to Total Developed Area is from 40.1% (2040 Medium) to 46.7% (2040 High). These compare to an estimated 23.9% for 2011. Similarly, the Impervious Cover expressed as a percentage of total Watershed area is projected to be from 12.9% (2040 Medium) to 20.6% (2040 High). These compare to an estimated 3.5% for 2011.

For the Middle Fish River Watershed, the Total Developed Area is projected to be from 15.1% (2040 Medium) to 24.6% (2040 High) of the total Watershed area. This compares to 9.6% for the 2011 LU/LC. The projected Impervious Cover surface area compared to Total Developed Area is from 33.0% (2040 Medium) to 41.5% (2040 High). These compare to an estimated 21.3% for 2011. Similarly, the Impervious Cover expressed as a percentage of total Watershed area is projected to be from 5.0% (2040 Medium) to 10.2% (2040 High). These compare to an estimated 2.1% for 2011.

For the Lower Fish River Watershed, the Total Developed Area is projected to be from 20.6% (2040 Medium) to 22.7% (2040 High) of the total Watershed area. This compares to 14.3% for the 2011 LU/LC. The projected Impervious Cover surface area compared to Total Developed Area is from 27.3% (2040 Medium) to 41.1% (2040 High). These compare to an estimated 22.9% for 2011. Similarly, the Impervious Cover expressed as a percentage of total Watershed area is projected to be from 5.6% (2040 Medium) to 9.3% (2040 High). These compare to an estimated 3.3% for 2011.

3.8 Shoreline Assessment

A shoreline assessment was performed for the tidally-influenced portions of waterbodies within the Weeks Bay Watershed. With minor exceptions, the assessment area included: (1) Fish River from its mouth (at Weeks Bay) upstream (northward) to approximately 0.58 mile north of the CR 32 bridge; (2) Magnolia River from its mouth at Weeks Bay upstream (eastward) to approximately 0.1 mile east of the CR 49 bridge; and (3) all shorelines of Weeks Bay (Figure 3.45). The Fish River and Weeks Bay portions of the assessment area are completely contained within the boundaries of the Lower Fish River Watershed (HUC 12: 0316 02050204), while the Magnolia River portions are located within the Magnolia River Watershed (HUC 12: 031602050203).

This shoreline assessment includes the following:

- An analysis of existing shoreline conditions (Section 3.10.1) consisting of a summary of findings from a 2009 study performed by Geological Survey of Alabama (GSA). The GSA study, entitled *Comprehensive Shoreline Mapping, Baldwin and Mobile Counties, Alabama: Phase I – Open File Report 0921* (Jones, Tidwell, and Darby 2009), is referred to in this Watershed Management Plan, as the GSA Phase I report. The GSA Phase I report quantified the lengths and types of shorelines and the lengths and types of shoreline armoring in Mobile Bay and a number of its tributaries, including Weeks Bay, Fish River, and Magnolia River;
- An analysis of shoreline changes over time (Section 3.10.2 below), performed by comparing shorelines visible in aerial photos from 1955 and 2015, in order to determine morphological changes that have taken place over that period; and
- A summary of findings from additional studies ranging from the 1970s to the present day (Section 3.10.3). These studies investigated various attributes and conditions of waterbodies, including Weeks Bay and its tributaries and Mobile Bay (which Weeks Bay drains into). These studies also analyzed the effects of natural processes and armoring on shorelines and nearby habitats.

3.8.1 Existing Shoreline Conditions in Tidal Weeks Bay Watershed

Although erosion and sedimentation are natural processes that affect shorelines, landowners often try to prevent erosion of their waterfront property by using hard shoreline stabilization techniques.

While installation of hard shoreline structures may reduce erosion of the shoreline in the exact location where the structures are placed, this technique has been found to:

- Negatively impact nearshore, intertidal, and upland habitat;
- Alter longshore sediment transport and shoreline dynamics;
- Destroy existing marsh and curtail marsh expansion and uphill migration;
- Decrease the aesthetic value of property; and
- Accelerate impacts on adjoining properties (Kana et al., 1995; PDEP, 2001; LaRoche, 2007; NPS, 2009).

Existing conditions of shorelines within the tidally-influenced portions of Fish River, Magnolia River, and Weeks Bay were assessed utilizing data obtained from the GSA Phase I report. The primary purpose of the GSA Phase I report was to classify shoreline types and shoreline armoring (protection) present within portions of Mobile Bay, Weeks Bay, and other select tributaries. The report was a cooperative effort between the GSA and the Coastal Section of the Alabama Department of Conservation and Natural Resources' (ADCNR's) State Lands Division.

The remainder of Section 3.8.1 through 3.8.4 summarizes portions of the GSA Phase I report that are relevant to the Weeks Bay Watershed, including an overview of past research, classification scheme, and categories used for both the shoreline *type* and shoreline *protection* classification systems, data collection methodology, and findings.

3.8.1.1 Shoreline Classification Scheme

The GSA developed the initial shoreline protection and shoreline type categories by researching publications from similar mapping projects (ACAB, 1980; Smith, 1981; Stewart, 2001; Toft et al., 2003) in other states. Following this initial exercise, GSA, in cooperation with ADCNR, modified the identified classifications to better fit the characteristics of coastal Alabama.

The GSA classified shoreline types and shoreline protection types through visual field observations. When shoreline stabilization structures created a visual obstruction, the shoreline type was determined by evaluating the area landward (up to 50 yards) behind the shoreline. The shoreline protection classification was conducted by characterizing the location of shoreline hardening materials relative to the shoreline. The three categories that were used included: seaward of the shoreline; along the shoreline; and landward of the shoreline.

3.8.1.2 Shoreline Type Classification

Table 3.30 presents the seven classification categories used in the GSA Phase I report to describe shoreline types found in the Weeks Bay Watershed. Several subcategories were developed to better represent shoreline types and are mainly applied to vegetated bank, sediment bank, and organic categories.

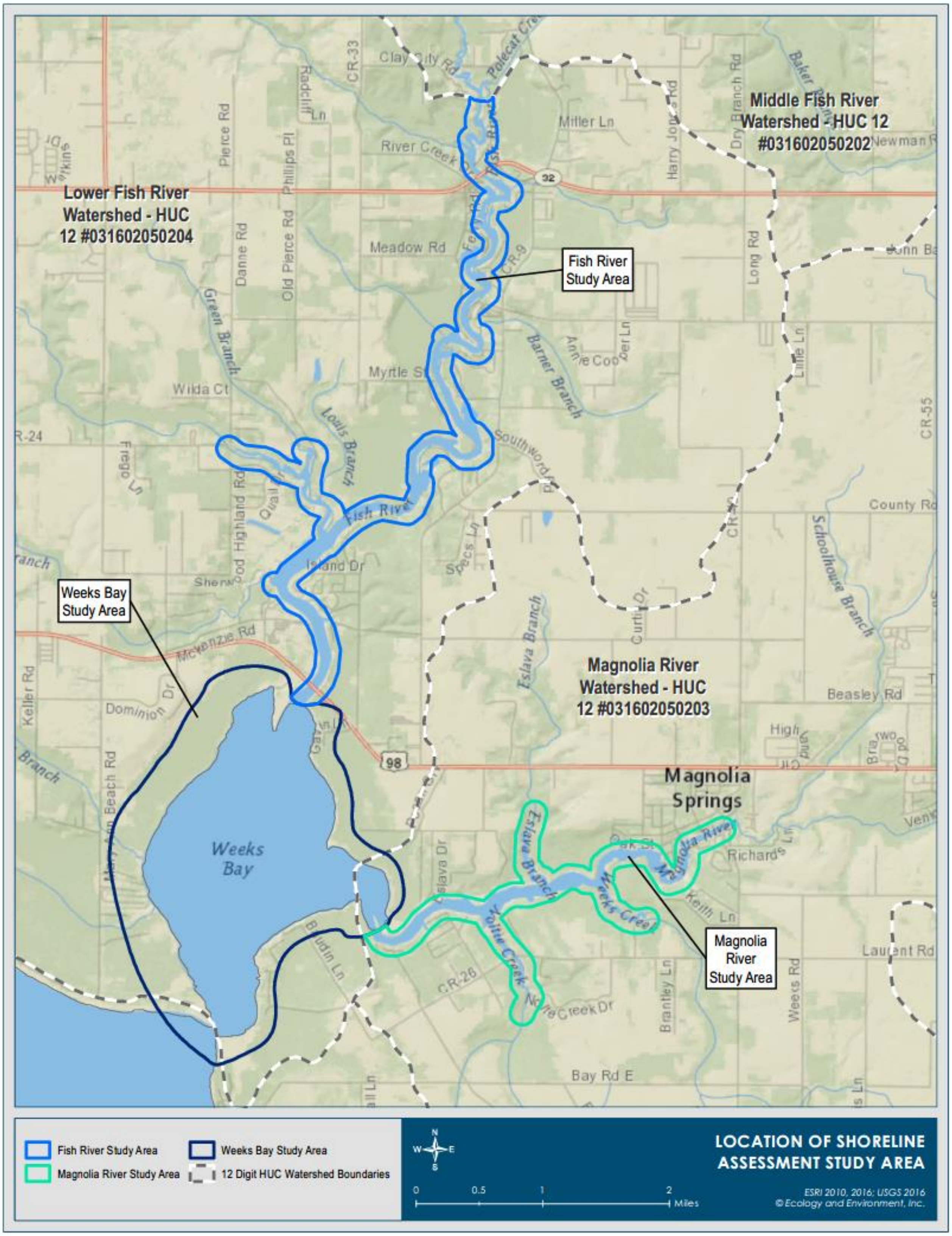


Figure 3.45 Location of Shoreline Assessment Areas

Table 3.30 Applicable Shoreline Type Classifications, as Defined in the GSA Phase I Report

Shoreline Type	Description
Artificial Shorelines	Shorelines built in areas previously occupied by water. Typically built for industrial and commercial use; examples include causeways, infilling, and shoreline extensions.
Vegetated Bank Shorelines	
a. Bluff	Greater than 20 feet above the high tide line (within 50 yards of the shoreline).
b. High Bank	5-20 feet above the high tide line (within 50 yards of the shoreline).
c. Low Bank	0-5 feet above the high tide line (within 50 yards of the shoreline).
Organic Bank Shorelines	
a. Open Shoreline Vegetated Fringe	Occurs where water grasses flourish just in front of the shoreline in shallow water.
b. Swamp Forest	Typically occurs where periodically inundated low-lying forests meet the shoreline.
c. Marsh	Occurs where saltwater or freshwater marsh habitat adjoins open water.
Sediment Bank Shorelines	
a. Bluff	Greater than 20 feet above the high tide line (within 50 yards of the shoreline).
b. High Bank	5-20 feet above the high tide line (within 50 yards of the shoreline).
c. Low Bank	0-5 feet above the high tide line (within 50 yards of the shoreline).
Inlet	Where unnavigable tributaries meet the open water, at the farthest mapped upstream locations, and in shallow channels within marsh habitat.
Pocket Beach	Mainly located between two shoreline protections structures extending into the water.
Rock Bank (low)	Occurs where bedrock or rock layers are exposed at the shoreline.

Source: Jones, Tidwell, and Darby, 2009

3.8.1.3 Shoreline Protection Types

Fourteen categories were designated in the GSA Phase I report to describe shore protection found in the Weeks Bay Watershed. These categories are listed and described in Table 3.31.

Table 3.31 Applicable Shoreline Protection Types, Identified in GSA Phase I Report

Shoreline Type	Description
Natural, Unretained	A natural setting with vegetation or sediment exposed and no apparent shoreline modification to protect the land behind it. The natural shore protection classification is commonly associated with wetland environments, undeveloped properties, and protected habitats, such as Weeks Bay.
Seawalls	A structure that provides shoreline protection from wave energy, but also retains soil.
Bulkheads	A vertical shoreline stabilization structure that primarily retains soil with minimal protection from waves (Blankenship 2004). Bulkhead, the most common type of shore protection, is a broad category with numerous subtypes. Further modifiers or subdivisions represent the various construction materials (concrete, steel, wood) and convey additional shore protections placed seaward or landward of the bulkhead (groins, riprap, retaining walls).
Abutments	Concrete or wood abutments are found where bridges intersect most mapped waterways.
Breakwaters	Typically used to dissipate wave energy where natural shoreline is desired. Breakwaters are constructed some minimal distance offshore. Breakwaters may be either fixed or floating, depending on the application.
Groins	Typically associated with bulkheads, but can be found isolated.
Jetties	Typically associated with an inlet and constructed normal to slightly oblique to the shoreline. Jetties are also commonly constructed around boat ramps and channels for either industrial or recreational traffic to flow through without running aground on shoals.
Beach Nourishment	Typically associated with Gulf-fronting shorelines; small beach nourishment projects are located on private land and public parks.

Table 3.31 Applicable Shoreline Protection Types, Identified in GSA Phase I Report (continued)

Shoreline Type	Description
Revetments	Mainly cabled concrete mattresses or carefully placed rocks are installed as permanent sloping structures along sloping shorelines.
Rubble/Riprap	Similar to a revetment except that its installation is not commonly engineered, but rather haphazardly placed by the property owner. Material can consist of rock, concrete and wood debris, and tires. Most have no aesthetic value and can take up much of the seaward shoreline.
Sills	Miniature versions of a breakwater designed to break wave action and allow sediment to fall out of suspension as wave energy dissipates.
Boat Ramps	Additional type of shoreline armoring constituting a very minor portion of the watershed’s shoreline.
Silt Fencing	Additional type of shoreline armoring constituting a very minor portion of the watershed’s shoreline.
Tires	Additional type of shoreline armoring constituting a very minor portion of the watershed’s shoreline.

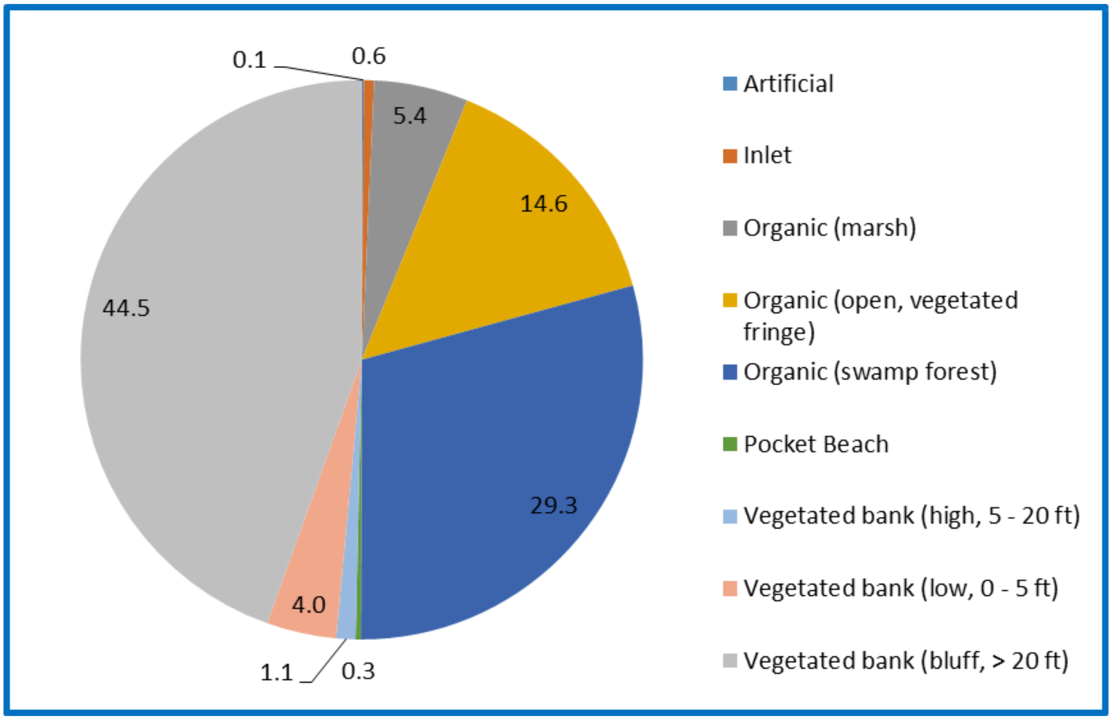
Source: Jones, Tidwell, and Darby, 2009

3.8.2 Fish River Study Area - Shoreline Type and Protection

3.8.2.1 Shoreline Type Classification

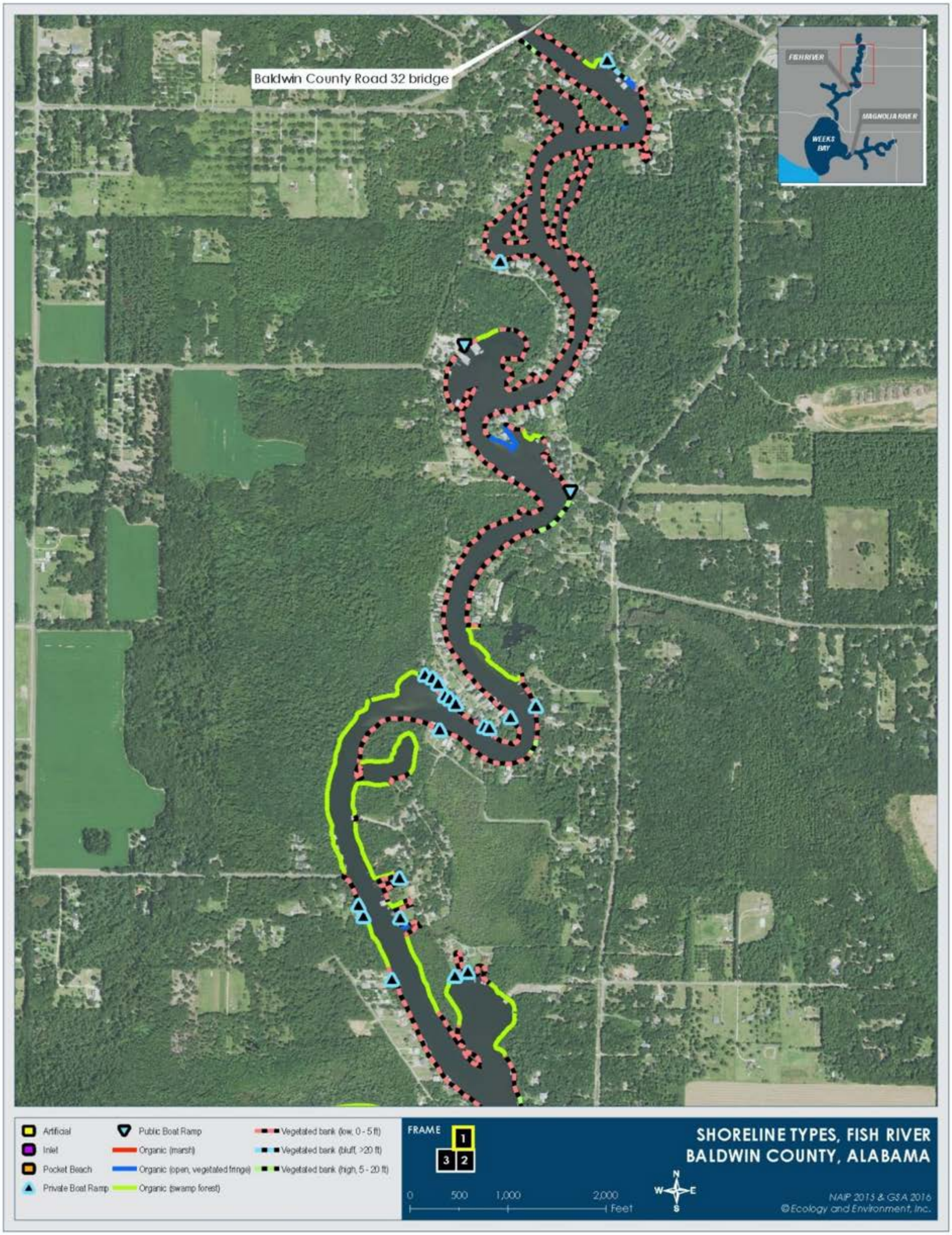
The Fish River portion of the GSA Phase I report extends from the Baldwin CR 32 bridge southward (downstream) to the U.S. Highway 98 bridge, where Fish River empties into Weeks Bay. Fish River contains approximately 30.1 linear miles of shoreline.

Vegetated bank shoreline types make up the largest portion of shoreline on the Fish River, comprising approximately 14.9 miles, or about 49.6 percent of the total shoreline. Organic shoreline types make up about 14.8 miles, or about 49.3 percent of the total shoreline. Additional, yet minor, shoreline types include inlets, artificial shorelines, and pocket beaches. Figure 3.46 illustrates the proportional breakdown of each shoreline type as a percentage of the entire shoreline for the Fish River study area. Figures 3.47, 3-48, and 3.49 provide the geographic distribution of shoreline types observed.



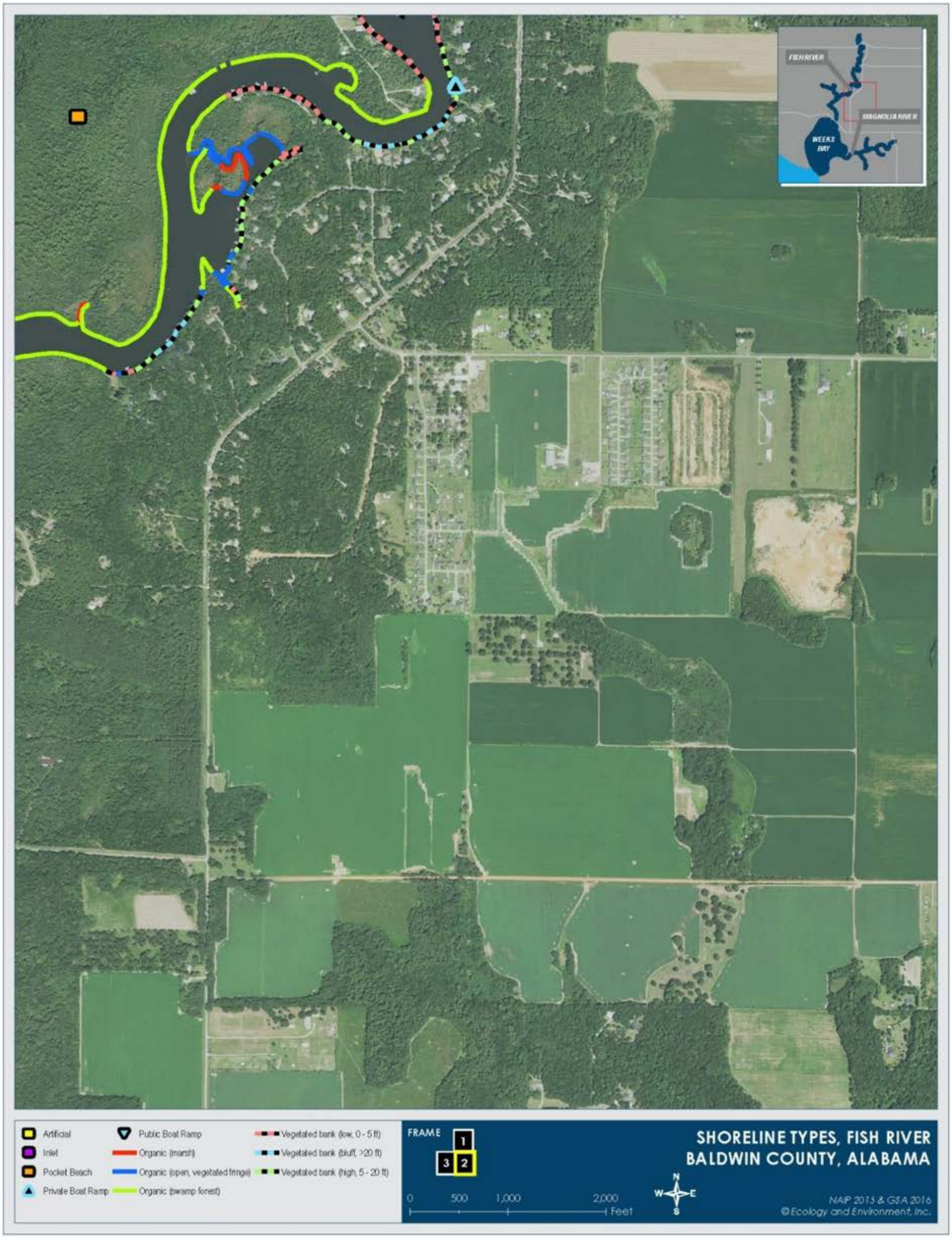
Source: Jones, Tidwell, and Darby, 2009

Figure 3.46 Proportional Breakdown by Shoreline Type, Fish River Study Area (Percent of Total)



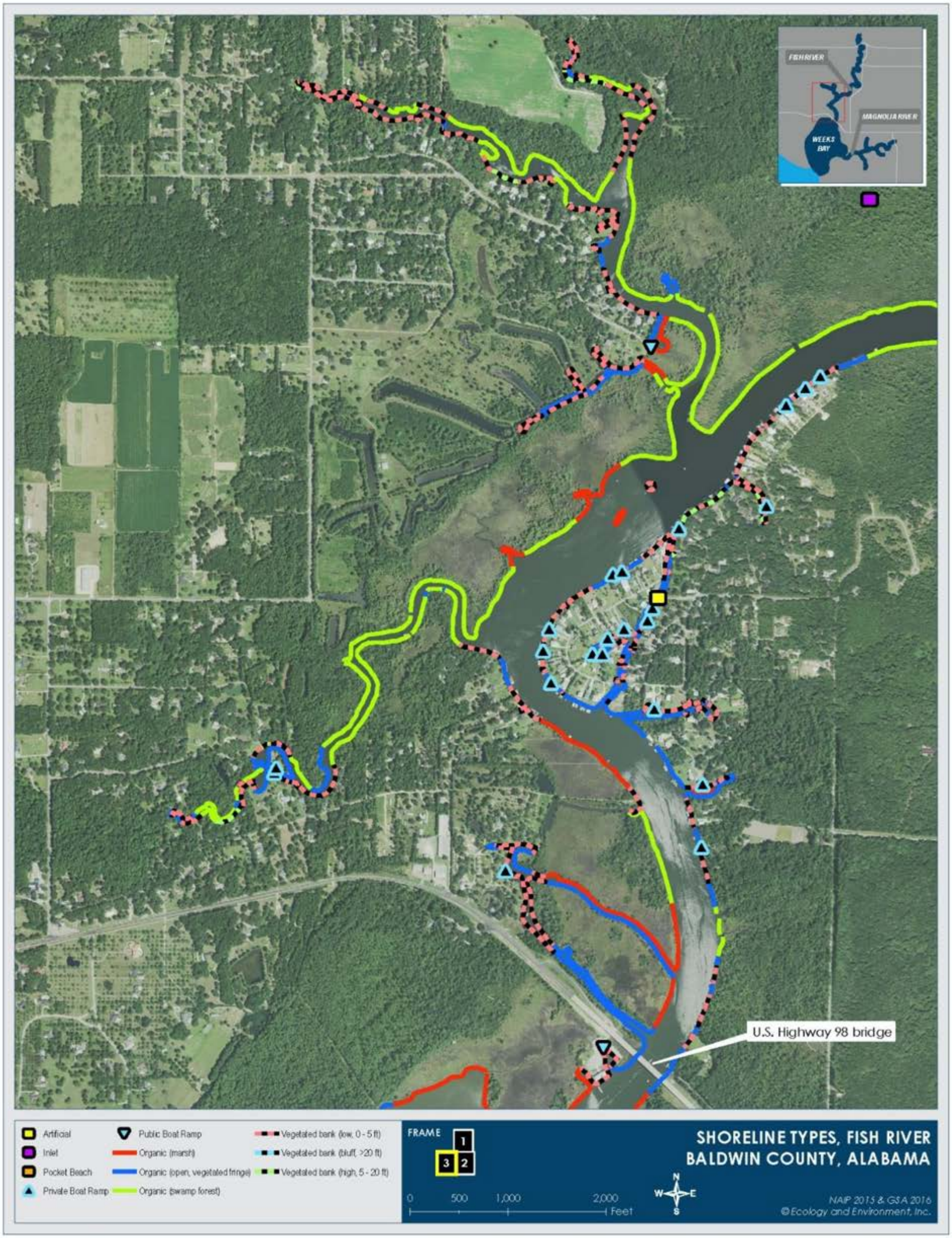
Source: Jones, Tidwell, and Darby, 2009

Figure 3.47 Geographic Distribution of Shoreline Types, Upper Portion of Fish River Study Area



Source: Jones, Tidwell, and Darby, 2009

Figure 3.48 Geographic Distribution of Shoreline Types, Middle Portion of Fish River Study Area

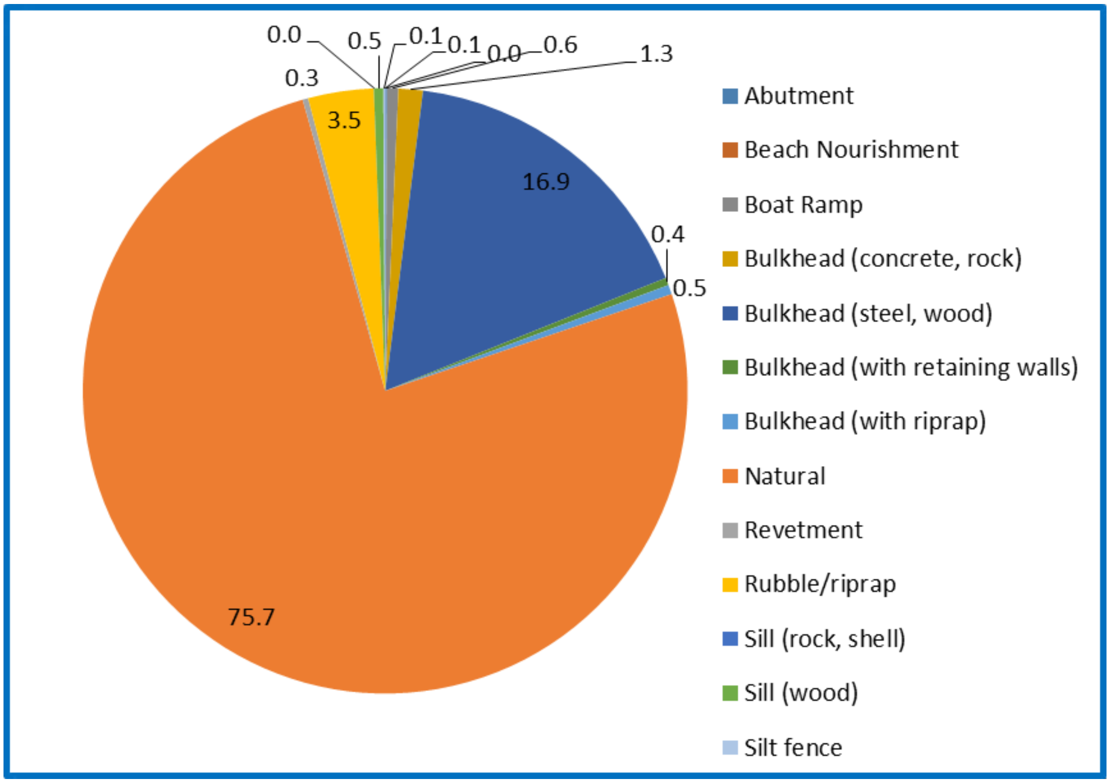


Source: Jones, Tidwell, and Darby, 2009

Figure 3.49 Geographic Distribution of Shoreline Types, Lower Portion of Fish River Study Area

3.8.2.2 Shoreline Protection Classification

Of the 30.1 miles of mapped shoreline for Fish River, 22.8 miles (75.7 percent) is natural and 7.3 miles (24.3 percent) is hard shore protection. The main hard shore protection on Fish River is from bulkheads accounting for 5.8 miles (19.1 percent) of the total shore protection assessment area. Figure 3.50 illustrates the proportional breakdown of each shoreline protection type as a percentage of the entire shoreline for the Fish River study area. Figures 3.51, 3.52, and 3.53 provide the geographic distribution of shoreline protection types observed.



Source: Jones, Tidwell, and Darby, 2009

Figure 3.50 Proportional Breakdown by Shoreline Protection Type, Fish River Study Area (Percent of Total)

Source: Jones, Tidwell, and Darby, 2009

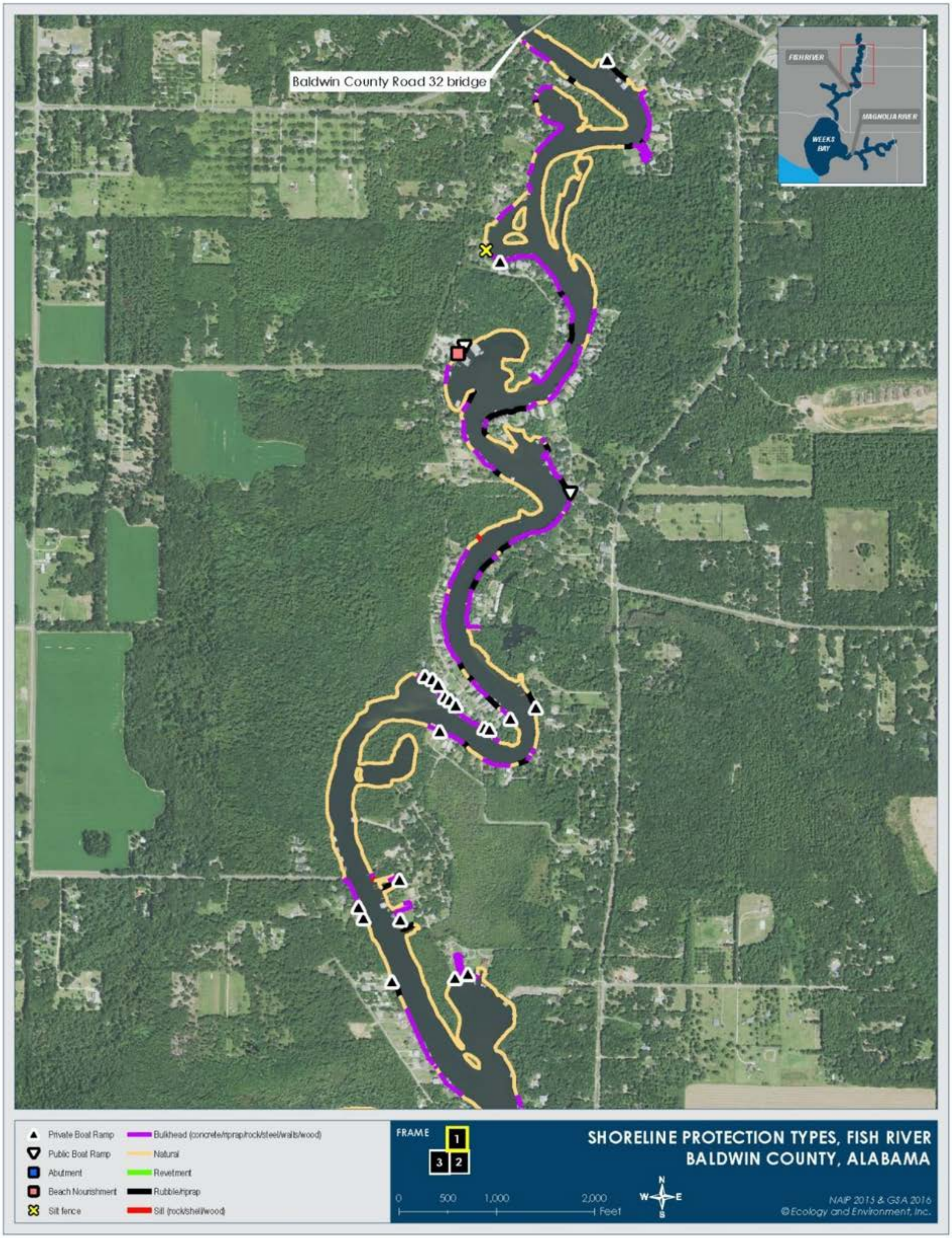
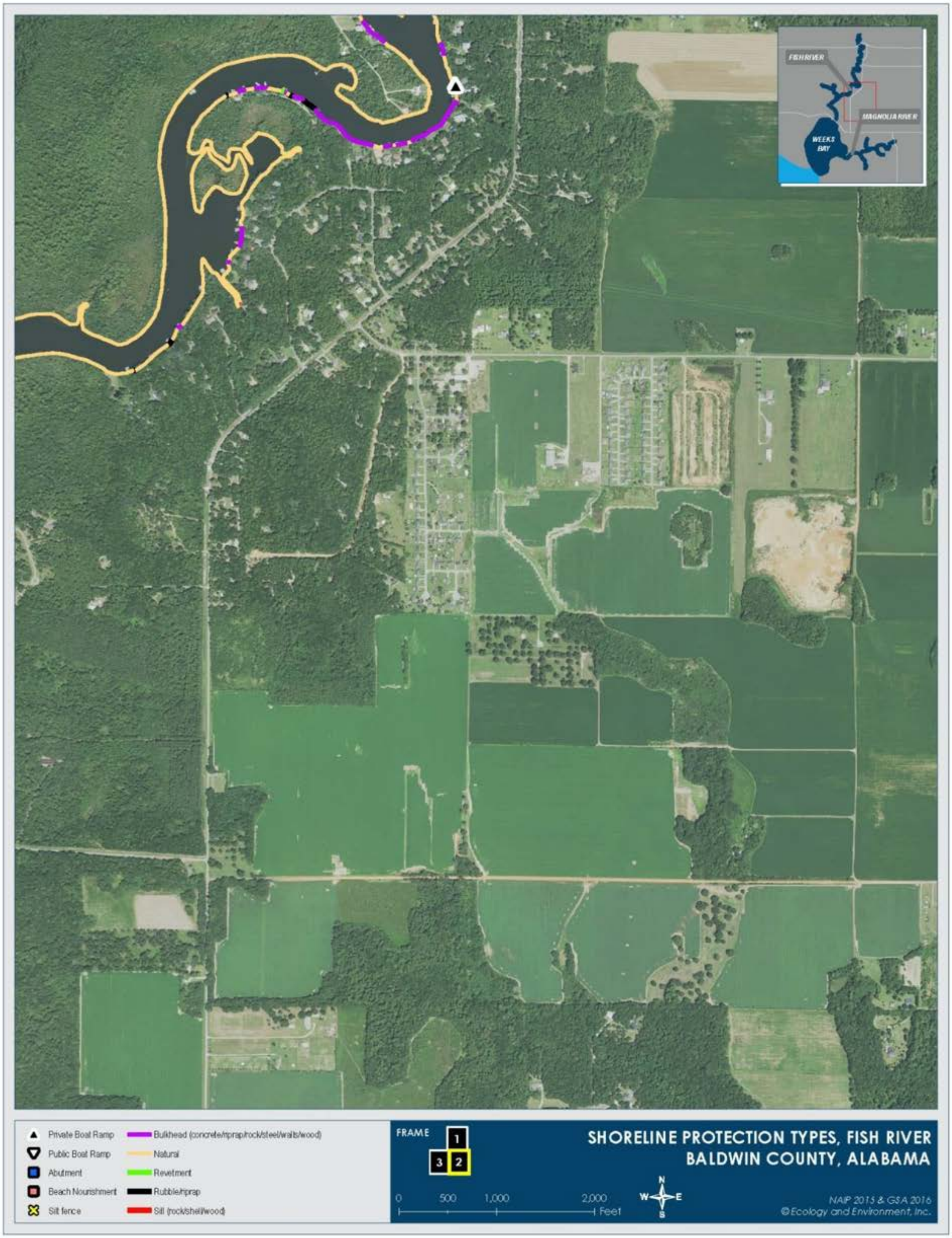
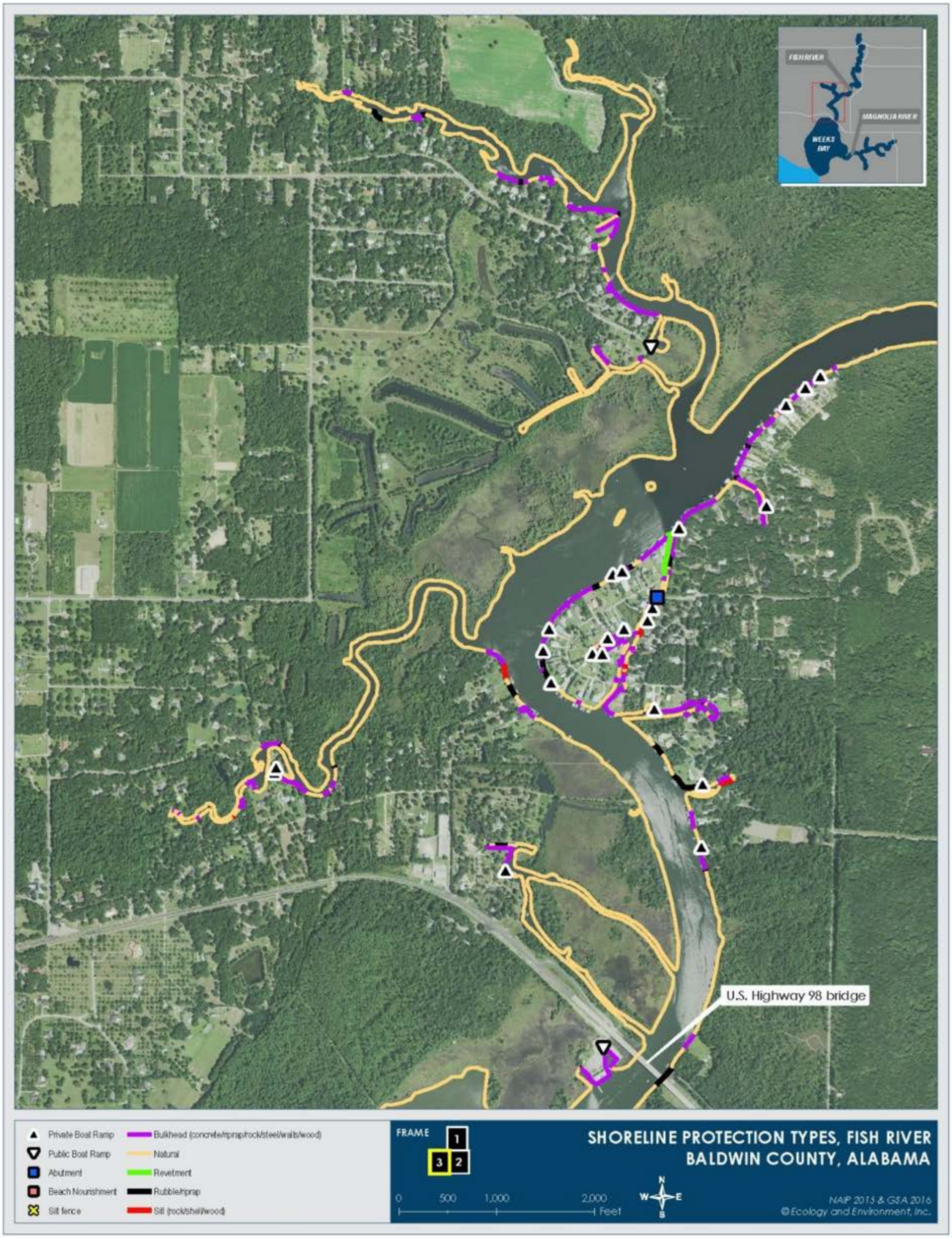


Figure 3.51 Distribution of Shoreline Protection Types, Upper Portion of Fish River Study Area



Source: Jones, Tidwell, and Darby, 2009

Figure 3.52 Distribution of Shoreline Protection Types, Middle Portion of Fish River Study Area



Source: Jones, Tidwell, and Darby, 2009

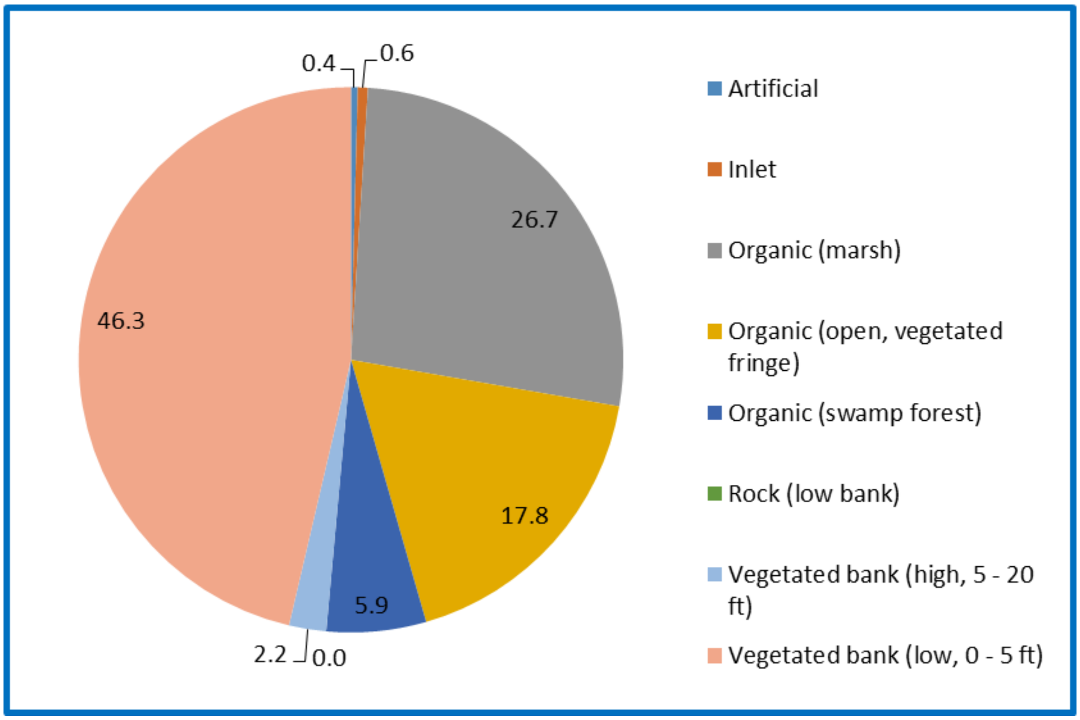
Figure 3.53 Distribution of Shoreline Protection Types, Lower Portion of Fish River Study Area

3.8.3 Magnolia River Study Area - Shoreline Type and Protection

3.8.3.1 Shoreline Type Classification

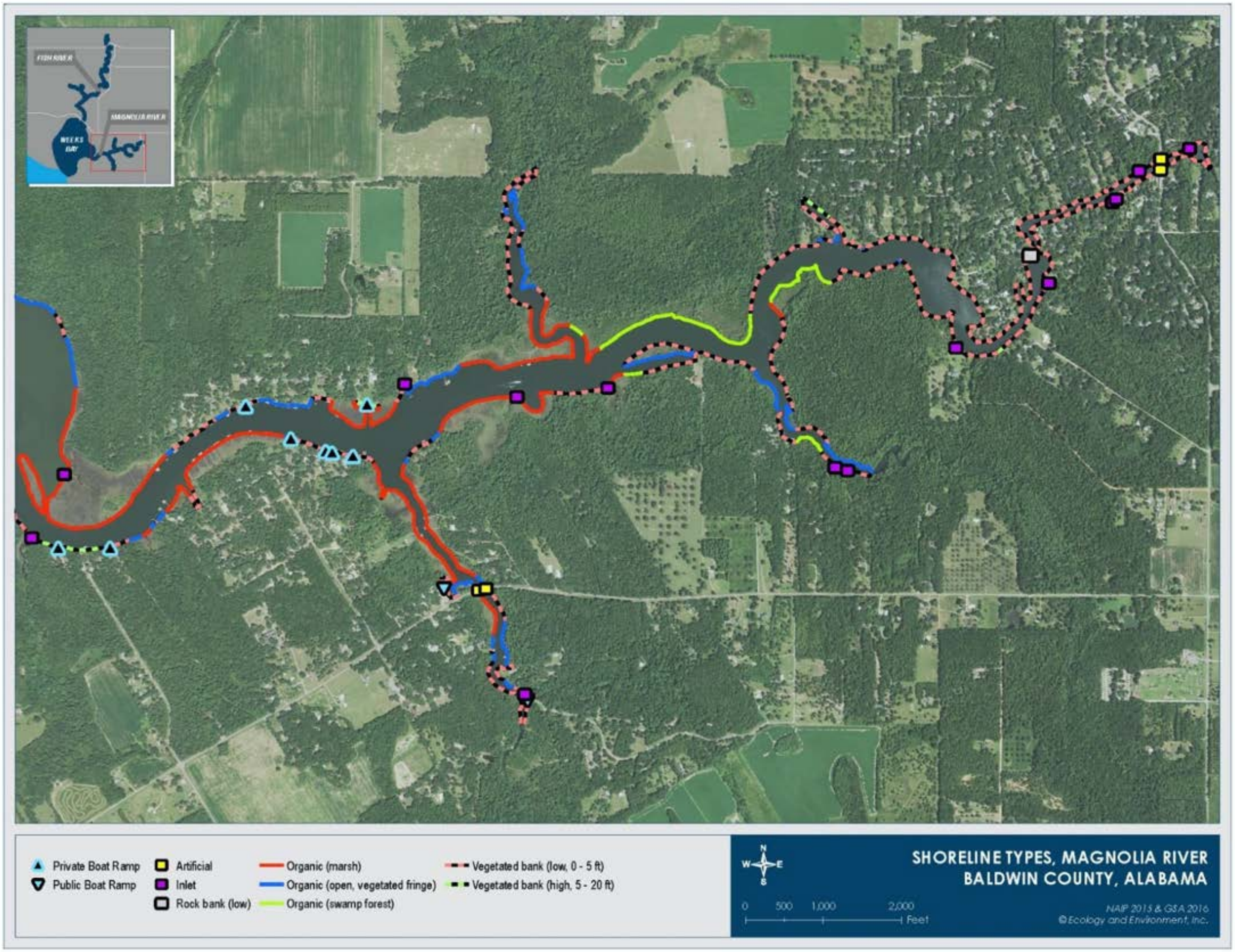
The Magnolia River portion of the GSA Phase I report extends from the Baldwin CR 49 bridge westward (downstream) to its discharge point on the eastern side of Weeks Bay. The Magnolia River contains approximately 15.4 linear miles of shoreline.

Organic shoreline types make up about 7.8 miles of shoreline, or about 50.4 percent of the total shoreline on the Magnolia River. Vegetated shoreline makes up about 7.5 miles of shoreline, or about 48.5 percent of the total shoreline. Figure 3.54 illustrates the proportional breakdown of each shoreline type as a percentage of the entire shoreline for the Magnolia River study area. Figure 3.55 provides the geographic distribution of the shoreline types observed.



Source: Jones, Tidwell, and Darby, 2009

Figure 3.54 Proportional Breakdown by Shoreline Type, Magnolia River Study Area (Percent of Total)

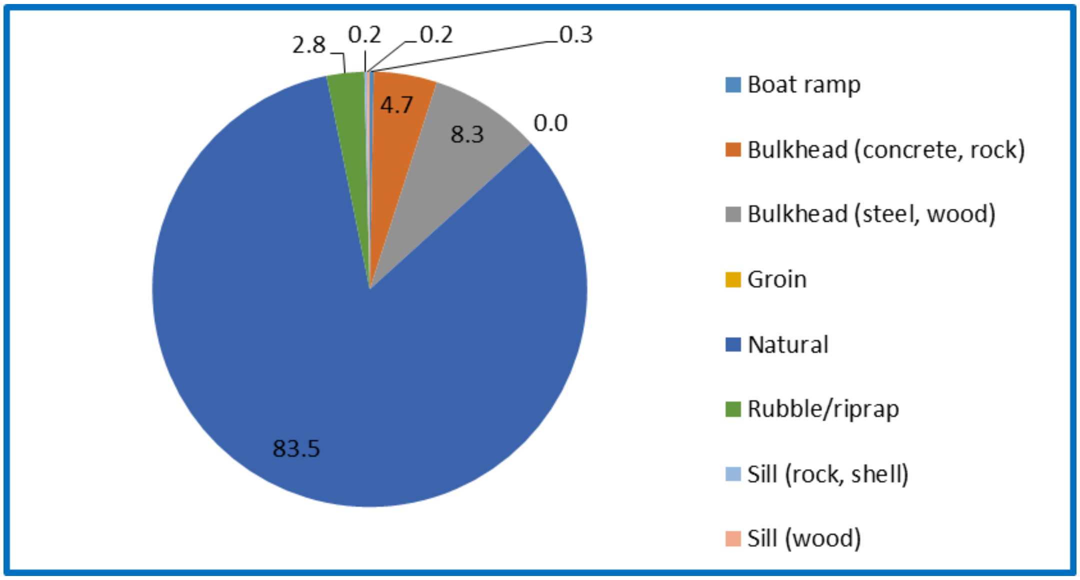


Source: Jones, Tidwell, and Darby, 2009

Figure 3.55 Geographic Distribution of Shoreline Types, Magnolia River Study Area

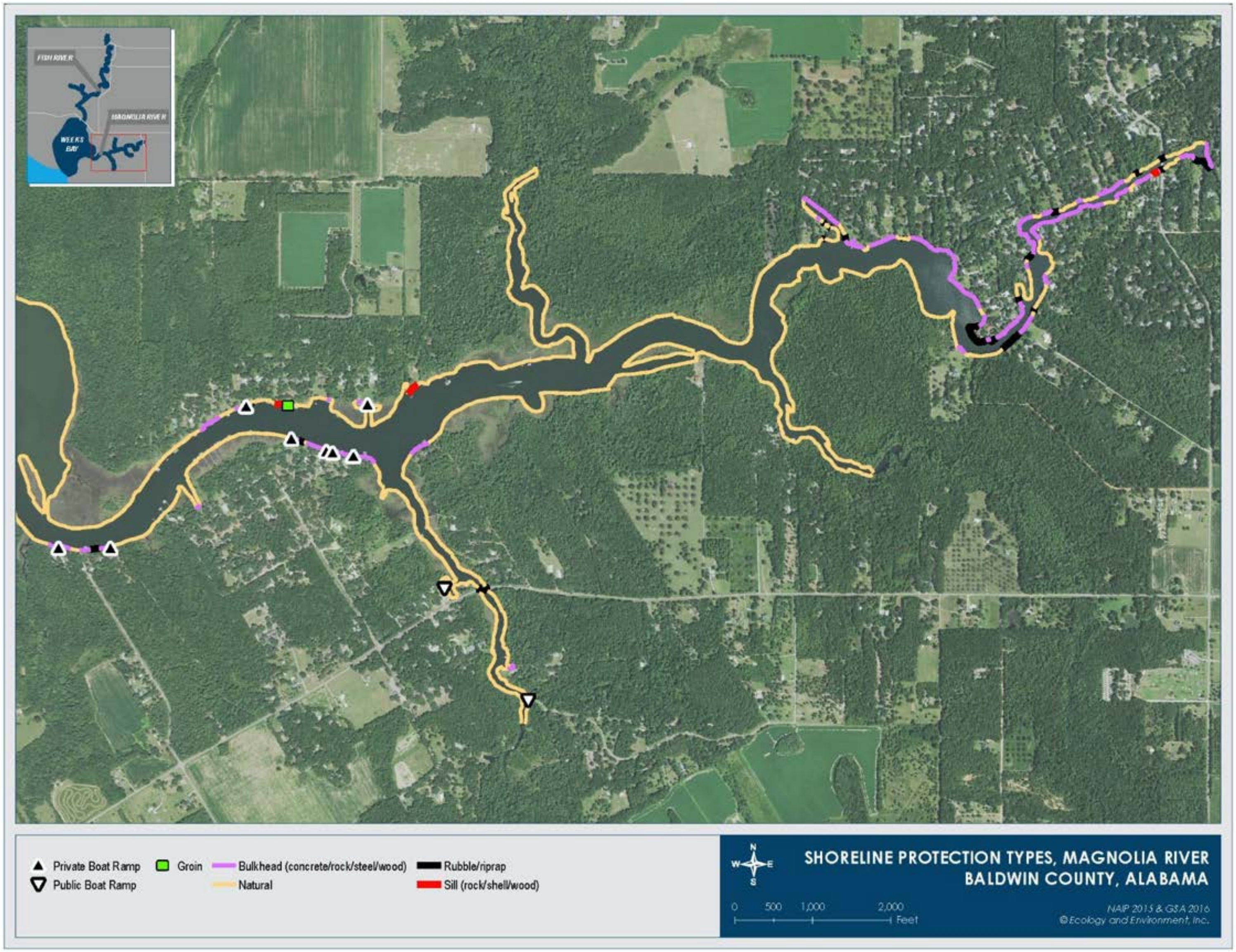
3.8.3.2 Shoreline Protection Classification

Of the 15.4 linear miles of shoreline in the Magnolia River study area, the dominant shore protection classification is classified as natural, unretained, and consists of approximately 12.9 miles, or about 83.5 percent, of the total shore protection. Only 2.5 miles (16.5 percent) is hard shore protection, consisting primarily of bulkheads. Figure 3.56 illustrates the proportional breakdown of each shoreline protection type as a percentage of the entire shoreline for the Magnolia River study area. Figure 3.57 provides the geographic distribution of shoreline protection types observed.



Source: Jones, Tidwell, and Darby, 2009

Figure 3.56 Proportional Breakdown by Shoreline Protection Type, Magnolia River Study Area (Percent of Total)



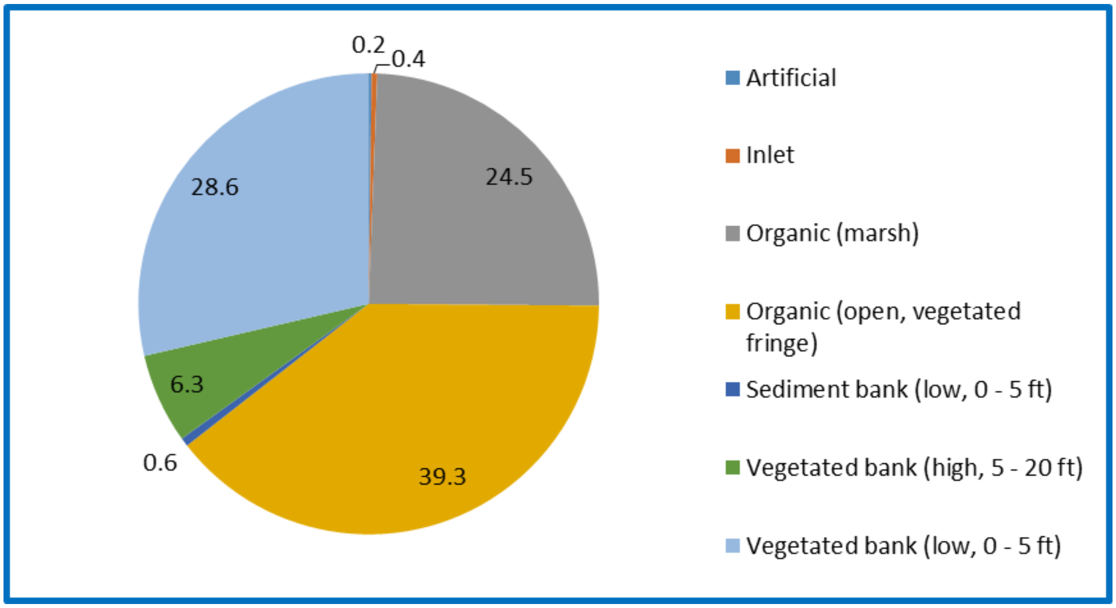
Source: Jones, Tidwell, and Darby, 2009

Figure 3.57 Geographic Distribution of Shoreline Protection Types, Magnolia River Study Area

3.8.4 Weeks Bay Study Area - Shoreline Type and Protection

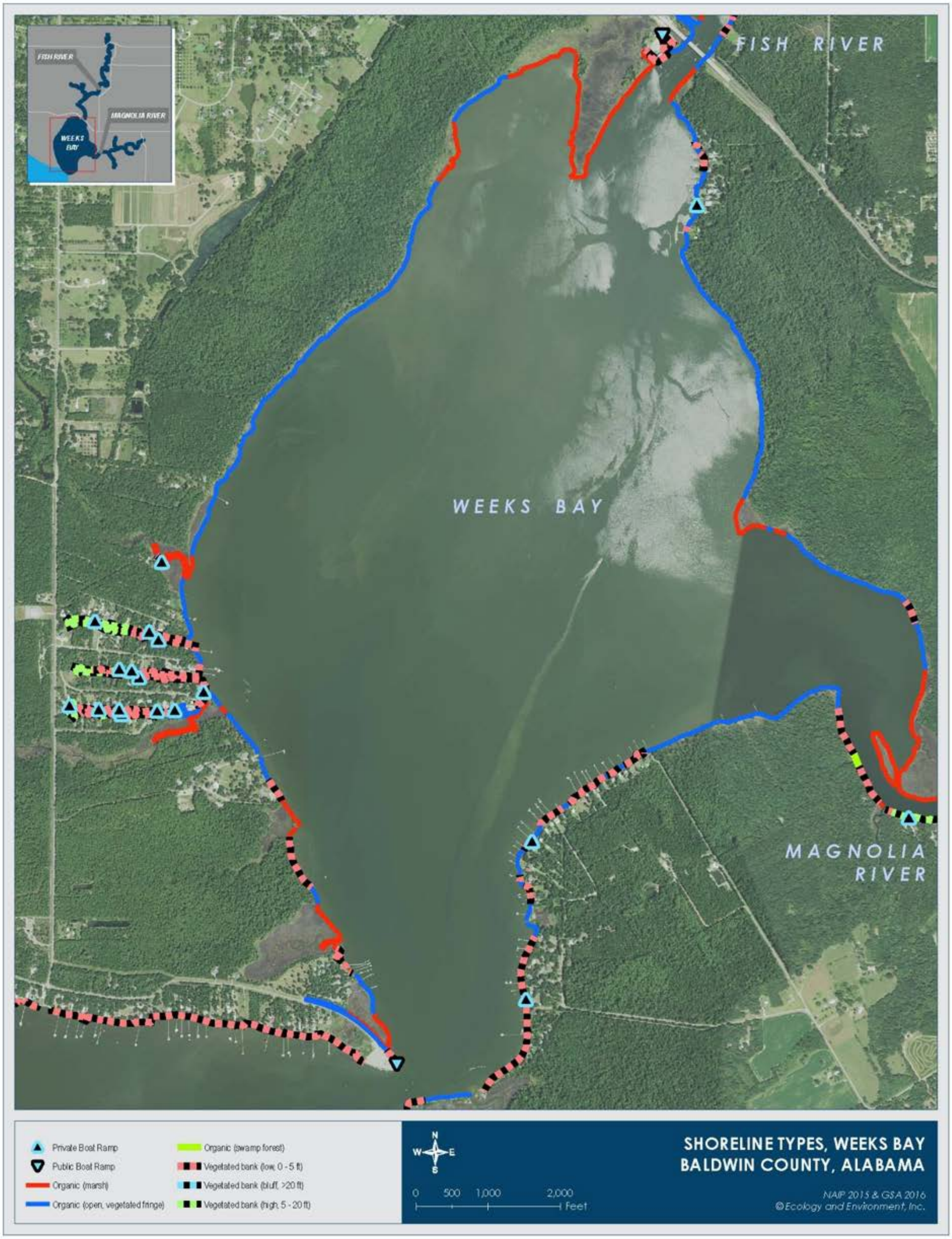
3.8.4.1 Shoreline Type Classification

The Weeks Bay portion of the GSA Phase I report extends from the mouth of the Fish River, at the U.S. Highway 98 bridge, southward to the mouth of the bay, which is located on the northern shore of Bon Secour Bay. Weeks Bay contains approximately 11.4 linear miles of shoreline. Organic shoreline types make up about 7.3 miles, or about 63.8 percent, of the total shoreline in Weeks Bay. Vegetated bank types make up about 4.0 miles, or about 34.9 percent, of the total shoreline in Weeks Bay. Additional, yet minor, components include inlets, artificial shorelines, and sediment banks (low). Figure 3.58 illustrates the proportional breakdown of each shoreline type as a percentage of the entire shoreline for the Weeks Bay study area. Figure 3.59 provides the geographic distribution of shoreline types observed.



Source: Jones, Tidwell, and Darby, 2009

Figure 3.58 Proportional Breakdown by Shoreline Type, Weeks Bay Study Area (Percent of Total)

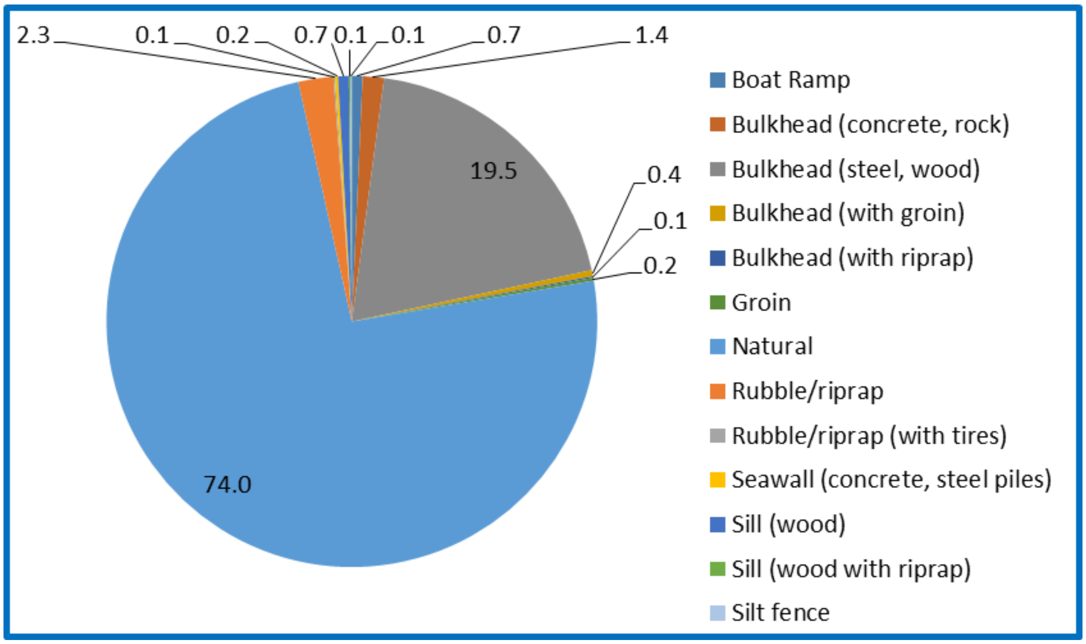


Source: Jones, Tidwell, and Darby, 2009

Figure 3.59 Geographic Distribution of Shoreline Types, Weeks Bay Study Area

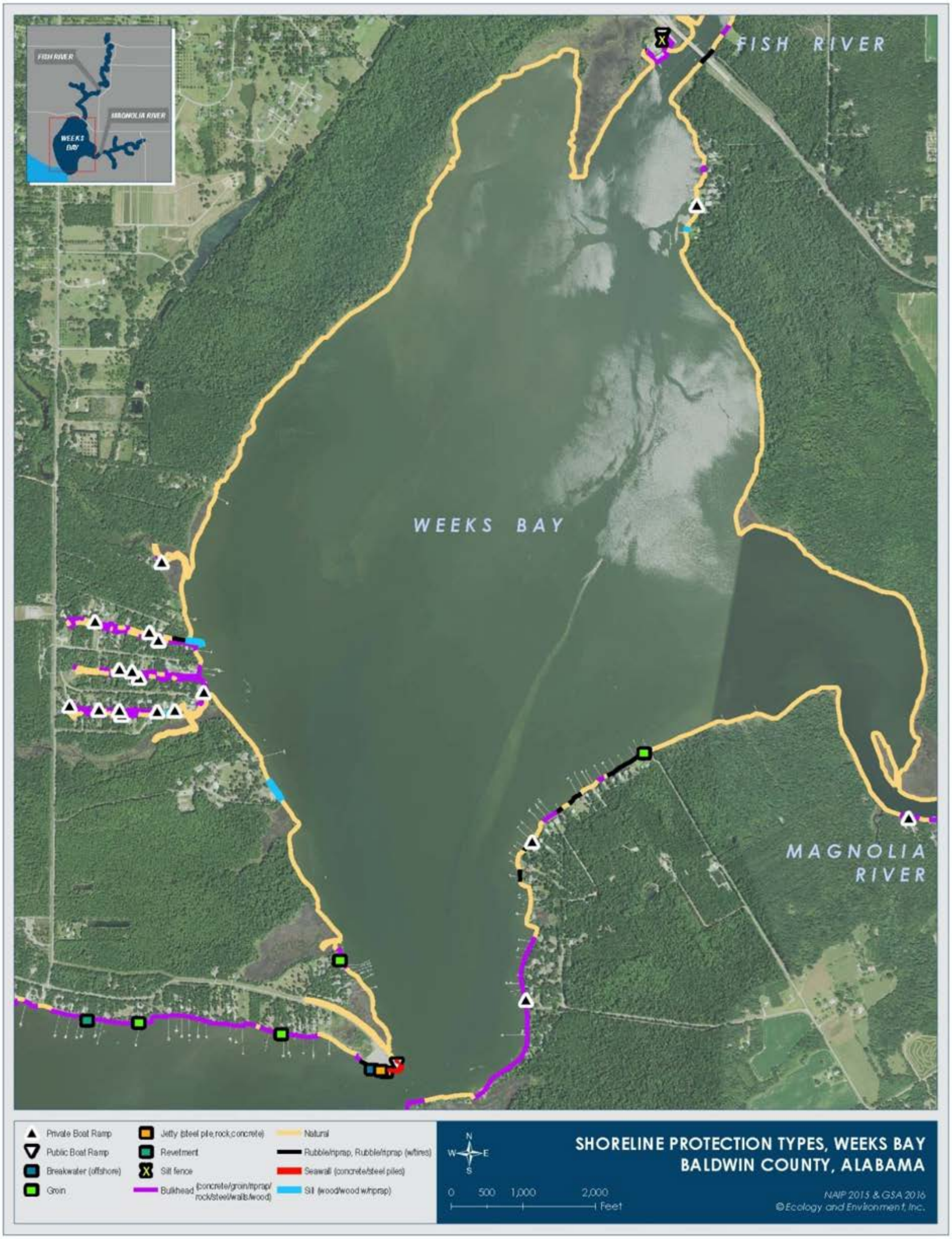
3.8.4.2 Shoreline Protection Classification

Although the majority of the shoreline in Weeks Bay is natural and is located in the Weeks Bay National Estuarine Research Reserve, Weeks Bay has numerous types of shore protection. Of the 11.4 miles of shoreline mapped in Weeks Bay, 8.4 miles (74.0 percent) were natural and 3.0 miles (26.1 percent) were hard shore protection. Bulkheads are the main hard shore protection, representing 2.5 miles (21.4 percent) of the total hard shore protection for Weeks Bay. Figure 3.60 illustrates the proportional breakdown of each shoreline protection type as a percentage of the entire shoreline for the Weeks Bay study area. Figure 3.61 provides the geographic distribution of shoreline protection types observed.



Source: Jones, Tidwell, and Darby, 2009

Figure 3.60 Proportional Breakdown by Shoreline Protection Type, Weeks Bay Study Area (Percent of Total)



Source: Jones, Tidwell and Darby, 2009

Figure 3.61 Geographic Distribution of Shoreline Protection Types, Weeks Bay Study Area

3.8.4.2.1 Fish River Findings

Fish River has 30.1 miles of shoreline, which are classified into three major types:

- **Vegetated** (bluff, high bank, and low bank): 14.9 miles, 49.6 percent;
- **Organic** (marsh, swamp, and open shoreline vegetated fringe): 14.8 miles, 49.3 percent; and
- **Pocket Beach** (sediment): 446 feet, 0.3 percent of the total shoreline types.

About 30.1 miles of shoreline on Fish River were mapped with 22.8 miles (75.7 percent) natural and 7.3 miles (24.3 percent) armored.

3.8.4.2.2 Magnolia River Findings

Magnolia River has 15.4 miles of shoreline, which are classified into two major types:

- **Organic** (marsh, swamp, and open shoreline vegetated fringe)**:** 7.8 miles, 50.4 percent; and
- **Vegetated** (high bank and low bank)**:** 7.5 miles, 48.5 percent of the total shoreline types.

Of the total shoreline on the Magnolia River, 12.9 miles (83.5 percent) are natural and 2.5 miles (16.5 percent) are armored.

3.8.4.2.3 Weeks Bay Findings

Weeks Bay has 11.4 miles of shoreline, which are classified into three major types:

- **Organic** (marsh and open shoreline vegetated fringe)**:** 7.3 miles, 63.8 percent;
- **Vegetated** (high bank and low bank)**:** 4 miles, 42.6 percent; and
- **Sediment** (low bank)**:** 338 feet, 0.6 percent of the total shoreline types.

Of the 11.4 miles of shoreline mapped in Weeks Bay, 8.4 miles (73.9 percent) were natural and unretained and 3.0 miles (26.1 percent) were armored.

3.8.5 Shoreline Changes Over Time

In order to assess changes to shorelines in the Watershed over time, aerial photographs from 1955 were compared with aerial photographs from 2015. The assessment area was limited to shorelines that are visible on the 1955 aerial photos. These areas generally correspond with portions of the Watershed that are considered navigable by most recreational boats, and are the most tidally-influenced. The assessment areas were: (1) the Lower Fish River Watershed (HUC 12: 031602050204), including all of Weeks Bay and Fish River to just north of the CR 32 bridge; and (2) the Magnolia River Watershed (HUC 12: 031602050203), from Weeks Bay to just east of the CR 49 bridge.

The assessment focused on observable changes to features, such as:

- Shoreline geometry;
- Width and route of the rivers and tributaries;
- Major man-made alterations to the shoreline;
- Size and shape of peninsulas and islands; and
- Location and extent of marshes.

Hardcopies of the 1955 aerial photographs were obtained from the Baldwin County Natural Resources Conservation Service (NRCS) office in Bay Minette, Alabama. These images were scanned at a high resolution and georeferenced using a geographic information system (GIS) software program. Once an image is georeferenced (properly positioned and scaled to match recent aerial photos), the GIS analyst can compare the width of a feature (e.g., river, island) from 50 years ago with the width of the same feature in a more recent aerial photograph. Due to the inherent margin of error when geo-referencing images, especially very old images, only qualitative comparisons were made to identify general trends and major changes, as opposed to being used in a quantitative fashion to determine exact acreage lost or gained, or exact widths of waterbodies and other visible features.

The remaining portions of this section provide a side-by-side view of selected sites in the assessment area (Figures 3.62 through 3.76) where notable changes, or lack thereof, have occurred between 1955 and 2015. Areas selected for comparison in the Lower Fish River Watershed are indicated as sites FR 1-4 (Fish River) and WB 1-4 (Weeks Bay), while areas in the Magnolia River Watershed are labeled MR 1-4 (Magnolia River). These comparison sites do not represent all areas where visible changes to the shoreline have occurred. They are, instead, provided as examples of various changes that are typical in the assessment area. Later sections provide additional information related to existing shoreline conditions in the upper reaches of the Magnolia River and Fish River, where shorelines were not visible on aerial photos.

3.8.5.1 Comparison of Historical and Current Aerial Photos - Fish River

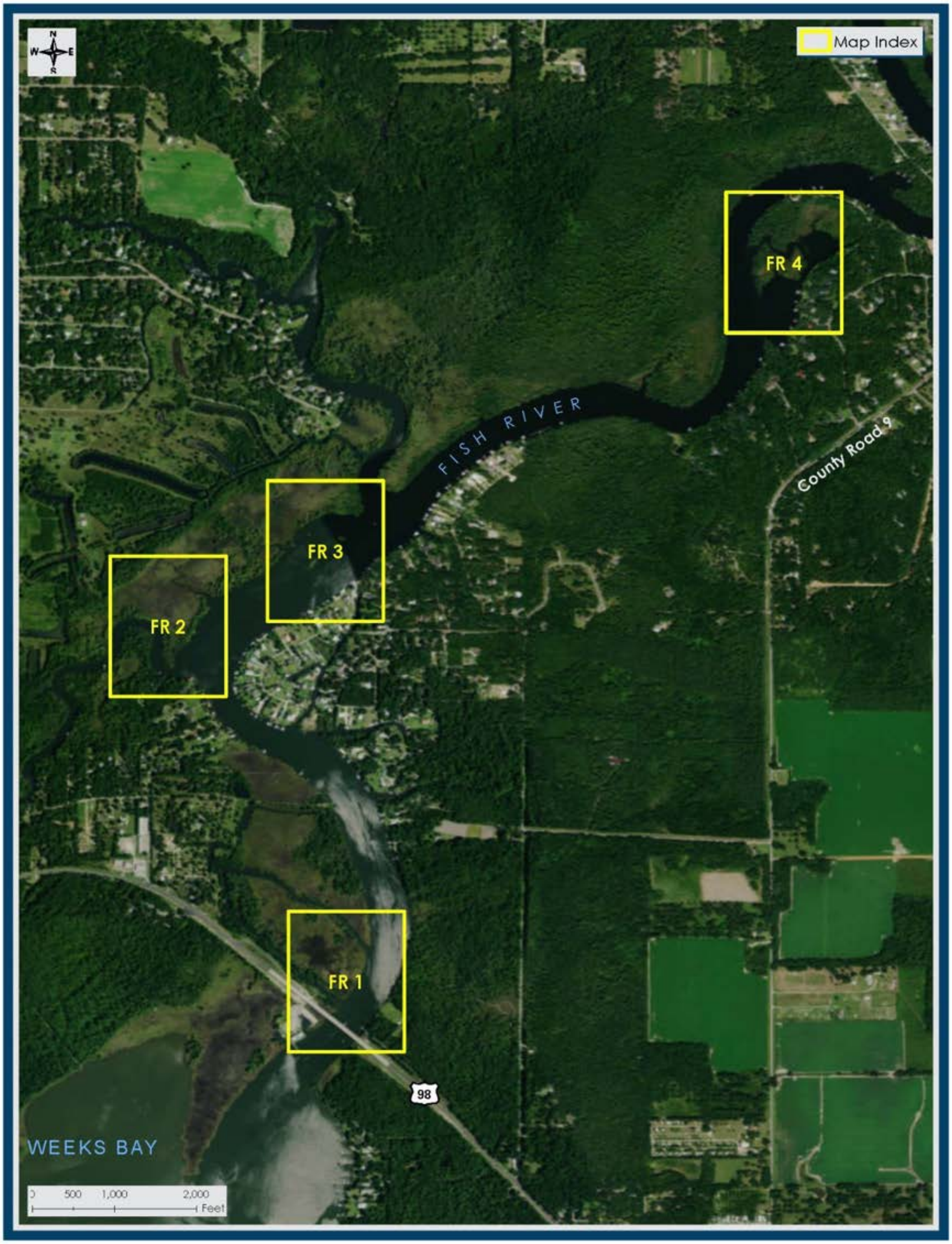


Figure 3.62 Comparison Observation Areas of Aerial Imagery from 1955 and 2015, Fish River (FR 1-4)

FR 1 - 1955

FR 1 - 2015

Figure 3.63 Comparison of Aerial Imagery from 1955 and 2015, Fish River Site 1 (FR 1)

FR 2 - 1955 **FR 2 - 2015**

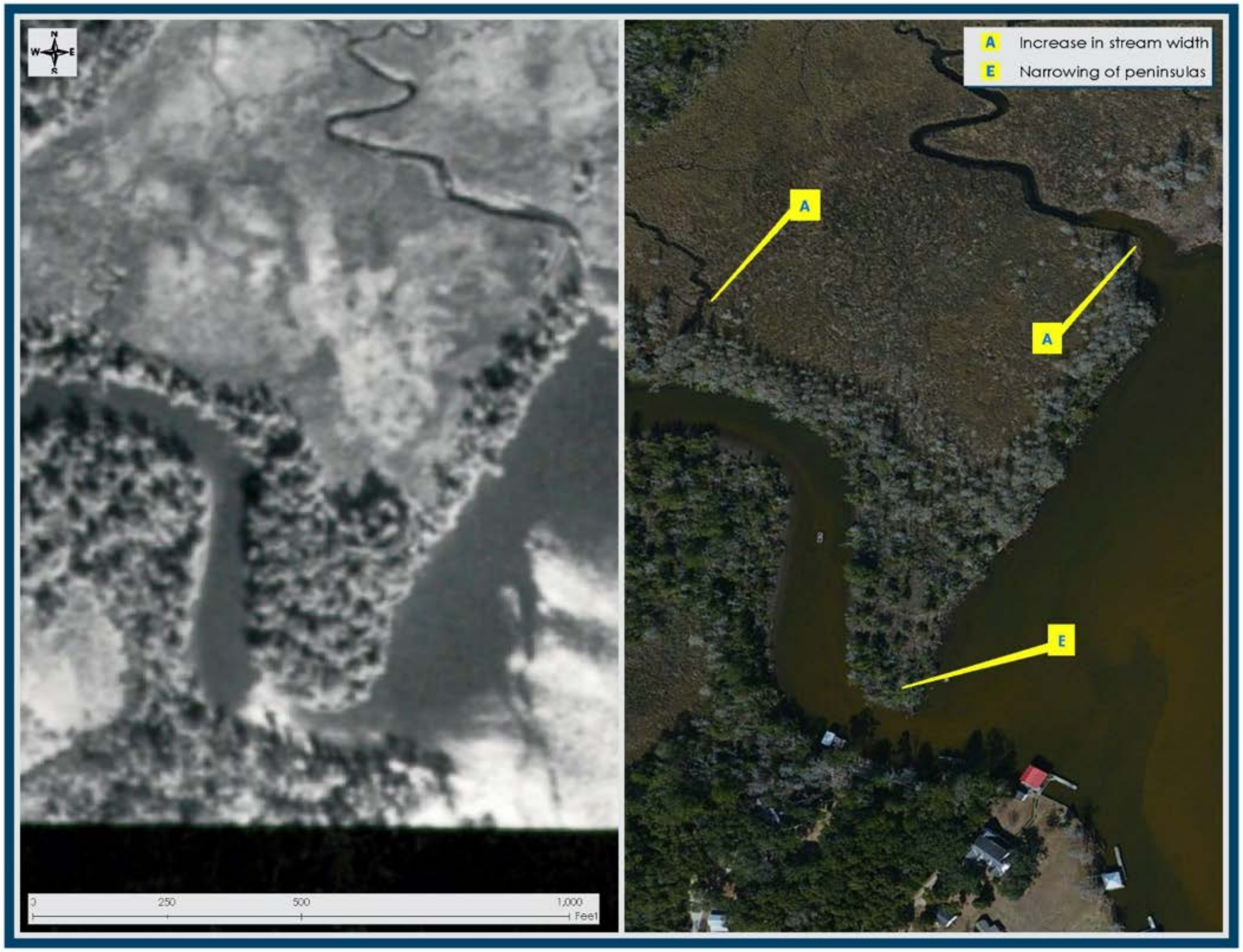


Figure 3.64 Comparison of Aerial Imagery from 1955 and 2015, Fish River Site 2 (FR 2)

FR 3 - 1955 FR 3 - 2015

Figure 3.65 Comparison of Aerial Imagery from 1955 and 2015, Fish River Site 3 (FR 3)

FR 4 - 1955 **FR 4 - 2015**

Figure 3.66 Comparison of Aerial Imagery from 1955 and 2015, Fish River Site 4 (FR 4)

3.8.5.2 Comparison of Historical and Current Aerial Photos - Magnolia River

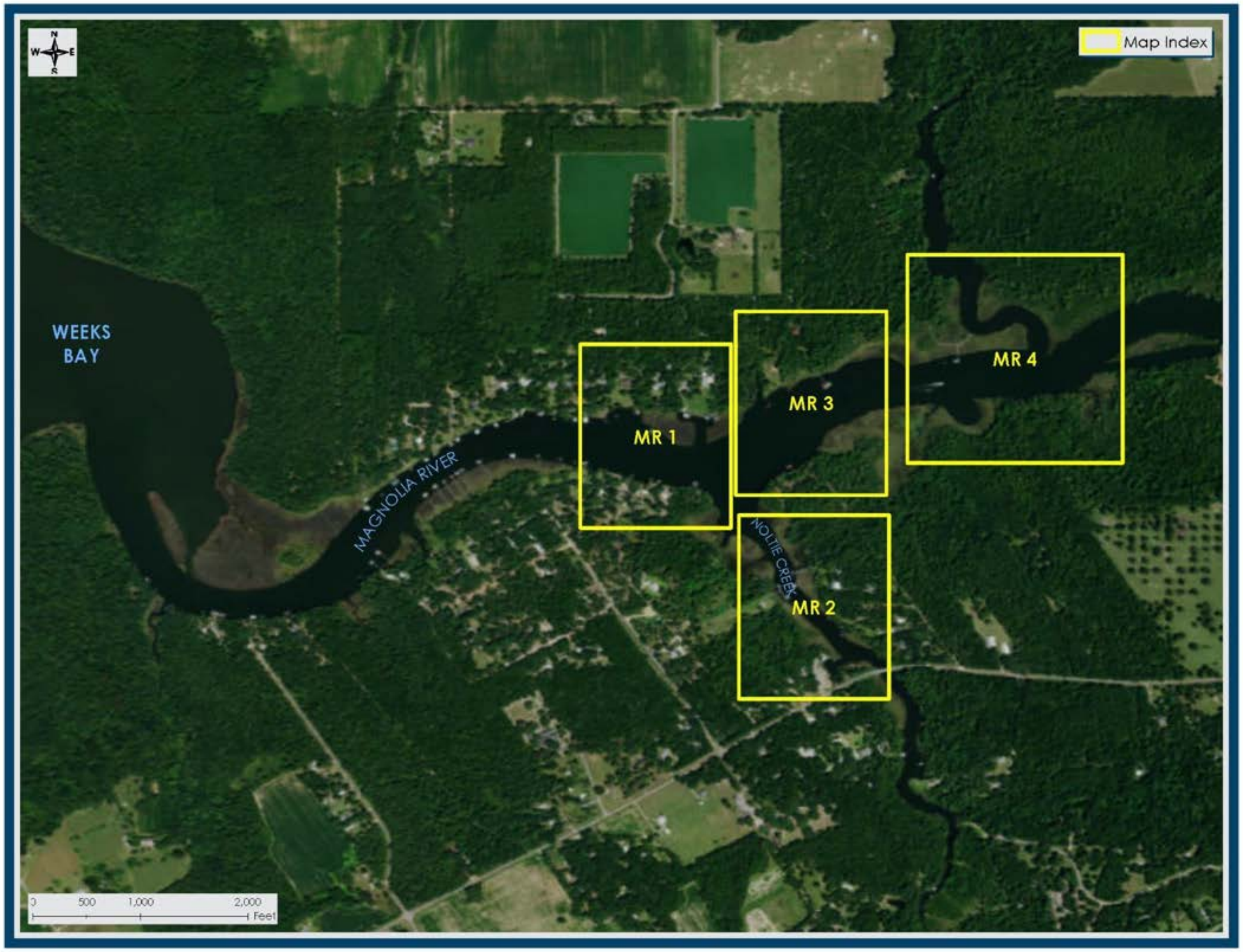


Figure 3.67 Comparison Observation Areas of Aerial Imagery from 1955 and 2015, Magnolia River (MR 1-4)

MR 1 - 1955 MR 1 - 2015

Figure 3.68 Comparison of Aerial Imagery from 1955 and 2015, Magnolia River Site 1 (MR 1)

MR 2 - 1955 **MR 2 - 2015**

Figure 3.69 Comparison of Aerial Imagery from 1955 and 2015, Magnolia River Site 2 (MR 2)

MR 3 - 1955 **MR 3 - 2015**

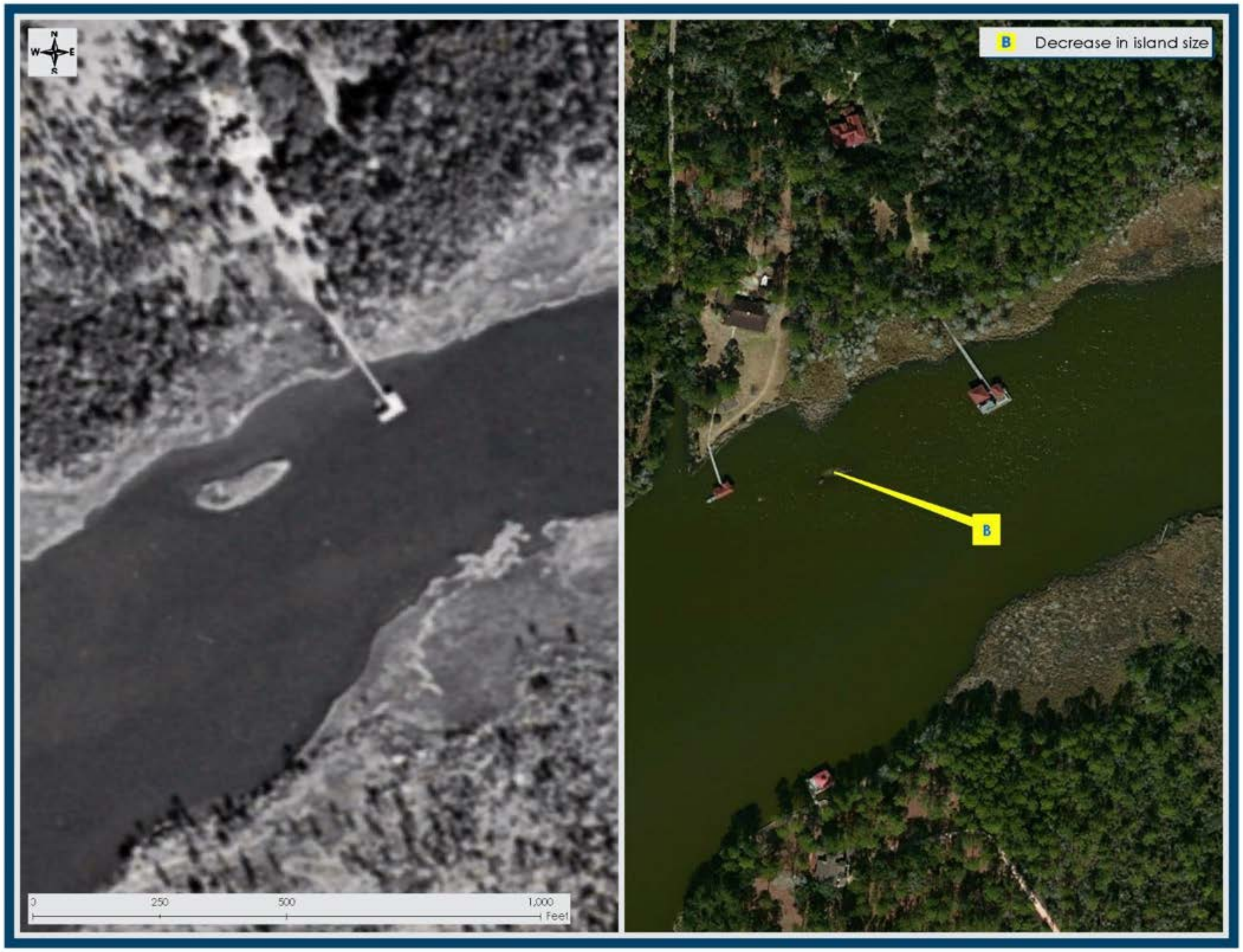


Figure 3.70 Comparison of Aerial Imagery from 1955 and 2015, Magnolia River Site 3 (MR 3)

MR 4 - 1955 **MR 4 - 2015**

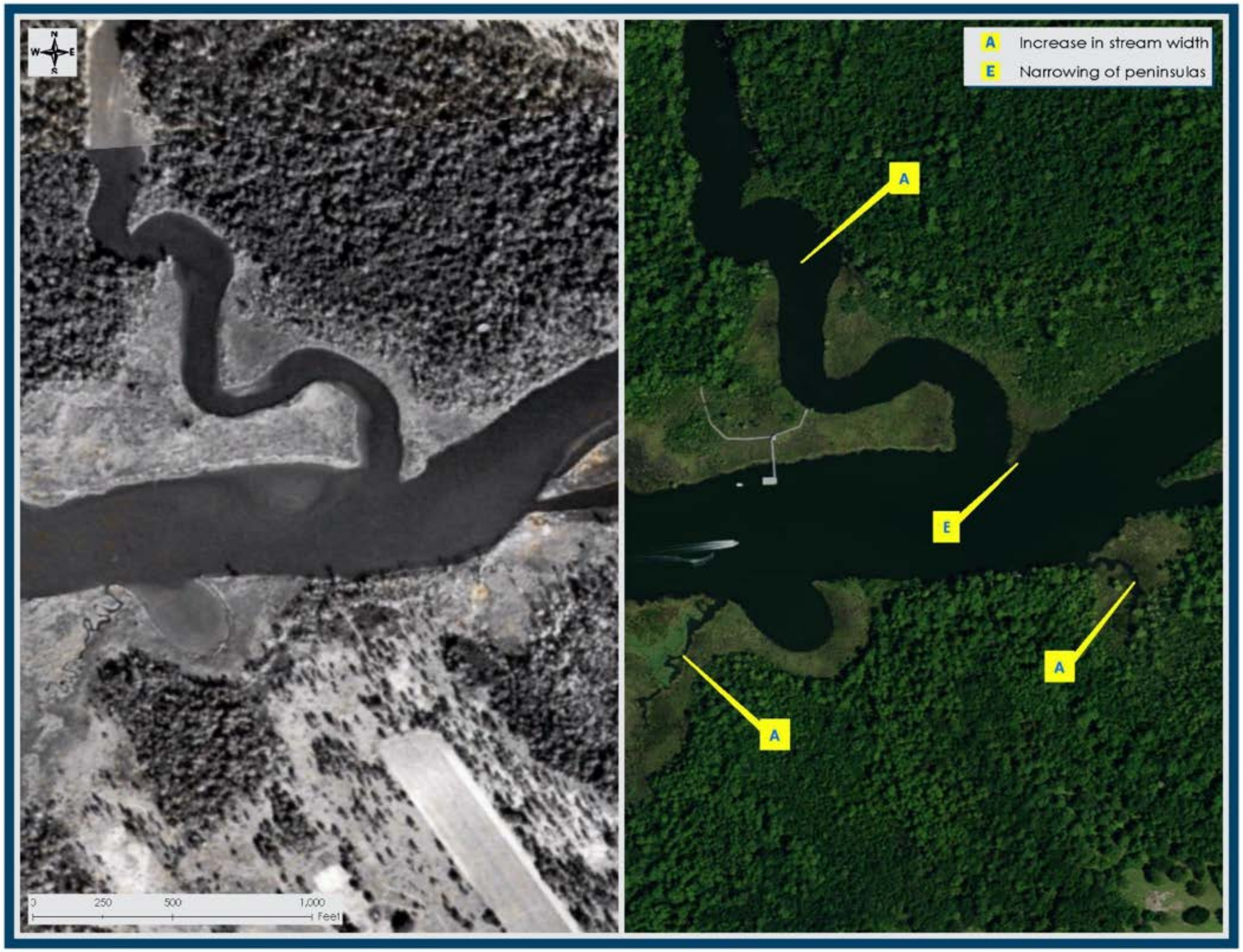


Figure 3.71 Comparison of Aerial Imagery from 1955 and 2015, Magnolia River Site 4 (MR 4)

3.8.5.3 Comparison of Historical and Current Aerial Photos – Weeks Bay

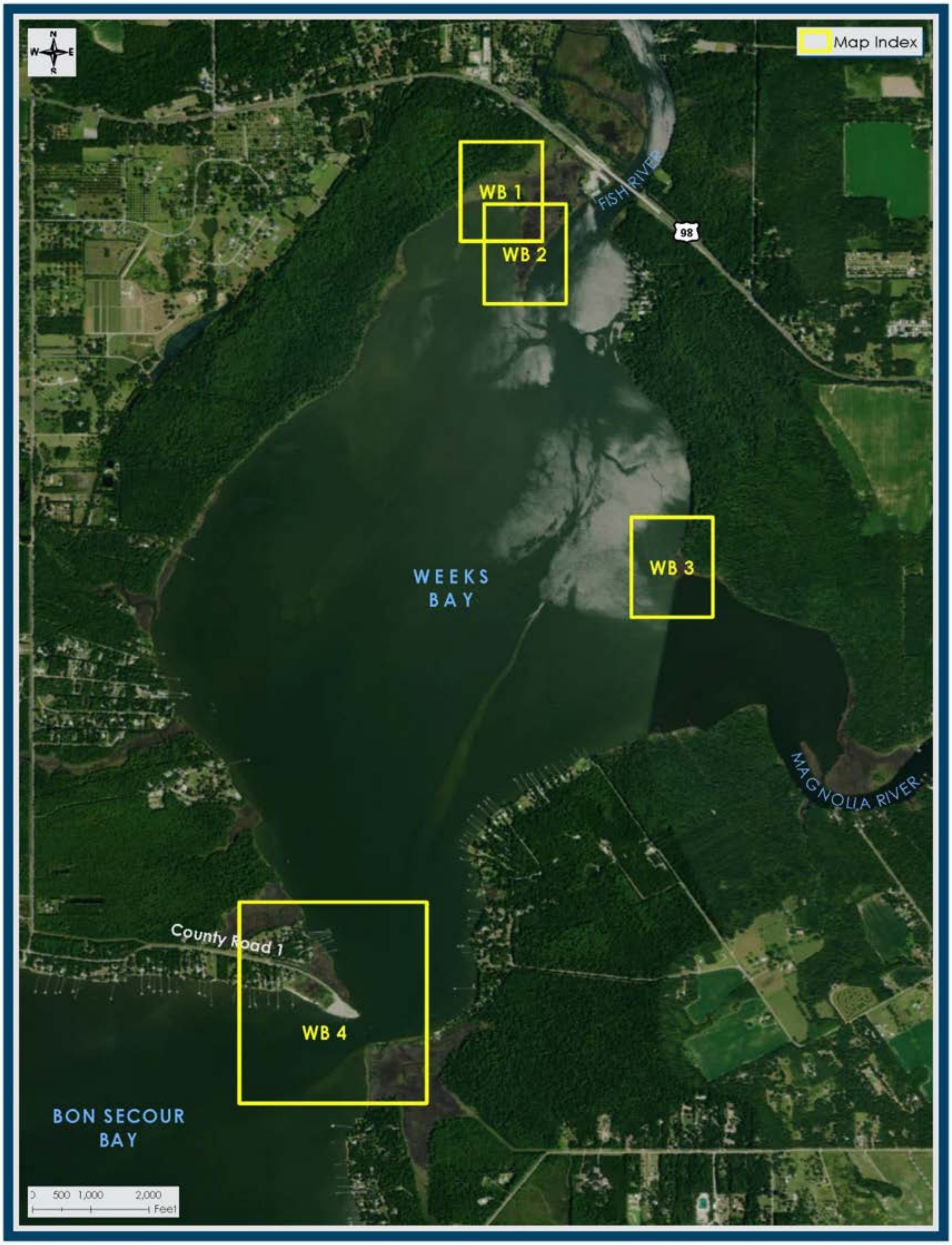


Figure 3.72 Comparison Observation Areas of Aerial Imagery from 1955 and 2015, Weeks Bay (WB 1-4)

WB 1 - 1955 **WB 1 - 2015**

Figure 3.73 Comparison of Aerial Imagery from 1955 and 2015, Weeks Bay Site 1 (WB 1)

WB 2 - 1955 **WB 2 - 2015**

Figure 3.74 Comparison of Aerial Imagery from 1955 and 2015, Weeks Bay Site 2 (WB 2)

WB 3 - 1955 **WB 3 – 2015**

Figure 3.75 Comparison of Aerial Imagery from 1955 and 2015, Weeks Bay Site 3 (WB 3)

WB 4 - 1955 | WB 4 - 2015

Figure 3.76 Comparison of Aerial Imagery from 1955 and 2015, Weeks Bay Site 4 (WB 4)

3.8.5.4 Results of Shoreline Change Assessment

3.8.5.4.1 Fish River Results

Of the four sites selected for comparison in the Fish River study area, notable changes were observed at site FR 1, including a man-made alteration of shorelines due to the excavation of boat launch facilities and canals. Site FR 2 exhibited widening of streams and narrowing of spits (peninsulas). The most notable change at site FR 3 was the loss in area of emergent islands. Site FR 4 exhibited increases in stream width, loss in area of emergent islands, and narrowing of peninsulas.

3.8.5.4.2 Magnolia River Results

Of the four sites selected for comparison in the Magnolia River study area, the most notable change was observed at site MR 1, where a man-made alteration of shorelines involved excavation of private boat slips and associated turning basins. Site MR 2 exhibited widening of streams (Noltie Creek) and man-made shoreline alterations (excavation of a canal and a public boat ramp turning basin). The most notable change at site MR 3 was the loss in area of emergent islands. Site MR 4 exhibited increases in stream width and narrowing of peninsulas.

3.8.5.4.3 Weeks Bay Results

Of the four sites selected for comparison in the Weeks Bay study area, the most notable observation at site WB 1 was the relative lack of change since 1955. Both the marsh and the wooded upland (surrounded by marsh and open water) appear to be roughly the same size and shape as they were in 1955. Site WB 2, which overlaps the southern portion of WB 1, exhibited primarily narrowing of the peninsula separating the northern most portion of Weeks Bay from the Fish River. The most notable change at site MR 3, which is located near the mouth of the Magnolia River, was the apparent conversion to a wetter habitat, as the terrace separating the marsh from Weeks Bay appears to have been converted to mostly marsh. Site WB 4 exhibited narrowing of the peninsula forming the western shore of the Weeks Bay mouth.

3.8.5.5 Conclusions from Shoreline Change Assessment

Man-made alterations of the shoreline due to excavation and narrowing of peninsulas were observed in all three assessment areas (Fish River, Magnolia River, and Weeks Bay). Conversion to a wetter habitat was noted primarily at site WB 3. Interestingly, at site WB 1, the marsh appeared to be relatively unchanged in size and shape (with the exception of marsh located on the narrowing peninsula along the western bank of Fish River).

The two most notable changes observed in this assessment include: (1) the loss of emergent island area; and (2) the widening of coastal streams. The two locations exhibiting the most obvious loss of island area are at sites FR 3 and MR 3. Both of these sites experience high levels of boat traffic and resulting wake, which could lead to erosion along the shores of these islands. Additional factors related to the size of these islands include the occurrence of flood events and tropical systems, which can cause increased flow and velocity leading to greater potential for bank erosion. The widening of streams was noted at sites FR 2, FR 4, MR 2, and MR 4. These streams are very small coastal streams typically running through marsh and have very small watersheds. They are typically not wide or deep enough to be navigable by motorized boats.

Another possible cause for both the loss of island area and the widening of stream channels is sea level rise (SLR). The National Oceanic and Atmospheric Administration's (NOAA's) nearest long-term tidal gauge (#8735180) is located at Dauphin Island, approximately 17 miles southwest from the mouth of Weeks Bay. Published data from this gauge show that relative mean sea level has risen 6.5 inches in the Mobile Bay area since the gauge was installed in 1966. Such a rise in mean sea level could also explain why the smaller streams, which experience little to no risk of erosion from boat wake and no significant upstream land use changes in their micro-scale watersheds, have widened to such an extent in a relatively short period of time. More detailed discussions related to SLR are provided in Section 3.9.

3.8.6 Additional Studies and Coastal and Fluvial Processes in Weeks Bay Area

Although not visible in aerial photographs and, thus, not included in the historical shoreline comparison study area, organizations such as the Mobile Bay National Estuary Program (MBNEP), the Weeks Bay National Estuarine Research Reserve (Weeks Bay NERR), and the Alabama Coastal Foundation (ACF), as well as other independent scientists, have recorded extensive erosion of stream banks along the upper reaches of Fish River and Magnolia River. Figure 3.77 provides an example of such erosional features that were noted during a 2009 study performed by the ACF, which was funded by the MBNEP. Figure 3.78 documents the effects of severe erosion and deposition along the upper reaches of Magnolia River, approximately one mile upstream (east) of the Baldwin CR 49 Bridge in the town of Magnolia Springs.

While erosion and deposition are naturally occurring processes, changes in land use can significantly increase the rate at which they occur. Forested habitats were present throughout the Watershed prior to human occupation in the area. The forested watershed allowed for slower stormwater runoff and greater infiltration, which, in turn, controlled the rate at which erosion and deposition occurred. Conversion of natural ecosystems to land uses that cause higher stormwater runoff rates and lower infiltration rates can cause drastic effects downstream. Such effects can include a greater potential for flash floods as well as increase the volume and velocity of runoff in general, which are all likely to result in greater erosion and deposition.

Source: ACF, 2009

Figure 3.77 Typical Bank Erosion Found in Middle and Lower Fish River Watersheds

Photos Courtesy of Brett Gaar

Figure 3.78 Erosion and Nearby Downstream Deposition in Middle Reaches of the Magnolia River

3.9 Climate Change Assessment

An assessment was performed of the current and future potential effects of climate change on the four HUC 12 Watersheds that comprise the greater Weeks Bay Watershed (Figure 3.79), which are:

- Upper Fish River Watershed: HUC 12: 031602050201;
- Middle Fish River Watershed: HUC 12: 031602050202;
- Lower Fish River Watershed, including Weeks Bay: HUC 12: 031602050204; and
- Magnolia River Watershed: HUC 12: 031602050203.

The assessment of potential climate change effects included:

- An overview of climate change;
- A presentation of recorded historical and predicted future SLR in the area;
- An examination of potential effects of SLR; and
- An analysis of predicted effects of various SLR scenarios on future habitat distribution in the Watershed, as predicted by existing Sea Level Affecting Marshes Model (SLAMM) output data.

3.9.1 Climate Change Overview

This section provides an overview of current and potential future effects that may occur as a result of climate change. Much of this section discusses the results of the 3rd National Climate Assessment: Climate Change Impacts in the United States, which was presented to the President and Congress in May 2014, in accordance with the Global Change Research Act (GCRA). The GCRA requires that, every four years, the U.S. Global Change Research Program (USGCRP) prepare an assessment of the effects of global change in the United States (Melillo, Richmond, and Yohe, 2014a). Some of report's findings, which are likely the most applicable to the Weeks Bay Watershed, are provided in the sections below.

3.9.1.1 Temperature Rise

Average temperatures in the United States have increased by 1.3 degrees Fahrenheit (°F) to 1.9°F since record keeping began in 1895; most of this increase has occurred since about 1970. The most recent decade was the nation's warmest on record. Temperatures in the United States are expected to continue to rise (Melillo, Richmond, and, Yohe 2014b).

The Southeast warmed during the early part of last century, cooled for a few decades, and is now warming again. Temperatures across the region are expected to increase in the future. Major consequences include significant increases in the number of hot days (95°F or above) and decreases in freezing events. Climate change is expected to increase harmful blooms of algae and several disease-causing agents in inland and coastal waters. The length of the frost-free season (and the corresponding growing season) has been increasing nationally since the 1980s, affecting ecosystems and agriculture.

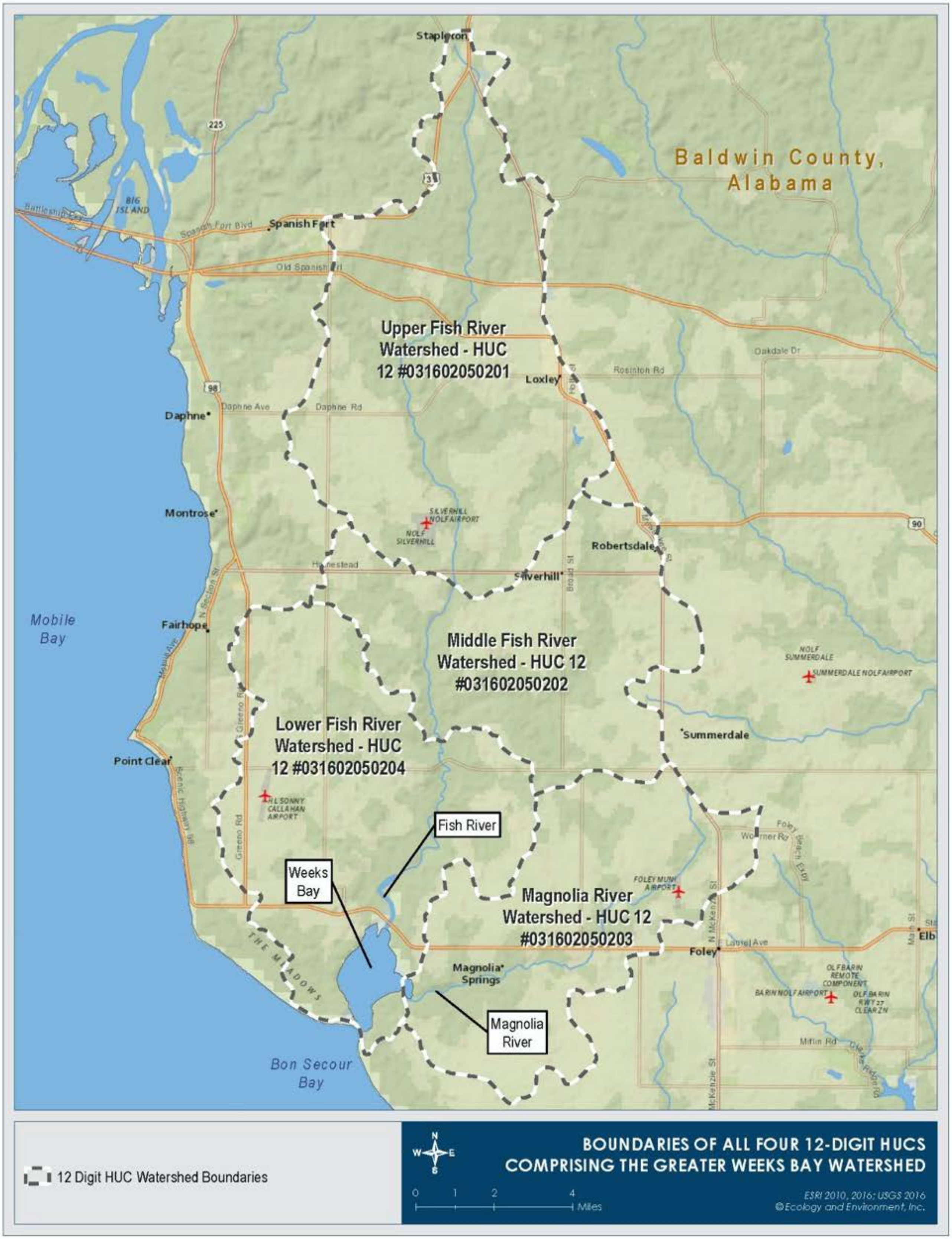


Figure 3.79 Boundaries of All Four 12-Digit HUCs Comprising the Greater Weeks Bay Watershed

Across the United States, the growing season is projected to continue to lengthen (Carter, et al. 2014) (Melillo, Richmond, and Yohe, 2014b).

3.9.1.2 Sea Level Rise

The global sea level has risen by about eight inches since reliable record-keeping began in 1880. It is projected to rise another one to four feet by 2100. In some areas, such as the greater Mobile Bay system (including Weeks Bay), the recorded local sea level relative to the ground surface (relative sea level) has risen higher than the global sea level (NOAA, 2016b). This effect can be the result of multiple factors, such as subsidence of the land and the configuration of shorelines and bathymetric conditions.

Some of the most notable impacts associated with SLR include loss of marshes and other important riparian systems, damage to infrastructure, loss of inhabitable uplands, increased stress on less resilient species of plants and animals, increased storm surge, increased salinity in freshwater surface waters and salt water infiltration into groundwater aquifers. These impacts are discussed in more detail in following sections.

3.9.1.3 Changes in Weather Patterns and Occurrence of Extreme Weather

There have been changes in some types of extreme weather events over the last several decades. In general, heat waves have become more frequent and intense across the nation, while cold waves have become less frequent and less intense. Some areas are also experiencing increased frequency and duration of droughts.

3.9.1.3.1 Hurricanes

The intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest (Categories 4 and 5) hurricanes, have all increased since the early 1980s. Hurricane-associated storm intensity and rainfall rates are projected to increase as the climate continues to warm.

3.9.1.3.2 Severe Storms

Winter storms have increased in frequency and intensity since the 1950s, and their tracks have shifted northward over the United States. Other trends in severe storms, including the intensity and frequency of tornadoes, hail, and damaging thunderstorm winds, are uncertain and are being studied intensively.

3.9.1.3.3 Increased Precipitation Frequency and Intensity

Average U.S. precipitation has increased since 1900, but some areas have had increases greater than the national average, while other areas have had decreases. Heavy downpours are increasing nationally, especially over the last three to five decades, with the largest increases in the Midwest and Northeast. Increases in the frequency and intensity of extreme precipitation events are projected for all U.S. regions.

3.9.1.4 Consequences of Climate Change in Coastal Areas

Chapter 25 of the Third National Climate Assessment provides the following "Key Messages" related to climate change, specifically in coastal areas (Moser et al., 2014):

- Coastal lifelines, such as water supply and energy infrastructure and evacuation routes, are increasingly vulnerable to higher sea levels and storm surges, inland flooding, erosion, and other climate-related changes;
- Nationally important assets, such as ports, tourism and fishing sites, in already vulnerable coastal locations, are increasingly exposed to SLR and related hazards. This threatens to disrupt economic activity within coastal areas and the regions they serve, and results in significant costs from protecting or moving these assets;
- Coastal ecosystems are particularly vulnerable to climate change because many have already been dramatically altered by human stresses; climate change will result in further reduction or loss of the services that these ecosystems provide, including potentially irreversible impacts; and
- Leaders and residents of coastal regions are increasingly aware of the high vulnerability of coasts to climate change and are developing plans to prepare for potential impacts on citizens, businesses, and environmental assets. Significant institutional, political, social, and economic obstacles to implementing adaptation actions remain.

Although there are many potential impacts associated with climate change, the most pronounced and easily observed of these impacts are those related to SLR. The remainder of Section 3.9 addresses past and future predicted SLR in the Weeks Bay Watershed and the associated impacts.

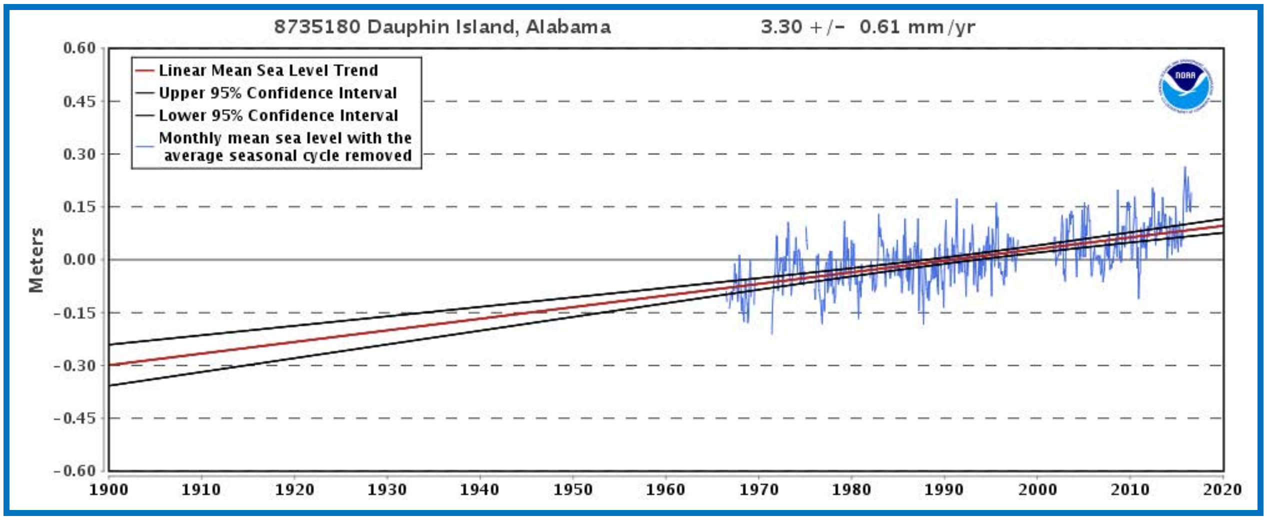
3.9.2 Recorded Historical and Predicted Future SLR

According to NOAA's 2012 publication entitled *Incorporating Sea Level Change Scenarios at the Local Level* global sea level change is caused by two processes (NOAA, 2012):

1. The melting of land-based ice that increases the volume of ocean water; and
2. Thermal expansion (i.e., as water warms, it expands).

Basin changes, such as the process of seafloor spreading, can also play an important role in sea level changes, but these changes usually occur on a protracted time scale of as much as 100,000 years or more. Global sea level change measurements are usually made using satellite altimetry. While these measurements and projections are important, local measurements and projections are needed for realistic local planning efforts.

Local sea level change rates reflect a variety of local factors, including vertical land motion (subsidence or uplift) and changes in estuarine and shelf hydrodynamics, regional oceanographic circulation patterns, and hydrologic cycles (river flow). Local data can be found on NOAA's Sea Levels Online website (www.tidesandcurrents.noaa.gov/sltrends) (NOAA, 2016b). Each tide station represented on the NOAA website provides historical sea level change information, with some stations having records that cover 100 years. Figure 3.80 contains mean sea level data recorded at NOAA's nearest long-term monitoring gauge (#8735180) located at Dauphin Island, Alabama, approximately 17 miles southwest of the mouth of Weeks Bay. The data show that mean relative sea level at this location has risen roughly 0.165 meter (6.5 inches) since it was installed in 1966 (NOAA, 2016b).



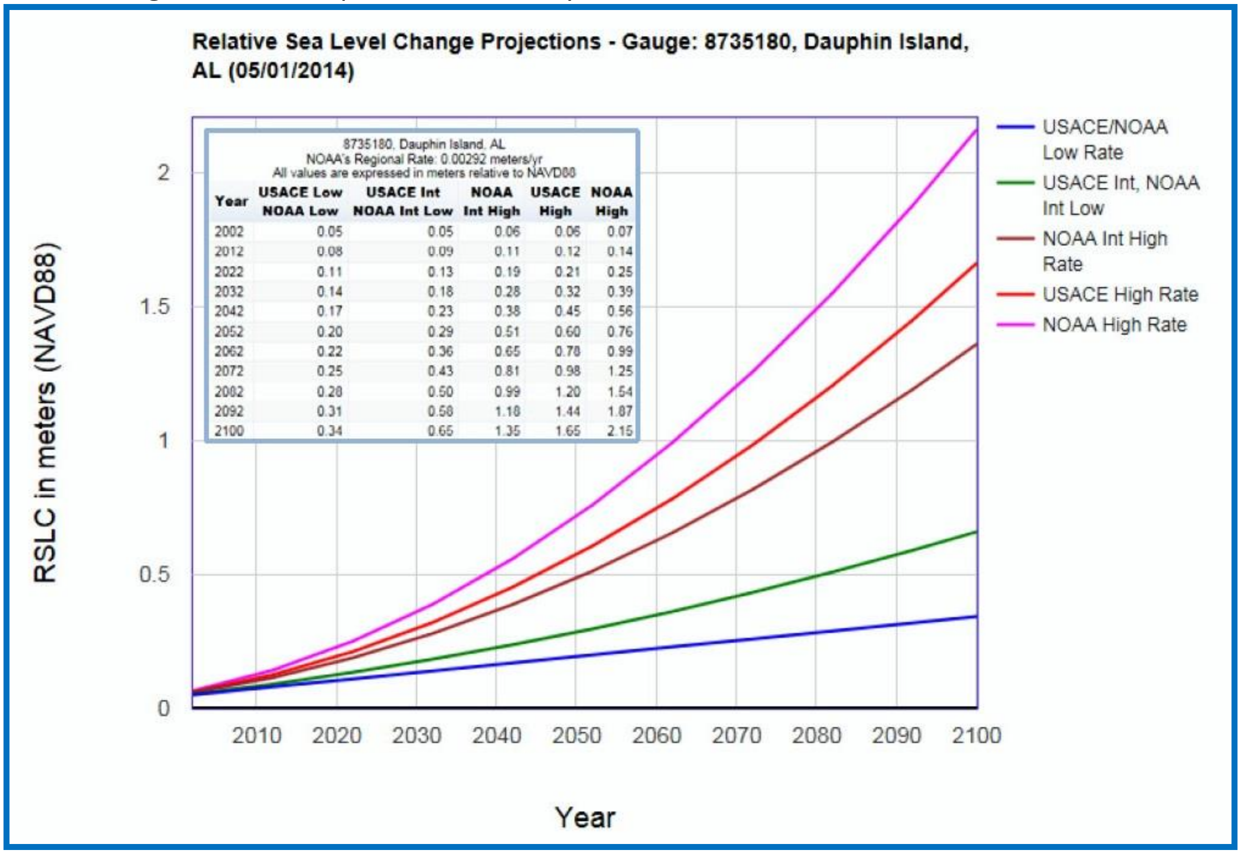
Source: NOAA, 2016b

Figure 3.80 Mean Sea Level Trend, Dauphin Island, Alabama (1966-2016)

To calculate projections, communities add to (or in some cases subtract from) global projections, since local rates vary greatly along the U.S. coastline. For example, high rates of relative SLR are found in the northern Gulf of Mexico because of regional and local land subsidence; however, high rates of relative sea level fall are found in the Gulf of Alaska from the loss of land-based glaciers and the uplift response to plate tectonics (NOAA, 2012).

Figure 3.81 shows relative sea level change predictions for the Dauphin Island tidal gauge. The graph shows NOAA and the U.S. Army Corps of Engineers (USACE) predictions of future changes in relative sea level (from the year 2002). Results of various scenarios are presented and based on possible rates of accelerated SLR. The scenarios presented in this figure include NOAA's Low, Intermediate Low, Intermediate High, and High rate scenarios. The graph also presents the USACE's predictions based on their Low, Intermediate, and High rate scenarios. Both NOAA and the USACE predicted that the lowest possible change in relative sea level at Dauphin Island in the year 2100 (from the year 2002) will result in an increase of 0.34 meter (1.1 feet). The USACE's highest predicted change by the year 2100 at this location is 1.66 meters (5.5 feet), while NOAA's highest possible SLR rate predicts a net increase of 2.15 meters (7.1 feet) (USACE, 2014). As demonstrated on Figure 3.81, there is still a large degree of uncertainty when it comes to the actual rate at which sea level will rise in the future. However, most of the predictions made by both the USACE and

NOAA (with the exception of the lowest SLR scenarios) show a relatively dramatic increase in SLR rates starting in the middle part of this century.



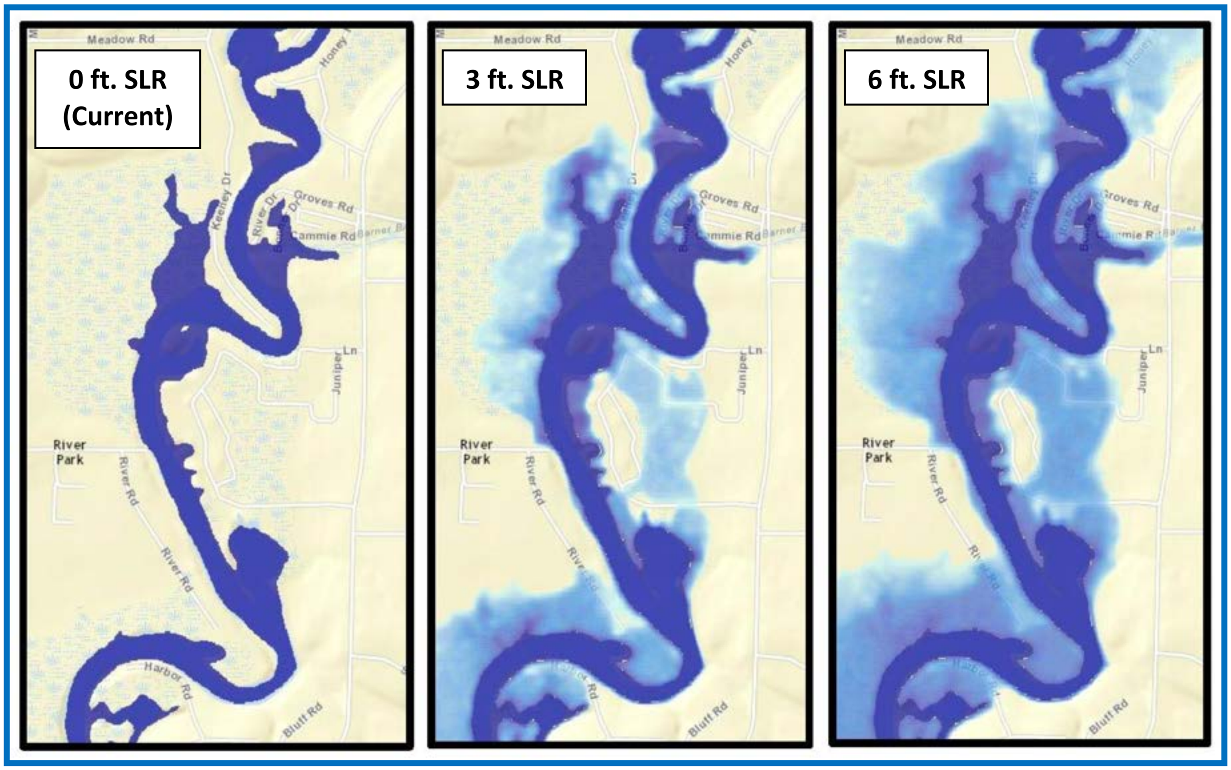
Source: USACE, 2014

Figure 3.81 Relative Sea Level Change Predictions, Dauphin Island, Alabama (2002-2100)

3.9.3 Potential Effects of SLR

3.9.3.1 Infrastructure and Land Loss

Rising seas can submerge low-lying lands, erode beaches, convert wetlands to open water, and exacerbate coastal flooding (NOAA, 2012). Figure 3.82 provides an example of how low-lying areas in the Lower Fish River Watershed, that in many cases contain residential developments and related infrastructure, will likely be affected by SLR in the future.



Source: NOAA, 2016a

Figure 3.82 Example of predicted inundation (MHHW) in a central portion of the Lower Fish River Watershed at 0 feet, 3 feet, and 6 feet SLR

3.9.3.2 Coastal Flooding, Storm Surge and Erosion

Low-lying areas that occasionally experience coastal flooding problems at the present time will likely eventually become inaccessible for much of the year as relative sea level continues to rise. The exact manner and rates at which these changes are likely to occur will depend on the character of coastal landforms and physical processes. In particular, sandy shore environments, coastal headlands, spits, and barrier islands will erode at a faster pace than experienced today. Shore erosion increases vulnerability to storms by removing the beaches and dunes that would otherwise protect coastal property from storm waves. As the rate of SLR accelerates, it is likely that some barrier islands in this region will cross a threshold where rapid barrier island migration or segmentation will occur. In estuarine areas like Weeks Bay, as marshes and similar riparian systems are converted to open water in response to SLR, their ability to buffer the effects of storm surge and prevent coastal erosion will greatly diminish.

3.9.3.3 Marsh Migration

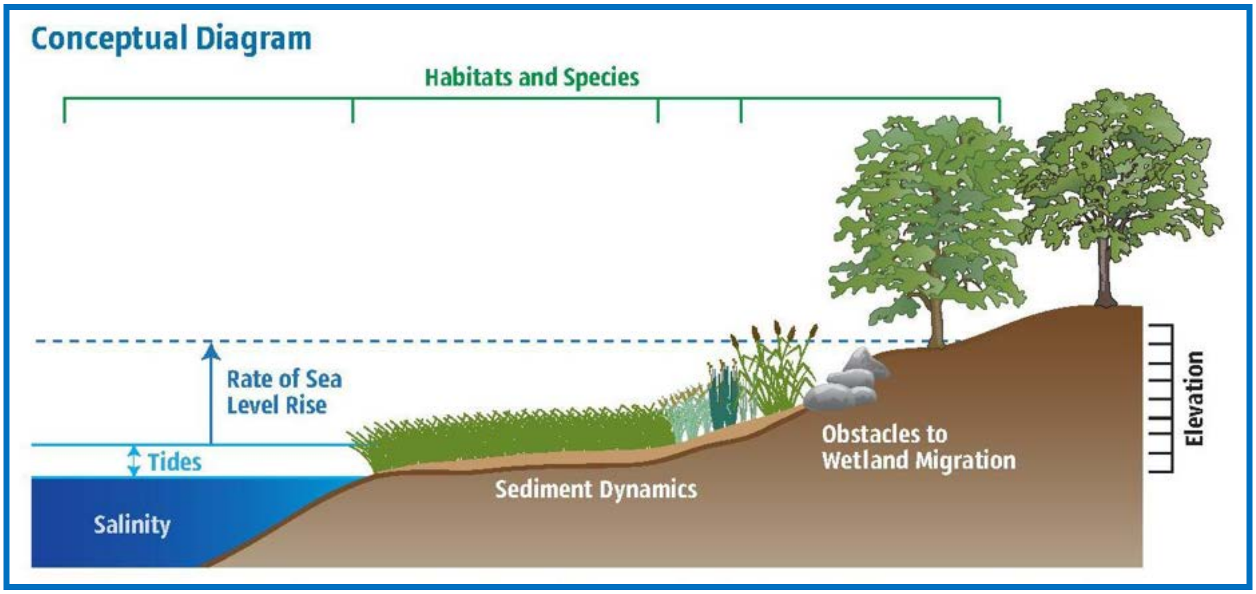
The health of coastal ecosystems is very closely linked to sea level. Many environments, including beaches, barrier islands, wetlands, and estuarine systems, attempt to adjust to increasing water levels by growing vertically, migrating inland, or expanding laterally (NOAA, 2012).
If the rate of sea level change accelerates significantly, coastal environments may not be able to respond accordingly and will decrease in size or be submerged. These changes can fundamentally

change the state of the coast. Rapid SLR can force rapid landward migration of the shoreline, which could submerge some barrier islands and destroy both estuarine and freshwater wetland systems. The lower portion of the Mississippi River Delta in southeast Louisiana is a good example of this effect. This area is experiencing a very rapid rise in sea levels relative the ground surface, which is sinking due to subsidence (NOAA, 2012).

As local sea levels increase, some marshes may migrate into neighboring low-lying areas, while other sections of marsh will be lost to open water or convert to an intertidal mudflat. In undeveloped or less developed coastal areas, ecosystems are more likely to be able to shift upward and landward with the rising water levels. Coastal development often presents a barrier to this natural migration. This eventually results in the ecosystem converting to open water, rendering coastal development more vulnerable to storm and flooding impacts. Section 3.9.4 provides an in-depth look at predicted changes to marsh and other riparian habitats in the future using various SLR scenarios.

Key parameters involved in wetland migration as a response to SLR are illustrated on Figure 3.83. These parameters are as follows:

- Rate of SLR: Not only the amount, but also the rate, of SLR is a key factor.
- Tides: Tide levels are important in determining wetland extent and persistence.
- Salinity: If the salinity regime changes, vegetation and wetland functioning may change.
- Elevation: Elevation is one of the most important data components for modeling SLR.
- Sediment Dynamics: If sediment accumulates, or accretes, in wetland systems as fast as the SLRs, then the wetland may avoid being submerged under the rising sea.
- Habitats and Species: Land cover data and habitat change assumptions can be used to project the anticipated effects of SLR on the locations of habitats and species. Physical obstacles to marsh migration are an important consideration when modeling these changes. Note that the locations of other intertidal and shallow subtidal habitats (e.g., oyster reefs and seagrass beds) may shift, too, but this report does not address models that account for changes in those habitats.
- Additional Complicating Factors: Many other factors complicate the process of modeling and projecting changes in coastal wetlands into the future. These factors are difficult or impossible to address in quantitative or numerical models, so they may be best addressed in conceptual models or qualitatively in the management process.



Source: TNC and NOAA, 2011

Figure 3.83 Response of Wetland Migration to SLR

Additional impacts from SLR include:

- Saltwater intrusion into surface waterbodies that are historically freshwater dominated;
- Net loss of some categories of freshwater wetland systems, such as the "Swamp" category in the Weeks Bay Watershed;
- Increased vulnerability to sensitive plant and animal populations that are not able to adapt quickly enough to keep up with changing conditions caused by accelerated SLR; and
- Loss of ecosystem services of certain habitat types that may be highly functioning currently, but will experience a lag time as they migrate landward and attempt to establish a new equilibrium in a higher elevation location, which may not yet have a healthy benthic community.

3.9.4 Predicted Effects of Various SLR Scenarios on Future Habitat Distribution in the Weeks Bay Watershed

3.9.4.1 SLAMM Model Overview

Although there are numerous SLR models available today, they are typically used to predict inundation patterns, and very few of the models account for biological impacts resulting from the conversion of habitats due to rising sea levels. The Sea Level Affecting Marshes Model (SLAMM) predicts when marshes are likely to be vulnerable to SLR and where marshes may migrate uphill in response to changes in water levels. SLAMM simulates the dominant processes involved in wetland conversions under various long-term SLR scenarios. The model then predicts the location and size of distinct wetland habitat types for different future timeframes in response to specified SLR scenarios. The model output includes maps, as well as tabular and graphical data (WPC, Inc., 2016).

SLAMM assumes that wetland types, distinct from one another, inhabit a range of vertical elevations that are functions of the tidal range. A more detailed description of model processes, underlying assumptions, and equations can be found in the SLAMM v. 6.5 Technical Documentation (WPC, Inc., 2016).

3.9.4.2 Background and Methodology for SLAMM Analysis in Weeks Bay Watershed

From 2008 to 2013, SLAMM v. 6.5 was applied to more than 2.5 million acres of the Gulf of Mexico coastline through funding from a variety of sources (e.g., Gulf of Mexico Alliance [GOMA], National Wildlife Federation, U.S. Fish and Wildlife Service [USFWS], U.S. Environmental Protection Agency [EPA], and The Nature Conservancy [TNC]). However, simulation results were not directly comparable, due to differences in model domain definitions, accretion modeling approaches, and future sea level assumptions. In addition, several gap areas had not yet been modeled. The results of the study were published in the October 2013 final report entitled *Modeling and Abating the Impacts of SLR on Five Significant Estuarine Systems in the Gulf of Mexico* (Geselbracht et al., 2013). For the purposes of this WMP, this document will be referred to in later sections as the TNC-GOMA study.

In 2014, the Gulf Coast Prairie Landscape Conservation Cooperative (GCPLCC) funded the analysis of the U.S. portion of the Gulf of Mexico coast in its entirety. The resulting output was included in a report prepared by WPC, Inc., for the GCPLCC entitled *Evaluation of Regional SLAMM Results to Establish a Consistent Framework of Data and Models*, published in June 2015 with minor revisions in March 2016 (WPC, Inc., 2016). For the purposes of this WMP, this document will be referred to as the 2016 GCPLCC report. Additional information related to methodology and results of this assessment are provided as Appendix H to this WMP.

The MBNEP requested that the WMP contract team extract data for the four HUC 12 Watersheds in the Weeks Bay Watershed individually from the 2016 GCPLCC project's SLAMM output in order to determine predicted future habitat distributions. The MBNEP also requested that the results include anticipated acreages of habitat types for the years 2002 (initial model run year), 2025, 2050, 2075, and 2100 and be based on three different SLR scenarios. The SLR scenarios chosen were 0.5, 1.0, and 2.0 meters of relative mean SLR in the area from the initial year (2002) to the year 2100.

GIS analysts obtained raster image outputs for the Mobile Bay model runs that were developed for the GCPLCC project. These raster images represented the predicted location of various habitat types at various points in the future based on different SLR scenarios. The raster images were then converted to a vector-based data layer, thus allowing for calculations and computations of the data. The data layers were then clipped to analyze only the four HUC 12 Watersheds in the WMP: Magnolia River, Upper Fish River, Middle Fish River, and Lower Fish River Watersheds (which includes Weeks Bay). Based on this input criteria, the data were analyzed, and predicted habitat acreages were calculated. The following sections provide a graphical and a tabular representation of the predictions under the various scenarios stated above.

3.9.4.3 Predicted Habitat Changes in the Upper Fish River Watershed Due to SLR

The Upper Fish River Watershed comprises HUC 12 #031602050201. This Watershed is the northernmost of the four HUC 12 Watersheds found in the greater Weeks Bay system. The Upper Fish River Watershed encompasses Fish River's headwaters and extends from Alabama Highway 104 northward for approximately 15 miles to the community of Stapleton. Of the four HUC 12 Watersheds analyzed, this Watershed was only one predicted to see no change in habitat by the year 2100 as a result of even the highest SLR scenario, due to its distance from the coast. As such, no charts or tables are provided below for this particular Watershed.

3.9.4.4 Predicted Habitat Changes in the Middle Fish River Watershed Due to SLR

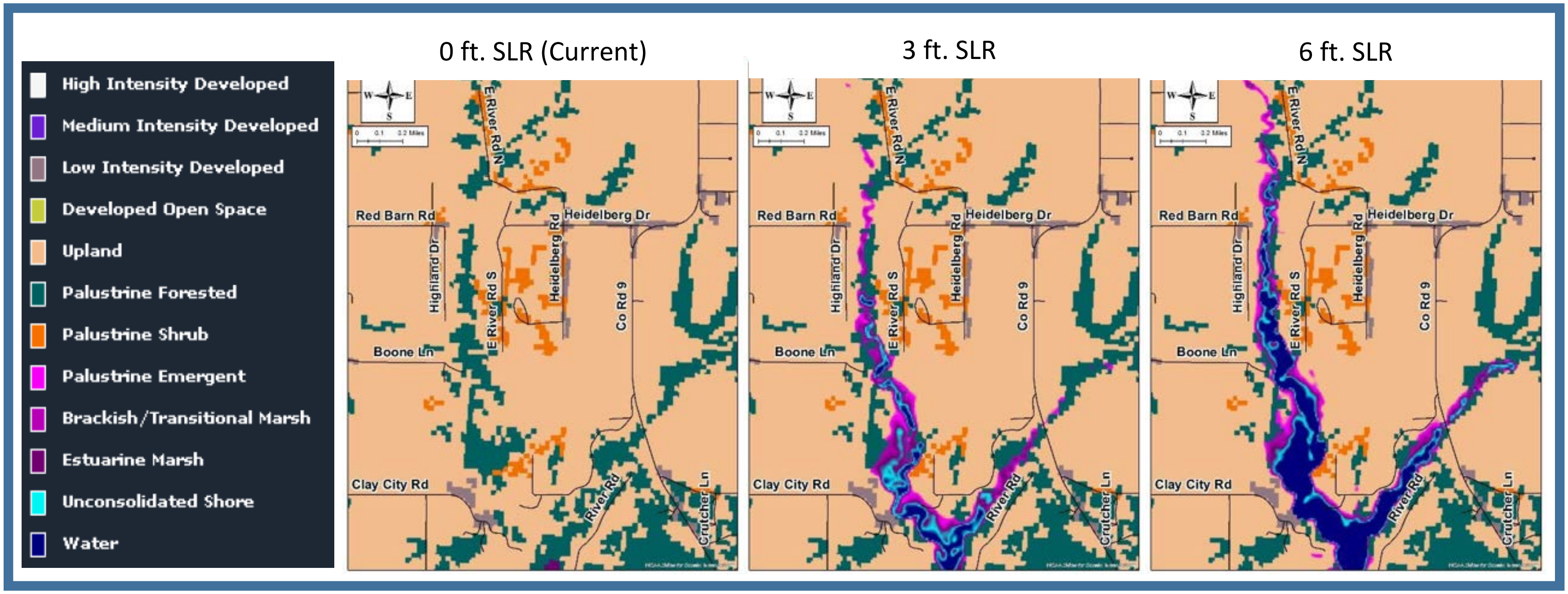
The Middle Fish River Watershed comprises HUC 12 #031602050202. As the name implies, this Watershed is located between the Upper and Lower Fish River Watersheds. The portion of the Fish River located in the extreme southern extent of this Watershed (just north of the Baldwin CR 32 bridge) is both tidally-influenced and navigable.

Under the 0.5-meter (approximately 1.5 feet) SLR scenario, the SLAMM predicts a net loss of approximately 41 acres of undeveloped dry land, swamp, and inland open water in the Middle Fish River Watershed, as these areas convert to transitional fresh marsh, estuarine open water, and regularly flooded marsh (in order of smallest to largest conversion).

The 1.0-meter (approximately three feet)SLR scenario yields a net loss of approximately 72 acres of undeveloped dry land, swamp, inland open water, and, to a very minor degree, developed dry land in the Middle Fish River Watershed, as these areas convert to tidal flats, transitional fresh marsh, estuarine open water, and regularly flooded marsh (in order of smallest to largest conversion).

The 2.0-meter (approximately six feet)SLR scenario yields a net loss of approximately 131 acres in the Middle Fish River Watershed, primarily consisting of undeveloped dry land (67 acres) and swamp (46 acres), and, to a lesser extent, inland open water (14 acres), and, to a very minor degree, developed dry land and inland fresh marsh, as these areas convert to tidal flats, transitional fresh marsh, estuarine open water, and regularly flooded marsh (in order of smallest to largest conversion).

Though not as useful for habitat acreage calculations as SLAMM, NOAA's Sea Level Rise Viewer (NOAA, 2016a) provides a somewhat easier means of visually interpreting similar habitat change predictions as SLAMM. Images obtained from the SLR Viewer are useful as a screening level tool to identify general trends related to anticipated changes to habitat distributions as a result of various future sea level rise scenarios. Figure 3.84 shows current and future potential distributions in the Middle Fish River Watershed, based on the predicted sea level rise scenarios of three feet and six feet, by the year 2100. These scenarios and resulting habitat distributions are very similar to the 1-meter and 2-meter SLR scenarios modeled in SLAMM (presented in graph and tabular formats in Appendix H).



Source: NOAA, 2016a

Figure 3.84 Predicted Habitat Distribution in Lower Portion of the Middle Fish River Watershed at 0 feet, 3 feet, and 6 feet SLR

3.9.4.5 Predicted Habitat Changes in the Lower Fish River Watershed Due to SLR

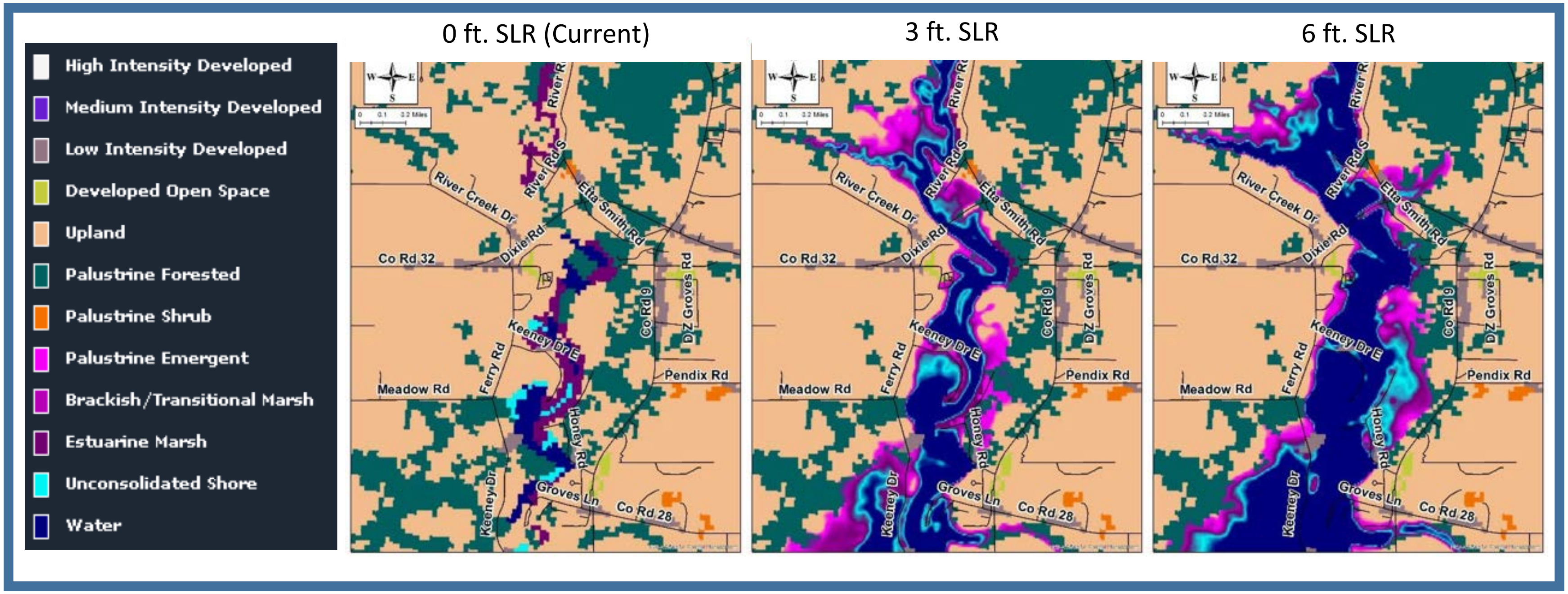
The Lower Fish River Watershed comprises HUC 12 #031602050204. This Watershed is located adjacent to, and downstream of, the Middle Fish River Watershed and encompasses all of Fish River, from its mouth at Weeks Bay upstream to just north of the Baldwin CR 32 bridge. The Watershed also includes all of Weeks Bay.

Under the 0.5-meter (approximately 1.5 feet) SLR scenario, the SLAMM predicts that the Lower Fish River Watershed will experience a loss of approximately 813 acres of primarily swamp, undeveloped dry land, and riverine tidal habitats, as these areas convert to regularly flooded marsh, transitional fresh marsh, and estuarine open water. Under the 0.5-meter SLR scenario, the SLAMM predicts that this Watershed will see a net loss of approximately 140 acres of various wetland habitats by the year 2100 as these habitats are inundated and convert to open water.

Under the 1.0-meter (approximately three feet) SLR scenario, the SLAMM predicts that the Lower Fish River Watershed will experience a loss of approximately 1,464 acres of primarily swamp, undeveloped dry land, riverine tidal, and developed dry land, as these areas convert to regularly flooded marsh and, to a lesser extent, transitional fresh marsh, estuarine open water, and flooded forest. Under the 1.0-meter SLR scenario, the SLAMM predicts that this Watershed will see a net loss of approximately 276 acres of various wetland and perhaps upland habitats by the year 2100 as these habitats are inundated and convert open water.

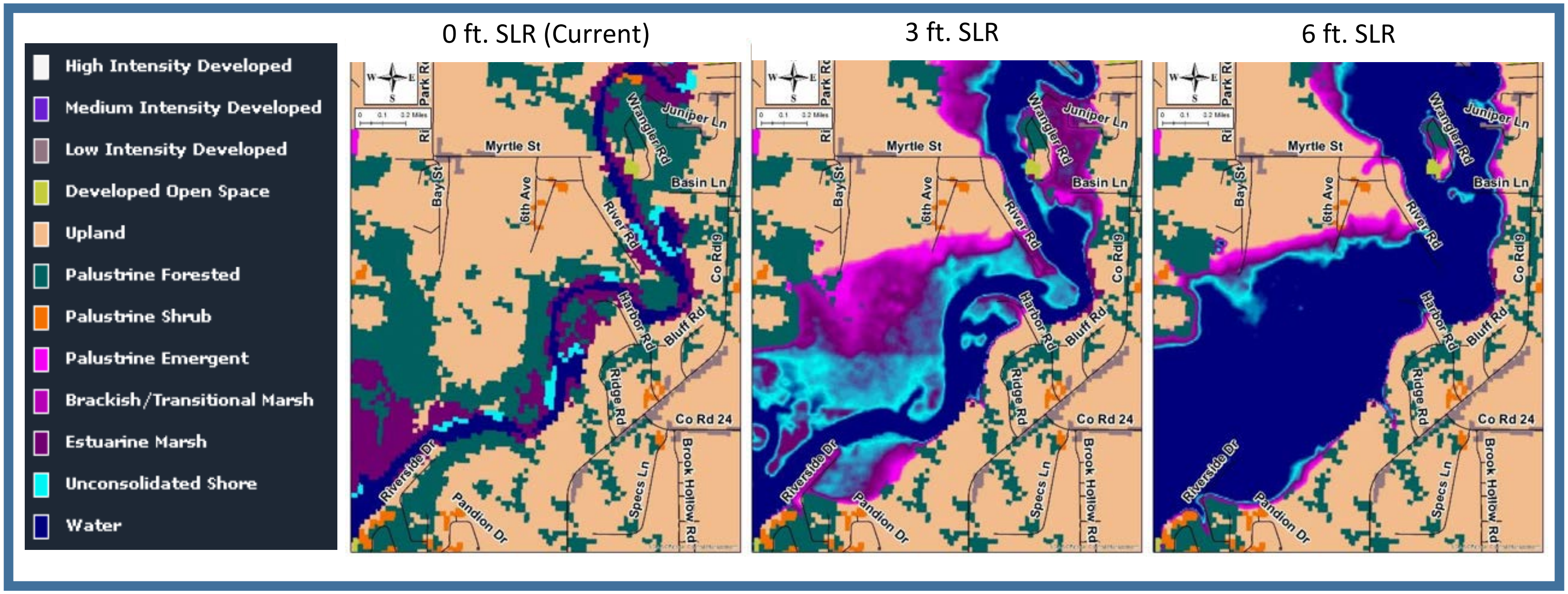
Under the 2.0-meter (approximately six feet) SLR scenario, the model predicts that the Lower Fish River Watershed will experience a loss of approximately 2,904 acres of primarily swamp (60 percent of total loss) and undeveloped dry land (24 percent) as these areas convert to transitional fresh marsh, estuarine open water, tidal flats, and regularly flooded marsh. Under the 2.0-meter SLR scenario, the SLAMM predicts that this Watershed will see a net loss of approximately 844 acres of various wetland and possibly upland habitats by the year 2100 as these habitats are inundated and convert to open water.

Images obtained from NOAA's SLR Viewer, were used to develop Figures 3.85 through 3.91. These figures show current and future potential habitat distributions in the Lower Fish River Watershed, based on the predicted sea level rise scenarios of three feet and six feet, by the year 2100. The scenarios and resulting habitat distributions are very similar to the 1-meter and 2-meter SLR scenarios modeled in SLAMM (presented in graph and tabular formats in Appendix H).



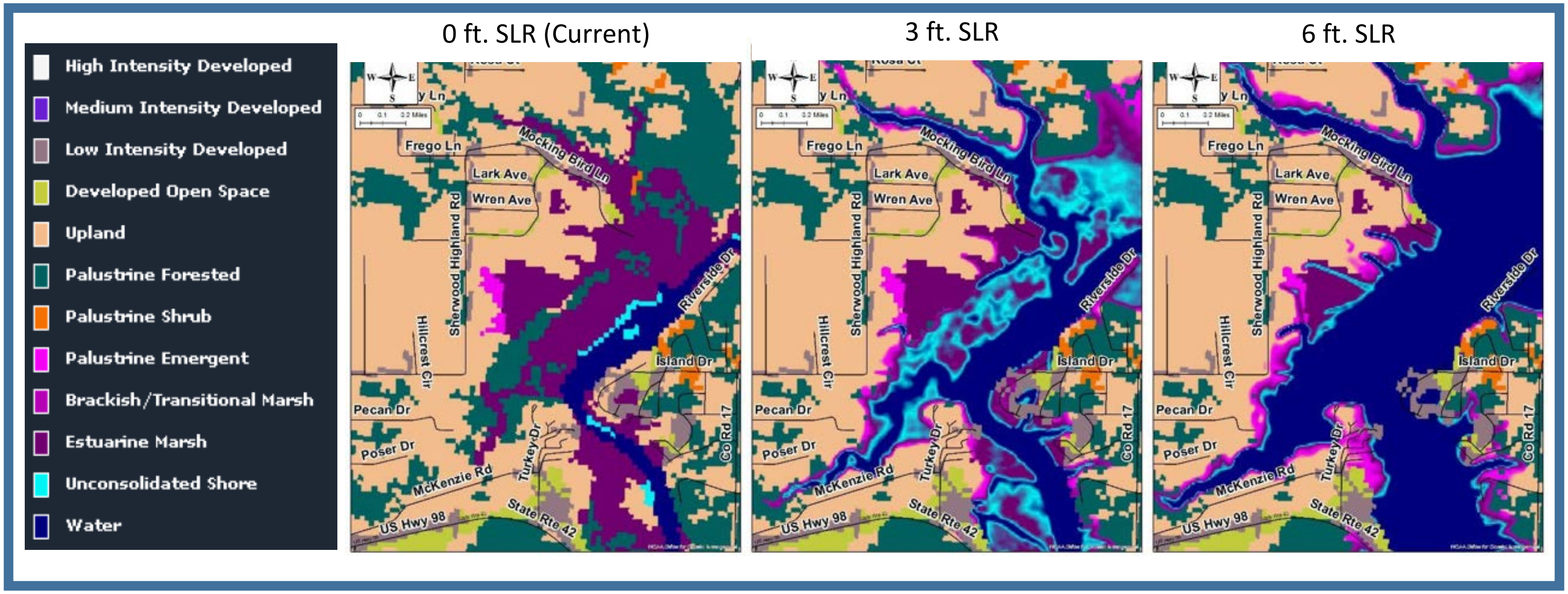
Source: NOAA, 2016a

Figure 3.85 Predicted Habitat Distribution in Upper Portion of Fish River (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR



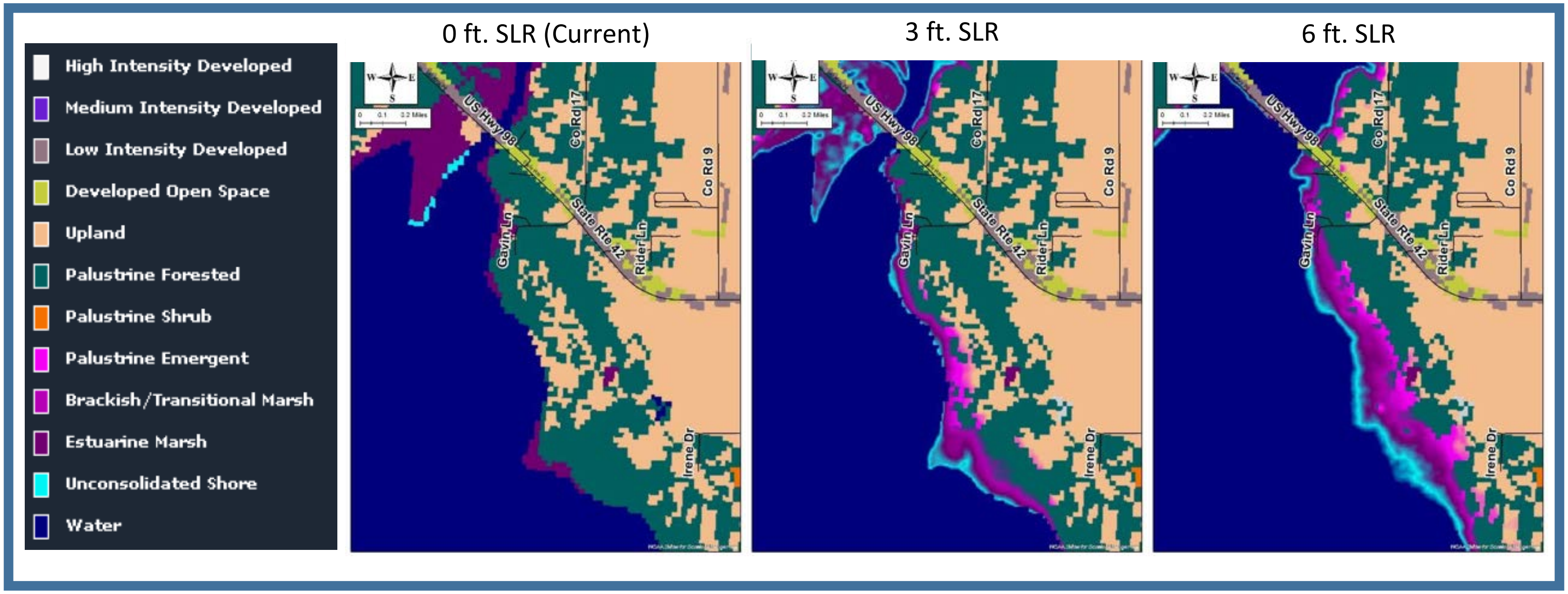
Source: NOAA, 2016a

Figure 3.86 Predicted Habitat Distribution in Middle Portion of Fish River (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR



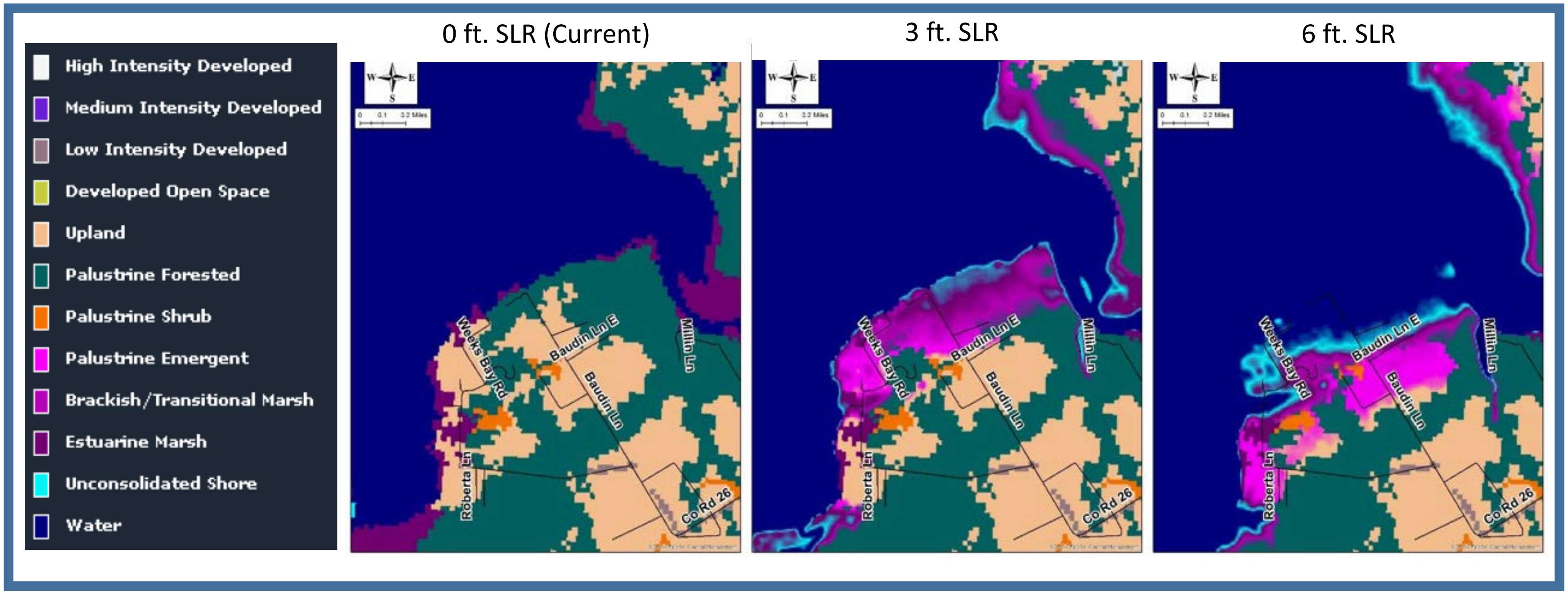
Source: NOAA, 2016a

Figure 3.87 Predicted Habitat Distribution in Lower Portion of Fish River (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR



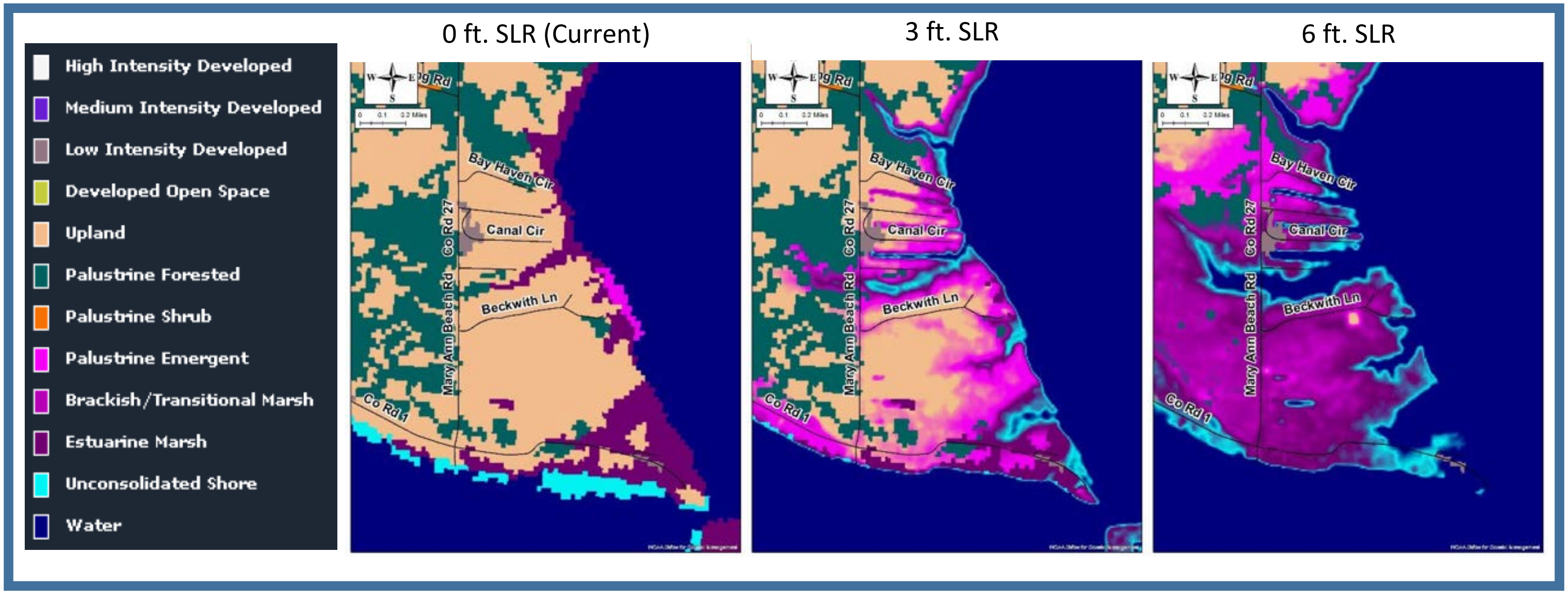
Source: NOAA, 2016a

Figure 3.88 Predicted Habitat Distribution in NE Portion of Weeks Bay (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR



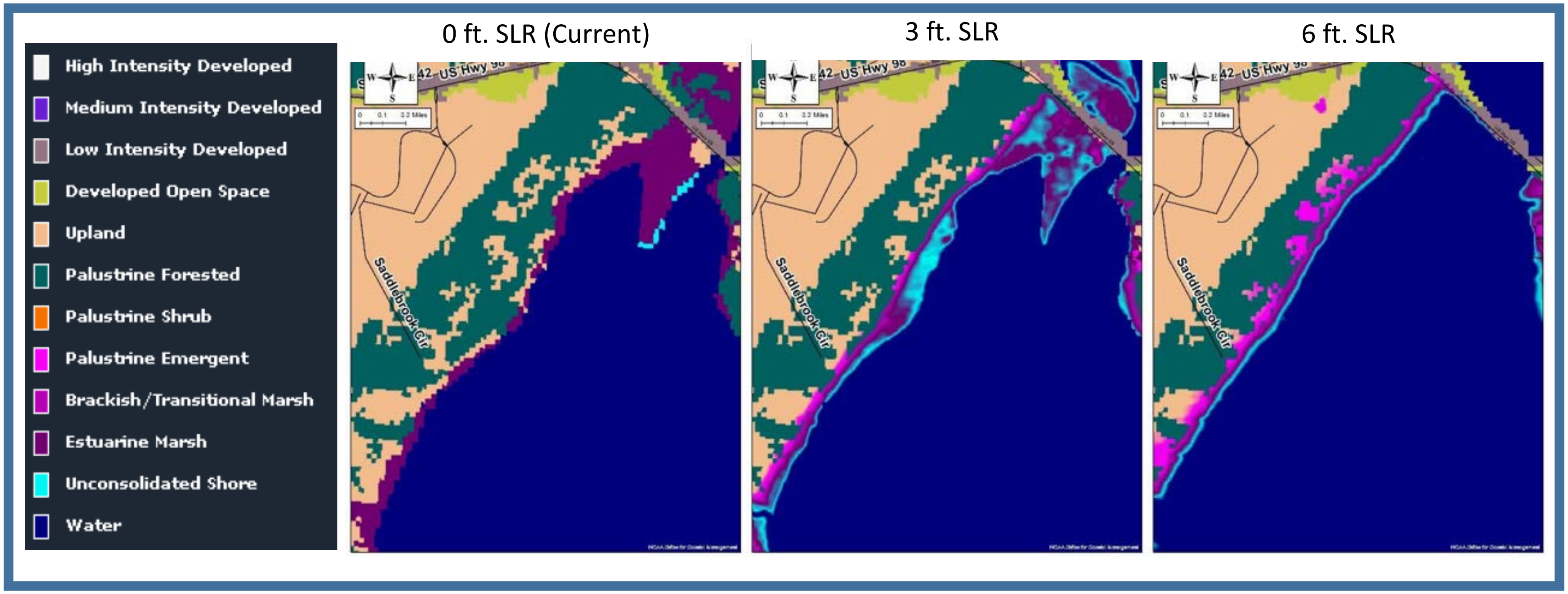
Source: NOAA, 2016a

Figure 3.89 Predicted Habitat Distribution in SE Portion of Weeks Bay (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR



Source: NOAA, 2016a

Figure 3.90 Predicted Habitat Distribution in SW Portion of Weeks Bay (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR



Source: NOAA, 2016a

Figure 3.91 Predicted Habitat Distribution in NW Portion of Weeks Bay (Lower Fish River Watershed) at 0 feet, 3 feet, and 6 feet SLR

3.9.4.6 Predicted Habitat Changes in the Magnolia River Watershed Due to SLR

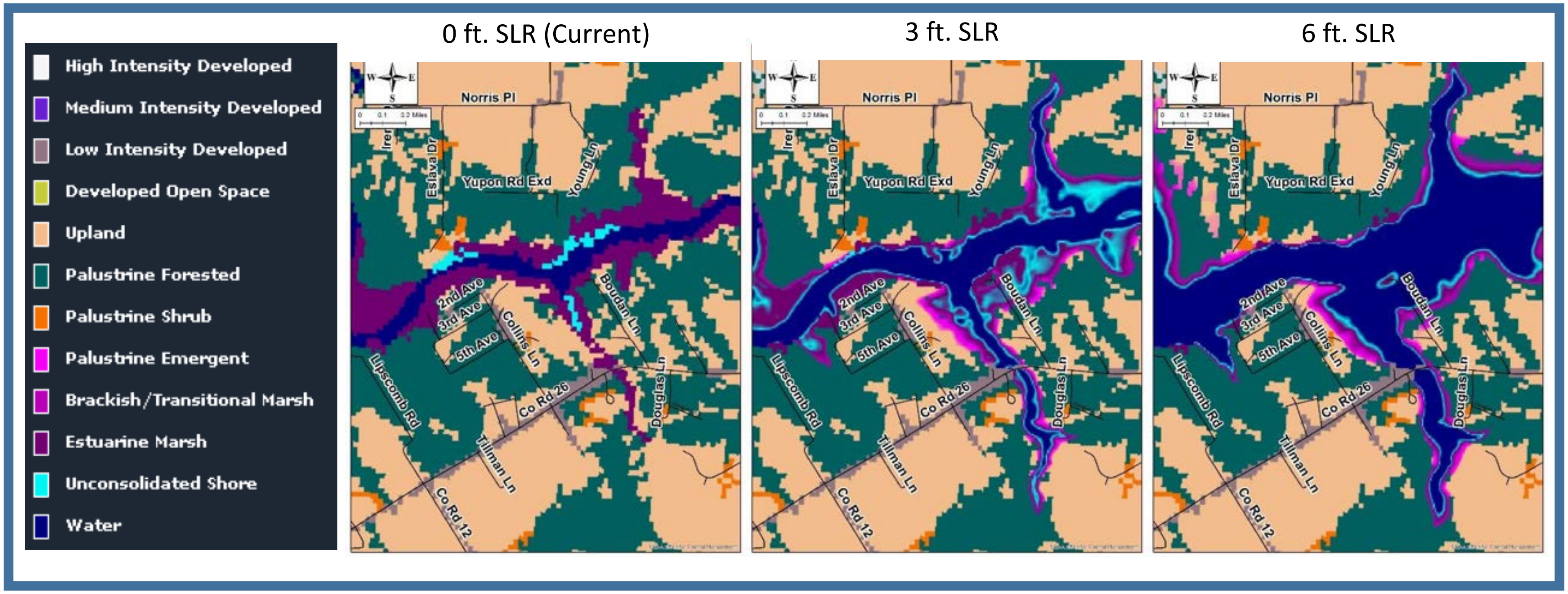
The Magnolia River Watershed comprises the HUC 12 #031602050203. This Watershed is located adjacent to and east of the southern extent of the Lower Fish River Watershed. This Watershed encompasses all of the Magnolia River and its tributaries, and extends from its mouth at Weeks Bay upstream in a northeasterly direction to its headwaters just north of Foley, near the intersection of CR 32 and Alabama Highway 59.

Under the 0.5-meter (approximately 1.5 feet) SLR scenario, the SLAMM predicts that the Magnolia River Watershed will experience a loss of approximately 142 acres of primarily swamp and undeveloped dry land as these areas convert to regularly flooded marsh. Under the 0.5-meter SLR scenario, the SLAMM predicts that this Watershed will see a net loss of approximately 0.4 acre of various wetland habitats by the year 2100 as these habitats are inundated and convert to open water.

Under the 1.0-meter (approximately three feet) SLR scenario, the SLAMM predicts that the Magnolia River Watershed will experience a loss of approximately 282 acres of primarily swamp, undeveloped dry land, and irregularly flooded marsh as these areas convert to regularly flooded marsh and, to a lesser extent, transitional fresh marsh and estuarine open water. Under the 1.0-meter SLR scenario, the SLAMM predicts that this Watershed will see a net loss of approximately 23.9 acres of various wetland and, perhaps, upland habitats by the year 2100 as these habitats are inundated and convert to open water.

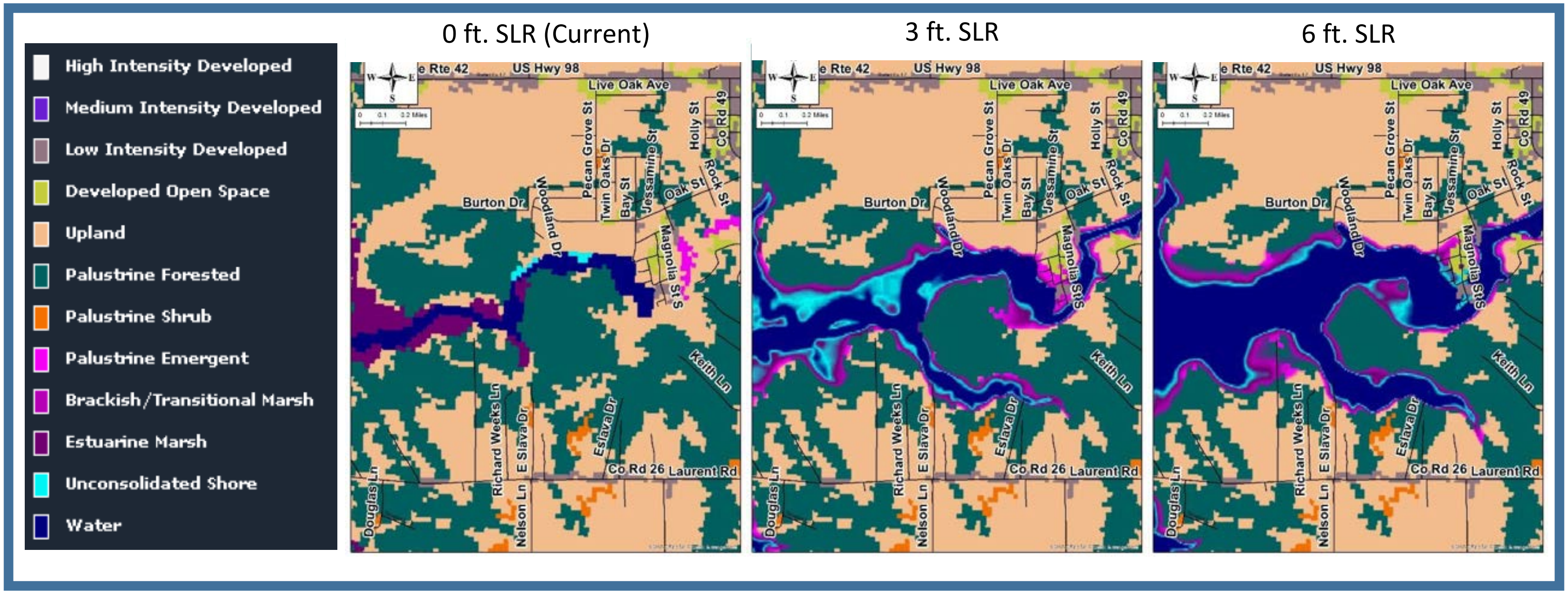
Under the 2.0-meter (approximately six feet) SLR scenario, the SLAMM predicts that he Magnolia River Watershed will experience a loss of approximately 560 acres of primarily undeveloped dry land (50 percent of the total loss) and swamp (31 percent of the total loss) and, as these areas convert to transitional fresh marsh, estuarine open water, tidal flats, and regularly flooded marsh. Under the 2.0-meter SLR scenario, the SLAMM predicts that this Watershed will see a net loss of approximately 178 acres of various wetland and, possibly, upland habitats by the year 2100 as these habitats are inundated and convert to open water.

Images obtained from NOAA's SLR Viewer, were used to develop Figures 3.92 through 3.94. These figures show current and future potential habitat distributions in the Lower Fish River Watershed, based on the predicted sea level rise scenarios of three feet and six feet, by the year 2100. The scenarios and resulting habitat distributions are very similar to the 1-meter and 2-meter SLR scenarios modeled in SLAMM (presented in graph and tabular formats in Appendix H).



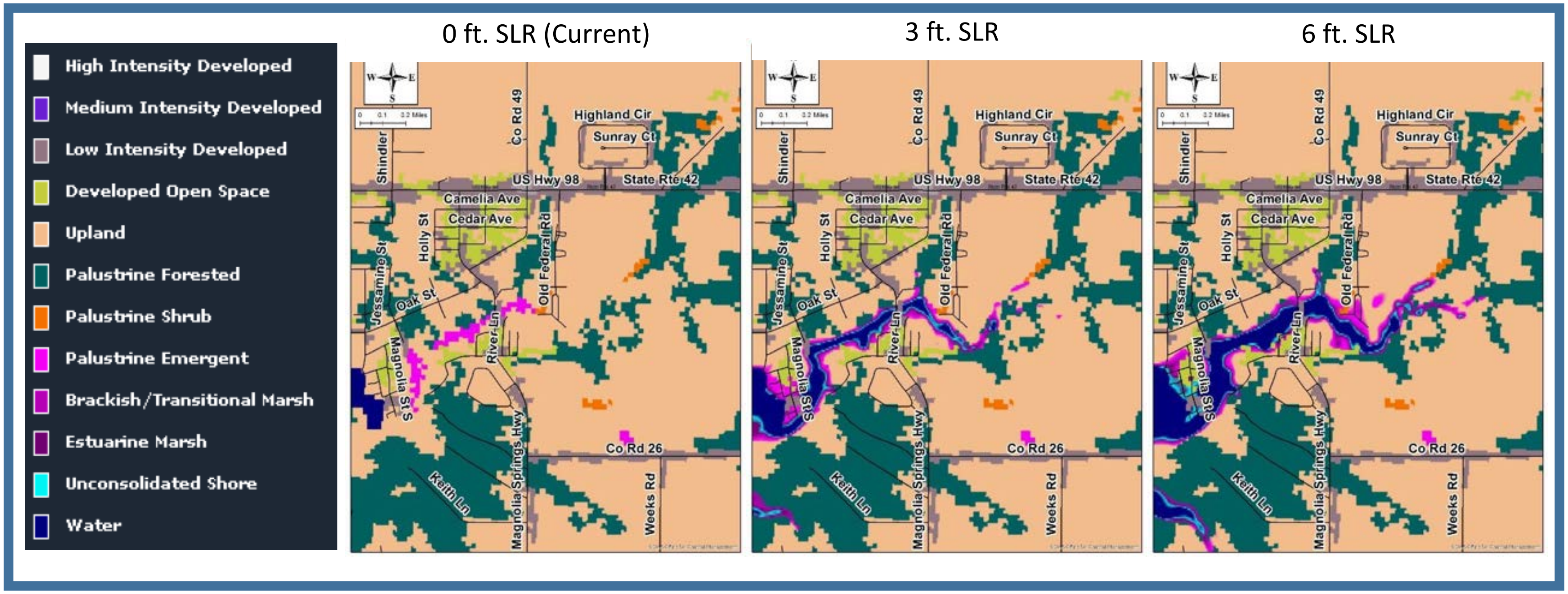
Source: NOAA, 2016a

Figure 3.92 Predicted Habitat Distribution in Western Portion of Magnolia River (Magnolia River Watershed) at 0 feet, 3 feet, and 6 feet SLR



Source: NOAA, 2016a

Figure 3.93 Predicted Habitat Distribution in Central Portion of Magnolia River (Magnolia River Watershed) at 0 feet, 3 feet, and 6 feet SLR



Source: NOAA, 2016a

Figure 3.94 Predicted Habitat Distribution in Eastern Portion of Magnolia River (Magnolia River Watershed) at 0 feet, 3 feet, and 6 feet SLR

3.9.4.7 Trends in Predicted Habitat Change in Weeks Bay Watershed

Following the analysis of each individual HUC 12 Watershed, predicted changes in habitat were compiled for the greater Weeks Bay Watershed as a whole. Figure 3.95 presents a proportional breakdown of habitats that are predicted to be lost and converted to a different habitat type (gained) by the year 2100. This simplistic breakdown was created in order to identify general trends and habitat types that are predicted to be most affected under the three SLRs. Review of the data presented on Figure 3.95 yielded the following observations:

- In all three SLR scenarios, the largest proportion of habitat predicted to have a net reduction in acreage (via conversion to another habitat type or types) was the "Swamp" category, which constituted greater than 50 percent of total loss in all scenarios;
- "Undeveloped Dry Land" was the second highest proportional net loss for all three SLR scenarios. Loss in this category increased from 21 percent in the 0.5-meter SLR scenario to 30 percent in the 2.0-meter (approximately 6 feet) SLR scenario;
- "Riverine Tidal" losses decreased proportionally from the 0.5-meter to the 2.0-meter SLR (approximately 1.5-6.0 feet) scenarios;
- In general, the habitat acreage lost resulted in a conversion to, and net acreage increase in, three major categories using the 0.5-meter (approximately 1.5 feet) SLR scenario: "Regularly-flooded Marsh" (58 percent), "Transitional Fresh Marsh" (27 percent), and "Estuarine Open Water" (16 percent);
- Under all three SLR scenarios, the "Regularly Flooded Marsh" category consistently showed the largest gains. However, as the SLR scenario was increased, this category's proportion of total habitat gained decreased as additional habitat categories, such as "Transitional Fresh Marsh," "Estuarine Open Water," and "Flooded Forest," began to increase; and
- The SLAMM predicts that the Weeks Bay Watershed will see a conversion of various wetland habitats by the year 2100 as these habitats are inundated and convert to open water. The amount of area predicted to convert into open water is approximately 155 acres for the 0.5-meter (approximately 1.5 feet) SLR scenario, 320.5 acres for the 1.0-meter (approximately three feet) scenario, and 1,057.8 acres for the 2.0-meter (approximately six feet) scenario.

The 2016 GCPLCC report notes, specifically, that, "The current Gulf-wide model application assumes that marshes will successfully migrate into all (non-diked) dry lands regardless of their current use, development status, or likely future protection. As such, the model is informative in terms of potential future marsh habitats, but likely overstates future marsh resilience to sea-level rise, numerically. Evaluation of marsh-migration pathways in conjunction with likely future developed-land footprints (or a public vs. private-land overlay) may help to constrain model predictions."

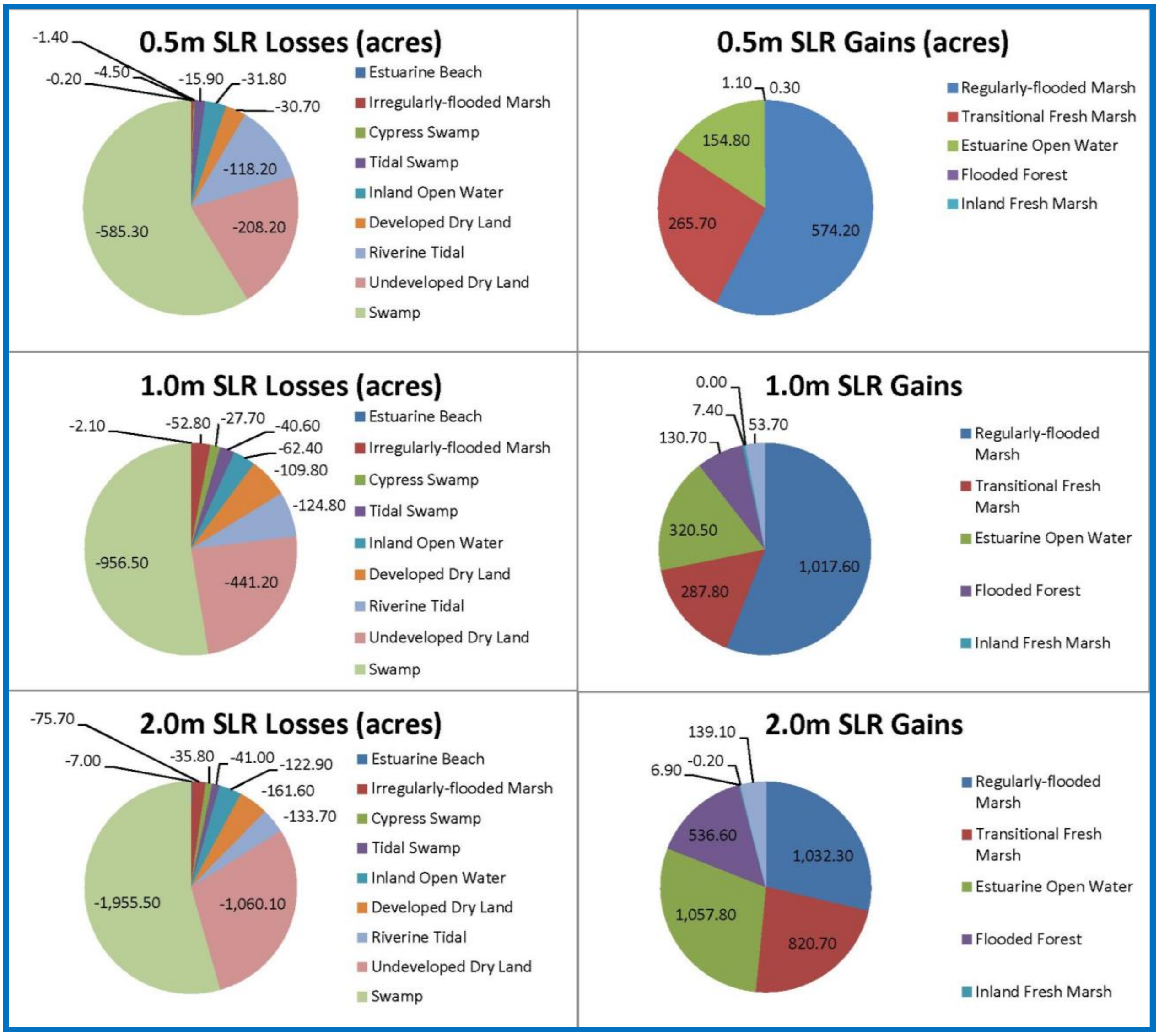


Figure 3.95 Predicted Habitat Losses and Gains in Entire Weeks Bay Watershed from 2002 to 2100 under the Three SLR Scenarios

4.0 Identification of Critical Issues and Areas

4.1 Inter-Governmental County/Municipal Coordination Issues

This issue relates to improvement of inter-governmental communication and cooperation at the County and municipality levels. Issues identified include:

- Lack of local government wetland/stream protection and LID requirements
- Improve the inspection, maintenance and reporting for post construction stormwater management facilities
- Inconsistent construction phase erosion and sediment control and stormwater management ordinances
- Inconsistent post construction stormwater management ordinances
- The potential for internal inconsistencies in existing ordinances that impact on stormwater management
- Inconsistent subdivision requirements related to watershed protection

There many different planning and zoning ordinances in the nine municipalities and the county across the entire Watershed, and many are lacking in support of Low Impact Development measures.

4.2 Low Impact Development and Green Infrastructure Issues

Urbanization increases the variety and amount of pollutants carried into our nation's waters. Clearly, urbanization of the Weeks Bay Watershed can be expected to result in adverse impacts to water quality of the Watershed's streams, especially within the areas experiencing development. Such impacts can be minimized by adopting measures to sustain the Watershed's hydrology. Such management measures are termed Low Impact Development (LID) and Green Infrastructure (GI).

Some of the municipalities fringing the boundaries of the Weeks Bay Watershed have adopted (or are adopting) ordinances to require or encourage LID/GI practices. Those ordinances have different provisions and are not consistent. Other municipalities and the unincorporated Watershed areas of Baldwin County outside of municipal jurisdiction have no or only limited provisions for LID/GI. Refer to Section 7 for discussions of federal/state regulations and local ordinances applicable to the Watershed areas.

4.3 Agricultural Issues

The agricultural land use within the Weeks Bay Watershed has historically and continues to dominate, currently covering approximately 50% of the Watershed. While many farmers have implemented conservation and watershed improvements on their land, many others have not. Agricultural practices continue to contribute sediment, nutrients, and pathogens to streams in the Watershed.

Examples of agricultural issues within the Watershed include:

- Livestock in wetlands and streams
- Scattered use of cover crops to decrease soil erosion and nutrient leaching, improve infiltration and increase soil organics
- Over fertilization on croplands rather than use of improved nutrient management through use of precision agriculture application of fertilizer and pesticides; split nitrogen application, etc. in order to reduce the potential for contaminated runoff and leaching.

4.4 Watershed Water Quality Issues

Based on water quality sampling within the Weeks Bay Watershed a number of water quality issues that have been identified through the WMP process include:

- Instream erosional “hot spots” on Fish and Magnolia Rivers (and tributaries)
- Unpaved roads, dirt pits, and other erosional areas within the Watershed
- Two significant areas of bank erosion have been identified during the WMP development, one on the lower Magnolia River and the second on a Fish River tributary near the junction of CR 9 and CR 32.
- Numerous pathogen sources within the Watershed contribute to bacterial pollution in several stream reaches. Sources include wildlife, livestock, pets, and human sources.
- The potential for water quality impacts associated with biosolids and animal manure application sites throughout the Watershed are yet to be assessed.
- The potential impacts of turf farms for runoff timing and volume, and pollutant loadings to streams has not been fully evaluated.

4.5 Ecological/Habitat Issues

Poor condition wetland and riparian buffers in the Watershed are associated mostly with agricultural and pasture lands. These areas are concentrated especially in the Magnolia River HUC 12, but generally are present at the upper margins of all four HUC 12 subwatersheds.

The Weeks Bay NERR 2017-2022 Management Plan cites riparian vegetation as performing an important role in trapping sediment, providing thermal cover to prevent water temperature extremes, and taking up excess nutrients that may be present in runoff. Catchments with relatively high nutrient loading in the 2011 SWAT Model output, particularly nitrogen, appear to correspond well with locations of poor quality riparian and wetland buffers.

Based on the wetland and riparian buffer condition analyses, field observations, and SWAT Model output, potential demonstration areas containing sites for buffer restoration include:

- Upper Eslava Branch
- Upper Weeks Creek
- Baker Branch
- Green Branch
- Corn Branch
- Polecat Creek

In 1998 the MBNEP Habitat Loss Working Group report assessed the status of historic habitat loss in the MBNEP study area, considering habitat types of scientific concern and those identified by habitat user groups as at-risk ecological systems. The identified systems are widely recognized as those providing significant habitat values for many species, including rare and endangered fauna. Priority habitats include tidal marshes, freshwater wetlands, longleaf pine, pine savannah, maritime forest, oyster reefs, and SAV. Habitats identified by the ADCNR Comprehensive Wildlife Conservation Strategy (2016) as in greatest need of conservation to include floodplain forests, swamps, wet pine savannah and flatwoods, maritime forest and coastal scrub, and estuarine and marine systems.

In general there is an abundance of infestations of invasive flora and fauna within the Watershed. These invasive species cause adverse impacts to the native plant and animal communities within the Watershed.

4.6 Coastal Erosion and Sea Level Rise Issues

The two most notable changes observed in the shoreline assessment include: (1) the loss of emergent island area; and (2) the widening of coastal streams. The two locations exhibiting the most obvious loss of island area are at locations in the Fish and Magnolia Rivers. Both of these sites experience high levels of boat traffic and resulting wake, which could lead to erosion along the shores of these islands. Additional factors related to the size of these islands include the occurrence of flood events and tropical systems, which can cause increased flow and velocity leading to greater potential for bank erosion. The widening of streams was noted at additional sites in Fish and Magnolia Rivers. These streams are very small coastal streams typically running through marsh and have very small watersheds. They are typically not wide or deep enough to be navigable by motorized boats.

Another possible cause for both the loss of island area and the widening of stream channels is sea level rise (SLR). The National Oceanic and Atmospheric Administration's (NOAA's) tidal gauge is located at Dauphin Island, approximately 17 miles southwest from the mouth of Weeks Bay. Published data from this gauge show that relative mean sea level has risen 6.5 inches in the Mobile Bay area since the gauge was installed in 1966. Such a rise in mean sea level could also explain why the smaller streams, which experience little to no risk of erosion from boat wake and no significant upstream land use changes in their micro-scale watersheds, have widened to such an extent in a relatively short period of time.

Predictions have been made for the Dauphin Island tidal gauge by the NOAA and the U.S. Army Corps of Engineers (USACE). Both NOAA and the USACE predicted that the lowest possible change in relative sea level at Dauphin Island in the year 2100 will result in an increase of 0.34 meter (1.1 feet). The USACE's highest predicted change by the year 2100 at this location is 1.66 meters (5.5 feet), while NOAA's highest possible SLR rate predicts a net increase of 2.15 meters (7.1 feet). There is still a large degree of uncertainty when it comes to the actual rate at which sea level will rise in the future.

The Sea Level Affecting Marshes Model (SLAMM) predicts when marshes are likely to be vulnerable to SLR and where marshes may migrate uphill in response to changes in water levels. The SLR scenarios chosen for analysis of the Weeks Bay Watershed were 0.5 (approximately 1.5 feet), 1.0, and 2.0 meters (approximately three and six feet, respectively) of relative mean SLR in the area from the initial year (2002) to the year 2100.

Review of the data yielded the following observations:

- In all three SLR scenarios, the largest proportion of habitat predicted to have a net reduction in acreage (via conversion to another habitat type or types) was the "Swamp" category, which constituted greater than 50 percent of total loss in all scenarios;
- "Undeveloped Dry Land" was the second highest proportional net loss for all three SLR scenarios. Loss in this category increased from 21 percent in the 0.5-meter (approximately 1.5 feet) SLR scenario to 30 percent in the 2.0-meter (approximately six feet) SLR scenario;
- "Riverine Tidal" losses decreased proportionally from the 0.5-meter to the 2.0-meter (approximately 1.5 feet to six feet) SLR scenarios;
- In general, the habitat acreage lost resulted in a conversion to, and net acreage increase in, three major categories using the 0.5-meter (approximate ly1.5 feet) SLR scenario: "Regularly-flooded Marsh" (58 percent), "Transitional Fresh Marsh" (27 percent), and "Estuarine Open Water" (16 percent);
- Under all three SLR scenarios, the "Regularly Flooded Marsh" category consistently showed the largest gains. However, as the SLR scenario was increased, this category's proportion of total habitat gained decreased as additional habitat categories, such as "Transitional Fresh Marsh," "Estuarine Open Water," and "Flooded Forest," began to increase; and
- The SLAMM predicts that the Weeks Bay Watershed will see a conversion of various wetland habitats by the year 2100 as these habitats are inundated and convert to open water. The amount of area predicted to convert into open water is approximately 155 acres for the 0.5-meter (approximately 1.5 feet) SLR scenario, 320.5 acres for the 1.0-meter (approximately three feet) scenario, and 1,057.8 acres for the 2.0-meter (approximately six feet) scenario.

5.0 Watershed Management Plan Goals and Objectives

Development of this Watershed Management Plan (WMP) for the Weeks Bay Watershed is the product of years of concerns over the degrading water quality in the Fish and Magnolia Rivers, Weeks Bay and Mobile Bay; high stormwater runoff velocities and volumes; the increasing urbanization of the Watershed; and how the ongoing Land Use/Land Cover (LU/LC) changes will influence these conditions in the future

This WMP is constructed to address a variety of goals and objectives related to the management of stormwater runoff and related problems associated with overland erosion and general degradation of the aquatic and wetland habitats within the Weeks Bay Watershed.

5.1 Goals Stated in Request for Qualifications (RFQ)

The RFQ was issued by the MBNEP and the BCSWCD on September 2, 2015, laying out the information needed to adequately address watershed planning for the Weeks Bay Watershed. According to the RFQ, the plan would chart a conceptual course for improving/protecting the things people value most about living along the Alabama coast.

- **Water Quality**: Identify actions to reduce point and non-point source pollution (including stormwater runoff and associated trash, nutrients, pathogens, erosion and sedimentation) and remediate past effects of environmental degradation thereby reducing outgoing pollutant loads into Mobile Bay, Mississippi Sound, and the Gulf of Mexico
- **Fish**: Identify actions to reduce the incidence and impacts of invasive flora and fauna and improve habitats necessary to support healthy populations of fish and shellfish.
- **Environmental health and resiliency**: Identify vulnerabilities in the watershed from increased sea level rise, storm surge, temperature increases and precipitation and improve watershed resiliency through adaptation strategies.
- **Access**: Characterize existing opportunities for public access, recreation, and ecotourism and identify potential sites to expand access to open spaces and waters within the watershed.
- **Culture and Heritage**: Characterize customary uses of biological resources and identify actions to preserve culture, heritage and traditional ecological knowledge of the watershed
- **Shorelines**: Assess shoreline conditions and identify strategic areas for shoreline stabilization and fishery enhancements;

In addition to the six values identified above, the plan should provide a strategy for conserving and restoring coastal habitat types providing critical ecosystem services and identified by the MBNEP's Science Advisory Committee as most threatened by anthropogenic stressors. These habitat types- **freshwater wetlands; streams, rivers and riparian buffers; and intertidal**

marshes and flats, were classified as most stressed from dredging and filling, fragmentation, and sedimentation, all related to land use change. These habitats and the ecosystem services they provide are related to many, if not each, of the six identified values.

The RFQ also stated that the plan should address the USEPA's Nine Key Elements of watershed planning (http://water.epa.gov/polwaste/nps/upload/watershed_mgmnt_quick_guide.pdf):

- Build Partnerships, including identification of key stakeholders and solicitation of community input and concerns (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 (2)
- Set Goals and Identify Solutions including determination of pollutant reduction loads needed and management measures to achieve goals (2-3)
- Design Implementation Program including implementation schedule, interim milestones, criteria to measure progress, monitoring component, information/education program, and identification of technical and financial assistance needed to implement plan (4-9)

The watershed plan must include sections to address: watershed characterization (including assessment of climate change vulnerabilities), stakeholder outreach and engagement, prescription of management measures, regulatory evaluation and adaptation, long-term financing, prioritizing and scheduling implementation activities, and monitoring and evaluation of success.

5.2 Comprehensive Conservation and Management Plan for Mobile Bay

The Weeks Bay WMP will contribute toward meeting the objectives and plans contained within the Comprehensive Conservation and Management Plan (CCMP) for Mobile Bay (MBNEP, 2014). The CCMP recognized that humans are an integral part of the Mobile Bay estuary ecosystem, and the needs of humans must be considered in developing a sustainable conservation and management plan for the Mobile Bay ecosystem. Reflective of that recognition, the CCMP contains the following objective to guide the development of future Human Uses strategies:

> "Provide consistent, enforceable, regional land and water use management that ensures smart growth for sustainable development and decreases the negative impacts of growth-related activities on human health and safety, public access, and quality of life by developing and implementing plans consistent with the CCMP…"

To fulfill the above human use objective, the following three priority issues were identified in the CCMP that must be addressed in future management planning and decisions:

- Sustainable land use planning
- Hydrologic modifications
- Public access

5.3 Conceptual Management Measures

The scope of work for the WMP called for the management measures to be developed to the conceptual level only. The following objectives guided development of the management options presented in Section 6.0.

- Implement engineering measures in developed areas to restore natural watershed hydrology to the extent feasible, by increasing retention of runoff and thereby reducing runoff rate, volume, and duration.

- Remediate and restore waterways, wetlands, riparian buffers, and floodplains which have been adversely impacted by human activities within the Watershed.

- Minimize further alteration of hydrology within undeveloped or low-development areas by establishing more effective standards and criteria for Low Impact Development measures and Green Infrastructure.

This Page Intentionally Left Blank

6.0 Management Measures

6.1 Establish a Watershed Management Plan Implementation Team

In order to assure implementation of the Watershed Management Plan we must identify leadership and funding. A Watershed Management Plan Implementation Team (WMPIT) must be identified to carry forward the work necessary to prioritize site specific projects, work with the various inter-governmental entities within the Watershed, and locate the necessary funding. The membership of the WMPIT should reflect the diversity of entities represented on the SWG that served to guide development of the WMP. The WMPIT must agree on an organizational “homeroom” (general terminology for an agency or organization responsible for administrative matters, taskings, scheduling, etc. on a day-to-day basis) or multiple “homerooms” (MBNEP, WBNERR, BCSWCD, NRCS, etc.). The SWG has discussed “homerooms” that best fit based on the subject matter of the specific recommendation, and are discussed with the various recommendations below. Notably the BCSWCD has approved a Watershed Coordinator position to provide oversight regarding the implementation of the WBWMP at their July 26, 2017 meeting. At the time of this writing, the BCSWCD has received a one-year commitment of $41,500 to partially fund the Watershed Coordinator position from the Baldwin County Commission, with continued funds if there is demonstrated progress/buy-in from other stakeholders. In addition, one-time donation commitments have been received from the Alabama Soil and Water Conservation Committee ($5,000), Alabama Association of Conservation Districts ($5,000), and Gulf Coast Resources Conservation and Development Council ($15,000). Other funding sources being explored by the BCSWCD include ADEM, EPA, and the municipalities in the Watershed. The BCSWCD staff position should not overlap or conflict with the existing roles of the WBNERR, MBNEP, or other local city/county staff positions, or other state/federal agencies, but rather complement those positions. The establishment of a Watershed Coordinator by the BCSWCD is vital to moving forward with plan implementation.

6.2 Develop Inter-Governmental County/Municipal Watershed Management Mechanism

The focus of this recommendation would be to foster inter-governmental cooperation. The inter-governmental entity could be either an informal group with periodic meetings (sort of like the informal municipality/county planner meetings that have been held over the past several months), or something more formal such as a watershed management authority, as authorized under Alabama law (AL Act 91-602) similar to the Choctawhatchee, Pea, and Yellow Rivers Watershed Management Authority.

An inter-governmental coordination mechanism could help address planning and zoning matters across the entire Watershed. In addition, such a mechanism could enhance approaches to deal with comprehensive watershed stormwater management throughout this large Watershed. Model ordinances could be developed to assist local communities achieve consistency in regulations yet allow flexibility to best fit their local needs.

6.3 Address Federal/State/County/Municipality Regulations

Based on the review of the regulatory framework throughout the Weeks Bay Watershed, to help further the goals of the WMP, the following management measures and recommendations related to the identified gaps and inconsistencies are recommended.

Management Measure: Convene a working group composed of local area planning officials, development entities, and engineering firms (as needed for technical input) whose purpose is to systematically review the identified gaps and inconsistencies, reach consensus on watershed management goals and appropriate levels of local government involvement, and address the regulatory framework recommendations.

Given the complexity of the regulatory framework within the Watershed, the number of gaps and inconsistencies identified, and the relative differences in available resources of the local units of government, it is felt that such a working group could benefit from sharing experiences and ideas related to watershed management efforts. Open discussions on how to achieve consistent management goals, devise consistent regulatory requirements (where appropriate) and share information will be critical to implementing the recommendations.

This activity was initiated through the WMP process by convening meetings of City, County, Baldwin County School Board and regional (SARPC) planners. This group has been meeting regularly since November 2016.

Management Measure: Initiate educational programs on priority Watershed issues (wetlands, water quality, stormwater management, sea level rise, etc.) targeted toward municipal officials, agricultural interests and homeowner associations.

Given the varying degrees of knowledge regarding the effects of ongoing urbanization on land use and water quality issues in the Watershed, outreach and education products should be developed that target different messages to different target audiences on issues relating to implementation of the WMP. The activities should be focused on increasing the sensitivity and understanding of the target audiences of the necessity of implementing the management measures outlined in the WMP to: (1) improve environmental quality; (2) enhance the quality of life; and (3) reduce the need to pursue future actions with public funds to correct the consequences of unwise development practices.

Recommendations: The recommendations regarding the regulatory framework reviewed as part of this WMP process are presented in tabular form in Table 6.1.

Table 6.1 Recommended Regulatory Framework Management Measures

Issue Area	Threats/Opportunities	Responsible Entity	Recommendations
Regulatory Gaps	Lack of applicable federal or state post construction stormwater management requirements	EPA NOAA ADEM ADCNR	• Develop appropriate post-construction stormwater management regulations applicable, at a minimum, to watersheds where urban runoff is an identified cause of water quality impairment. • Expand the inland geographical boundary of the state coastal management area to incorporate more of the Watershed that would be afforded the resource protection provisions of the program.
	Lack of regulatory requirements or enforcement for agricultural activities impacting water quality	EPA USDA ADEM	• Explore mechanisms to increase the use of appropriate BMPs where agricultural activities are identified as a direct cause or direct contributor to contraventions of state water quality standards, particularly for §303(d) listed stream segments.
	Lack of local government wetland/stream protection and LID requirements	County Local Municipalities	• Formulate a consistent set of local wetland and stream protection and LID requirements throughout the Watershed. These requirements should focus on stormwater runoff total volume reduction using Low Impact Development (LID) concepts and stormwater retention (Volume Based Hydrology (VBH)), and runoff velocity and peak flow management (timing) where and when appropriate. • Review existing buffer requirements, in consultation with qualified stream and wetland specialists, to ensure buffer and setback widths are adequate depending on the landscape (wetland type, slopes, soils, stream impairment, cover of adjacent lands, etc.). • LID requirements should reference the *Alabama LID Handbook*.

Table 6.1 Recommended Regulatory Framework Management Measures (continued)

Issue Area	Threats/Opportunities	Responsible Entity	Recommendations
	Improve the inspection, maintenance and reporting for post construction stormwater management facilities	County Local Municipalities	• Formulate a consistent set of post construction stormwater management facility inspection, maintenance and reporting requirements. These requirements should focus on ensuring inspections are performed by qualified individuals; the frequency is appropriate to ensure the intended stormwater management benefits are being achieved (more frequent for large or complex systems); maintenance or repair is performed in a timely manner, and documented, to restore proper function. The inspections could be performed by the local government or be required of the entity responsible for the facility (owner). • Prepare and maintain a GIS based Watershed-wide inventory of all properties (subdivisions, schools, businesses, etc.) with significant stormwater management facilities that includes, at a minimum: location, design specifications, receiving water, maintenance history and ownership information.

Regulatory Inconsistencies	Inconsistent construction phase erosion and sediment control and stormwater management ordinances	County
		Local Municipalities
			• Work collectively with an appropriately qualified BMP specialist to develop a common set of construction phase stormwater technical design standards, including:
			    • BMP plan preparation based on ADEM or EPA guidance;
			    • A design storm equivalent to the 2-year frequency event;
			    • Open area stabilization (temporary and permanent) to reduce the time and acreage of soils that are exposed to rainfall;
			    • BMP repair/maintenance timeframes of no more than 48 hours.
			• All BMP design and implementation requirements should meet or exceed those in the current edition of the *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas*.

Table 6.1 Recommended Regulatory Framework Management Measures (continued)

Issue Area	Threats/Opportunities	Responsible Entity	Recommendations
	Inconsistent post construction stormwater management ordinances	County Local Municipalities	• Work collectively with an appropriately qualified engineering firm to develop a common set of post-construction stormwater technical design standards focused on runoff reduction (VBH) and timing that would be applicable, at a minimum, to the Weeks Bay Watershed. The *Alabama LID Handbook* should be utilized. Tools such as the existing Baldwin County flood modeling study should serve as a guidance tool to determine the potential positive and/or negative impacts of various design alternatives prior to adoption of regulatory requirements.
	The potential for internal inconsistencies in existing ordinances that impact stormwater management	County Local Municipalities	• Each local entity should undertake a detailed review of all of its ordinances and regulations to determine if there are internal inconsistencies (e.g. differing setback requirements under different ordinances, etc.), if a specific requirement impacts upon or precludes the use of LID or innovative stormwater management measures, or if there are requirements conflicting with minimization of impervious cover (e.g. excessive parking area requirements) or other recognized stormwater management practices and how requirements for roadway and drainage construction impacts stormwater management objectives.
	Inconsistent subdivision requirements related to Watershed protection	County Local Municipalities	• Based on the inventory of subdivisions, catalogue and review existing subdivision restrictions and covenants to identify ones that may need to be updated to reflect Watershed protection goals. Provide assistance for updating restrictions or retrofitting existing poor performing facilities. • Encourage through education and outreach the use of LID practices, good stormwater facility maintenance, highlighting Watershed protection and respect of upstream and downstream impacts.
Enforcement	Lack of routine self-inspection requirements at the local level	County Local Municipalities	• Local authorities should consider requiring self-inspections be performed by permittees during the course of construction or, alternatively, specify that inspections performed under the ADEM permit be made available to the local authority.

6.4 Address Stormwater Management and Flooding

Baldwin County is encouraged to regularly run flood prediction models with updated land use forecasts. The County is recommended to add a county GIS layer on which municipalities can list high potential development projects in order to improve inter-governmental coordination that could have impacts beyond the boundaries of an individual municipality.

The County and all municipalities are recommended to conduct an inventory and assessment of stormwater detention systems (HOA owned and business owned). Methods to incentivize maintenance, as well as retrofitting of HOA stormwater detention systems should be explored. Regional alternatives to multiple HOA systems should be considered.

The details of a recommended project to inventory, map, and assess existing stormwater ponds, and construct several demonstration project retrofit designs to improve water quality flowing from these ponds are provided below. These stormwater pond retrofits would be designed to not adversely impact flood protection, but would provide substantial benefits for improving water quality. The Thompson Team performed an aerial photograph inventory of detention ponds within the Watershed based on Google Earth™ imagery, identifying approximately 260 ponds (Figure 6.1).

The project will consist of in-depth mapping and data collection of the stormwater basins within the Watershed. The size, location, and type (wet or dry detention or retention) will be documented. Site visits will be performed to document the status of the ponds, their functionality during storm events, and potential for retrofitting projects. At the end of the project timeline, a second map will be created to show any new basins that have been created during the project time and the site location of the selected pilot retrofitting projects. The project will also include an outreach to provide information to HOA groups or businesses on inspection and management activities to ensure the long-term functionality of their stormwater basins, including maintenance recommendations. Retrofit treatment options for the demonstration sites may include:

- extended detention
- conversion of dry ponds to wet ponds
- constructed wetlands within ponds
- bioretention
- additional filtering practices, including native grass plantings
- swales
- other (roof runoff treatment using rain gardens, rain barrels, planters, etc.)

The option selected for each site will be based on the major issue with that site, such as flow rate, retention time, sedimentation within the pond, or invasive plant pressure.

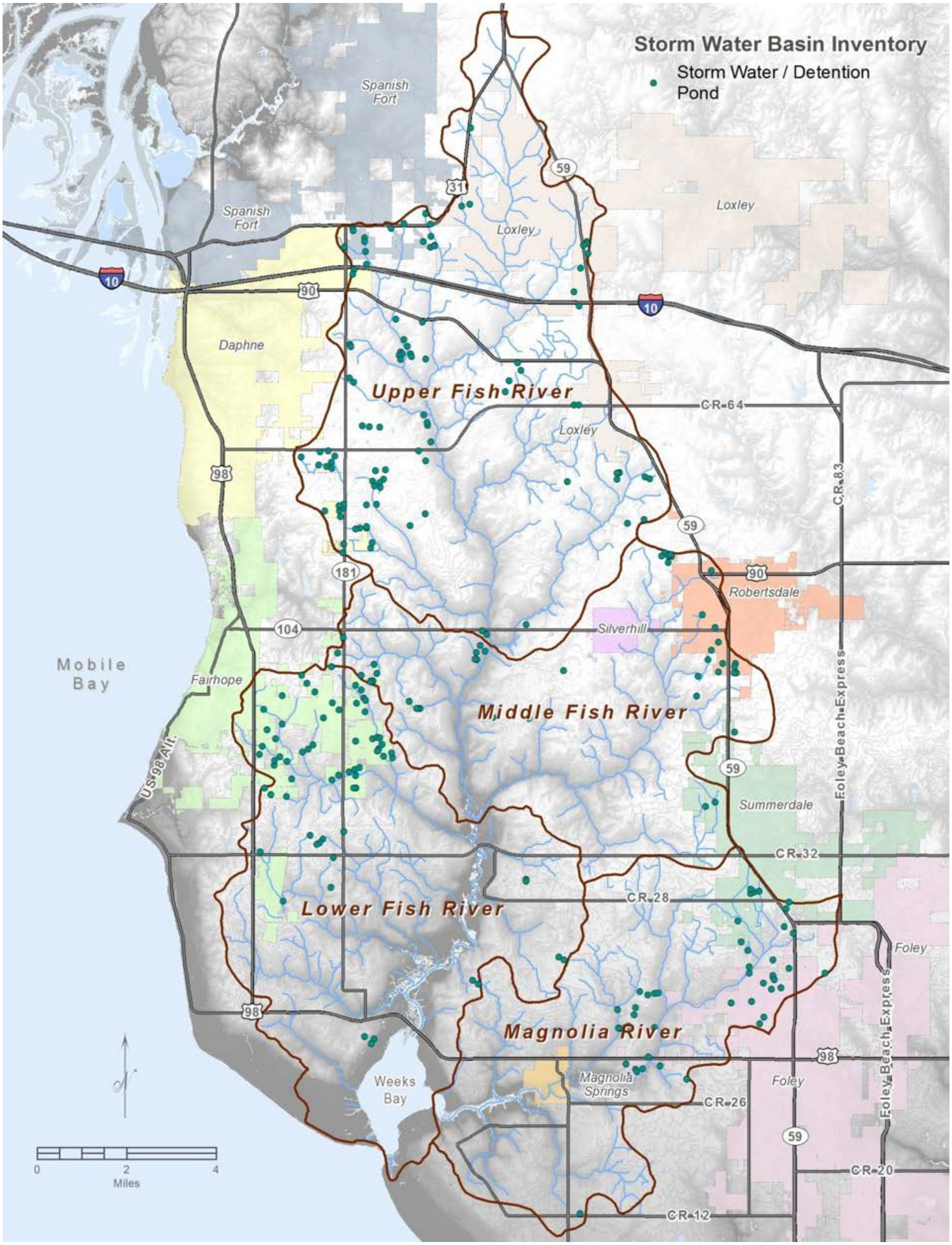


Figure 6.1 Inventory of Stormwater Detention Ponds in the Weeks Bay Watershed

6.5 Sustain Watershed Hydrology by Promoting Low Impact Development (LID) and Green Infrastructure (GI)

6.5.1 Background

The impacts of urbanization on stream water quality due to increased Impervious Cover (IC) surface area have been presented in Section 2.8.3. Generally stated urbanization and increased IC modifies a watershed's natural hydrology resulting in increased stormwater runoff volumes and reduced infiltration. Increased runoff scours streambeds, erodes streambanks, and causes large quantities of sediment and associated pollutants to enter streams when it rains. Section 2.8.3.3 presents IC estimates for existing conditions of the watershed (as well as recent changes) based on NLCD datasets for 2001, 2006, and 2011. Section 2.8.2.2 presents existing land use and projected land use changes for 2040, utilizing two scenarios (2040-Medium and 2040-High). Section 3.7 discusses future IC estimates based on the land use change projections. Analysis of these land use projections indicates that significant increases in IC are expected for all portions of the Watershed. The combined Weeks Bay Watershed "Developed Areas" (13.1% in 2011) are expected to increase to as high as 29.4% in the 2040-High projection. Compared to Total Watershed Area, the combined Weeks Bay Watershed Impervious Cover (IC) surface area (2.9% in 2011) is projected to increase to as high as 12.9% in the 2040-High projection. When the IC surface area is compared to the "Developed Area" acreage (22.5% in 2011), the projected increase is as high as 44.1% for the 2040-High projection.

Section 3.7 provides similar estimates for each HUC 12 subwatershed. The largest increases are projected for the Upper Fish River Subwatershed.

Clearly, urbanization of the Weeks Bay Watershed can be expected to result in adverse impacts to water quality of the Watershed's streams, especially within the areas experiencing development. Such impacts can be minimized by adopting measures to sustain the Watershed's hydrology. Such management measures are termed Low Impact Development (LID) and Green Infrastructure (GI).

6.5.2 What does LID and GI mean?

Urbanization increases the variety and amount of pollutants carried into our nation's waters. In urban and suburban areas, much of the land surface is covered by buildings, pavement and compacted landscapes. These surfaces do not allow rain to soak into the ground which greatly increases the volume and velocity of stormwater runoff (USEPA https://www.epa.gov/nps/nonpoint-source-urban-areas). Stormwater runoff is a major cause of water pollution in urban areas. Stormwater drains through gutters, storm sewers, and other engineered collection systems and is discharged into nearby water bodies. The stormwater runoff carries trash, bacteria, heavy metals, and other pollutants from the urban landscape. Higher flows resulting from heavy rains also can cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure (USEPA https://www.epa.gov/green-infrastructure/what-green-infrastructure).

Interest in and awareness of the need to better manage stormwater runoff in urban and suburban landscapes has increased in recent years. Multiple studies have identified the negative impacts of poorly managed post construction stormwater on our nation's waters. As landscapes become more urbanized, there is a corresponding increase in the amount of impervious surfaces that limit the ability of stormwater to infiltrate into the ground. In some watersheds, as much as 55% of rainfall runs off an urban landscape that is covered by parking lots, roads, and buildings and only 15% of rainfall soaks into the ground. In comparison, a more natural landscape will infiltrate 45% of the rainfall with only 10% running off. The negative environmental impacts of an increase in stormwater runoff and subsequent peak instream flows in developed landscapes leads to increases in its delivery of pollutants such as nutrients, pathogens, metals, and sediment (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf).

Careful consideration of stormwater management is critical for planners, environmental program managers, elected officials, homeowners, business owners, developers, contractors, design professionals, and others; however, it is rare that these groups have an opportunity to work together in planning for future development and redevelopment, particularly on a watershed level. Low impact development or LID is an interdisciplinary systematic approach to stormwater management that, when planned, designed, constructed, and maintained appropriately, can result in improved stormwater quality, improved health of local water bodies, reduced flooding, increased groundwater recharge, more attractive landscapes, wildlife habitat benefits, and improved quality of life (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf).

The term *low impact development* (LID) refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat. USEPA currently uses the term *green infrastructure* (GI) to refer to the management of wet weather flows using these processes, and to refer to the patchwork of natural areas that provide habitat, flood protection, cleaner air and cleaner water. At both the site and regional scale, LID/GI practices aim to preserve, restore and create green space using soils, vegetation, and rainwater harvest techniques. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels and permeable pavements. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions (USEPA, https://www.epa.gov/nps/urban-runoff-low-impact-development).

Low impact development minimizes runoff and employs natural processes such as infiltration, evapotranspiration (evaporation and transpiration from plants), and storage of stormwater at multiple fine scale locations to be as near to the source of stormwater as possible. Successful implementation of LID recreates a more natural hydrologic cycle in a developed watershed. Recently, Green Infrastructure (GI) has emerged as the term to describe planning and implementation of projects that use vegetation, soils, and natural processes to manage water and create healthier urban environments. On a broad, watershed scale GI may encourage the linking of new and existing greenways, promotion of canopy cover to assist with energy reductions and carbon sequestration, and the preservation of natural areas. As the scale becomes finer, GI encompasses the stormwater management approach recommended by LID to treat stormwater close to its source through infiltration, evapotranspiration, and storage (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf).

6.5.3 Considerations for LID/GI Implementation

Compared to many other watersheds of the region, such as the D'Olive Watershed in Daphne and Spanish Fort, the Weeks Bay Watershed has the advantage of being relatively undeveloped by urbanization. As such, incorporating LID/GI measures within new development will provide the best opportunity to minimize the impacts of urbanization. Ben Franklin's old adage is applicable here - "An ounce of prevention is worth a pound of cure."

Some of the municipalities fringing the boundaries of the Weeks Bay Watershed have adopted (or are adopting) ordinances to require or encourage LID/GI practices. Those ordinances have different provisions and are not consistent. Other municipalities and the unincorporated watershed areas of Baldwin County outside of municipal jurisdiction have no or only limited provisions for LID/GI. Refer to Section 7 for discussions of federal/state regulations and local ordinances applicable to the Watershed areas. It is recommended that the WMPIT (recommended in Section 6.1) and the inter-governmental mechanism (recommended in Section 6.2) promote and encourage LID/GI throughout the Watershed, and promote consistency of those measures within the various jurisdictions.

Successful implementation of LID/GI practices at the watershed scale will require communication and coordination among the multiple local jurisdictions. It must be initiated during early community planning processes and carry forward through all phases of site selection, design, and approvals. Additional information extracted from the previously referenced Alabama LID Handbook on community planning, site selection considerations, and LID practices is included in Appendix I.

There are several LID and GI projects in the Watershed, and the number is increasing as engineers, architects, developers, builders etc. embrace these technologies. A GIS database showing the locations of LID and GI projects is recommended to increase public awareness and education. The best "homeroom" for such a project would be the MBNEP or the WBNERR.

6.6 Encourage Improved Agricultural/Forestry BMPs

Examples of agricultural BMPs that should be encouraged within the Watershed include:

- Livestock exclusion from wetlands/streams and protection of riparian buffers along streams
- Increased use of cover crops to decrease soil erosion and nutrient leaching, improve infiltration and increase soil organics
- Improved nutrient management through increased use of precision agriculture application of fertilizer and pesticides; split nitrogen application, etc. in order to reduce the potential for contaminated runoff and leaching
- Identify/Remediate areas with high livestock numbers where manure runoff is found to be a source of pathogens associated with water quality issues

Appendix F provides a detailed description of various agricultural and forestry practices.

There are a number of conservation programs available for both public and private landowners through the NRCS and Farm Service Agency (FSA). A brief description of each appears below (Source: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/).

- Conservation Stewardship Program provides financial and technical assistance to agricultural producers to implement enhanced conservation practices to improve plants for wildlife, grazing management to reduce soil compaction and improve riparian function.
- Environmental Quality Improvement 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 and non-industrial forestland. Within EQIP, the Air Quality Initiative provides financial ass stance to implement conservation practices that address air resource issues (greenhouse gas emissions, ozone precursors, volatile organic compounds, airborne particulate matter, and some odor-related volatile compounds) for designated locations.
- Emergency Watershed Protection Program (EWP) provides financial assistance for recovery efforts in response to natural disasters and is designed to help people conserve natural resources by relieving imminent hazards to life and property caused by floods, fires, drought, windstorms and other natural occurrences.
- Regional Conservation Partnership Program (RCPP) provides for public-private partnerships focused on improving water quality, combating drought, enhancing soil health, supporting wildlife and protecting agricultural viability.
- The Watershed and Flood Prevention Operations Program (WFPO) provides technical and financial assistance to state and local governments for planning and installing watershed projects.

- The Agricultural Water Enhancement Program (AWEP) and the Wildlife Habitat Incentive Program (WHIP) were repealed on February 7, 2014 and new enrollments are no longer accepted. Conservation practices previously covered under the two programs are usually eligible under EQIP.

Through these various programs, there are a number of conservation practices promoted by the NRCS that are on-going throughout the Weeks Bay Watershed for various agricultural activities including:

- Cropland: Contour farming, crop residue management, cover crop, crop rotation, field borders, terraces, tile outlet terraces, sod waterways, gully structures, conservation tillage, and sediment retention structures.
- Grassland: Pasture management, controlled grazing, weed control, stream crossing, gully structures, livestock exclusion, and cropland conversion.
- Forestland: Tree planting, planting desirable species, control burning, control undesirable invasive species, water breaks, gully structures, access roads.

Appendix F contains a copy of the NRCS Conservation Catalog (October 2016) with complete descriptions of the various agricultural practices.

Representatives from the BCSWCD and NRCS have participated as members of the SWG in the development of this WMP, and they should take the leadership role for implementation of this recommendation.

6.7 Address Watershed Water Quality Issues

Recommendations dealing with water quality issues that have been identified through the WMP process include:

- Identify instream erosional “hot spots” on Fish and Magnolia Rivers (and tributaries) and prioritize and implement stream restoration and bank stabilization to reduce sediment contributions. For example, a number of unpaved roads, dirt pits, and other erosional areas have been identified within the Watershed and they warrant further field investigation and development of remedial measures. Also two significant areas of bank erosion have been identified during the WMP development, one on the lower Magnolia River and the second on a Fish River tributary near the junction of CR 9 and CR 32. In addition paving of priority unpaved roads that contribute sediment to the streams and wetlands would help reduce sediment loading within the Watershed.
- Refine SWAT model results to identify and map “critical source areas” (CSAs) at the hydrologic response unit (HRU) level within the subwatersheds having high sediment and nutrient yields/loadings, with goal of remediation of sediment and nutrient “hotspots”.

- Conduct a detailed turbidity source survey in tributaries with frequently elevated turbidity levels (Corn Branch, Pensacola Branch, Baker Branch and Cowpen Creek) to pinpoint sources of excessive turbidity and develop detailed plans to reduce, minimize or eliminate the sources.
- Conduct detailed pathogen source tracking and identification in areas of the Watershed with frequent high pathogen levels to distinguish between wildlife, livestock, pets, and human contributions in order to develop detailed plans to remediate pathogen sources.
- Develop a pathogen monitoring program that will support development of a hydrologic model that can be used to predict the occurrence of high levels of bacteria and implement a public advisory system that warns of potential health risks associated with whole body contact recreation during period of elevated bacteria concentrations (similar to the model used to close waterbodies to oyster harvest).
- Develop an inventory of septic tanks that predate the existing ADPH inventory and design and implement an effort to quantify the contribution of septic tanks to both the pathogen and nutrient loadings within stream segments having water quality issues. After that inventory is complete conduct a GIS analysis to identify “hot spots” where septic tank locations are in poor soil types for such facilities and are in close proximity to streams and wetlands.
- Identify and assess potential water quality impacts associated with biosolids and animal manure application sites throughout the Watershed.
- Assess impacts of turf farms for runoff timing and volume, and pollutant loadings to streams.

6.8 Address Environment/Habitat Issues

6.8.1 Degraded Wetlands and Riparian Buffers

Poor condition wetland and riparian buffers in the Watershed are associated mostly with agricultural and pasture lands. These areas are concentrated especially in the Magnolia River HUC 12, but generally are present at the upper margins of all four subwatersheds.

The Weeks Bay NERR 2017-2022 Management Plan cites riparian vegetation as performing an important role in trapping sediment, providing thermal cover to prevent water temperature extremes, and taking up excess nutrients that may be present in runoff. Catchments with relatively high nutrient loading in the 2011 SWAT Model output, particularly nitrogen, appear to correspond well with locations of poor quality riparian and wetland buffers. To determine potential buffer restoration sites, criteria should include:

- Locations identified as nutrient or sediment loading hotspots;
- ADEM 303d streams;
- Former drainageways and wetlands on crop land with marginal production; and
- Proximity to Weeks Bay

Because most wetlands in the Watershed are associated with rivers, streams, and drainageways, riparian buffer restoration actions will involve some level of stream and wetland restoration. Based on the wetland and riparian buffer condition analyses, field observations, and SWAT Model output, potential demonstration areas containing sites for buffer restoration include:

- Upper Eslava Branch
- Upper Weeks Creek
- Baker Branch
- Green Branch
- Corn Branch
- Polecat Creek

In identifying demonstration sites in the Watershed for riparian buffer and wetland restoration, a number of factors should be considered, particularly if the intent is remediation or amelioration of nutrient and sediment loading from agricultural fields. Wetlands converted from former agricultural fields can be a significant source of nutrients to downstream receiving waters (Aldous et al., 2005; Moreno-Mateos et al., 2009; Ardón et al., 2010; Steinman and Ogdahl, 2011). Steinman and Ogdahl (2011) recommended that the concentrations and release rates of sediment nutrients be measured before agricultural areas are converted to wetlands to ensure they serve as nutrient sinks instead of nutrient sources. Both organic and inorganic forms of N and P, as well as the coupled movements of their various forms, should be considered when assessing potential benefits of buffer restoration at specific sites (Ardón et al., 2010). Alternative implementation designs combining buffer creation with other practices capable of altering nutrient loads, and reestablishing riparian hydrology and instream habitat, may be necessary (Smiley et al., 2011). Buffer restoration can be primarily designed and intended to prevent excessive nutrient and sediment loading; however, secondary purposes, such as for stormwater attenuation or wildlife habitat, should also be considered and evaluated.

6.8.2 Vulnerable High Quality Habitats for Protection

Two important types of high quality habitats should be considered for protections: (1) coastal zone tidal areas around Weeks Bay, particularly tidal marshes currently outside of conservation easements, and (2) upstream strategic locations and ecologically significant habitats, e.g., locations with habitat or species tracked by the Alabama Natural Heritage Program, subwatershed areas with intact riparian buffers, especially headwater areas. Figure 6.2 shows the current land area (total of 1,772 acres) within the Watershed that is protected by the State of Alabama, Baldwin County, and the Weeks Bay Foundation. The majority of the protected acreage (1,631 acres) is located in the Lower Fish River Subwatershed at the WBNERR, with the remainder located in the Upper Fish River Subwatershed (125 acres) and Middle Fish River Subwatershed (15 acres). Most of the protected lands are in fee simple title with a few areas protected under conservation easements.

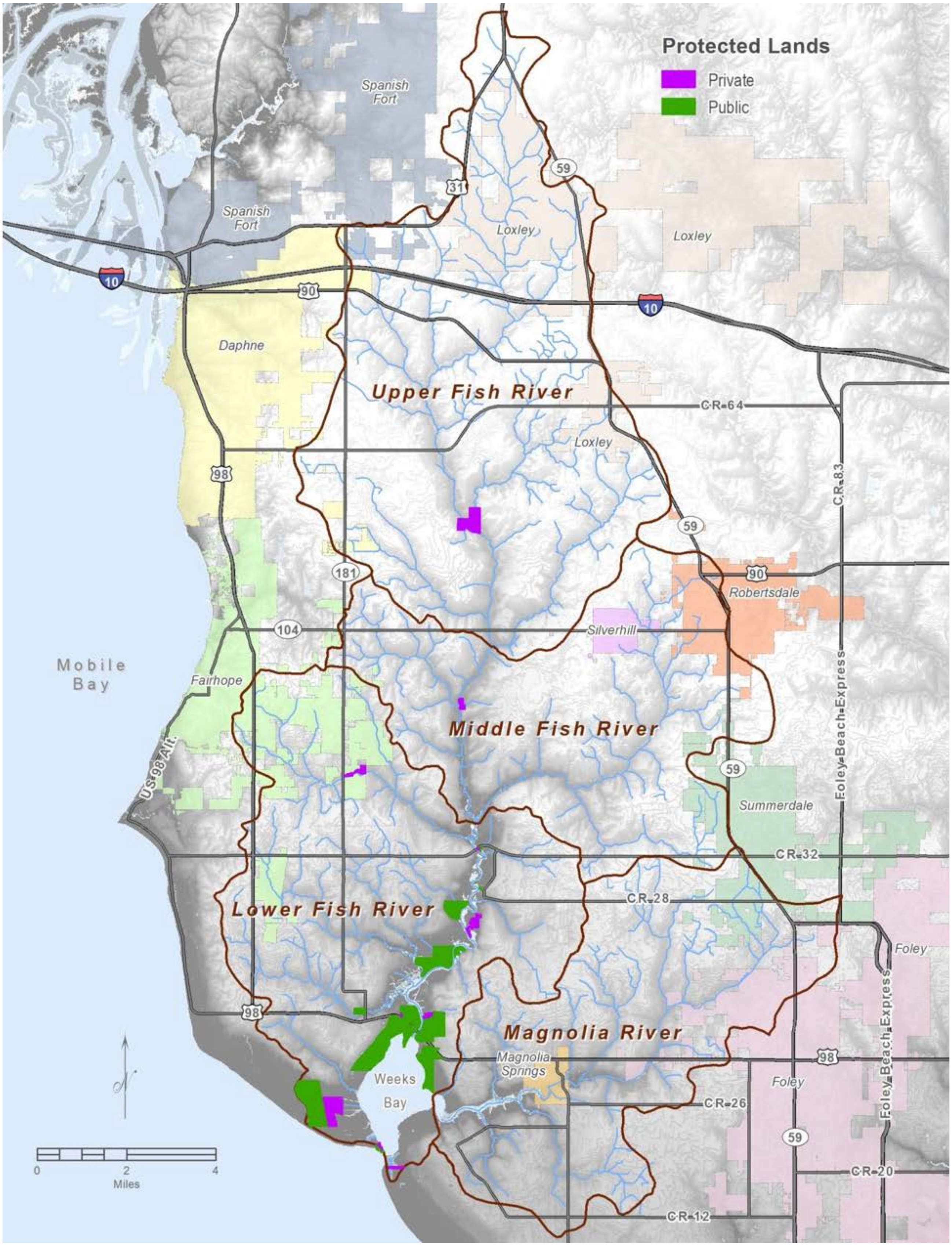


Figure 6.2 Weeks Bay Watershed Lands Protected by Public and Private Ownership

In 1998 the MBNEP Habitat Loss Working Group report assessed the status of historic habitat loss in the MBNEP study area, considering habitat types of scientific concern and those identified by habitat user groups as at-risk ecological systems. The identified systems are widely recognized as those providing significant habitat values for many species, including rare and endangered fauna. Priority habitats include tidal marshes, freshwater wetlands, longleaf pine, pine savannah, maritime forest, oyster reefs, and SAV. Habitats identified by the ADCNR Comprehensive Wildlife Conservation Strategy (2016) as in greatest need of conservation to include floodplain forests, swamps, wet pine savannah and flatwoods, maritime forest and coastal scrub, and estuarine and marine systems.

Tidal marsh systems are considered high quality habitat due to their level of ecosystem services provision, including habitat for fisheries and species of high conservation concern. Total estuarine emergent acreage in the Watershed is 507 acres (Figure 6.3). The total area of tidal marshes that are currently protected by fee simple or easement acquisition is 180 acres, with 327 acres not currently contained in protective ownership. All tidal wetlands are considered priority for acquisition and conservation.

The ALNHP identifies areas of switchgrass (*Panicum virgatum*) tidal fringe habitat at two locations in the Magnolia River HUC 12. This community type is considered a habitat of extreme rarity in Alabama (S1). Tidal pond cypress (*Taxodium distichum*) habitat, also an S1 habitat, has identified occurrences in the area of lower Eslava Branch and near Weeks Creek. The ALNHP data also include an area of streamside white-cedar (*Chamaecyparis thyoides*) swamp habitat (S1) in the Upper Fish River HUC 12, associated with Turkey Branch near Highway 90. Longleaf pine-turkey oak (*Pinus palustris* and *Quercus laevis*) woodland habitat (S2) occurs near Fish River in the Middle Fish River HUC 12, south of CR 48. All of these locations should be investigated to verify the occurrence of these rare habitats, and document their extent and ecological condition, prior to consideration of establishing conservation easements for their protection.

A deep acid swamp occurs on the eastern side of Fish River, just north of existing conservation easements that include forested wetlands and the Wintermeyer Nature Trail bog. These baygall wetlands comprise high quality habitat near the terminus of Fish River, and should be considered for acquisition. Another site outside of existing protection is a remnant wet pine forest located near the southern terminus of Mary Ann Beach Road (CR 27), west of Weeks Bay and north of CR 1. The site appears to be a good candidate for restoration through controlled burning.

In general, the main stem of Fish River has intact riparian and wetland buffers. Future development in the County should proceed with a heightened awareness of the value of maintaining these areas in a natural state. A number of strategic ecologically valuable land parcels are currently being considered by public and private entities such as the ADCNR/Weeks Bay NERR and the Weeks Bay Foundation.

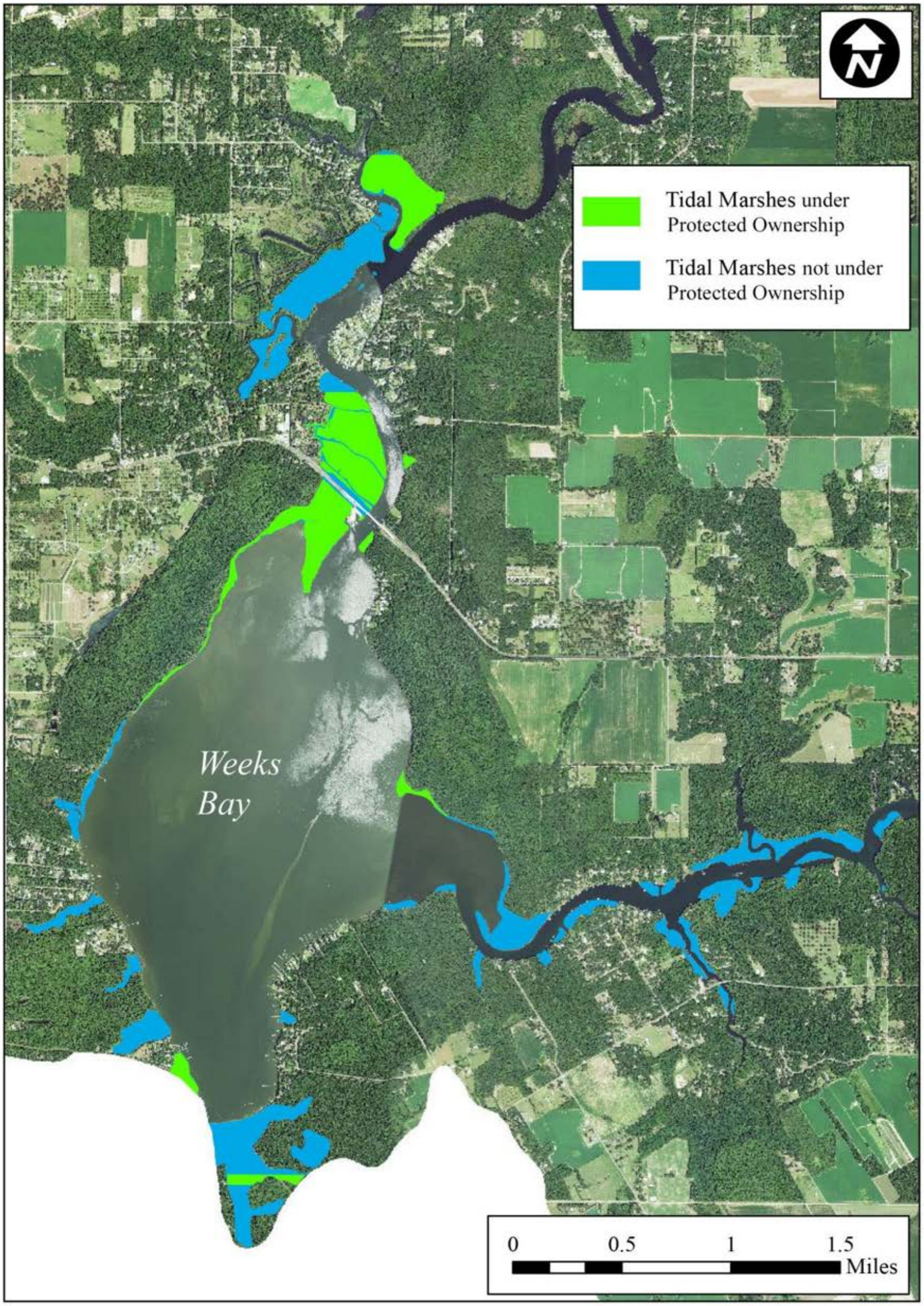


Figure 6.3 Tidal Marshes Inside and Outside Existing Protection in the Weeks Bay Watershed.

6.8.3 Invasive and Exotic Species

In general there is an absence of existing, comprehensive programs and mechanisms to detect infestations of invasive flora and fauna, and to take action to manage or eradicate them once identified. The Weeks Bay NERR 2017-2022 Management Plan cites efforts to eradicate waterthyme from areas of the Watershed, including Barner Branch. The efforts apparently were successful, but monitoring for invasive exotics typically involves ongoing management, due to the difficulties in permanent eradication. Ongoing collection of data would be valuable to determine to what extent non-native species have impacted the Watershed, and how best to predict the occurrence of notable plant pests for the purposes of eradication, maintenance of biodiversity, and management of threatened natural resources.

Establishing invasive exotic plant management projects is most likely to be effective on public lands, where managers have right-of-access. In 2004 the MBNEP conducted a strategic assessment of habitats throughout Mobile and Baldwin Counties to identify priority sites for restoration and conservation. The objective was to protect, enhance, restore, and manage valuable public lands and work with property owners to accomplish habitat protection goals on important, privately held lands. Establishing a public-private collaboration program for management of invasive exotic flora and fauna, and for inventorying important habitats and species, would be of significant value for long-term conservation and management.

6.9 Address Coastal Erosion and Sea Level Rise Issues

Findings of the shoreline and climate change assessments have yielded the following recommendations that should help mitigate past and future impacts on shorelines and habitats in the Watershed, caused by both man-made and natural processes:

6.9.1 Planning/Awareness of Potential Sea Level Rise

The potential for sea level to continue to rise as it has over the past 50 years (6.5 inches as measured at the Dauphin Island tide gage) makes it is important to adequately plan and prepare for sustainable coastal communities within the Watershed. The public (including policy makers) needs to understand the reality and implications of SLR. Therefore, it is important to promote programs/workshops to improve stakeholder awareness of:

- Recorded SLR in the greater Mobile Bay area over the last 50 years;
- SLR predictions based on various agencies and models;
- Potential effects on infrastructure, residential properties, and habitats in the Watershed due to future SLR; and
- sea level rise adaptation options.

6.9.2 Protect and Enhance Coastal Habitats

In addition to providing habitat for a wide range of marine species, well-established, contiguous marshes and oyster reefs promote sediment accumulation and shoreline stabilization, protect riparian habitats, and buffer upland areas against wind and wave activity that expedite erosion, thereby helping to slow or offset the impacts of Sea Level Rise (SLR). As a result, these habitats serve as an important buffer between uplands and estuaries, filtering pollutants before they enter the water and reducing waves before they reach land.

Identify specific sites, at the parcel level in the lower reaches of the Watershed, that are candidates for construction of living shoreline or other shoreline protection/restoration measures. Suitable sites would typically consist of areas that currently are (or anticipated in the future) exhibiting erosion or habitat loss. Some of the potential impacts of future SLR can be somewhat mitigated by construction of living shorelines. Specific activities can include the following:

- Creation and enhancement of oyster reefs, which can help attenuate wave energy and have the potential to increase in elevation at the rate of SLR; and
- The planting of emergent shoreline vegetation can help capture and stabilize sediments in areas that have sufficient sedimentation accretion rates and appropriate bathymetric conditions.

6.9.3 Plan/Design for Sea Level Rise

Once adequate awareness and planning has occurred, implementation of SLR adaptation projects can be successful, including but not limited to:

- Implementation of coastal infrastructure retrofits (built for anticipated higher sea level);
- Development of adaptation and land use plans that account for anticipated future sea level;
- Acquisition of properties for conservation, where aquatic and riparian habitats are allowed to move up-gradient with the increase in sea level;
- Long-term monitoring and adaptive management of implemented SLR adaptation measures in the Watershed; and
- Increase current and future investments in coastal green infrastructure projects (such as living shorelines) that will protect shorelines and adapt to changes in sea level.

6.9.4 Other Potential Actions

Additional actions to help mitigate the impacts of SLR may include efforts to replace lost habitat. These may include the following:

- Assess the current and potential ecological benefits provided by the protection and/or restoration of multiple disappearing (drowning) islands found in the lower reaches of Fish River and Magnolia River; and
- Develop new intertidal habitat (with upland opportunities for marsh migration) by beneficial use of dredged material.

6.10 Develop Appropriate Monitoring and Adaptive Management Mechanisms

The monitoring program should track the number of management measures that are implemented in each HUC 12 subwatershed and the degree to which they are implemented. Potential indicators would be such things as: acres of wetlands preserved; acres of wetlands restored, miles or acres of riparian buffer restored, acres treated for invasive plant removal, number of septic tanks inspected and serviced and/or taken out of service, number of alternative on-site sewage disposal systems installed, miles of livestock exclusion fencing installed, number and type of agricultural BMPs implemented, acres enrolled in NRCS conservation programs, number or miles of stream restoration, etc. Since this Plan identifies several areas where additional investigation is needed to identify pollutant sources in order to development appropriate management measures, the number of source identification studies or investigations conducted should also be tracked.

There are have been a number of various sample collection locations throughout the Weeks Bay Watershed over the past 20 years including those of the USGS, ADEM, Weeks Bay NERR, Geological Survey of Alabama, USEPA, Cook, and several other investigators. Samples should be collected on a monthly or quarterly basis at each location site or consistent enough to accurately monitor trends in Watershed conditions and parameters. The sampling schedule should not be burdensome to the field teams or an excessive drain on budgets. All monitoring activities should be conducted in accordance with ADEM or Alabama Water Watch (AWW) protocols, as appropriate for the parameter being monitored.

A vital element of the Watershed Monitoring Program will be citizen participation through volunteering as an AWW monitor. With the help of volunteers, the Watershed Monitoring Program will enable successful implementation and establish a sense of community ownership within the watersheds. Efforts should be made to recruit as many volunteer monitors as possible.

6.11 Continue Stakeholder and General Public Outreach and Education

Community outreach and public education about the Weeks Bay Watershed has been and will continue to be the responsibility of the Weeks Bay NERR and the Weeks Bay Foundation. According to OutdoorAlabama.com, "*education and training programs at Weeks Bay Reserve target K-12 students, teachers, university and college students and faculty, as well as coastal decision maker audiences. Components of our education program include school field trips, summer camps, teacher training programs, science-based workshops and seminars,* *community outreach, exhibits, and the production of curricular, informational and technical materials. All Reserve education, training, and outreach activities are designed to enhance public awareness of the importance of estuarine systems and provide opportunities for public education and interpretation.*" The current Weeks Bay NERR Management Plan which describes many of their outreach and education activities can be found on www.OutdoorAlabama.com.

Our focus in the development of the WMP was to respond to the key issues identified in the Workshop at the beginning of the project: The top issues were flooding and water quality caused by development and population growth exacerbated by the lack of a comprehensive, multi-jurisdictional stormwater management plan. The top recommendation on how to develop a stormwater management plan was to develop ways to continue discussions between stakeholders in order to address issues where multiple regulatory groups (cities, county, state, federal) are involved.

We did this in two major ways. The first was to maintain a large (25-30 member) Stakeholder Work Group with members from the types of constituencies and interest groups in the Watershed. We recommend that this group stay engaged during the implementation phase of the WMP.

The second was to partner with the City of Foley to host approximate monthly meetings with planning staff from the municipalities and the county. They were joined by others who are also concerned about growth in this, the fastest growing county in Alabama: school system, utilities, the South Alabama Regional Planning Commission (SARPC), and members of the Thompson Team. At the time of this writing, six city/county planner meetings have been conducted, and the planners have seen value in these frequent meetings and intend to continue meeting.

Another key outreach has been with members of the agricultural community. Several members of the SWG are farmers and have shared with us that the farming technology has improved dramatically over the last 25 years. Even so, the effects of production of food and other agricultural products will continue to be seen in the Watershed. The BCSWCD has agreed to take a leadership role with the agricultural community. This will likely use the same format as the planning community: regular meetings with farmers to share low impact and productivity improvement practices and other topics of interest to the participants.

This Page Intentionally Left Blank

7.0 Regulatory Review

7.1 Introduction

As evidenced in the previous Sections, the Weeks Bay Watershed is an expansive and complex ecosystem that is in constant motion and continually impacted by natural phenomenon and human activities. Realizing the need to protect public health and safety, the environment, and to provide for orderly development and regulate certain activities for the common good, societies have developed various laws and regulations at several levels. As part of the development of the Watershed Management Plan (WMP) for the Weeks Bay Watershed, a review of existing laws, regulations, permits and ordinances at the federal, state, and local levels was conducted. The geopolitical boundaries of the Weeks Bay Watershed include overlapping jurisdictions and adjacent portions of Baldwin County, the Cities of Daphne, Spanish Fort, Fairhope, Foley, Robertsdale and Silverhill, the Towns of Loxley, Magnolia Springs and Summerdale, with all lands under state and federal jurisdiction. The current status of permitting requirements, ordinances, inspections, and compliance issues were compiled from each local government through their respective official or inspector, as well as representatives of the Alabama Department of Transportation (ALDOT), the Alabama Department of Environmental Management (ADEM), and Alabama Department of Conservation and Natural Resources (ADCNR) State Lands Division - Weeks Bay National Estuarine Research Reserve (WBNERR). The laws, regulations and ordinances reviewed focus on water quality; stormwater management (pre and post construction); erosion and sediment control; coastal resource management (wetlands and streams protection); low impact development; and shoreline stabilization. The list includes portions of the following:

- Clean Water Act, 33 USC § 1251, et seq.
- Alabama Water Pollution Control Act, Ala. Code § 22-22-1, et seq.
- ADEM Administrative Code R. 335-6-6 (NPDES)
- ADEM Administrative Code R. 335-6-10 (water quality)
- ADEM Administrative Code R. 335-8 (coastal area management)
- ADEM Construction Stormwater NPDES General Permit ALR10 (April 1, 2016)
- Baldwin County Zoning Ordinance (May 17, 2016)
- Baldwin County Subdivision Regulations (May 19, 2015)
- City of Fairhope Subdivision Regulations (March 8, 2007)
- City of Fairhope Code of Ordinance, Chapter 7 Article VII (Erosion) (September 23, 1996)
- City of Fairhope Code of Ordinance, Chapter 7 Article IX (Wetlands) (October 13, 2008)
- City of Daphne Ordinance No. 2014-14, CBMPP Ordinance (April 21, 2014)
- City of Daphne Land Use and Development Ordinance (July 18, 2011)

- City of Spanish Fort Zoning Ordinance, Article VIII (May 31, 1996)
- City of Spanish Fort Subdivision Regulations (February 8, 2016)
- Town of Loxley Zoning Ordinance (July 14, 2014)
- Town of Loxley Subdivision Regulations (April 13, 2009)
- City of Robertsdale Land Use Ordinance (January 23, 2012)
- Town of Silverhill Zoning Ordinance (January 17, 2000)
- Town of Magnolia Springs Zoning Ordinance (June 22, 2010),
- Town of Magnolia Springs Subdivision Regulations (January 12, 2012)
- Town of Summerdale, Alabama Zoning Ordinance (April 9, 2012)
- Town of Summerdale Building Code Ordinance 521-13 (March 11, 2013)
- City of Foley Code of Ordinance, Chapter 6.5 Article III (Erosion Control) (March 16, 2015)
- City of Foley Code of Ordinance, Chapter 4 Article IV (Construction) (October 1, 2007)
- City of Foley Code of Ordinance Chapter 4 Article VIII (Shorelines) (January 21, 2008)

federal, state and local governments are continuously in the process of changing and evolving through practical experience, technology and interpretation, and during preparation of this Plan, agencies were developing proposed changes to, or changed their existing regulatory procedures. Examples of such changes to regulations and requirements for compliance include:

- The ADEM General Permit for Phase II Municipal Separate Storm Sewer Systems (MS4) expired in January of 2016 and was being administratively continued until a new version of the permit was issued effective October 1, 2016.
- The ADEM modified ADEM Administrative Code R. 335-6-10, the state's water quality standards, effective February 23, 2017, changing where the standards for "coastal waters," apply.
- The City of Spanish Fort has been considering the adoption of a "water quality" specific ordinance.
- During this project ADEM issued a new General Permit for construction stormwater (ALR10) effective April 1, 2016. The new permit includes a requirement for a 25-foot natural riparian buffer adjacent to all waters of the State of Alabama and deletes the previous permit's turbidity monitoring requirements for priority construction sites.
- In March 2017, the Corps of Engineers §404 Nationwide Permits (NWP) for wetland fill expired and new versions were issued effective March 19, 2017. Additionally, ADEM issued new and updated Coastal Consistency and CWA§401 Water Quality Certifications for most, but not all, of the NWPs Permits are valid for 5 years and can be viewed at: http://www.sam.usace.army.mil/Missions/Regulatory/NWP/.
- As a result of the WMP process and the "City/County Planner Group" that has been formed, several municipalities indicate that they are now considering modifications to the local ordinances based on the preliminary Regulatory Matrix.
- The jurisdiction of the primary federal law related to water quality, the Clean Water Act, is "waters of the U.S. (WOTUS)", the definition of which has been revised several

times, the subject of numerous court cases and U.S. Supreme Court decisions, and has currently been remanded to EPA and the Corps of Engineers for “review and revision” by Executive Order (EO #13778).

Flood control ordinances were not specifically reviewed in detail, since flooding is not one of the stated primary issues (i.e. the eight MBNEP Expected Watershed Plan Components; or nine EPA Minimum elements) to be addressed during the watershed management planning process. However, flooding, particularly on the lower end of the Watershed, was one of the highest concerns expressed by citizens and flood control goals and stormwater treatment goals are often thought to be in opposition; the first trying to remove water as quickly as possible, the latter trying to slow release rates and/or volumes. A more detailed review of flood control requirements and comparison to stormwater management requirements could be beneficial in identifying potential conflicts and crafting solutions to support LID and improved land and water management. Further, all aspects of local development requirements (e.g. parking space requirements, sidewalks) that could potentially conflict with stormwater quality management, particularly low impact development practices, were not studied.

7.2 Overview of Laws, Regulations

Generally, the federal, state and local laws are discussed throughout this Watershed Management Plan, specifically in Section 3.0 where detailed examples are provided. The actions, permitting, restrictions, studies and funding, even the watershed planning process, are all driven by legal authorities (sometimes several layers thick), legal documents (rules, regulations, ordinances, RFPs, studies, management plans, case law/rulings/judgments, notice and rulemaking procedures, etc.), legal criteria and legal rights (private, public, government, political, riparian, littoral). Although the following descriptions and details of certain laws, rules, regulations, and permits will be separated for convenience, in reality, they overlap with much interplay, imposing various conditions and requirements, as well as creating conflicting situations from time to time.

7.2.1 Federal

The Federal Water Pollution Control Act (FWPCA) and the Clean Water Act (CWA) Amendments.

The FWPCA of 1972 and the subsequent series of amendments, including the CWA amendments of 1977, provide the basis for the primary regulatory and permitting procedures relating to water quality, stormwater management, and the discharge of dredged and fill materials into jurisdictional "waters of the U.S." ("WOTUS") including aquatic sites, the estuary, salt march and adjacent wetlands, freshwater, wetlands, floodplains, savannahs, streams and tributaries within the Weeks Bay Watershed. The following specific sections of the CWA are particularly pertinent to conducting activities regulating recreational use, research, developments (commercial, residential and public), stormwater, erosion and sedimentation, and use and discharge of chemicals, fuels and lubricants, fertilizer and pesticides within the Watershed.

CWA §404 (33 USC § 1344). This law is administered by the Corps of Engineers and the EPA to regulate activities resulting in the discharge of dredged or fill materials into navigable waters or waters of the United States ("WOTUS"). The Corps and EPA, through particular rulemaking procedures, have proposed, noticed, and issued rules and regulations to CWA §404 (Corps 33 CFR 320; EPA 40 CFR 230). The agencies also issue a number of other interpretive writings, including Regulatory Guidance Letters (RGL), Interpretive Guidance (usually following a lawsuit and judicial opinion, Executive Order, or Congressional Act), Standard Operating Procedures (SOP), and Memorandum of Agreements or Understanding (MOA/MOU) intended to guide implementation and enforcement of the law. Essentially, the law states that no dredged material or fill material can be discharged by anyone or entity, including governmental entities, agencies and programs, without a permit (or an exemption) into jurisdictional waters of the United States, including jurisdictional wetlands (and flood plains, streams, rivers, bay, estuaries, and other aquatic sites).

There are several types of permits which can be issued including an individual CWA §404 permit, a letter of permission, a general permit, a regional permit, a Nationwide permit (NWP), and even an after-the-fact permit. Permits may also impose general and/or regional conditions, local conditions or criteria (such as activities in Weeks Bay), CWA §401 water quality certification conditions, coastal program consistency certification conditions, and/or require approvals from ADCNR (submerged lands lease or riparian easement if in state waters or on state water bottoms).

CWA §401 (33 USC §1341) and CWA §401(a) Water Quality Certification. CWA §404 permit applications, pursuant to CWA §401(a), must be submitted to ADEM for review of the proposal's consistency with the state's water quality program. ADEM reviews applications to ensure the proposed discharge of dredged or fill material will not cause or contribute to a violation of state water quality standards as set forth in ADEM Administrative Code R. 335-6-10.

CWA §402. EPA has primary authority over the CWA water quality program and is responsible for administering the regulations for the National Pollutant Discharge Elimination System (NPDES) (40 CFR 122) and permitting discharges from point sources to waters of the United States. The NPDES program covers point source discharges from industrial facilities, municipal stormwater conveyances, concentrated animal feeding operations (CAFO), stormwater runoff from land clearing activities and construction sites, publicly owned treatment works (POTW), combined sewer overflows (CSO) and sanitary sewer overflows (SSO). EPA has delegated the authority to administer the NPDES program to ADEM. ADEM regulates and permits certain point source discharges in accordance with ADEM Administrative Code R. 335-6-6. Through the NPDES permit program discharges from construction sites and land clearing are regulated by the ADEM Construction General Permit, ALR100000 (effective April1, 2016), which is applicable to discharges from construction activities resulting in land disturbance of one acre or more (and smaller sites that are part of a common plan of development or sale) and imposes requirements for erosion and sediment control and the use of best management practices; as well as imposes requirements for inspections, reporting and enforcement. Other ADEM NPDES programs regulate discharges from industrial and municipal waste treatment systems and municipal separate storm sewer systems (MS4). ADEM requires large municipalities and certain other large operations (e.g. ALDOT) to obtain and comply with the terms of a NPDES permit (ALR040000) to control the discharges from their stormwater collection, conveyance and discharge systems. Notably exempt from the NPDES permitting requirements of §402 are agricultural activities.

CWA §303 (33 USC §1313). The Clean Water Act, Section 303 relates to the development and implementation of state specific water quality standards and numeric and non-numeric criteria. §303(d) [33 USC § 1313(d)] mandates that EPA (hence ADEM) develop pollutant loading capacities for receiving streams (waterbodies receiving NPDES discharges) such as those occurring within the Weeks Bay Watershed. The loading capacities are termed “total maximum daily loads” (TMDLs) and are used to set limits on the amount and type of pollutant or contaminant discharges that can be made to the stream without further degradation. Once a stream or stream segment has been classified as impaired (i.e. listed on the state’s 303(d) list because water quality does not meet the published criteria) and the contaminant identified, EPA and ADEM must perform inspections and samplings to determine the amount or limit of the loading to the stream. The 303(d) list is required to be updated every two years. The most current can be accessed at: http://adem.alabama.gov/programs/water/wquality/2016AL303dList.pdf. A thorough discussion of the application of §303 by ADEM within the Watershed is in Section 3.0 – Watershed Conditions.

Coastal Zone Management Act (P.L. 92-583; 16 U.S.C. §1451 et seq) (CZMA). The Coastal Zone Management Act was enacted in 1972 and is administered by the National Oceanic and Atmospheric Administration (NOAA). Through the regulations promulgated by NOAA (15 CFR 921-930), the CZMA provides coastal states an opportunity to develop and implement coastal area management programs. States electing to do so are provided with partial funding support. The CZMA places certain requirements on federal agencies to ensure that their activities (and the activities they permit) are consistent with approved state programs (15 CFR 930). Alabama developed a Coastal Area Management Program in 1979 (ACAMP) and continues to maintain a federally approved program (see program description under state regulations). The authority to administer the ACAMP is currently shared by ADEM (regulatory portions) and the ADCNR-State Lands Division, Coastal Section (planning and grants). The federal consistency provisions most relevant to the Watershed Management Plan include the requirement that CWA §404 and

§402 permits comply with Alabama's Coastal Area Management Program (ADEM Administrative Code R. 335-8). ADEM issues a written "coastal consistency certification" for individual state and federal permits unless the activity is within the parameters of a blanket coastal consistency certification applicable to general or NWPs. ADEM has also developed a non-regulatory Coastal Non-Point Pollution Control Program pursuant to Section 6217 of the Act.

7.2.2 State

Several of the State of Alabama statutes that affect activities in the Weeks Bay Watershed have been mentioned in the discussion of the federal statutes. ADEM is the primary state environmental regulatory agency in Alabama, overseeing the various water quality (surface and groundwater), drinking water, air quality, solid and hazardous waste programs. In addition, the Alabama Department of Conservation and Natural Resources (ADCNR) may also have jurisdiction over certain activities that affect state waters, state natural resources (such as fish and wildlife), and state lands. The Alabama Department of Public Health, through the Baldwin County Health Department, regulates the placement of on-site sewage disposal systems (septic tanks) throughout the county.

Alabama Water Pollution Control Act. The Alabama Water Pollution Control Act, Alabama Code § 22-22-1, like its federal counterpart (CWA), prohibits the discharge of pollutants to waters of the state without a permit and provides the foundation for the state's delegated authority to implement various federal water quality programs, including the §402 NPDES permitting program, §303 water quality standards and TMDL, and §319 Non-Point Source programs. Water quality programs are generally implemented through ADEM Administrative Code R. 335-6.

CWA §401(a) State Water Quality Certification. As previously mentioned, CWA §404 permit applications, pursuant to CWA §401(a), must be submitted to ADEM for review of the proposal's consistency with the state's water quality program. ADEM reviews applications to ensure the proposed discharge of fill material will not cause or contribute to a violation of state water quality standards as set forth in ADEM Administrative Code R. 335-6-10.

CWA §402 NPDES Permitting Program. Section 402 of the CWA sets forth the national permitting program for discharges of pollutants to waters of the United States. ADEM is a delegated state, authorized to implement the NPDES permitting program within Alabama and administers the program through ADEM Administrative Code R. 335-6-6. Facilities discharging pollutants are divided into a number of categories based on the type and/or size of the facility (e.g. major industrial, major municipal, minor industrial, mining, etc.) and level of treatment required. Discharge limitations are generally similar within the classifications but may vary where the water quality of the waterbody receiving the discharge is a limiting factor. The larger facilities, such as sewage treatment plants and heavy industrial facilities, usually are authorized to discharge under an "Individual" NPDES permit. Smaller facilities of a similar nature (i.e. concrete plants, construction sites, etc.) are usually grouped under a "General Permit" developed to cover the specific industrial sector. This program also includes the NPDES Municipal Separate Storm Sewer System (MS4) permitting covering large municipalities and urban areas. A more detailed discussion of the NPDES permitting program and permitted facilities within the Watershed, can be found in Section 3.0 – Watershed Conditions.

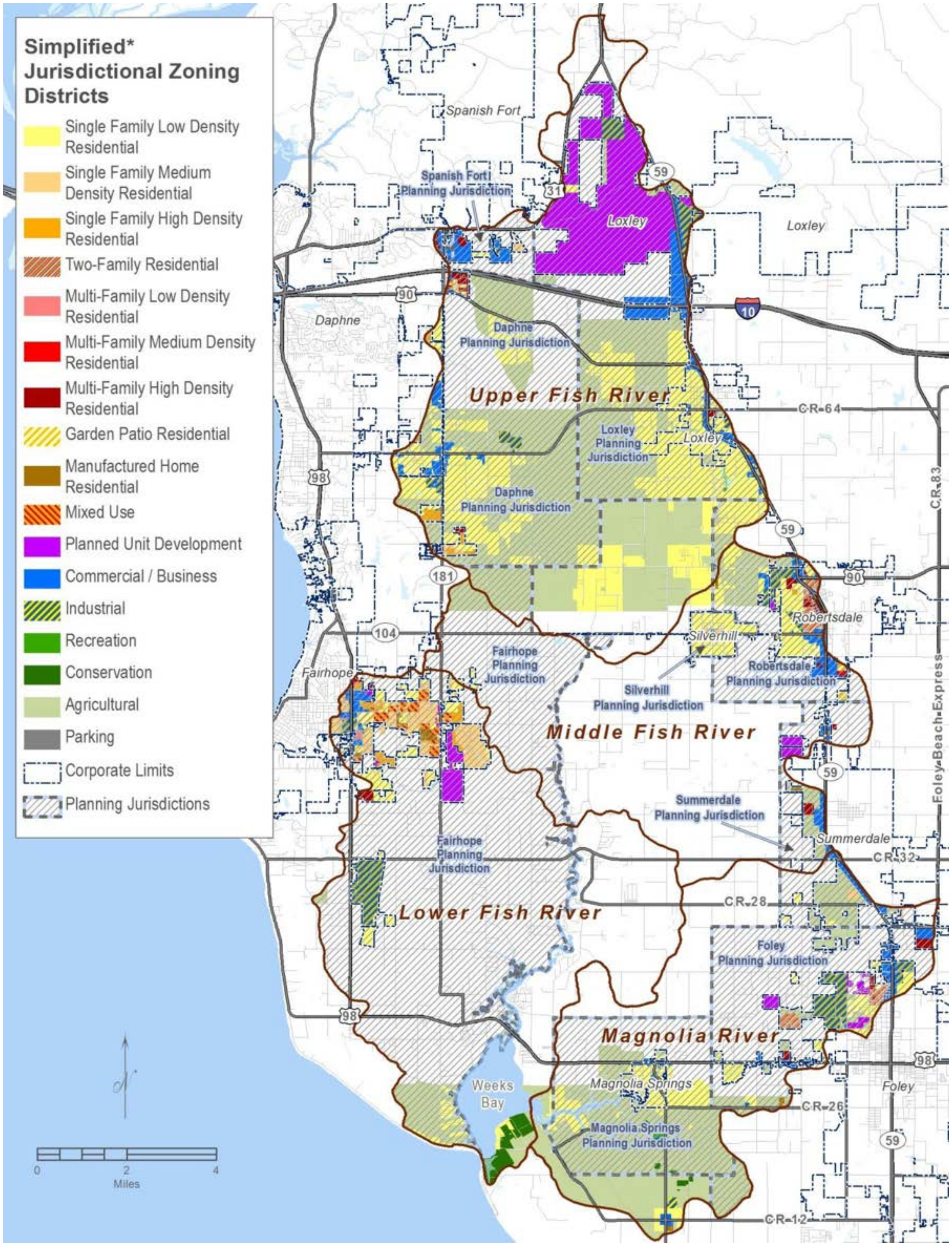
7.2.3 Local Government Regulations

As mentioned previously, in addition to the overarching federal and state regulations, there are nine municipalities and the county that have various and sundry regulations, ordinances and permitting requirements covering activities within the Weeks Bay Watershed. In lieu of a detailed discussion of each local ordinance, to determine "who" was regulating "what" and "how" they were implementing and enforcing the local requirements, each local entity was sent a questionnaire and matrix (table), listing various water quality and resource protection related topics, and asked to complete and return each. Site visits were made to two of the municipalities to assist in completion of the matrix and the Thompson Team completed the matrix for two localities. Nine of the ten entities eventually responded to the questionnaire regarding implementation.

The 6 topics covered in the matrix for which detailed information was requested included:

- Construction phase Best Management Practices (BMP) implementation requirements
- Post construction stormwater management requirements
- Coastal Area resource protection requirements
- Low Impact Development (LID) initiatives
- Shoreline protection requirements, and
- MS4 permit status

To help demonstrate the complexity of the regulatory requirements within the Watershed, Figure 7.1 represents the jurisdictional zoning coverage of each of the nine municipalities and all or portions of six Baldwin County Planning Districts which have adopted zoning (Planning Districts 12, 15, 20, 21, 26, and 28), as shown on Figures 2.18 and 2.19 earlier in this report. A large area in the central portion of the Watershed has no local zoning regulations (Baldwin County Planning District 14 and a portion of District 18), however, those areas are subject to the county-wide subdivision regulations. The local municipality requirements are applicable within the corporate limits as well as their respective planning jurisdictions, which vary from 0 to 5 miles beyond the corporate limits.



*This zoning map represents a compilation from various jurisdictional zoning data. Due to the variation in zoning ordinances and districts across jurisdictions, similarly zoned districts were grouped into generalized (or simplified) zoning districts for analysis and representation purposes.

Figure 7.1 Jurisdictional Zoning Districts in the Weeks Bay Watershed

The ten local authorities (nine municipalities and the county) identified 20 individual ordinances applicable to habitat, water quality, or stormwater management:

Baldwin County Zoning Ordinance (May 17, 2016)
Baldwin County Subdivision Regulations (May 19, 2015)
City of Fairhope Subdivision Regulations (March 8, 2007)
City of Fairhope Code of Ordinance, Chapter 7 Article VII (September 23, 1996)
City of Fairhope Code of Ordinance, Chapter 7 Article IX (October 13, 2008)
City of Daphne Ordinance No. 2014-14, CBMPP Ordinance (April 21, 2014)
City of Daphne Land Use and Development Ordinance (July 18, 2011)
City of Spanish Fort Zoning Ordinance, Article VIII (May 31, 1996)
City of Spanish Fort Subdivision Regulations (February 8, 2016)
Town of Loxley Zoning Ordinance (July 14, 2014)
Town of Loxley Subdivision Regulations (April 13, 2009)
City of Robertsdale Land Use Ordinance (January 23, 2012)
Town of Silverhill Zoning Ordinance (January 17, 2000)
Town of Magnolia Springs Zoning Ordinance (June 22, 2010)
Town of Magnolia Springs Subdivision Regulations (January 12, 2012)
Town of Summerdale Building Code Ordinance 521-13 (March 11, 2013)
Town of Summerdale Zoning Ordinance (April 9, 2012)
City of Foley Code of Ordinance, Chapter 6.5 Article III (March 16, 2015)
City of Foley Code of Ordinance, Chapter 4 Article IV (October 1, 2007) (update pending)
City of Foley Code of Ordinance Chapter 4 Article VIII (January 21, 2008)

In summary, it was determined that all local jurisdictions address both construction phase BMP implementation and post construction stormwater management. However, the degree to which each entity is engaged in these efforts varies greatly. Half of the local jurisdictions have some form of wetland and/or stream protection initiative, usually in the form of a setback. Four local governments have some reference to Low Impact Development (LID) or Green Infrastructure (GI), although only one appears to have a mandatory LID requirement, and only two have shoreline protection initiatives. Four currently have MS4 permit coverage.

When the details of each of these six general topics are reviewed, the degree of inconsistency becomes apparent. Examining the responses related to construction phase BMPs, 6 of 10 use the same design standards and are consistent with ADEM; 1 specifies a 2 year design storm (consistent with ADEM), 2 specify a 10 year storm, two specify a 25 year storm and the remainder do not specify a design storm; stabilization time varies from “not specified” to 30 days; the 3 that specify a BMP repair timeframe all use 2 days (compared to ADEM at 5 days); and, when required, no two buffer requirements are the same. The inconsistency of post-construction stormwater management requirements is also apparent. Although all 10 address stormwater quantity (flooding), only two actually address stormwater quality; although 6 of 10 agree on a design storm (2 through 100 year), only two address the timing of the stormwater discharges; all ten require the developer/owner of a stormwater management facility to be responsible for maintenance, but only 4 require any inspection of facilities and only 2 of those require reporting (3 of these indicated in the questionnaire that an inventory of facilities existed). Interestingly, most municipalities also indicate that stormwater facility maintenance is a significant issue. Additionally, the different methods utilized to estimate pre and post construction stormwater runoff can yield radically differing results. Various methods of calculations can provide drastically different results depending on a number of site specific factors. The rational method commonly employed is believed to underestimate runoff on larger sites (according to Practices in Detention of Urban Stormwater, American Public Works Association Special Report #43, "use of the rational equation should be limited to drainage areas of less than 20 acres."). This inconsistency in specified calculation method(s) is another potential area of concern. The ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf provides, within its Appendix A on Stormwater Hydrology, a good discussion of basic stormwater calculations and their applicability. The complete matrix, which also lists the ADEM requirements, includes the specific regulatory requirements and appears in Table 7.1. Table 7.2 includes both the requirement and the precise regulatory citation for each requirement. Both tables are located at the end of this Section.

Topics included in the questionnaire related generally to how the permitting or regulatory program was being implemented, its perceived degree of effectiveness, and whether changes were currently being considered. All jurisdictions reported that stormwater facility design submittals are being reviewed by a Professional Engineer, either in-house or third party. All jurisdictions indicated that waivers or variances to stormwater requirements were rare and that enforcement beyond a “warning” was also very rare. All but one local government indicated that they felt that their existing regulatory framework was effective in achieving their goals, which were most frequently cited as being “orderly development” and “flood control”, while one entity (not the same) indicated that regulatory changes that would impact stormwater management were currently under consideration.

7.2.4 Subdivision and Restrictive Covenants

The exact number of platted subdivisions, and phases of subdivisions, within the Weeks Bay Watershed has not been enumerated, but aerial imagery indicates that they are comprising an increasing percentage of the urban land area within the Watershed. Usually within a residential subdivision, property owners’ associations are incorporated and for most there exist various subdivision restrictions that have been recorded and are imposed to regulate the activities within the subdivision. The restrictions of some of the older subdivisions and phases address routine issues regarding yard and side setbacks, building signs, and permissible land uses, but do not address land clearing, erosion control, wetland and stream protection, or stormwater management issues. It is evident that the trend of stormwater management within the Watershed has evolved over time, with increased requirements being placed on the newer subdivisions developed. Not all of the older subdivisions have recorded restrictions, and in some instances, only a portion of the subdivision may be within the Weeks Bay Watershed. Subdivision restrictions are usually limited and temporary in nature. They are not designed to be perpetual or permanent, recognizing that over time, attitudes and practices do change. However, most have a long initial term (usually several years) with provisions for automatic extensions of the term unless a contrary vote of lot owners entitled to vote is made to permeate or replace the restrictions.

The municipalities and/or county generally require that subdivision plats and restrictive covenants be recorded and, as evidenced in the matrix, responsibility for stormwater management facilities are being consistently relegated to homeowner associations. Concerns over stormwater volume, stormwater velocity, use of low impact development practices to control stormwater and erosion, as well as protection of natural features such as streams, wetlands and riparian buffers, have only recently been expressed. These are not the types of covenants normally found in subdivision restrictions and many homeowner associations may not even be aware that they own and are responsible for the long-term maintenance of the subdivision's stormwater management facilities. By their nature, subdivision restrictions look inward without consideration of neighboring and unrelated subdivision developments within the same watershed or the same community. Once restrictions and covenants are imposed, enforcement then becomes an issue. Enforcement is an expensive procedure normally funded by dues, assessments or fees from the lot owners who are governed. To be effective, enforcement must be impartially pursued by the person or entity with the authority to do so, which may include a neighbor of any lot owner, the property owner's association or a third-party given the right to do so. It is very likely that the inconsistencies among subdivision restrictions, as they relate to stormwater management, are as varied as there are subdivisions. A current inventory of facilities within the Watershed is not available, but a review of aerial imagery (Google Earth™, 2016) indicates that there are over 250 stormwater management ponds in the Weeks Bay Watershed (shown on Figure 6.1 in the previous section of this report).

7.3 Regulatory Framework: Overlap, Gaps and Inconsistencies

One of the objectives of this watershed planning process was to review the existing regulatory framework and attempt to identify areas of overlap, gaps and inconsistencies as they may relate to sound stormwater management. There will always be some degree of overlap among federal, state, and local requirements, simply due to the fact that the town is part of the county which is part of the state which is part of the union, and the potential for regulatory inconsistency is high. Further, good stormwater management and good watershed planning and development can only be achieved where neighboring jurisdictions have, if not consistent regulatory requirements, at least consistent goals and objectives. Also, too often the regulatory framework and regulatory requirements are slow to reflect emerging technologies and new information being generated in the area of stormwater management. One also must consider the political climate relative to new or more stringent regulatory requirements, at all levels of government. The same regulatory requirements discussed herein will also be applicable to any watershed restoration projects undertaken.

7.3.1 Overlap

Obviously, federal, state and local requirements overlap within the Watershed. The over-arching federal and state water quality regulations apply to all areas of the county and within in each of the local jurisdictions. By example, any proposal to fill jurisdictional wetlands, no matter where located within the Weeks Bay Watershed, must have:

- A proper CWA §404 permit – either an individual permit with review by all agencies and the public, or a Nationwide Permit (NWP);
- Appropriate ADEM §401 water quality certification;
- Consideration of CWA §303(d) impacts (for listed stream segments);
- ADEM coastal program consistency determination (if in the coastal area);
- A CWA §402 NPDES construction stormwater permit (if greater than 1 acre will be disturbed);
- City and/or County land disturbance permits;
- City and/or County development permits and plat approvals; and
- City and/or County building permits.

The Cities' extra-territorial jurisdictions extend beyond their boundaries for up to five miles for planning purposes and overlap into the County, but not an adjacent municipality. Each City exerts its jurisdiction and permitting requirements within their respective geographical boundaries. Each local entity requires permits for development, land disturbance and building construction, depending on jurisdiction, that are in addition to the federal and state permit requirements. Often the federal or state permit is a prerequisite to issuance of the local permit. Where City and County jurisdictions overlap, it is customary for the "more stringent" requirements to apply. In general, the current level of regulatory overlap is not considered a significant issue relative to stormwater management within the Watershed.

7.3.2 Gaps

Often the federal or state regulatory requirements serve to provide a measure of consistency or provide some minimum baseline for local regulation, and often local units of government rely on, or defer to, the state or federal requirements. Without this foundation, it is difficult to achieve regulatory consistency among local units of government. Even when state and federal regulations are in place, they are usually of such a broad nature and scope (national or statewide) that they may not be meaningful at a watershed specific level. In such cases, it falls to the local units of government to adopt and implement regulations that are effective in achieving specific watershed management goals. Currently, with the exception of compliance with FEMA, there are no overarching federal or state regulatory requirements for post construction stormwater quantity or quality. Also, although there are a number of available cost-share, incentives and payment programs related to wetland and water quality protection, most agricultural activities (other than certain animal feeding operations), including silviculture, which represent the majority of the current land use in the Watershed, are unregulated at any level of government.

Regulatory "gaps" can also be due to antiquated regulations. At the state level, the coastal area management program regulations relating to resource impacts (ADEM Administrative Code R. 335-8-2) have not been revised in over 20 years. ADEM and ADCNR struggle to maintain a federally approved coastal management program, due in part to the lack of a regulatory framework that will allow the state to ensure the federal goals can be met. Significant advancements in resource protection alternatives have been realized during the intervening years, some of which may actually be precluded by outdated regulations.

Because federal and state regulatory requirements are so broad in nature and scope, development and implementation of local stormwater management regulations and ordinances are often the best or only way to achieve watershed resource protection goals and/or address local stormwater related impacts. Such local programs have utilized various methods and rationales to develop design standards to address local pollutants of concern within specific watersheds (usually §303(d) listed and/or TMDL limited) or other geographical areas (e.g. Georgia's Coastal Stormwater Supplement (*Coastal Stormwater Supplement to the Georgia Stormwater Management Manual First Edition*, April 2009), and Virginia Department of Conservation and Natural Resources Stormwater Management Regulations (*Virginia Code of Regulations, 4VAC-20 et.seq.*)). The Baldwin County Commission funded a study of the flooding issues in several watersheds within the county, including the Fish River and Magnolia River. Modeling performed for the Baldwin County Commission (*Fish River and Magnolia River Watershed Study*, 2011 and 2014, Hydro Engineering Solutions) as part of the study seems to indicate that the timing of stormwater discharge plays a particularly critical role in downstream flooding (basically suggesting more detention upstream, less downstream). Based on these results, Baldwin County revised its regulations pertaining to stormwater management and design storm events within these watersheds and detention requirements are now based on where within the Watershed the development is occurring. At least one local authority is also embracing this concept of stormwater discharge timing relative to watershed position.

Local governments often assume that the maze of federal and state permitting requirements will be sufficient to protect the natural function of these systems. Unfortunately, this is rarely the case. The State of Alabama currently has no codified buffer or setback requirements (other than the setback requirements in the construction GP ALR100000) and federal and state permits are routinely issued that allow wetlands to be impacted either directly or indirectly. Although mitigation for stream and wetland impacts may be required by the permit, mitigation often takes place outside of the watershed in which the impacts actually occur. Therefore, local governments will play a critical role in protecting these vital resources from both direct and indirect impacts associated with development. Further, there are some activities that are not regulated, or only minimally so, with potential environmental impacts (biosolids application, agriculture, forestry).

The matrix identifies where local ordinances beneficial to good watershed management may be falling short or lacking all together.

7.3.3 Inconsistencies

Regulatory inconsistencies between federal, state and local units of government are inevitable and can contribute to ineffective watershed management, serve as impediments to restoration efforts, and cause confusion in the regulated community. Addressing regulatory inconsistency was a high priority item identified during the March 2016 planning workshop by both the development community and the local government representatives. Consistency among the local government ordinances will be a key factor in effectively implementing the management measures necessary to protect the Watershed's natural resources. In short-sightedness, local governments may use regulatory differences to entice new development, and usually end up "throwing the baby out with the wash water". Development entities often gravitate to, or seek incorporation into, jurisdictions with "less regulation". The long-term costs to the broader community and its citizens will be realized as flooding increases; flood zones expand increasing insurance rates; and waterbodies become polluted, prompting additional regulatory oversight, expensive restoration projects and increased stormwater treatment costs; and stormwater conveyance, maintenance and dredging costs manifest and increase.

However, one size does not fit all and some degree of differentiation may be necessary for individual communities to maintain or foster the character of the community; but these differences would rarely be related to stormwater management and should not compromise the overall goals and objectives for protecting the Watershed. Areas where regulatory consistency is of most benefit, with a brief discussion of each follow.

- Design standards for construction phase BMP implementation. The current recommendations by EPA, the *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas (2014),* and the ADEM stormwater general permit all reference the 2-year 24-hour frequency event.

This is generally the physical limitation of most all of the temporary construction phase BMPs currently available, and designing for a larger event is impracticable.

- Having requirements for construction phase BMP plan preparation and BMP design and selection that are compatible with the ADEM guidance and requirements also reduces the potential for applicants having to prepare multiple plans under differing guidelines.
- Erosion and sedimentation issues are directly related to the “extent and duration” of the area exposed, i.e. how much denuded area is exposed to rainfall and how long it is exposed before being stabilized. ADEM’s construction stormwater general permit requires that areas that have been disturbed and will not have activity for 13 days or more be temporarily stabilized <u>immediately</u> (emphasis added). Based on guidance from EPA the ALDOT limits exposure to 17.5 acres, unless waived by the project engineer, to help control the extent of an area exposed. Local governments are encouraged to set consistent requirements that would limit, through temporary stabilization, the extent and duration of areas exposed to rainfall during construction.
- The effectiveness of construction phase BMPs is directly related to maintenance of the individual control measures. The ADEM permits allows 5 days (from the date of discovery) to repair, maintain or replace ineffective BMPs. Three municipalities within the Watershed use a 48-hour repair or maintenance timeframe, which is consistent with recommendations in the D’Olive Creek WMP and other areas of the state.
- The effectiveness of post construction stormwater management is directly related to adequate design and installation and routine inspection and maintenance. There are no federal or state requirements, so having consistent local requirements that meet both flood mitigation goals and watershed protection goals are critical. As noted previously, while all entities responsible for stormwater management address stormwater quantity (flooding), only two actually address stormwater quality. Also, only four of the 10 local governments have some reference to Low Impact Development (LID) or Green Infrastructure (GI), and only one of these has mandatory requirements. EPA post construction stormwater management guidance for federal facilities encourages retention of the local 95th percentile storm event. ADEM has estimated the 95th percentile storm event for the Mobile area at 2.46 inches. Various other guidance documents and programs reference the local 90th through the 75th percentile storm event. In the ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf, it is recommended that the “first flush” be captured and retained. This water quality “capture depth” ranges from 1.0 – 1.5 inches across the state, with 1.5 inches applicable to coastal plain regions. The theory has been that if X% of the runoff is eliminated (retained on-site) a corresponding reduction in pollutant loading will result. Some opinions (Andrew Reese in *Stormwater*, Vol. 10 No. 6) are that even the traditional methods of using pre-and post- construction peak discharge limitations to address flooding and downstream impacts and/or pollutant reductions may not be as an

effective approach as originally thought, and that the total pre and post construction discharge volume should be considered (an idea known as Volume Based Hydrology). Reese also postulates that peak discharge controls may even exacerbate downstream erosion, particularly in humid climates, by forcing larger volume flows into the channel cross-section rather than allowing them to flow partially along floodplain paths. Standardization of the design criteria and calculation method(s) will help ensure that watershed protection goals can be achieved. Design storm events should be focused on runoff reduction (VBH) and timing that would be applicable, at a minimum, to the Weeks Bay Watershed. Since Baldwin County has adopted ordinances based on the Hydro Engineering Solutions study and model, it could be used to help determine the design-storm, and varying the detention/retention volume and the timing of stormwater releases depending on where a project is located within the Watershed, to maximize the benefit of any regulatory requirements. However, since the GSSHA model does not consider water quality treatment or LID practices, it cannot be utilized as a "stand alone" determinate for regulatory development.

- Developing a consistent set of maintenance and repair requirements for permanent stormwater management facilities will ensure that watershed protection goals can be sustained. This will also facilitate the compilation of an inventory of systems that can be used to systematically inspect and prioritize the repair, maintenance or retrofitting of systems throughout the Watershed. Although there is consensus on the problem (lack of maintenance), there are varied opinions on who should be responsible for performing inspections and maintenance, and the few local entities that have requirements are using different approaches. Most local governments suggest that the "owner" be responsible, however the local governments specify the design standards and readily assume responsibility for a development's streets and the stormwater drainage infrastructure appurtenant to those streets. Also for those with MS4 permits, the municipalities/entities are responsible for what is ultimately discharged from the stormwater management system. Therefore, it would seem logical that the local government is vested in the proper operation and maintenance of the stormwater management facilities and should consider assumption of that responsibility concurrent with acceptance of new streets.

Resolving the majority of the inconsistencies identified in the matrix to achieve common watershed protection goals would be beneficial to both local governments and the developers/builders and will foster wise stewardship of the resources of the Watershed.

7.4 Enforcement

Enforcement, as used herein, is considered in a broader sense to include not only instigating a formal administrative or legal action to compel compliance; but the regulatory requirements to comply with the terms of a permit and conducting routine monitoring and maintenance to ensure stormwater management controls function properly. Rules, regulations, ordinances, restrictions and the like usually require some degree of enforcement to ensure compliance. To achieve the ultimate objective of the rule, enforcement must be timely and meaningful. Further, to maintain the integrity of the implementing agency, enforcement must be consistent and impartial. Each program reviewed contained enforcement provisions ranging from warnings to "stop work orders" to civil or criminal penalties.

Although a detailed review of each agency's enforcement history was not performed, most local agencies indicated that formal enforcement was "rare". In several cases identified during the review process, local governments were relying of enforcement by the state for construction phase BMP compliance, routinely referring non-compliant sites to ADEM for action.

Routine inspection, monitoring and maintenance is a critical component of maintaining construction phase BMPs and insuring that post construction stormwater management facilities function properly. Agency resources are, in many cases, scarce and routine regulatory oversight of permitted activities can be all but non-existent, particularly at the federal and state level. ADEM, under the provisions of the construction stormwater permit, is currently the only agency that requires "self-monitoring" and reporting be performed during construction, but generally only perform their own inspection when a citizen complaint is lodged or a referral is made by local government. Many of the local entities reported that their staff were routinely monitoring projects during the construction phase to ensure compliance with state or local requirements. However, most entities were not routinely performing post construction inspections (other than a final "as built" inspection), or requiring that the responsible entity perform regular inspections, of stormwater management facilities. Inspections and any resulting repair or maintenance cost money and will rarely be performed unless mandated.

TABLE:7.1 **WEEKS BAY WATERSHED MANAGEMENT PLAN**
STORMWATER REGULATORY MATRIX LISTING REGULATORY REQUIREMENTS

	ADEM	Baldwin County	Fairhope	Daphne	Spanish Fort	Loxley	Robertsdale	Silverhill	Magnolia Springs	Summerdale	Foley
Construction Phase BMPs Requirements	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Design Standards	AL Handbook	AL Handbook	AL Handbook	AL Handbook	AL Handbook ALDOT Specifications	Loxley Regulations USDA Field Manual	USDA Field Manual	USDA Field Manual	AL Handbook	EPA	AL Handbook
Design Storm	2yr-24hr	Not Specified	Not Specified	2yr-24hr	10 yr	10 yr	25 yr	Not Specified	25yr -24hr	Not Specified	Not Specified
Site Size	>1 ac.	Any	All	$>1,000\ ft^2$	>1 ac.	1, 5,& 10 ac	>1 ac.	>1 ac	Not Specified	>1 ac	500 $feet^2$
Stabilization Time	Immediate	10 or 13 days	10 days	13 days	30 days	Not Specified	"minimized"	30 days	13 days	Not Specified	14 days
Site Inspections	I/month + 3/4" rain	Yes	City-Random; Contractor-Daily	Yes	Yes	No	No	No	No	No	City-Random / Contractor-"regular"
BMP Repair/Maint. Time	5 days	Not Specified	2 Days	2 Days	Not Specified	Not Specified	No	Not Specified	Not Specified	Not Specified	2 Days
Non-compliance Reporting	Yes	No	No	No	No	No	No	No	No	No	No
Buffer Requirement	Yes- 25'	No	20' / 30'	No	Yes, Unspecified Width	No	Yes-Unspecified Width	Yes-Unspecified Width	Yes - Varies	No	30'-Wetland / 50'-Waterway
Post Construction SW Mngt Requirements	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Stormwater Quality	No	No	Treat 1.8", 85% Capture, 80% TSS Removal	Yes	No	No	No	No	Yes	No	Yes- Treat First Flush (1")
Stormwater Quantity	No	Yes - Considers Timing	Yes - Considers Timing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Design Storm	N/A	2 - 100 yr	2 - 100 yr	2 - 100 yr	2 - 100 yr	20 yr	25 yr - 24hr	10 yr	2 - 100 yr - 24hr	100 yr	2 - 100 yr
Site Size	N/A	Any	All Subdivisions	Any	Non-SF Developments: > 1 ac. SF Developments: 5 ac. Any Subdivision.	1, 5 & 10 ac	All Subdivision, Commercial, Industrial	Commercial, Industrial, Residential Subdivisions	Not Specified	> Triplex SF, Commercial, Industrial	500 $feet^2$
Routine Inspection	N/A	No	1/ 3 yr	1 / 5 yr	No	No	No	No	1 per 3 yr / 1 per 2 yr	No	Annual
Maintenance	N/A	Developer Owner	Developer/Landowner	Developer Trustee	Developer/Owner Assoc.	Developer/Landowner	Developer/Owner	Developer/Landowner	Developer/Landowner	Developer/Owner	Owner
Reporting	N/A	No	Yes	Yes	No	N/A	No	No	No	No	No
Calculation Method	N/A	SCS	Rational <100 ac, SCS >100 ac	Rational or Modified Rational Method	<200 ac. Rational Method >200 ac. Regression Equations or SCS	Loxley Regulations USDA Field Manual	Rational </= 200 ac	SCS	Not Specified	Not Specified	Various
Coastal Area Resource Protection	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**No**	**No**	**No**	**Yes**	**No**	**Yes**
Wetland/Stream Buffer	25 ft.	N/A	Wetland-20'/30' Streams 50'-100' (by watershed)	Stream 50' Wetland 30'	15'-50'	N/A	No	N/A	30 feet	N/A	30'-Wetland / 50'-Waterway
Permit Requirement	Yes	N/A	Yes	USACOE	Yes	N/A	No	N/A	Yes	N/A	USACE/ADEM
Low Impact Development	**No**	**No**	**Yes**	**Yes**	**Yes**	**No**	**No**	**No**	**Yes**	**No**	**No**
Development Size	N/A	N/A	Not Specified	No	N/A	No	No	N/A	Not Specified	N/A	N/A
Impervious Cover	No	No	Optional	No	N/A	No	No	N/A	Optional	N/A	N/A
On-site Retention	No	No	Optional	No	N/A	No	No	N/A	Optional	N/A	N/A
LID Standards	No	No	Not Specified	Yes	N/A	No	No	N/A	85% Treatment - 80% TSS Removal	N/A	N/A
Impediments to LID	N/A	N/A	No	No	N/A	No	No	N/A	No	N/A	N/A
Shoreline Stabilization	**Yes**	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**Yes**	**No**	**Yes**
Piers and Bulkheads	Yes	N/A	N/A	USACE, ADCNR ADEM Verification	N/A	No	No	N/A	Yes	N/A	Yes
Living Shorlines	No	N/A	N/A	USACE, ADCNR ADEM Verification	N/A	No	No	N/A	Not Specified	N/A	No
MS4 Permit Coverage	**N/A**	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**No**	**No**	**No**	**No**	**No**

* *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* , September 2014

Foot Notes:

1 ADEM Construction Stormwater NPDES GP ALR10 effective April 1, 2016
2 ADEM CBMPP Guidance issued February 2012
3 Baldwin County Zoning Ordinances, Section XIII, amended May 17, 2016 (Applicable only to zoned areas of County)
4 Baldwin County Subdivision Regulations, May 19, 2015 (Applicable County wide)
5 City of Daphne Ordinance No. 2014-14, CBMPP Ordinance April 21, 2014 (Applicable to SF residential)
6 City of Daphne Land Use and Development Ordinance, July 18, 2011 (Applicable to commercial developments and subdivisions)
7 City of Spanish Fort Zoning Ordinance, Article VIII, May 31, 1996
8 City of Spanish Fort Subdivision Regulations, February 8, 2016
9 City of Fairhope Subdivision Regulations, March 8, 2007
10 City of Fairhope Code of Ordinance Chapter 7 Article VII (Erosion and Sediment Control Ordinance 1398), September 23, 1996
11 City of Fairhope Code of Ordinance Chapter 7 Article IX (Wetland Ordinance 1370), October 13, 2008
12 Regulation/Ordinance indicates that permitting authority may do inspections but frequency is not indicated - no requirement for self-monitoring/reporting
13 ADEM Administrative Code R. 335-8, May 8, 2013 (Coastal Program)
14 The Town of Summerdale, Alabama Zoning Ordinance July 13, 2000 revised through April 9, 2012
15 City of Robertsdale - Land Use Ordinance, January 23, 2012
16 USDA Soil Conservation Service - National Engineering Field Manual for Conservation Practices, January 2012
17 Town of Loxley Zoning Ordinance, August 9, 2004 as amended through July 14, 2014
18 Town of Loxley Subdivision Regulations, July 8, 1991 as amended through April 13, 2009
19 Town of Magnolia Springs Zoning Ordinance (No. 2010-06), June 22, 2010
20 Town of Magnolia Springs Subdivision Regulations, August 23, 2007 as amended January 12, 2012
21 Zoning Ordinance of the Town of Silverhill, Alabama. January 17, 2000
22 City of Foley Code of Ordinance Chapter 6.5 Article III (Erosion and Sediment Control Ordinance 15-1003) March 16, 2015
23 City of Foley Code of Ordinance Chapter 4 Article IV (Manual for Design and Construction Standards Ordinance 1008-07) October 1, 2007 (proposed update pending)
24 City of Foley Code of Ordinance Chapter 4 Article VIII (Shoreline Construction Activity Ordinance 1024-08) January 21, 2008
25 Town of Summerdale Building Code Ordinance 521-13, March 11, 2013

TABLE 7.2 **WEEKS BAY WATERSHED MANAGEMENT PLAN**

STORMWATER REGULATORY MATRIX LISTING SPECIFIC REGULATORY CITATIONS

	ADEM	ADEM Citations	Baldwin County	Baldwin County Citations	Fairhope	Fairhope Citations	Daphne
Construction Phase BMPs Requirements	**Yes**		**Yes**		**Yes**		**Yes**
Design Standards	AL Handbook*	1 @ Part III.A.14.(a)	AL Handbook	3 @ 13.12.4	AL Handbook	9 @ 5.F.6.k & 10 @ 7-158	AL Handbook
Design Storm	2yr-24hr	1 @ Part III.A.14.(b)	Not Specified	n/a	Not Specified	N/A	2yr-24hr
Site Size	>1 ac	1 @ Part I.A	Any[10]	3 @ 13.12.7	All	10 @ 7-155	>1,000 ft^2
Stabilization Time	Immediate	1 @ Part III.C	10 or 13 days	3 @ 13.12.5(f)-(l)	10 days	10 @ 7-158.b.1	13 days
Site Inspections	I/month + 3/4" rain	1 @ Part III.H	Yes[12]	4 @ 5.13.2(b)	City-Random; Contractor-Daily	10 @ 7-159.a & 7-159.b	Yes[12]
BMP Repair/Maint. Time	5 days	1 @ Part III.I	Not Specified[9]	N/A	2 days	10 @ 7-160.c	48 hours
Non-compliance Reporting	Yes	1 @ Part IV.J	No	N/A	No	N/A	No
Buffer Requirement	Yes- 25'	1 @ Part III.B	No	N/A	20' / 30'	11 @ 7-196 / 9 @ 5.F.4	No
Post Construction SW Mngt Requirements	**No**		**Yes**		**Yes**		**Yes**
SW Quality	No	N/A	No	N/A	Treat 1.8", 85% Capture, 80% TSS Removal	9 @ 5.F.8	Yes
SW Quantity	No	N/A	Yes	4 @ 5.12.2	Yes - Considers Timing	9 @ 5.F.7	Yes
Design Storm	N/A	N/A	2 thru 100 yr	4 @ 5.12.2	2 through 100 yr	9 @ 5.F.7.a	2 through 100 yr
Site Size	N/A	N/A	Any [except SF Residence]	4 @ 5.12.1	All Subdivisions	9 @ 5.F.3	Any
Routine Inspection	N/A	No	1 / 5 yr	No	No	N/A	1/ 3 yr
Maintenance	N/A	N/A	Developer/Owners	4 @ 5.12.4	Developer/Landowner	9 @ 5.F.7.b	Developer/Trustee
Reporting	N/A	N/A	No	N/A	Yes	9 @ 5.F.3.a(3)	Yes
Calculation Method	N/A	N/A	SCS	4 @ 5.12.2(d)	Rational <100 ac, SCS >100 ac	9 @ 5.F.5.b	Rational or Modified Rational Method
Coastal Area Resource Protection	**Yes**		**No**		**Yes**		**Yes**
Wetland/Stream Buffer	Yes[13] / 25 ft.[1]	13 @ 335-8-2-.02 1@ Part III.B	N/A	N/A	Wetland-20'/30', streams 50'-100' (varies by watershed)	11 @ 7-196 / 9 @ 5.F.4	Stream 50' / Wetland 30'
Permit Requirement	Yes[13, coastal area]	13 @ 335-8-2-.02	N/A	N/A	Yes	11 @ 7-196	USACOE
Low Impact Development	**No**		**No**		**Yes**		**Yes**
Development Size	N/A	N/A	N/A	N/A	Unspecified	9 @ 5.F.11.b	No
Impervious Cover	No	N/A	No	N/A	Option		No
On-site Retention	No	N/A	No	N/A	Option		No
LID Standards	No	N/A	No	N/A	Not Specified	N/A	Yes
Impediments to LID	N/A	N/A	N/A	N/A	No	N/A	No
Shoreline Stabilization	**Yes[13, coastal area]**		**No**		**No**		**No**
Piers and Bulkheads	Yes[13, coastal area]	13 @ 335-8-2-.05 and.06	N/A	N/A	N/A	N/A	USACE, ADCNR ADEM Verification
Living Shorlines	No	No	N/A	N/A	N/A	N/A	USACE, ADCNR ADEM Verification
MS4 Permit Coverage	**N/A**	**N/A**	**Yes**	**ALR040042**	**Yes**	**ALR040040**	**Yes**

* *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* , September 2014

	Robertsdale	Robertsdale Citations	Silverhill	Silverhill Citations	Magnolia Springs	Magnolia Springs Citations
Construction Phase BMPs Requirements	**Yes**		**Yes**		**Yes**	
Design Standards	USDA Field Manual[16]	15 @ 15.2 B.8	USDA Field Manual	21 @ Article IX §9.3	AL Handbook	20 @ 5.8.3(i) / 19 @ 6.E.8
Design Storm	25 yr.	15 @ 15.2 B.8	Not Specified	N/A	25-yr-24hr	20 @ 5.8.3(d)
Site Size	>1 ac.	15 @ 15.2 C	>1 ac	21 @ Article IX §9.3	unspecified	N/A
Stabilization Time	"minimized"	15 @ 15.2 B.3	30 days	21 @ Article IX §9.3.6.1(b)+(c)	13 days	20 @ 5.8.2(c) / 19 @ 6.E.8
Site Inspections	No	N/A	No	N/A	No	N/A
BMP Repair/Maint. Time	No	N/A	Not Specified	N/A	unspecified	N/A
Non-compliance Reporting	No	N/A	No	N/A	No	N/A
Buffer Requirement	Yes-unspecified	15 @ 15.2 B.7.a	Yes-Unspecified	21 @ Article IX §9.3.6.1(a)	Yes - Varies	20 @ 5.9.9(b)
Post Construction SW Mngt Requirements	**Yes**	**15 @ 7.4**	**Yes**		**Yes**	
SW Quality	No	N/A	No	N/A	Yes	20 @ 5.9.4(i)
SW Quantity	Yes	15 @ 15.3 B.9	Yes	21 @ Article IX §9.3.8.2	Yes	20 @ 5.9.4
Design Storm	25yr - 24hr	15 @ 15.3 B.9	10 yr	21 @ Article IX §9.3.7	2 through100yr - 24hr	20 @ 5.9.4(h)(5) / 19 @ 6.E.3.b
Site Size	All Subdivision, Commercial, Industrial	15 @ 15.1.D	Commercial, Industrial, Residential Subdivisions	21 @ Article IX §9.3.8.1(a)	Unspecified	N/A
Routine Inspection	No	N/A	No	N/A	1 per 3yr / 1 per 2 yr	19 @ 6.E.7a
Maintenance	Development Entity/Owner	15 @ 15.2 B.11 & 15.3.D	Developer/Landowner	21 @ Article IX §9.3.9	Developer/Landowner	20 @ 5.9.8(b) & 19 @ 6.E.7a
Reporting	No	N/A	No	N/A	No	N/A
Calculation Method	Rational up to 200ac	15 @ 15.1.J	SCS	21 @ Article IX §9.3.7	Appropriate Method	20 @ 5.9.4(c)
Coastal Area Resource Protection	**No**		**No**		**Yes**	
Wetland/Stream Buffer	No	N/A	N/A	N/A	30 feet	20 @ 5.2.2
Permit Requirement	No	N/A	N/A	N/A	Yes	20 @ 6.E.9
Low Impact Development	**No**		**No**		**Yes**	20 @ 5.9.4(i)(2)(a) & 19 @ 6.B.3
Development Size	No	N/A	N/A	N/A	Unspecified	N/A
Impervious Cover	No	N/A	N/A	N/A	Optional	
On-site Retention	No	N/A	N/A	N/A	Optional	
LID Standards	No	N/A	N/A	N/A	85% Treatment - 80%TSS	20 @ 5.9.4(i)(1)-(2)
Impediments to LID	No	N/A	N/A	N/A	No	N/A
Shoreline Stabilization	**No**		**No**		**Yes**	
Piers and Bulkheads	No	N/A	N/A	N/A	Yes	19 @ 4.F
Living Shorlines	No	N/A	N/A	N/A	Not specified	N/A
MS4 Permit Coverage	**No**	**No**	**No**	**N/A**	**N/A**	**N/A**

* *Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas* , September 2014

Foot Notes:

1 ADEM Construction Stormwater NPDES GP ALR10 effective April 1, 2016
2 ADEM CBMPP Guidance issued February 2012
3 Baldwin County Zoning Ordinances, Section XIII, amended May 17, 2016 (Applicable only to zoned areas of County)
4 Baldwin County Subdivision Regulations, May 19, 2015 (Applicable County wide)
5 City of Daphne Ordinance No. 2014-14, CBMPP Ordinance April 21, 2014 (Applicable to SF residential)
6 City of Daphne Land Use and Development Ordinance, July 18, 2011 (Applicable to commercial developments and subdivisions)
7 City of Spanish Fort Zoning Ordinance, Article VIII, May 31, 1996
8 City of Spanish Fort Subdivision Regulations, February 8, 2016
9 City of Fairhope Subdivision Regulations, March 8, 2007
10 City of Fairhope Code of Ordinance Chapter 7 Article VII (Erosion and Sediment Control Ordinance 1398), September 23, 1996
11 City of Fairhope Code of Ordinance Chapter 7 Article IX (Wetland Ordinance 1370), October 13, 2008
12 Regulation/Ordinance indicates that permitting authority may do inspections but frequency is not indicated - no requirement for self-monitoring/reporting
13 ADEM Administrative Code R. 335-8, May 8, 2013 (Coastal Program)
14 The Town of Summerdale, Alabama Zoning Ordinance July 13, 2000 revised through April 9, 2012
15 City of Robertsdale - Land Use Ordinance, January 23, 2012
16 USDA Soil Conservation Service - National Engineering Field Manual for Conservation Practices, January 2012
17 Town of Loxley Zoning Ordinance, August 9, 2004 as amended through July 14, 2014
18 Town of Loxley Subdivision Regulations, July 8, 1991 as amended through April 13, 2009
19 Town of Magnolia Springs Zoning Ordinance (No. 2010-06), June 22, 2010
20 Town of Magnolia Springs Subdivision Regulations, August 23, 2007 as amended January 12, 2012
21 Zoning Ordinance of the Town of Silverhill, Alabama. January 17, 2000
22 City of Foley Code of Ordinance Chapter 6.5 Article III (Erosion and Sediment Control Ordinance 15-1003) March 16, 2015
23 City of Foley Code of Ordinance Chapter 4 Article IV (Manual for Design and Construction Standards Ordinance 1008-07) October 1, 2007 (proposed update pending)
24 City of Foley Code of Ordinance Chapter 4 Article VIII (Shoreline Construction Activity Ordinance 1024-08) January 21, 2008
25 Town of Summerdale Building Code Ordinance 521-13, March 11, 2013

Daphne Citations	Spanish Fort	Spanish Fort Citations	Loxley	Loxley Citations
Yes	**Yes**		**Yes**	
6 @ Article 18-6E & 5 @ Section VI-2	AL Handbook/ALDOT Specifications	8 @ VI.F.1.d	Loxley Regulations/USDA Field Manual	18 @ 5.3 (D) 7
6 @ Article 18-6E & 5 @Section VI-2	10-year	7 @ 8.62	10 yr	18 @ 5.3 (D) 7
5 @ Section VI-1	>1 acre	7 @ 8.613	1, 5,& 10 ac	18 @ 5.3 (D) 8
6 @ Article 18-6F1 & 5 @ Section VII-10	30 days	7 @ 8.613	Not Specified	N/A
6 @Article 18-6L1-6 & 5 @ Section VIII1-2	Yes[12]	7 @ 8.9	No	N/A
6 @ Article 18-6M(4)I & 5 @ Section VIII1-2	Not Specified	N/A	Not Specified	N/A
No	No	N/A	No	N/A
N/A	Yes, unspecified width	7 @ 8.611	No	N/A
	Yes		**Yes**	
6 @ Article 18-4B	No	N/A	No	N/A
6 @ Article 18-4B	Yes	8 @ V.F.1.n	Yes	N/A
6 @ Article 18-4B(2)iv	2 thru 100 yr	8 @ V.F.1.n	20 yr	18 @ 5.3 (B)
6 @ Article 18-4B(2)ii	Non-SF Developments: > 1 acre SFDevelopments: 5 acres Any subdivision.	7 @ 8.711 and 8 @ V.F.1.a	1, 5 & 10 ac	18 @ 5.3 (D) 8
No	No	1 per 3 yr / 1 per 2 yr	No	N/A
6 @ Article 18-5C	Developer/Owner Assoc.	7 @ 5.6 and 8 @ VI.F.8	Developer/Landowner	18 @ 2.1 5.3 (D) 13
6 @ Article 18-5C	No	N/A	N/A	N/A
6 @ Article 18	<200 acres: Rational Method >200 acres: Regression Equations or SCS	8 @ V.F.3.a	Loxley Regulations/USDA Field Manual	18 @ 5.3 (D) 7
6 @ Appendix 0	**Yes**		**No**	
6 @ Article 18-3D	15'-50'	8 @ V.C.9-10	N/A	N/A
N/A	Yes	7 @ 9.16	N/A	N/A
	Yes	**8 @ V.G**	**No**	
N/A	N/A	N/A	No	N/A
N/A	N/A	N/A	No	N/A
N/A	N/A	N/A	No	N/A
6 @ Article 20	N/A	N/A	No	N/A
N/A	N/A	N/A	No	N/A
	No		**No**	
	N/A	N/A	No	N/A
	N/A	N/A	No	N/A
ALR040039	**Yes**	**ALR040041**	**No**	**N/A**

Summerdale	Summerdale Citations	Foley	Foley Citations
Yes		**Yes**	
EPA	25 @ Sec. 4.L	AL Handbook	22 @ 6.5-58
Not Specified	N/A	Not Specified	N/A
>1 ac	25 @ Sec.8.Other.F	500 square feet	22 @ 6.5-55
Not Specified	N/A	14 days	22 @ 6.5-58(2)a
No	N/A	City-Random / Contractor-"regular"	22 @ 6.5-59(a) / (b)
Not Specified	N/A	2 days	22 @ 6.5-64(b)
No	N/A	No	N/A
No	N/A	30'-wetland / 50'-waterway	23 @ Div 2 Sec.4-112(1)(b) / (3)(b)
Yes		**Yes**	
No	N/A	Yes- Treat first flush (1")	23 @ Div.3 Sec. 4-123(6)(b)
Yes	14 @ Artilce IX 907.1	Yes	
100 yr	14 @ Article IV 403.b	2-100 yr	23 @ Div. 3 Sec. 4-123(6)(d)
> Triplex SF, Commercial, Industrial	N/A	500 square feet	22 @ 6.5-55
No	N/A	Annual by City	N/A
Developer/Owner	25 @ Sec. 4.I	Owner	23 @ Div.3 Sec.4-124(c)
No	N/A	No	N/A
Not Specified	N/A	Various	23 @ Div.3 Sec.4-123(1)
No		**Yes**	
N/A	N/A	30'-wetland / 50'-waterway	23 @ Div 2 Sec.4-112(1)(b) / (3)(b)
USACOE/ADEM	25 @ Sec.8.Other.F	USACOE/ADEM	N/A
No		**No**	
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
No		**Yes**	
N/A	N/A	Yes	24 @ Sec.4-226
N/A	N/A	No	N/A
No	**N/A**	**No**	**N/A**

8.0 Financing Alternatives

8.1 Introduction

Funding projects and activities throughout an entire watershed is not a simple undertaking. Successful implementation of the management measures recommended in this Watershed Management Plan will require the long-term commitment of significant financial resources and community support. The design, construction, and maintenance of stormwater improvements; implementation of water quality improvements (e.g., pathogens, nutrients, sediment); purchase of strategic land tracts for preservation; protection/restoration of shorelines to reduce erosion; and the establishment of an inter-governmental coordination mechanism (to improve communication between the nine municipalities and the county) will require significant and reliable funding. Because the jurisdictional areas of political entities that might provide funding do not follow or encompass the Watershed boundaries, a public-private partnership may be the most effective way to accomplish management goals. Successful implementation of local watershed management efforts requires adequate program funding. However, funding water quality improvements on a watershed basis is a challenging endeavor. There are a variety of different resources to consider for the Weeks Bay WMP, including federal, state, local funding sources, as well as public-private partnerships.

To acquire the funding necessary to undertake significant restoration, preservation, and/or management projects, political and private entities will have to consider and compare all available funding options. Many financial assistance opportunities, primarily in the form of federal grants and cooperative agreements, are available to help restore, enhance, and preserve the Weeks Bay Watershed. However, increases in watershed recovery efforts by communities around the nation have substantially increased competition for these resources.

A watershed approach to design, construct, and maintain stormwater improvements will require a significant and steady stream of funding. Municipalities and other political subdivisions should consider and compare various funding options for stormwater management, such as the creation of a stormwater utility authority and/or public-private partnerships.

There are a number of different financial structures that could facilitate funding for the projects identified in this WMP. Some structures could be helpful across the entire Watershed and some within limited areas. Many would require public-private partnerships in the sense of cooperation among landowners and governments or civic/non-profit groups and governments, rather than being imposed by governmental entities.

Alternatives for funding and financing stormwater improvements in the Weeks Bay Watershed are discussed based on the type of funding source: state, federal, private, or private-public partnerships.

8.2 Funding and Regional Planning

Multi-organization partnerships are an important funding strategy for this WMP. It is an effective way to incorporate stakeholders across all sectors to ensure efforts are not duplicated. A structure is typically needed to guide multi-stakeholder watershed initiatives. Therefore, it is recommended that an organizational framework include a centralized infrastructure, a dedicated staff, and a structured process that leads to common goals, such as could be led by the WMP Implementation Team (WMPIT) recommended in Section 6.1. The Baldwin County Soil and Water Conservation District has expressed an interest in leading an effort to establish a publicly funded position for a Weeks Bay Watershed Coordinator who would spearhead such an organization framework. Creating a cooperative approach would allow for nonprofits, governments, business, and the public to come together to collaborate on the many serious and complex issues.

While implementing the financial process for the WMP, the following principals are an essential guidance to the formation of a support organization. In order to do so, certain conditions must be met: (1) shared measurement system, (2) mutually reinforcing activities, (3) continuous communication, (4) backbone support organizations, and (5) common agenda (Kania and Kramer 2011). Implementation committees should strive to achieve actions that target water quality and involve a diverse group of local and regional partners. A shared measurement system would involve collecting data and measuring results consistently across all participants to ensure efforts remain aligned and participants hold each other accountable. Participant activities must be differentiated while still being coordinated through a mutually reinforcing plan of action. Consistent and open communication among Watershed stakeholders is necessary to build trust and ensure mutual objectives and common motivation. Organizing and managing collective impact requires a separate organization or organizations with a specific set of skills to serve as the backbone for Watershed-wide, multi-scale initiatives and inter-agency cooperation.

The following entities should be considered in the financial planning and implementation process (Table 8.1).

Table 8.1 Potential Financial Supporters for WBWMP Implementation Process

Baldwin County Soil and Water Conservation District	US Environmental Protection Agency
Mobile Bay National Estuary Program	USDA, Natural Resource Conservation Service
Weeks Bay National Estuarine Research Reserve	USDA, Forest Service
City of Fairhope	US Fish and Wildlife Service
City of Daphne	US Geological Survey
City of Spanish Fort	US Army Corps of Engineers
Town of Loxley	Baldwin County Sewer Service
City of Robertsdale	Baldwin County-Alabama Cooperative Extension
Town of Silverhill	Riviera Utilities
Town of Summerdale	Alabama Power Company
City of Foley	Weeks Bay Foundation
Town of Magnolia Springs	National Fish and Wildlife Foundation
Baldwin County Commission	Dauphin Island Sea Lab
Baldwin County Health Department	Auburn University Marine Extension and Research Center
Baldwin County Public Schools	Alabama Water Watch
Alabama Department of Environmental Management	Mobile Baykeeper
Alabama Department of Conservation and Natural Resources	The Nature Conservancy
Alabama Department of Public Health	University of South Alabama
Geological Survey of Alabama	Alabama Coastal Foundation
Alabama Forestry Commission	Alabama Wildlife Federation
Alabama Department of Transportation	Alabama Forest Resources Center
National Oceanic and Atmospheric Administration	Pelican Coast Conservancy
Gulf Coast Ecosystem Restoration Council	US National Park Service
National Science Foundation	Southeastern South Aquatic Resources Partnership

8.3 Financial Strategy

8.3.1 Federal Funding Programs

The United States Federal government provides numerous sources of grants, loans, and revenue sharing that may be used by municipalities and non-profit groups to conduct studies and construct projects related to watershed protection, stream restoration, and stormwater management. The U.S. Environmental Protection Agency (USEPA) distributes grant money to state and local governments to support collaborative partnerships to protect and restore the nation's water resources. USEPA also provides financial support for non-point source and pollution control measures, including Section 319 (non-point source management) and Section 106 (water pollution control). A number of other programs funded by USEPA help with environmental education, habitat restoration, coastal resilience, and water quality improvements.

NOAA (National Oceanic and Atmospheric Administration) is another federal agency that provides funding opportunities for coastal management and marine ecosystems. Litter reduction and clean up has been a continuous effort in the Weeks Bay Watershed. NOAA provides grants that can support litter reduction efforts, mainly the Community-based Marine Debris Removal Program grant and the Marine Debris Preventions, Education and Outreach grant. The Community-based Restoration Program leverages local resources and promotes community involvement in habitat restoration activities. NOAA funding opportunities are suitable for all aspects of the Weeks Bay Watershed.

The Department of the Interior funds a number of conservation initiatives through USFWS (United States Fish and Wildlife Service). Many wildlife and fisheries habitat grants could support actions recommended in the WMP to implement habitat protection in Weeks Bay. Among the many USFWS programs, the Coastal Program is the most beneficial funding alternative to protecting fish and wildlife habitat in priority coastal areas. The USFWS Boating Infrastructure Grant program is an example of a federal program that could provide ADCNR maintenance funding to improve the quality of boat landing, pier and other public-access related facilities within each watershed.

In addition, other federal agencies have programs and funding available for planning and implementation of watershed management activities, e.g., cooperative stream flow/WQ monitoring by the U.S. Geological Survey, ecosystem restoration programs by the U.S. Army Corps of Engineers, etc.

The Baldwin County Soil and Water Conservation District office in Bay Minette cooperatively coordinates federally funded programs beneficial to rural producers and riparian landowners in the Watershed. 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). The U.S. Department of Agriculture financial resources provide applicants with financial assistance to address erosion control, soil quality, grazing lands, forestry/wildlife health, and irrigation water management and invasive species control. The Baldwin County District Conservationist works with agricultural producers to determine specific qualifications and the level of financial assistance available within each program.

8.3.2 State Funding Programs

The Alabama Coastal Area Management Program (ACAMP) was approved by NOAA in 1979 as part of the National Coastal Zone Management Program. Its purpose is to balance economic growth with the need for preservation of Alabama’s coastal resources for future generations. Annual program activities include coastal cleanup, implementation of public access construction projects, planning support for local governments, and providing funds to Alabama’s coastal communities and partners. ACAMP’s annual grant program supports projects that protect, enhance, and improve the management of natural, cultural, and historical coastal resources and that increase the sustainability, resiliency and preparedness of coastal communities and economies. Therefore, ACAMP should be considered as a top financial resource on the state level. The Clean Water State Revolving Fund (CWSRF) is another program that should be considered for stormwater/nonpoint source projects. The CWSRF is a loan assistance authority for water quality improvement projects. For example, implementation committees might consider financing streambank restoration and buffer projects by using an SRF loan.

8.3.3 Local Government

The Thompson Team recommends that the local government sector of the Weeks Bay WMP Implementation Team include: the municipalities of Fairhope, Daphne, Spanish Fort, Loxley, Robertsdale, Silverhill, Summerdale, Foley, and Magnolia Springs and Baldwin County. Of these ten governmental entities, we believe Baldwin County/Baldwin County Soil and Water Conservation District possesses both the greatest opportunity and best coordination capacity among authorities to successfully guide this inter-governmental team within this geographically and regulatory diverse Watershed.

8.3.4 Business and Industry

The Weeks Bay Watershed encompasses a highly diverse business and industry community spanning a large agricultural sector, plus manufacturing, retail, wholesale, industrial operations, technology, medicine, utilities, maritime industries, and residential and commercial development. Each and every one of these commercial interests has an economic stake in the health of the Watershed and will directly benefit from its recovery or suffer from its decline. To help lead the involvement of this expansive community of stakeholders, the Thompson Team recommends leveraging the organization and leadership capacity of the Chambers of Commerce in the Watershed, particularly the Eastern Shore Chamber. The Chambers have a long and impressive record of success in facilitating the business partnerships needed to help Baldwin County's growth and competitiveness, which it has achieved through the continued innovation and focus of its membership.

8.3.5 Potential Funding Sources

The Resources and Ecosystems Sustainability, Tourist Opportunities and Revived Economies (RESTORE) Act, National Fish and Wildlife Foundation's (NFWF) Gulf Environmental Benefit Fund, and the Gulf of Mexico Energy Security Act (GOMESA) represent some of the most promising and challenging of these opportunities for this Watershed.

The RESTORE Act was signed into law on July 6, 2012, as part of the Moving Ahead for Progress in the 21st Century Act (Public Law 112-141). The legislation established a mechanism for providing funding to the Gulf region to restore ecosystems and rebuild local economies damaged by the Deepwater Horizon Oil Spill. The RESTORE Act established in the Treasury of the U.S. the Gulf Coast Restoration Trust Fund (Trust Fund), consisting of 80 percent of an amount equal to any administrative and civil penalties paid after the date of the RESTORE Act by the responsible parties in connection with the Deepwater Horizon Oil Spill to the U.S., pursuant to a court order, negotiated settlement, or other instrument in accordance with Section 311 of the Federal Water Pollution Control Act (FWPCA, 33 U.S.C. 1321).

The RESTORE Act divides the funds into five separate allocations and sets the parameters for how the funds are to be spent in each:

1. Thirty-five percent of the funds are divided equally among the five Gulf Coast states for ecological and economic restoration. Eligible activities include: restoration and protection of natural resources; mitigation of damage to natural resources; work force development and job creation; improvements to state parks; infrastructure projects, including ports; coastal flood protection; and promotion of tourism and Gulf seafood.
2. Thirty percent of the funds will be administered for restoration and protection according to the comprehensive plan developed by the Gulf Coast Ecosystem Restoration Council.
3. Thirty percent of the funds are dedicated to the Gulf Coast states based on a formula. This formula will be based on the number of miles of shoreline that experienced oiling, the distance from the Deepwater Horizon mobile drilling unit at the time of the explosion, and the average population as of the 2010 Census. Each state is required to have a Council-approved plan in place for use of these funds.
4. Two-and-a-half percent of the funds are dedicated to the Gulf Coast Ecosystem Restoration Science, Observation, Monitoring and Technology Program, which will be established by NOAA for marine and estuarine research, ecosystem monitoring and ocean observation, data collection and stock assessments, and cooperative research.
5. Two-and-a-half percent of the funds are dedicated to the Centers of Excellence Research Grants Program. The funding is distributed through the states to nongovernmental entities to establish Centers of Excellence that will focus on the following disciplines: coastal and deltaic sustainability; restoration and protection; fisheries and wildlife ecosystem research and monitoring; offshore energy development; sustainable and resilient growth; and comprehensive observation, monitoring, and mapping in the Gulf.

Private foundations and corporations may be another source of funding for improvements in the Weeks Bay Watershed. The NFWF provides various grants when working with partners to implement watershed restoration measures. NFWF is an independent nonprofit organization that works with both the public and private sectors to protect and restore our nation’s fish, wildlife, plants and habitats. WMP implementation has already been funded by NFWF throughout Baldwin County through the Gulf Environmental Benefit Fund.

As a part of NFWF, the Five Star Urban Waters Restoration Program seeks to develop nation-wide-community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. The Gulf Coast Conservation Grants Program, another NFWF program, supports conservation projects that enhance coastal habitats of the Gulf of Mexico and sustain fish and wildlife populations, while strengthening resilience within the coastal region. These NFWF grants provide invaluable opportunities to develop and enhance conservation partnerships in the Weeks Bay Watershed.

8.3.6 Stormwater Programs

According to the USEPA, the most stable source of funding for stormwater management is the stormwater utility. Stormwater utility fees typically provide the most equitable and transparent source of funding for stormwater management. A stormwater utility would provide a stable, predictable, long-term funding mechanism dedicated to stormwater improvements. The stormwater utility could undertake planning and construction programs to enable resolution of chronic problems. Sustainable revenues would be generated based on consumption and user fee-based services.

Although stormwater utility authorities are used extensively in many areas of the country, the authority to create a local stormwater utility in Alabama must be granted by legislative statute. To study, establish, and begin operating a stormwater utility authority could potentially take years. Among the many issues to be considered in creating a stormwater utility are fee (rate) methodologies, billing and/ or collection mechanisms, credits and surcharges, and fee exemptions.

The stormwater user fee typically appears as a separate line item on residential or commercial water and/or sewer bills, as a special assessment on property tax bills, or on a stand-alone bill. This makes these fees highly-visible to the general public. The concept of stormwater management is difficult for the average citizen to grasp, resulting in skepticism about the need for stormwater user fees. The user fee is often seen as a tax, which can be subject to legal challenges. Local stormwater ordinances must be carefully crafted to avoid or prevent such challenges.

Stormwater user fees can be based on parcel size and/or the impervious areas within the parcel. Fees for residential and commercial properties may be calculated differently (e.g., a fixed fee for each residential parcel versus a fee based on the amount of impervious area for commercial parcels). Credits may be allowed for on-site attenuation and/or treatment of stormwater or for watershed stewardship activities and surcharges may be added for the type of land use or industrial activity present on the site. Stormwater fee collection is commonly enforced by utility shutoff or by tax liens on the owner's property. Most stormwater utilities allow exemptions for certain categories of property. Streets/highways, undeveloped land, and railroad rights-of-ways are typically exempt from paying stormwater user fees.

About seven years ago, realizing the ever increasing need for better stormwater management, the Baldwin County Watershed Coalition (BCWC) formed as a result of collaboration among municipal and county representatives (comprised of both staff and elected officials), representatives of local environmental organizations, state legislators, and representatives of local business and development interests. BCWC proposed a stormwater referendum to address the water quality and drainage issues. As a result, residents strongly opposed the new plan and therefore, referred to it as the “rain-tax” plan. Despite the backlash, the growing need for watershed-scale stormwater management is still a concern. Stormwater drain fees, property taxes, general funds, and special assessment districts are a few examples of regional funding methods that have financed stormwater initiatives in other areas of the country. These options should be considered as alternatives for financing regional stormwater programs in Baldwin County.

Table 8.2 lists an overview of financial resources that could support implementing the recommendations included in the Watershed Management Plan. Funding categories are represented as: (1) financial assistance, (2) technical assistance, (3) water quality monitoring, and (4) information and education.

Table 8.2 Funding Available to Support Plan Implementation

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
Gulf Coast Ecosystem Restoration Council	Council-Selected Restoration Component of the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE)	Federal	Financial 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

Table 8.2 Funding Available to Support Plan Implementation (continued)

Funding Source	Description	Type	Actions Funded
	FY2017 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 Park Service	National Maritime Heritage Grant	Federal	Financial assistance, information and education
National Science Foundation	Environmental Engineering R&D Grant	Federal	Technical assistance, water quality monitoring
Southeastern South Aquatic Resources Partnership	Aquatic Habitat Restoration Program	Federal	Financial assistance
U.S. Department of Agriculture, Natural Resource Conservation Service	Environmental Quality Incentives Program	Federal	Financial assistance, technical assistance, water quality monitoring
	Conservation Stewardship Program	Federal	Financial assistance, technical assistance
	Agricultural Conservation Easement Program	Federal	Financial assistance, technical assistance
U.S. Environmental Protection Agency	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
	State Water Protection Grants	Federal	Information and education, financial assistance, water quality monitoring
	Urban Waters Small Grants	Federal	Technical assistance, water quality monitoring
	Gulf of Mexico (and the Gulf of Mexico Program partnership Gulf Guardian Awards)	Federal	Financial assistance, water quality monitoring

Table 8.2 Funding Available to Support Plan Implementation (continued)

Funding Source	Description	Type	Actions Funded
U.S. Fish and Wildlife Service	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 Grants Program	Federal	Financial assistance
	Urban Wildlife Refuge Partnership	Federal	Financial assistance, information and education
	National Fish Habitat Action Plan	Federal	Technical assistance, financial assistance
Conservation Alabama Foundation	Watershed Management Plan Outreach Program	Private-public partnership	Information and education
United States 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
Cornell Douglas Foundation Grants	Cornell Douglas Foundation Grants	Private	Information and education, financial assistance
The Home Depot	Community Impact Grants Program	Private	Financial assistance

Table 8.2 Funding Available to Support Plan Implementation (continued)

Funding Source	Description	Type	Actions Funded
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
Royal Bank of Canada	Blue Water Project	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 Environmental	Private	Financial assistance, information and education
National Environmental Education Foundation	Everyday Capacity Building Grants	Private	Financial assistance, information and education
National Endowment for the Humanities	Common Heritage Grant Program	Private	Financial assistance, information and education
National Fish and Wildlife Foundation	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
National Fish and Wildlife Foundation	Five Star & Urban Waters Restoration Program	Private	Financial assistance, information and education, water quality monitoring
	Gulf Coast Conservation Grant Program	Private	Financial assistance

Additional information and website links are located in Appendix J. The financial arena is perpetually changing and the WMPIT should use the information provided as a guide when evaluating potential partners to involve in financing of the WMP implementation; however, the WMPIT must maintain flexibility to explore other funding opportunities as they come available.

8.4 Summary

There are considerable support opportunities to finance the management measures recommended by the Weeks Bay WMP. However, because the Weeks Bay Watershed falls within ten governmental jurisdictions (nine municipalities and the county), it lacks a central authority to administer many of the potential funding sources. Establishment of an inter-governmental partnership may provide additional funding options for Watershed management. Additionally, it clearly illustrates to funders the community's active resolve to serve as vested and committed partners in the Watershed management process. This endeavor would significantly enhance the viability of the Weeks Bay WMP and its competitiveness and position going forward as federal, state, local, and private grant assistance needed for implementation is pursued.

9.0 Community Outreach and Public Education

Community outreach and public education about the Weeks Bay Watershed has been and will continue to be the responsibility of the Weeks Bay Reserve and the Weeks Bay Foundation. According to OutdoorAlabama.com, "*education and training programs at Weeks Bay Reserve target K-12 students, teachers, university and college students and faculty, as well as coastal decision maker audiences. Components of our education program include school field trips, summer camps, teacher training programs, science-based workshops and seminars, community outreach, exhibits, and the production of curricular, informational and technical materials. All Reserve education, training, and outreach activities are designed to enhance public awareness of the importance of estuarine systems and provide opportunities for public education and interpretation.*" The current Weeks Bay NERR Management Plan which describes many of their outreach and education activities can be found on www.OutdoorAlabama.com.

Our focus in the development of the WMP was to respond to the key issues identified in the Workshop at the beginning of the project: The top issues were flooding and water quality caused by development and population growth exacerbated by the lack of a comprehensive, multi-jurisdictional stormwater management plan. The top recommendation on how to develop a stormwater management plan was to develop ways to continue discussions between stakeholders in order to address issues where multiple regulatory groups (cities, county, atate, federal) are involved.

We did this in two major ways. The first was to maintain a large (25-30 member) Stakeholder Work Group with members from the types of constituencies and interest groups in the Watershed. We recommend that this group stay engaged during the implementation phase of the WMP.

The second was to partner with the City of Foley to host monthly meetings with planning staff from the municipalities and the county. They were joined by others who are also concerned about growth in this, the fastest growing county in Alabama: school system, utilities, the South Alabama Regional Planning Commission (SARPC), and members of the Thompson Team.

The Eastern Shore Metropolitan Planning Organization (MPO) shared its growth forecasting methodology in the first meeting of this group (November 10, 2016). The planners agreed that when this plan is refreshed, the cities not in the MPO would like to also contribute in a way that we end up with a growth forecast for the whole county through 2045. The planners also agreed that there would be value to each of them if there were a GIS layer available on which each of them could share potential large projects like new subdivisions.

In the second meeting (January 11, 2017), we shared how we used this methodology to create a baseline growth forecast in the parts of the Watershed that are not in the MPO. In this meeting we also shared a matrix that compared building regulations for each municipality and the county. SARPC agreed to take this matrix back to those communities whose watershed-related regulations were the most out of date.

In the third meeting (February 22, 2017), the EPA offered to share interactive community planning software ("CHARM") with members of the planning community. The Weeks Bay NER said that they were drafting a response to a NOAA RFP to provide funding to evaluate stormwater retention/detention ponds. The planners agreed to provide input and support. SARPC reported that three of the municipalities were considering updating their building regulations and one of them had already contracted an engineering firm to draft up-to-date regulations.

In the fourth meeting (March 23, 2017), the Baldwin County School System shared their procedure for forecasting school facility needs across the county.

In the fifth meeting (May 2, 2017), the City of Foley shared their inventory and management recommendations for stormwater basins, as well as their new Low Impact Development regulations that will take effect in July.

In the sixth meeting (June 6, 2017), the Thompson Team discussed the proposed draft section of the Weeks Bay Watershed Management Plan dealing with recommendation for city and county regulations regarding environmental matters, e.g., stormwater management, wetlands, etc.

At the time of this writing, the planners have seen value in these frequent meetings and intend to continue meeting monthly.

Another key outreach has been with members of the agriculture community. Several members of the SWG are farmers and have shared with us that the farming technology has improved dramatically over the last 25 years. Even so, the effects of production of food and other agricultural products will continue to be seen in the Watershed.

The BCSWCD has agreed to take a leadership role with the agricultural community. This will likely use the same format as the planning community: Regular meetings with farmers to share low impact and productivity improvement practices and other topics of interest to the participants. In addition, the BCSWCD has approved a watershed coordinator position to provide oversight regarding the implementation of the WBWMP at their July 26, 2017 Board Meeting. This BCSWCD staff position should not overlap or conflict with the existing role of the WBNERR, MBNEP, or other staff positions in the municipalities or Baldwin County, or other state or federal agencies, but rather complement those positions. The establishment of a Weeks Bay Watershed Coordinator by the BCSWCD is vital to moving forward with plan implementation.

10.0 Monitoring

10.1 Introduction

Monitoring can be divided into two basic categories: administrative and environmental. Administrative monitoring consists of tracking program accomplishments, the degree to which management measures are implemented (number of acres where BMPs are applied, etc.) and other programmatic indicators. Environmental monitoring consists of direct measurement or tracking of various environmental indicators (water quality, wetland health, etc.) in an effort to detect changes or monitor long term environmental trends. Administrative monitoring is fairly straight forward and easily performed by those responsible for implementing the Watershed Management Plan. Environmental monitoring is more complex.

A monitoring program to track the efforts and success of this Watershed Management Plan (WMP) should be developed and pursed in a consistent fashion. The Monitoring Program should clearly define the relevant questions that need to be answered and be focused on assessing the implementation of recommended management measures and the success of those measures in accomplishing the goals and objectives stated in Section 5 of this WMP. Development of a Monitoring Program that complies with the specific grant requirements of Section 329i of the Clean Water Act is essential to the documenting the success of Plan implementation. The monitoring program should track the number of management measures that are implemented in each HUC 12 watershed and the degree to which they are implemented. Potential indicators would be such things as: acres of wetlands preserved; acres of wetlands restored, miles or acres of riparian buffer restored, acres treated for invasive plant removal, number of septic tanks inspected and serviced and/or taken out of service, number of alternative on-site sewage disposal systems installed, miles of livestock exclusion fencing installed, number and type of agricultural BMPs implemented, acres enrolled in NRCS conservation programs, number or miles of stream restoration, etc. Since this Plan identifies several areas where additional investigation is needed to identify pollutant sources in order to development appropriate management measures, the number of source identification studies or investigations conducted should also be tracked.

10.2 Monitoring Watershed Conditions

There are a number of different environmental indicators that can be monitored to determine the overall environmental conditions in a watershed and track environmental trends. In order for the indicators to be meaningful, they must be monitored in a consistent manner (protocols) and be in a format that is comparable to some accepted baseline condition. The measures of Watershed conditions can be quantitative and/or qualitative and be made by direct measurement (sampling) or through the use of remote sensing. Measures such as wetland health, riparian buffer health, presence of invasive species, or changes in streambank or shoreline morphology and changes in LULC are examples of environmental conditions that lend themselves to the use of remote sensing with limited ground truthing required and are often only apparent over relatively long time periods (years to decades).

- **Wetland and Riparian Buffer Assessment**: As discussed elsewhere in this Plan the condition of wetlands and riparian corridors within the Weeks Bay Watershed are significantly degraded in portions of the Watershed. Periodic condition surveys should be performed every five to ten years to monitor the condition of these valuable resources. These condition surveys will be based upon aerial photograph comparison with the baseline conditions as documented in this Watershed Management Plan. Due to the large size of the Watershed limited field checks will be included in the periodic monitoring of wetlands and riparian buffers.
- **Invasive Species Assessment**: Invasive species infestations are a common issue throughout the entire Weeks Bay Watershed, and compromise the overall health. Visual inspections of invasive species should be made during each monitoring activity. All sampling teams should be trained in the identification of each invasive species that are known to appear in the Watershed and be able to document in field notes and photographs.
- **Coastal Shoreline Assessment**: All coastal shorelines that are most vulnerable should be analyzed on an annual basis. There should be periodic, time-sequenced, geo-referenced, aerial photographs taken from the same location and orientation for each shoreline. These monitoring techniques will help identify shorelines that are continually eroding and help evaluate the success of current projects for coastal zones.
- **Impervious Cover**: A major indicator of watershed conditions is the percent of impervious cover. Remote sensing imagery and technology has been employed to measure and monitor changes in Impervious Cover (IC) over time. IC measurements should be targeted to occur at 5-year intervals consistent with the USGS National Land Cover Database updates (Homer, C.H. et al., 2012); however, the IC data must be processed and analyzed by GIS staff to determine the rate of change for these 5-year intervals. The resulting data should be reported in electronic map format, with accompanying attribute tables to facilitate future data interpretation and analysis. The electronic map format should be compatible with the Baldwin County GIS so that separate Impervious Cover data layers could be prepared for each period.
- **Stormwater Ponds**: Based on a desktop survey of aerial imagery (Google Earth™) approximately 260 stormwater ponds were identified within the Weeks Bay Watershed. A more detailed field assessment of the stormwater ponds should be undertaken to verify the GPS location of the outlet structure and status of maintenance. This monitoring could also identify candidates for retrofitting with measures to improve the water quality of stormwater leaving the facility. Following the field inventory/assessment the stormwater facilities should be monitored every 3-5 years by the appropriate municipality or the County.

Other environmental conditions, such as water quality, are usually monitored through direct sampling and on a more frequent basis. These parameters usually include conductivity, pH, temperature, pathogen loads, nitrogen, phosphorus, turbidity, and dissolved oxygen. In order to ensure comparability of monitoring data to existing State or Federal water quality standards, specific monitoring protocols and analytical methodologies should conform to current guidance from State (ADEM) and Federal (USEPA) authorities. The following Watershed conditions and analytical parameters should be routinely monitored:

- **Standard Field Parameters**: Standard procedure, when collecting water quality samples, should include a collection of *in situ* measurements necessary to interpret any analytical data. These are known as "field parameters" which are geochemical and physiochemical characteristics (abiotic factors) of water to be measured each time sampling is done. These parameters are well understood, there are existing water quality standards established for most of these parameters, and the underlying question to be answered by monitoring is: "Does the waterway meet the ADEM established water quality standard?" Dissolved oxygen, pH, specific conductivity (salinity), and water temperature are typical field parameters. Baseline data provided by routine monitoring of standard field parameters will aid in detection of future Watershed issues and long-term water quality trends. ADEM, in its SFTE study (GOMA, 2013), made the following recommendations relative to typical field parameters: Incorporate future monitoring with existing NERRS continuous monitoring effort. The existing long-term monitoring effort by NERRS offers an excellent opportunity for analyzing long-term dynamics of DO, salinity, and other environmental variables in the Weeks Bay system. Future monitoring should use existing data and provide a complementary effort to better characterize nutrient conditions in the bay.
- **Sediment Transport**: One of the primary areas of investigation and consideration in the Plan is sediment loading to the Rivers, tributaries and Weeks Bay. Although the SWAT model provides a useful means to estimate current and future loadings, actual measurements are more desirable to actually document long term trends and determined the effectiveness of sediment related management measures. Also monitoring is preferred to modelling because models do not accurately capture future changes of potential conservation practices, behavioral changes, new technological developments, which may all help reduce the fingerprint of urban developments, agriculture, etc. The underlying question to be answered by sediment monitoring is: "Are sediment loadings (TSS, turbidity and bedload) increasing, decreasing or remaining constant within the Watershed?" Continued monitoring of TSS and turbidity at the existing ADEM trend stations is recommended, along with several additional sites in the Fish and Magnolia River watersheds. A repetition of Cook's 2009 (Magnolia River) and 2016 (Fish River) studies, in whole or in part, or similar investigations are suggested at regular intervals (3-5 year) once management measures start being implemented.
- **Pathogens**: Pathogen loading has been a vital issue throughout the Weeks Bay Watershed. Pathogens have caused the Fish River to be the subject of ADEM's development of a Total Maximum Daily Load (TMDL) in 2013 as a result of this stream being listed on Alabama's 303(d) list for fecal coliform bacteria in 1998. For more on pathogens and the condition of the Watershed, refer to Section 3.0. The underlying question to be answered by pathogen monitoring is: "Are the waterways in compliance with the bacteriological standard for recreational use?" Pathogen monitoring to

determine a waterbody's status relative to the ADEM water quality standard is complicated by the fact that the majority of the Watershed loading is likely localized and occurs during and immediately following rainfall events. Maintaining the existing ADEM trend station sampling stations will help with tracking long term trends and periodic "sanitary surveys", with sampling performed consistent with ADEM's protocol for the Swimming classification (minimum of 5 samples within 30 days, with samples at least 24 hours apart), performed during the swimming season. However, to have a more robust and meaningful dataset, additional volunteer monitors should be recruited for *E.coli* monitoring, particularly in areas of high recreational use.

- **Nutrients**: Total dissolved nitrogen and total dissolved phosphorus concentrations should be included while monitoring for nutrients loading in the Watershed, additionally the species of nitrogen or phosphorus is also of interest. Monitoring for nutrients is significant when trying to pinpoint sources such as farms (fertilizer and livestock manure), lawns, or septic tank contributions, sewer overflows and point source outfalls. Nutrient loading has been identified as a significant water quality concern and baseline nutrient data are available to facilitate this monitoring. There is a need for long-term nutrient data to provide the basis for the development of nutrient water quality standards and to monitor trends in nutrient loading to both the streams and Weeks Bay. To properly monitor nitrogen and/or phosphorus, water samples need to be collected at known sampling locations and then analyzed using appropriate analytical methodology. Suggested nutrient analytical parameters include: Nitrate-Nitrite, TKN, TON, TP, TOC, CBOD, benthic macroinvertebrates and chlorophyll *a*. ADEM in its SFTE study (GOMA, 2103) makes the following monitoring recommendations relative to nutrient monitoring in Weeks Bay:

1. Incorporate future monitoring with existing NERRS study and insure data comparability. One of the best uses of the NERRS data set is to provide comparable chlorophyll *a* measurements at the same or similar locations. Also, future monitoring should provide additional monitoring that NERRS does not now offer, e.g., TKN, TP, TOC, or CBOD.
2. Monitoring should be conducted over multiple years to account for temporal variability, which appears far greater than spatial (within bay) variability. Longer term monitoring is needed to better capture that variability across the range of environmental gradients. At least 3 years of monitoring data are needed to provide better confidence in statistical assumptions.
3. Increase the frequency of biological monitoring. Because of the small size of Weeks Bay, it would be useful and informative to take future benthic samples from at least the four stations where NERRS is conducting continuous monitoring. This would target those sites for annual sampling over multiple years and would contribute to better understanding the nature and effects of nutrient input from the two principal freshwater inflows and from Mobile Bay proper.
4. Reduce the scale of the overall water quality monitoring effort from that used during the SFTE study. Freshwater streams were observed to have relatively

constant water quality conditions during the study period, and, thus, the measurement/sampling frequency for many of the parameters could be reduced to help save budgetary resources. Also, instead of three sites on the Fish River, sufficient data would be produced from one site placed on the mainstem, upstream of tidal influence and downstream of the confluence of the major tributaries, preserving additional resources. For water chemistry and chlorophyll *a*, future sampling would be sufficient at upper wadeable streams (two sites), tidal streams (two sites), mid-bay (five sites), and one in Mobile Bay itself (ten sites total).

5. Reduce the total number of sampling events from that used during the SFTE study. Episodic nutrient surveys and sonde continuous monitoring provides valuable information on daily fluctuations of environmental parameters. This information has been recorded by NERRS, so future monitoring should focus more resources on monthly changes.

6. Reduce the number of parameters from that used in the SFTE study and increase data consistency and comparability. For purposes of investigating nutrient dynamics, several water quality parameters used during the SFTE could be dropped from future monitoring activities. For example, substantial redundancy exists among alkalinity, hardness, conductivity, chloride, and TDS; they are all salinity-related parameters. Measuring them all individually provides only minimal additional interpretive strength related to nutrients. Because of the existing long-term data set of the NERRS/CDMO for chlorophyll *a*, future monitoring should use the fluorometric method, but reconciliation with ADEM monitoring methods are necessary to provide a linkage.

10.3 Potential Sample Collection Locations

There are have been a number of various sample collection locations throughout the Weeks Bay Watershed over the past 20 years including those of the USGS, ADEM, NERR, Geological Survey of Alabama, USEPA, Cook, and several other investigators. The longer standing monitoring stations that are currently active are listed below and shown on the Figure 10.1

USGS: https://waterdata.usgs.gov/al/nwis/rt

1. Gauge 02378300, Magnolia River at U.S. Highway 98 near Foley, AL; Lat: 30.406545 and Long: -87.736894
2. Gauge 02378500, Fish River at Alabama Highway 104 near Silverhill, AL; Lat: 30.545490 and Long: -87.798228.

NERR: https://coast.noaa.gov/nerrs/reserves/weeks-bay.html

1. Fish River Station; Lat: 30.4162 and Long: -87.8228
2. Middle Bay Station; Lat: 30.3961 and Long: -87.8335
3. Magnolia River Station; Lat: 30.39 and Long: -87.8177
4. Weeks Bay Station; Lat: 30.3808 and Long: -87.832

ADEM: http://www.adem.state.al.us/programs/water/waterquality.cnt

1. FI-1 located on Fish River at Alabama Highway 104, just above its confluence Perone Branch, and just above the outlet for the Upper Fish River hydrologic unit; Lat: 30.545490 and Long: -87.798228.
2. WB-1 where the main stem of Fish River discharges into Weeks Bay at U.S. Highway 98; Lat: 30.543833 and Long: -87.736667

AWW: http://www.alabamawaterwatch.org/water-data/AWWmap/

1. Silver Creek; Site 06003032; Oscar Johnson Memorial Park Hwy 104; Lat: 30.543833 and Long: -87.736667
2. Fish River; Site 06003044; CR 48 south of bridge along west bank; Lat: 30.52363 and Long: -87.80925
3. Polecat Creek; Site 06003083; River Road West; Lat: 30.487982 and Long: -87.798434
4. Fish River; Site 06003060; Marlow Park off Honey Road at boat launch Beach (off CR 9); Lat: 30.46203 and Long: -87.80124
5. Weeks Creek; Site 06003029; Bay Road East; Lat: 30.368667 and Long: -87.7735

Historically a much larger number of AWW sites have been monitored within the Watershed but, since this program is dependent upon volunteers to collect the monthly field data, most have been discontinued for various reasons. Table 10.1 provides a list of all historic and current AWW water quality monitoring sites, with color coding to indicate: active/current sites (green), good historic record counts and strategic location (yellow), small number of historic records, but strategic location (blue).

Table 10.1 Alabama Water Watch Water Quality Monitoring Sites, Historic and Active

Site Code	Location	Lat	Long	Last Date	Chem. Count	Bact. Count
6003024	Fish River @ Hwy 59	30.726	-87.7901	9/22/1997	9	4
6003045	Turkey Branch @ Hwy 90	30.6505	-87.84	11/30/2003	39	15
6003030	Bay Branch @ Hwy 90	30.6461	-87.8204	11/30/2003	51	9
6003022	Fish River @ I-10	30.6536	-87.7918	6/11/1997	15	8
6003019	Fish River @ Hwy 90 bridge crossing upstream	30.63709	-87.79988	12/11/2010	79	29
6003074	Bay Branch @ 20 yds dwnstrm of Plantation Hills WWTP outfall	30.6343002	-87.819244	4/15/2004	0	13
6003052	Corn Branch @ Hwy 64	30.6183	-87.7848	4/21/1995	1	0
6003071	Corn Branch @ Baldwin CR 64 upstrm of culvert	30.618	-87.78	11/30/2003	24	13
6003051	Corn Brach UT @ Hwy 49	30.6124	-87.7592	4/21/1995	1	0
6003084	Fish Riv @ 30 yds S of CR 64, E side of riv	30.6039	-87.8175	8/30/2004	0	13
6003023	Fish River @ Baldwin CR 64	30.602333	-87.8175	11/30/2003	38	5
6003086	Lk Raynagua, just above weir outfall to Perone Br	30.5925	-87.7449	6/20/2009	59	33
6003085	Perone Br 1/4 mi. dwnstrm from Lk Raynagua outfall	30.5886	-87.7481	3/1/2006	51	20
6003006	Perone Branch @ Hwy 54	30.567337	-87.770987	9/2/2002	150	58
6003025	Fish River @ Hwy 54	30.567403	-87.79519	8/10/2003	149	59
6003064	Fish River @ Hwy 104 Silverhill	30.545642	-87.798624	8/27/2011	82	13
6003004	Perone Br @ Baldwin CR 104	30.545704	-87.788272	10/3/2011	7	1
6003032	Silver Ck @ Memorial Park Hwy 104	30.543833	-87.736667	4/11/2017	130	11
6003044	Fish Riv @ Hwy 48 S of brg along W bnk	30.52363	-87.80925	4/11/2017	131	7
6003034	Pensacola Br @ CR 48 @ Fish Riv	30.5237	-87.8125	6/6/2004	148	0

Site Code	Location	Lat	Long	Last Date	Chem. Count	Bact. Count
6003054	Cowpen Ck @ Rt. 44 west of CR. 13	30.5019	-87.8725	3/6/1998	4	0
6003002	Cowpen Creek @ Baldwin CR 27	30.495667	-87.852667	9/26/2003	110	39
6003013	Weeks Bay @ mouth of Magnolia Riv	30.5015	-87.799833	11/16/1995	17	0
6003041	Fish Riv @ 18830 Highland Dr F'hope	30.49627	-87.80823	3/4/2000	17	0
6003083	Polecat Creek @ 18045 River Rd. W	30.487982	-87.798434	4/17/2017	3	0
6006015	Polecat Creek @ Baldwin CR 9	30.4906	-87.79677	12/19/2010	133	58
6003016	Polecat Creek @ Baldwin CR 55	30.498297	-87.751192	6/23/2002	14	3
6003001	Cowpen Creek @ Baldwin CR 33	30.483142	-87.819058	7/28/2013	70	7
6003067	Fish Riv @ East Bnk N of Polecat Ck	30.4845	-87.804	12/19/2010	243	106
6003076	Polecat Ck, 100 yds upstrm of mouth	30.4838963	-87.801682	7/20/2004	0	13
6003068	Baker Branch @ Baldwin CR 55 upstrm of bridge	30.4759	-87.75073	11/30/2003	32	16
6003062	Cowpen Creek @ mouth to Fish River	30.47746	-87.80388	7/24/2000	10	0
6003046	Fish Riv 75 ft dwnstrm of CR 32 brg	30.474407	-87.802743	9/8/2012	336	0
6003020	Fish River @ N. of River Park Marina	30.47121	-87.80225	11/11/1996	8	0
6003060	Fish River @ Marlow Park off Honey Rd at boat launch Beach	30.46203	-87.80124	3/18/2017	78	61
6003078	Fish Riv, 75 yds S of Riv Prk Marina	30.4636154	-87.803711	7/20/2004	0	15
6003021	Fish River @ Marlow Park	30.45957	-87.80409	12/9/2002	74	3
6003061	Barner Branch @ Marlow boat basin just before meets Fish River	30.455833	-87.802333	12/30/2007	133	57
6003059	Barner Branch @ CR 9 in Marlow	30.456167	-87.799	1/19/2003	50	15
6003072	Barner Branch @ 2500 ft upstrm of bridge on CR 9	30.458	-87.78	12/8/2002	16	0
6003053	Turkey Branch @ Hwy 98 at Rt. 24	30.4431	-87.88672	5/23/2014	2	0
6003065	Fish River @ end of CR 33 west side	30.4505	-87.80803	11/12/2000	12	0
6003058	Waterhole Br, CR 32 S of Danne Rd	30.441333	-87.8355	4/28/2009	128	0
6003033	Waterhole Br upstrm from Green Br	30.44212	-87.83133	5/5/1997	18	0
6003050	Fish River @ main river at 4m on Harbor Ridge Rd Hwy 9	30.443124	-87.809086	12/27/1998	12	0
6003043	Fish River @ main river at 0.5m on Harbour Ridge Rd Hwy 9	30.443013	-87.807627	12/27/1998	35	10
6003042	Fish River @ basin at 0.5m on Harbor Ridge Hwy 9	30.441866	-87.806726	12/11/2000	22	10
6003079	Waterhole Br 300 yds upstr from mouth	30.4359093	-87.822296	8/30/2004	0	17
6003026	Fish River UT near Ridge Rd subdivision	30.434244	-87.809	3/23/1996	17	0
6003069	Brantley Branch @ Baldwin CR 24 btw George Younce Rd and CR 55	30.43597	-87.73292	6/7/2003	40	0
6003036	Magnolia River @ Baldwin CR 24	30.43653	-87.69859	6/30/2009	34	8
6003080	Turkey Br 200 yds upstrm from mouth	30.4284419	-87.83065	8/30/2004	0	16
6003005	Fish River @ Isle of Pines	30.429649	-87.824959	7/37/2012	33	0
6011008	Magnolia Riv @ Foley Airport Bridge	30.430717	-87.704553	1/9/2011	0	2
6003011	Magnolia River @ Baldwin CR 65 V9A	30.424863	-87.7171	7/28/2008	244	93
6003010	Magnolia River @ Baldwin CR 65	30.4247	-87.7176	7/19/1999	24	2
6003017	Turkey Branch @ Baldwin CR 27	30.42	-87.843833	3/19/2002	27	11
6003018	Turkey Branch @ Moore Dock	30.420667	-87.837167	8/30/2004	16	13
6003081	Fish River unnamed canal @ boat ramp @ Safe Harbor RV Park	30.4180851	-87.825172	8/30/2004	0	16
6003075	Weeks Bay UT @ 25 yds from mouth S of LuLus Rest Site	30.4150372	-87.826096	8/30/2004	0	17
6003012	Weeks Bay @ mouth of Fish River	30.41516	-87.8246	8/30/2004	16	12

Site Code	Location	Lat	Long	Last Date	Chem. Count	Bact. Count
6003063	Fish Riv @ Manatee Prk N of Hwy 98	30.413333	-87.823333	3/30/2003	77	1
6003082	Weeks Bay @ mid bay in boat channel	30.3948746	-87.82856	8/30/2004	0	16
6003056	Weeks Bay @ Lipscomb pier	30.391386	-87.848396	11/16/1995	2	0
6003014	Weeks Bay @ Camp Beckwith pier	30.38844	-87.8422	6/23/2008	26	0
6003048	Weeks Bay @ west side Canal Circle mouth of south most canal of Bay Haven Subdivision	30.387	-87.8435	4/24/2004	133	55
6004002	Mobile Bay @ east shore 0.25 mi. W of Weeks Bay	30.378272	-87.847256	9/23/2000	0	1
6003066	Weeks Bay @ western shore @ Pelican Point Park CR 1	30.374833	-87.836667	9/27/2003	78	34
6003070	Magnolia Riv @ dock at end of CR 9	30.39	-87.809	7/5/2009	42	9
6011007	Nolte Creek upstrm of confluence with Magnolia River	30.388412	-87.800593	6/14/2010	1	2
6003007	Nolte Creek @ south of CR 26	30.383	-87.797167	9/14/2009	94	53
6003003	Eslava Creek @ mouth	30.39346	-87.79362	6/14/2010	92	21
6003077	Weeks Ck 200 yds upstrm from mouth	30.3905907	-87.784966	6/14/2010	8	25
6003028	Weeks Creek @ Baldwin CR 26	30.382833	-87.772833	9/27/2003	105	1
6003029	Weeks Creek @ Bay Rd E Baldwin Co.	30.368667	-87.7735	8/20/2016	256	207
6011009	Magnolia River @ The Woodlands	30.397233	-87.783267	4/11/2011	0	2
6011002	Magnolia River @ main channel upstrm of No Wake sign	30.39323	-87.777586	3/21/2010	13	7
6003073	Magnolia River @ Bay Rd	30.39135	-87.77382	6/1/2011	51	34
6011004	Magnolia River @ Laurendine Pier	30.394308	-87.775378	4/26/2009	15	3
6011005	Magnolia River @ Houser Dock	30.397253	-87.775408	7/19/2008	1	0
6011003	Magnolia River at Holk Dock	30.397822	-87.775633	3/6/2011	25	14
6003009	Magnolia Riv @ 300 yds W of CR 49	30.397	-87.772167	9/25/2005	232	107
6011001	Mag Riv @ 100 yds W of CR 49 brg	30.399289	-87.770794	9/14/2008	5	4
6003008	Magnolia Riv @ CR 49, 30 yds E	30.398333	-87.769333	9/25/2005	231	109
6011006	Magnolia Riv @ the rocks near Riv Ln	30.399839	-87.767961	7/27/2011	35	38
6003047	Magnolia Riv @ US Hwy 98 @ Pine Rest Cemetery	30.404667	-87.737	11/30/2003	107	31

In addition, a number of other agency and research monitoring has taken place within the Watershed over the past few decades. Selecting the same locations where historical information exists is helpful in assessing long term trends. Table 10.2 lists proposed sampling locations, parameters, frequency and implementing entity.

Table 10.2 Proposed Long Term Water Quality Monitoring Program

Waterbody	Location	Parameters[1]	Frequency	Entity
Fish River	Hwy 104	Flow	Continuous	USGS
Fish River	Hwy 104	FP, Nutrients, Bact, Sediment[2]	Monthly[2]	ADEM
Fish River	CR 54	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Fish River	CR 48	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Fish River	HWY 98	FP, Nutrients, Bact, Sediment	Monthly	ADEM
Pensacola Br.	CR 48	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Cowpen Ck.	CR 33	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Baker Br.	CR 55	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Magnolia River	Hwy 98	Flow	Continuous	USGS
Magnolia River	Hwy 98	FP, Nutrients, Bact, Sediment	Monthly	ADEM
Magnolia River	CR 65	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Weeks Ck.	CR 26	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Unnamed tributary of Magnolia River	CR 24, just E of Langford Ln	FP, Nutrients, Bact, Sediment	Quarterly	TBD
Magnolia River	CR 24	FP, Nutrients, Bact, Sediment	Quarterly	TBD

[1] Parameters: FP=Field Parameters, Bact=pathogens, Sediment=TSS and Turbidity only
[2] Sediment sites to be monitoring for loading analysis (suspended and bedload) every 3-5 years.

10.4 Monitoring Program Approach and Schedule

Samples should be collected on a monthly or quarterly basis, as indicated in Table 10.1, at each location site or consistent enough to accurately monitor trends in Watershed conditions and parameters. The sampling schedule should not be burdensome to the field teams or an excessive drain on budgets. Water quality samples are usually collected more frequently than on a quarterly or annual basis because Watershed conditions and indicators can change rapidly and are affected by many factors. Each sampling data point taken represents a snapshot of Watershed conditions at a certain point in time. The more samples collected the easier it is to put the data into context and analyze the health of the overall Watershed. All monitoring activities should be conducted in accordance with ADEM or Alabama Water Watch (AWW) protocols, as appropriate for the parameter being monitored.

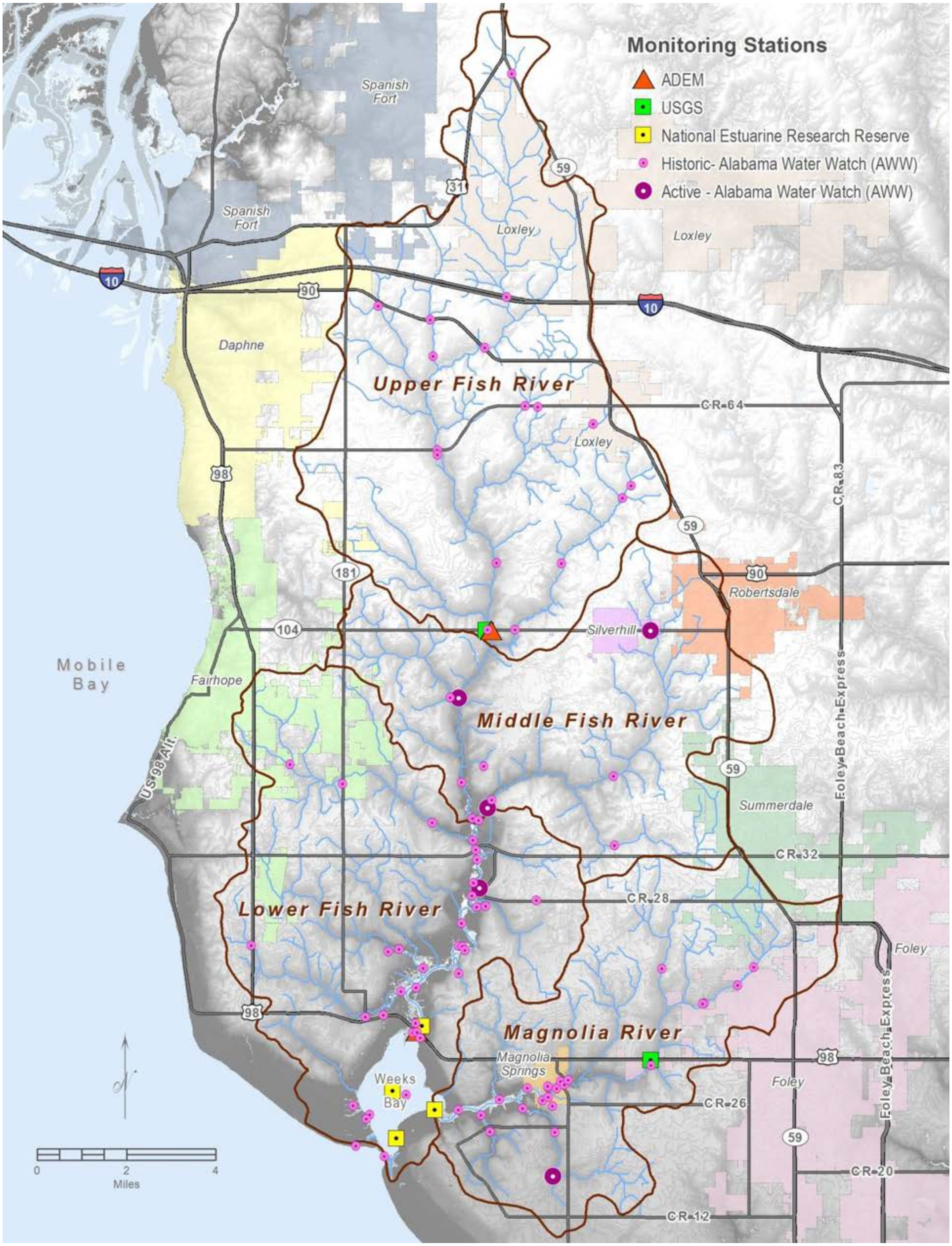


Figure 10.1 Monitoring Station Location Map

10.5 Citizen Participation and Volunteering

A vital element of the Watershed Monitoring Program will be citizen participation through volunteering as an AWW monitor. With the help of volunteers, the Watershed Monitoring Program will enable successful implementation and establish a sense of community ownership within the watersheds. Community volunteers are able to take part in watershed management by assisting with collecting data as members of field sampling teams and participating in public outreach events. Previous volunteer watershed monitoring networks have proven to be a successful model for long-term monitoring and community engagement in watershed throughout the country. Efforts should be made to recruit as many volunteer monitors as possible.

10.6 Adaptive Management

Adaptive management principles will be implemented as the Watershed Management Plan transitions into the implementation phase. Adaptive management will maximize the effectiveness and efficiency of implemented management measures. The adaptive management process will consist of an annual review of progress reports for each of the HUC 12 subwatersheds and comparison of watershed conditions against goals and objectives identified in this Weeks Bay 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 assessed 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 positive measureable results.

10.7 Anticipated Costs

It is believed an adequate Monitoring Program (in addition to current USGS, ADEM, WBNERR, and AWW monitoring) can be established and pursued at an initial annual cost of approximately $50,000 for five new monitoring sites. Additional monitoring sites would be added at a rate of five per year, up to a total of 30 sites that are not currently being monitored, increasing the annual monitoring cost to $600,000. This cost estimate covers four HUC 12 watersheds, encompassing approximately 130,000 acres. Ultimately, the overall monitoring costs will be dependent on the exact parameters to be monitored, number of stations, and frequency of sampling.

This Page Intentionally Left Blank

11.0 Implementation Strategies

11.1 Formation of Watershed Management Plan Implementation Team

A variety of management measures are needed to improve the health of the Weeks Bay Watershed. A clear and concise strategic approach will be necessary to successfully implement these measures. This approach should involve all stakeholders within the Weeks Bay Watershed, as well as the nine municipalities, county, state, and federal agencies listed as participants in the SWG (see Table 1.1) and potential financial support partners for WMP implementation identified (see Table 8.1).

Coordination of so many stakeholders would be greatly enhanced by the establishment of a public-private Watershed Management Plan Implementation Team (WMPIT) to carry forward the momentum gained during the preparation of the WBWMP. The membership of the WMPIT should reflect the diversity of entities represented on the SWG that served to guide development of the WMP over the past 22 months. The strategies listed below will help to successfully implement the management measures recommended in Section 6 of this WBWMP. Many of these actions can be concurrently executed.

As discussed in Section 6, the WMPIT must agree on an organizational “homeroom” or multiple “homerooms” (MBNEP, WBNERR, BCSWCD, NRCS, etc.). The SWG has discussed “homerooms” that best fit based on the subject matter of the specific recommendation. Notably the BCSWCD has approved a Watershed Coordinator position to provide oversight regarding the implementation of the WBWMP at their July 26, 2017 meeting. At the time of this writing, the BCSWCD has received a one-year commitment of $41,500 to partially fund the Watershed Coordinator position from the Baldwin County Commission, with continued funds if there is demonstrated progress/buy-in from other stakeholders. In addition, one-time donation commitments have been received from the Alabama Soil and Water Conservation Committee ($5,000), Alabama Association of Conservation Districts ($5,000), and Gulf Coast Resources Conservation and Development Council ($15,000). Other funding sources being explored by the BCSWCD include ADEM, EPA, and the municipalities in the Watershed. The BCSWCD staff position should not overlap or conflict with the existing roles of the WBNERR, MBNEP, or other local city/county staff positions, or other state/federal agencies, but rather complement those positions. The establishment of a Watershed Coordinator by the BCSWCD is vital to moving forward with plan implementation.

This section provides a strategy to address the critical issues identified for the Weeks Bay Watershed by implementing recommended management measures presented in Section 6, identifies associated costs, and presents a two-phased implementation approach (short-term phase and long-term phase) to achieve success for those management measures.

Components for completing this WMP were reviewed during its preparation, and a MBNEP checklist of these components is presented as Appendix K.

The issues and problems threatening the health of the Weeks Bay Watershed occur throughout the entire Watershed and extend across political boundaries. All of the water bodies in the Watershed are connected, such that construction in the headwaters of a stream affects runoff, flows, and water quality throughout the Watershed. The majority of the Watershed is in the unincorporated area of Baldwin County, but all or portions of nine municipalities are in the Watershed. Therefore, the responsibility for site inspections and enforcement of management ordinances are spread across those various jurisdictions. The presence of the WBNERR and the Weeks Bay Foundation tremendously adds to the resources and expertise to carry forward the implementation of the WBWMP. The MBNEP Project Implementation Committee (PIC) is an established group comprising many of the agencies and/or entities represented on the SWG and can provide a broad geographic support base dealing with coastal Alabama issues in Baldwin and Mobile Counties.

11.2 Phase One Implementation: Short-Term Measures

Feedback gained through the stakeholder and public outreach efforts associated with the WBWMP stressed the need for short-term wins or tangible successes promptly following WMP adoption to gain the confidence of the stakeholders 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. The short-term management measures were chosen based on their likelihood of successful implementation within the next two years. Some facets of implementation of these short-term measures will likely extend longer than the two years, but are included since substantial progress is anticipated over this two year period.

Table 11.1 lists each short-term measure and provides a rough order-of-magnitude cost estimate to implement the measure. It should be noted that preparation of detailed cost estimates was not possible due to the large size of the Weeks Bay Watershed and the conceptual level of planning that guided development of this WMP. The cost estimates are intended for preliminary budgetary considerations. Additional descriptions of each recommended management measure are provided in Section 6. The following are the recommended management measures that fall into the short-term category:

- Create the WMPIT
- Establish a Weeks Bay Watershed Coordinator position at BCSWCD
- Establish an inter-governmental partnership for the nine municipalities and county to track compatibility of watershed regulations and handling of issues
- Create a forum for periodic dialogue of municipality and county elected officials on broad watershed issues

- Continue monthly municipal/county planner meetings regarding development
- Add a municipality/county GIS layer for the municipalities and county to track potential large residential and commercial projects
- Promote and expand the use of LID/GI practices across the various jurisdictions
- Periodically run the Baldwin County flood model with updated land use forecasts
- Develop HOA/POA Stormwater Inspection Guide/Checklist, including training forum
- Develop scope of work/cost estimate and seek funding for stormwater basin inventory and assessment for the Watershed
- Develop a demonstration project for retrofitting of a few stormwater basins for water quality improvements
- Establish and initiate the monitoring program
- Establish the public outreach and education program

Table 11.1 Short-Term Management Measures

Measure	Area	Unit	# of Units	Unit Cost	Total Cost
Watershed Management Plan Implementation Team (WMPIT)	WBW	Implementation Team	1	See Note 2	See Note 2
Establish Watershed Coordinator	WBW	BCSWCD Position	1	$75,000/yr	$75,000/yr
Intergovernmental Partnership	WBW	Partnership	1	See Note 2	See Note 2
Elected Officials Forum	WBW	Forum	1	See Note 2	See Note 2
Local Planner/Regulatory Monthly Meetings	WBW	Municipality/County Planners	1	See Note 2	See Note 2
County GIS Platform for Planners	WBW	GIS Platform	1	See Note 2	See Note 2
Promote LID/GI Practices	WBW	Municipality/County Planners	1	See Note 2	See Note 2
Run Flood Model LULC Updates	WBW	County	1	$50,000 (software & training)	$50,000
HOA/POA Stormwater Basin Inspection Guide/Checklist, and Conference	WBW	Guide/Checklist, and Conference	1	$150,000	$150,000
Conduct Stormwater Basin Inventory/Assessment	WBW	Field Evaluation	1	$525,000	$525,000
Design/Construction Demonstration Stormwater Basin Retrofits	WBW	Basin Retrofits	8 (2/HUC12)	$80,000	$640,000
Initiate the monitoring program	WBW	Field Monitoring	5 sites for yr 1, 10 sites for yr 2	$10,000/site/yr	$100,000/yr (at yr 2)
Continue public outreach and education	WBW	Public Involvement Program		$30,000/yr	$30,000/yr

Note 1: WBW=Weeks Bay Watershed
Note 2: Cost to be absorbed by internal administrative costs of participating organizations, municipalities, county, and agencies.

As previously mentioned additional information on these short-term management measures is presented in Section 6 of this WMP. More details on some of the specific short-term measures are discussed in the following paragraphs.

11.2.1 Promote LID/GI Practices

The narrative below presents information on timeframe (short or long-term), success criteria, and costs for the Management Measure presented in Section 6.5, *Sustain Watershed Hydrology by Promoting Low Impact Development (LID) and Green Infrastructure (GI).* Promoting the expansion of LID/GI practices in the Watershed would be initiated in the short-term planning horizon, but will continue into the long-term beyond two years. As discussed in the regulatory analysis, Section 7, some of the municipalities in the Watershed currently have regulations that require or encourage LID/GI practices. Those ordinances have different provisions and are not consistent. Other municipalities and the unincorporated Watershed areas of Baldwin County have no or only limited provisions for LID/GI.

The impacts of urbanization on stream water quality due to increased Impervious Cover (IC) surface area have been previously discussed. The negative environmental impacts of an increase in stormwater runoff and subsequent peak instream flows in developed landscapes leads to increases in its delivery of pollutants such as nutrients, pathogens, metals, and sediment (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf). Higher flows resulting from heavy rains also can cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure. Urbanization of the Weeks Bay Watershed can be expected to result in adverse impacts to water quality of the Watershed's streams, especially within the areas experiencing development. Such impacts can be minimized by adopting measures to sustain the Watershed's hydrology. Such management measures are termed Low Impact Development (LID) and Green Infrastructure (GI). As presented earlier, the SWAT model developed for the Weeks Bay WMP (Appendix G) was used to evaluate water quality effects of anticipated Land Use / Land Cover (LULC) changes. The modeling evaluated two scenarios of urban development growth for the year 2040, termed 2040-Medium and 2040-High, and compared these scenarios to a baseline year of 2011. Sediment loadings to Weeks Bay from Fish River were estimated to increase by as much as 33.8%, whereas sediment loads from Magnolia River are estimated to increase by as much as 12%. Similarly, increased Total Nitrogen loadings to Weeks Bay are projected to increase as high as 70.5% above 2011 levels from Fish River, and as much 79.4% higher from Magnolia River. Conversely, no significant increases of Total Phosphorus loadings to Weeks Bay are anticipated from the LULC changes that were modeled.

Implementation of LID/GI practices during future urban growth within the Weeks Bay Watershed will reduce the predicted increases in sediment and Total Nitrogen loadings, and other related pollutants as well. Thus, at least theoretically, success criteria for LID/GI practices would be tied to measurements of loadings at future points in time. However, although loadings in the future can be estimated, it will difficult if not impossible to differentiate the cause–effect relationships that have resulted in the changes. Therefore, it is recommended that success criteria for implementation of LID/GI in the watershed be based on an accurate compilation and accounting of LID/GI projects that are implemented (with pertinent data on their features and characteristics). The recommended GIS database showing the locations of LID/GI projects will provide such accountability, and will help facilitate public awareness and education. For it to become an effective tool, such a database must have input from all municipalities and Baldwin County, and must be consistently updated.

The capital costs of implementing LID/GI practices in new development and redevelopment projects will be borne by the developer and be reflected in added value of the developed properties. For retrofits to existing development, capital costs will most likely be incurred within the public sector. The only major retrofit project contemplated in this WMP is the inventory and assessment of and improvements to existing stormwater detention basins, and those costs are presented under the stormwater basin retrofit short-term measure in Table 11.1.

Within the LID framework, the goal of any construction project is to design a hydrologically functional site that mimics predevelopment conditions. This is achieved by using design techniques that infiltrate, filter, evaporate, and store runoff close to its source. Rather than rely on costly large-scale conveyance and treatment systems, LID addresses stormwater through a variety of small, cost-effective landscape features located on-site. This design approach incorporates strategic planning with micro-management techniques to achieve environmental protection goals while still allowing for development or infrastructure rehabilitation to occur.

When deciding whether to adopt LID practices on a wide scale, communities should consider life cycle costs and performance of traditional stormwater control practices versus LID. Grey infrastructure is typically designed to reduce flooding risk, but often does not adequately protect water quality and habitat. Incorporating LID practices provides many supplemental benefits, some of which are difficult to quantify, including improved aesthetics and community livability, expanded recreational opportunities, increased property values and a cleaner environment. Adding LID practices can also reduce the amount of grey infrastructure needed to manage flooding and avoid expensive capacity expansions.

In many cases, LID practices are more economical than conventional practices. LID typically includes a variety of low- cost elements such as bioswales that retain rain water and encourage it to soak into the ground rather than allowing it to run off into storm drains where it would otherwise contribute to flooding and pollution problems. LID projects typically include smaller overall development footprints, reduce the amount of runoff generated and increase the amount of natural areas on a site, thereby reducing costs when compared to traditional stormwater management and flood control. A study by the USEPA of 17 LID case studies around the country found that, in the majority of cases, total capital cost savings ranged from 15 to 80 percent when LID methods were used (USEPA, 2007).

As with any built practice, LID requires a schedule of maintenance tasks to promote long-term pollutant removal efficiencies. The concern that this maintenance burden will be greater than conventional “grey” stormwater practices should not be a barrier – it is different maintenance, not necessarily more maintenance. In fact, the USEPA has noted that LID life cycle costs are usually less than traditional practices. Traditional stormwater practices may have a greater initial capital investment, use valuable land area for stormwater storage, and incur operation and maintenance costs such as dredging, inlet pumping, and residuals disposal. LID practices typically have lower initial investment, but require more maintenance in the first years of establishment. Once established, they may be maintained in a manner similar to other landscaped areas. Additionally, these practices may help reduce the cost of mowing and irrigation post establishment. Additional LID elements to include in a cost/benefit comparison include improved aesthetics, wildlife habitat, community quality of life, citizen involvement and engagement, and the pride of implementing practices that allow economic and community development to proceed with minimized impacts on water resources. These elements are part of the overall picture of LID that encourages a connection by all stakeholders to transform stormwater into being viewed as a valuable resource (ADEM *Low Impact Development Handbook for the State of Alabama,* http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf).

Example Economic Benefits of LID Elements

- Adding roadside bioswales, making roads narrower and designing smaller or porous parking lots with on-site runoff retention **saves money by reducing the amount of pavement, curbs and gutters needed**.
- Installing green roofs, disconnecting roof downspouts from impervious surfaces (driveways or streets), and incorporating bioretention areas to capture on-site runoff **saves money by eliminating the need for costly runoff detention basins and pipe delivery systems**.
- Designing more compact residential lots **saves money by reducing site grading and building preparation costs, and can increase the number of lots available for sale**.
- Preserving natural features in the neighborhood **can increase the value and sale price of residential lots**.
- Using existing trees and vegetation **saves money by reducing landscaping costs and decreasing stormwater volume**.

11.2.2 Homeowner Associations/Property Owner Associations Stormwater Basin Assistance

Homeowner associations represented at the August 2017 public workshop on the draft WBWMP expressed interest in learning more about stormwater pond management, as well as improving coordination and networking between various HOA/POA groups to encourage technology transfer. As land use in the county changes, the storm water management protocols have also changed. Within the watershed, the number of subdivisions and housing communities has risen dramatically over the last decade. With thousands of new homes, driveways, and roads, these developed areas create a new set of impermeable storm water runoff locations. Stormwater from these rain events is often funneled through stormwater basins. These basins are intended to slow the water down and manage the release water back into the watershed at rates closer to pre-development flow volumes.

Unfortunately, the management of these basins often falls onto unknowing or undereducated homeowner and property owner associations (HOAs and POAs). Thus, the basins are often neglected and do not perform correctly and can sometimes be more detrimental to the adjacent watershed than no stormwater system at all. Unmaintained basins collect large amounts of polluted, sediment-filled storm water, and shunt it into neighboring waterways in huge volumes. This can cause erosion, eutrophication, siltation, and pathogen contamination.

This project will approach outreach through the creation of a printed "Stormwater Basin Resiliency Guidebook" and "Stormwater Manager Checklist." These will both be printed to be presented at a "Stormwater Basin Stakeholder Conference." The Guidebook and checklist are specifically for basin managers who are unsure of their role, want to make sure they are current in their maintenance, and ensure that they are using the best management practices. The guidebook will include definitions of the various types of stormwater basins, the features of each structure, what successful rainfall processing should look like, and how to trouble shoot basic issues. There will also be sections on routine and periodic maintenance. The "Stormwater Manager Checklist" is a document that the HOA representative can take out to their basin during regular checkups, or after a large storm, to make sure all features of the structure are still working properly. The City of Foley recently developed a tri-fold brochure "Homeowners Guide to Stormwater Pond Maintenance" (copy in Appendix L). More detailed information is contained in the USEPA's "Stormwater Wet Pond and Wetland Management Guidebook" (2009) to assist communities in developing an integrated stormwater management system which includes proper maintenance of existing wet ponds and wetlands, as well as exploration of retrofit opportunities (copy included in Appendix L). The Guidebook contains templates for a "Homeowner Pond Inspection Checklist" and more detailed "Pond/Wetland Maintenance Inspection Form" (copy of Guidebook in Appendix L). The Guidebook does not address the maintenance needs of dry ponds or underground detention since these practices are not widely recommended as stand-alone practices that provide water quality and water quantity benefits. Dry ponds, however, exist in many areas of the Watershed, as flood control facilities, and many of the maintenance considerations for stormwater ponds and wetlands present in the Guidebook are relevant to dry ponds.

The documents listed above will be made available at the "Stormwater Basin Stakeholder Conference," along with informational workshops for developers, managers, municipalities, and the county. This one day conference will have tracts for each type of stakeholder, where they can learn pertinent information to their role in effective stormwater basin permitting, construction, and management. This event will also give the stakeholders the opportunity to meet one another. The HOA/POA representatives can meet their local city planners and environmental consultants. Developers can discuss cutting edge design with environmental engineers and municipality/county representatives. This will encourage community connectivity and communication down the road, when storm events do occur.

The success criteria for this project contain several different measures. The number of stakeholders, the amount that they learn, and their subsequent behavior change will all be evaluated to determine the success of the program. Participant numbers will be calculated from stakeholder conference attendance and the number of written information tools given out. The depth of their knowledge before and after this experience will be calculated using participant-completed evaluation forms. The subsequent behavior change will be monitored through email evaluation forms sent out at the one month and six month interval from the stakeholder conference.

11.2.3 Stormwater Basin Inventory and Assessment

Preliminary evaluation of aerial photographs of the Weeks Bay Watershed has identified over 250 existing stormwater basins. The project will do in depth mapping and data collection of the basins throughout the Watershed. The size, location, and use (wet or dry) will be documented. Site visits will be performed to document the status of the ponds, their functionality during storm events, and potential for retrofitting projects to achieve water quality improvements. Examples of field data to be collected include: 1) site photographs; 2) physical dimensions of inflow and outfall structures along with condition ratings; 3) observation of overall bank, fill slope, cut slope, pond invert, and vegetative cover; 4) soil probe of pond invert to estimate siltation depth; 5) record visible high water marks; and 6) review any available stormwater pond design plans. The data collected will be utilized to develop a rating scheme to rank the condition of the stormwater ponds, estimated amount of impairment, proximity to downstream sensitive environmental features, or human population density areas, etc. The rating system would be used to rank the ponds and develop a priority list for retrofitting purposes. The mapping data will complement the Weeks Bay Watershed Management Plan mapping data and help the WMPIT grant team, municipalities, and county when selecting the demonstration retrofitting project sites.

The completion of the inventory and assessment in and of itself will be a success given that it will be the first comprehensive mapping of stormwater basins in the Watershed. The new data will be examined against what is currently known to see how much is learned through the mapping, inventory, and assessment process. An increase in the data related to stormwater basins within the project area, which can be used for priority retrofitting, would also be classified as a success.

11.2.4 Demonstration Projects for Stormwater Basins Retrofits

As a result of the above inventory and assessment project, the WMPIT, municipalities, and HOA/POA organizations will also have the opportunity to learn about demonstration sites throughout the area (two water quality retrofit demonstration project projected for each of the four HUC 12 subwatershed in the Weeks Bay Watershed) that have been selected by the WMPIT and its partners for retrofitting projects. In this way, participants will be able to see first-hand how a basin can be made more efficient, functional, and sustainable. Retrofit treatment options for the demonstration sites may include:

- extended detention
- conversion of dry ponds to wet ponds
- constructed wetlands within ponds
- bio-retention
- additional filtering practices, including native grass plantings
- swales
- other (roof runoff treatment using rain gardens, rain barrels, planters, etc.)

The option selected for each site will be based on the major issue with that site. This could be flow rate, retention time, sedimentation within the pond, or invasive plant pressure. After the site selection, the implementation of the retrofits will take approximately six months. Additional information related to retrofitting of existing wet ponds and wetlands are found in the USEPA's "Stormwater Wet Pond and Wetland Management Guidebook" (2009) (Appendix L).

Success criteria will consist of documentation of physical modifications made for the demonstration project ponds and field data collection. "As Built" plan drawings will be prepared following the retrofitting is completed at each site. Water quality/quantity data will be collected at all of the stormwater basin sites prior to retrofitting. Once the sites have been retrofitted, additional post-construction data will be completed to evaluate impacts on parameters such as flow, nutrients, and sediment. Based on the outcome of the demonstration retrofit projects in the Watershed, funding for additional stormwater pond retrofit projects will be sought for design and construction and addressed in the Phase Two – Long-Term Measures as discussed in Section 11.3, below.

11.3 Phase Two Implementation: Long-Term Measures

Phase Two projects include a number of projects that could be initiated within two years, but some may require additional time for further analysis, planning, data collection, design, etc., prior to full implementation. Due to the large size of the Weeks Bay Watershed, the list of long-term recommended measures is not intended to be an exhaustive list of potential projects.

Table 11.2 lists each long-term measure and provides a rough order-of-magnitude cost estimate to implement the measure. It should be noted that preparation of detailed cost estimates was not possible due to the large size of the Weeks Bay Watershed and the conceptual level of planning that guided development of this WMP. The cost estimates are intended for preliminary budgetary considerations. Additional descriptions of each recommended management measure are provided in Section 6. The following are the recommended management measures that fall into the long-term category:

- Support widespread expansion of stormwater pond retrofitting to improve the quality of waters released from these ponds.
- Encourage use of conservation programs available for both public and private landowners through the NRCS and Farm Service Agency (FSA) programs
- Encourage broader implementation of good agricultural/forestry practices. BCSWCD to take a lead role in convening farmers, foresters, and other agricultural groups
- Support efforts to implement sediment loading reduction measures (BMPs, restoration, etc.), with expanded SWAT data analysis/field review for subwatersheds with the highest sediment yield (Figure 3.13)
- Pave high priority unpaved roads: Lipscomb Road, Norris Lane, Mannich Lane [S2], Mannich Lane [S4], Paul Cleverdon Road, and Sherman Road.
- Consider paving other Watershed unpaved roads listed in Tables 3.9 – 3.12
- Support efforts to implement nutrient loading reduction management measures (BMPs, restoration, etc.) with expanded SWAT data analysis for subwatersheds with the highest nutrient yield (see Figure 3.16)
- Address pathogen source location and remediation measures for human and livestock sources
- Restore degraded streams, wetlands, and riparian buffers in the Watershed
- Implement strategic acquisition of high quality coastal and headwater habitats
- Develop invasive species detection and management program
- Long term municipal and county planning to recognize uncertainties of potential future sea level changes in the Watershed over the next century
- Identify specific oyster reef and contiguous marshes that are candidates for construction of living shoreline or shoreline protection/restoration measures
- Continue Appropriate Monitoring and Adaptive Management Mechanisms
- Continue Stakeholder and General Public Outreach and Education

Table 11.2 Long-Term Management Measures

Measure	Area	Unit	# of Units	Unit Cost	Total Cost
Support more stormwater retrofits for water quality improvements	WBW	Stormwater Pond	65	$80,000	$5,200,000
Encourage NRCS/FSA conservation programs for landowners	WBW	See text narrative	TBD	TBD	TBD
Encourage more use of agricultural/forestry BMPs	WBW	See text narrative	TBD	TBD	TBD
Identify/reduce sediment producing hotspots	WBW	See text narrative	TBD	TBD	TBD
-UT of Fish River near Etta Smith Road	LFR	Bank/Stream Restoration	1	$100,000	$100,000
-Magnolia River near CR 49	MR	Bank/Stream Restoration	1	$1,375,000	$1,375,000
Pave six priority dirt roads-Lipscomb, Norris, Mannich-S2, Mannich-S4, Paul Cleverdon, and Sherman	MFR, LFR, MR	Per Mile a. Lipscomb b. Norris c. Mannich[S2] d. Cleverdon e. Mannich[4] f. Sherman	7.4	$879,000	 $800,000 $1,800,000 $450,000 $1,400,000 $1,400,000 $900,000
Assess/pave other dirt roads in Watershed (Tables 3.9-3.12)	WBW	Per Mile a. UFR-8.6 b. MFR-10.5 c. LFR-2.6 d. MR-13.6		$879,000	 $7,600,000 $9,300,000 $2,300,000 $12,000,000
Identify/reduce nutrient producing hotspots	WBW	See text narrative	TBD	TBD	TBD
Identify/reduce pathogen producing hotspots	WBW	See text narrative	TBD	TBD	TBD
Restore degraded streams, wetlands, and riparian buffers (see Table 11.3)	WBW	Acres	413	$2,500	$1,032,500
Acquire strategic tidal and headwater habitats (see Table 11.3)	WBW	Acres	300	$2,900	$870,000
Increase invasive species management (see Table 11.3)	WBW	Acres (initial treatment and 25-yr follow-up treatments)	800 (200/HUC 12)	$12,000	$9,600,000

Table 11.2 Long-Term Management Measures (continued)

Measure	Area	Unit	# of Units	Unit Cost	Total Cost
Planning/awareness workshops of potential sea level rise	WBW	Workshop	5	$20,000	$100,000
Restore tidal area degraded areas with living shoreline measures	WBW	WBW Marsh Health and Recovery Study	1	$500,000	$500,000
-Lower Fish River Demo Project	LFR	Lump Sum	1	$2,700,000	$2,700,000
-WBW Living Shoreline Projects	LFR, MR	200 foot living shoreline	15 sites (5ea in LFR, MR, Weeks B)	$50,000	$750,000
Continue monitoring program	WBW	Field monitoring	30 sites	$10,000/yr/site	$300,000/yr
Continue public outreach and education	WBW	Public involvement program	1	$30,000/yr	$30,000/yr

Notes: WBW=Weeks Bay Watershed; UFR=Upper Fish River Watershed; MFR=Middle Fish River Watershed; LFR=Lower Fish River Watershed; MR=Magnolia River Watershed

The following paragraphs, in addition to other discussions in sections of this report, provide supplemental information on these long-term management measures.

11.3.1 Support Additional Stormwater Pond Retrofits

While the demonstration project retrofits proposed in the short-term measures discussed in Section 11.2.4 (two stormwater pond retrofits in each HUC 12 subwatershed), the long-term objective (over the next 20 years) is to retrofit a substantial number of the 260+ stormwater ponds within the Watershed, particularly with areas suffering from water quality degradation resulting from urbanization and development. A goal for this project is to retrofit 25% of the stormwater ponds within the Watershed, targeting the small basins that have substantial water quality degradation regarding sediment, nutrients, and pathogens. Therefore, the goal of this project is to retrofit 65 stormwater ponds with features to improve water quality – particularly by utilizing the outcome of the demonstration projects constructed during the Phase One Implementation, Short-Term Measure Implementation.

11.3.2 Encourage NRCS/FSA Conservation Programs

Sections 3.2.4.2, 3.2.4.3, and 6.6 describes the agricultural and forestry BMPs practiced in the Watershed, a list of NRCS and FSA conservation programs, and Appendix F provides a detailed description of various agricultural and forestry practices.

11.3.3 Encourage More Use of Agricultural/Forestry BMPs

Sections 3.2.4.2, 3.2.4.3, and 6.6 describes the agricultural and forestry BMPs practiced in the Watershed, a list of NRCS and FSA conservation programs, and Appendix F provides a detailed description of various agricultural and forestry practices.

11.3.4 Identify/Reduce Sediment Producing Hotspots

Data from Cook (2016) and the SWAT model results, as well as other studies, indicate that several of the tributaries to the Fish and Magnolia Rivers have sediment yields/loadings that are higher than expected and exceed Cook's estimated natural erosion rate and TSS concentrations are often reported above the ADEM ecoregion reference value. To identify and reduce elevated sediment loading, a targeted field reconnaissance, modelling (SWAT at HRU level), and sampling of subwatersheds identified with potentially high sediment yields and/or loadings is needed to identify specific sources and contributing factors. The subwatershed SWAT model and/or NRCS T-Factors would be utilized to develop reasonable baseline or target erosion rate for the subwatershed. Based on the findings, development and design of site specific measures and conservation practices to reduce or eliminate sources and contributing factors such that subwatershed sediment yields are at or below the estimated subwatershed baseline erosion rate. Costs estimates for this recommended action include:

1. Targeted subwatershed investigation: $75,000/each
2. Develop subwatershed specific sediment reduction target: $5,000
3. Implement subwatershed appropriate management measures based on site specific needs and as enumerated from the following suite of potential measures: TBD

Watershed appropriate management measures will be consistent with the Alabama Coastal Nonpoint Pollution Control Program (ACNPCP) and other published guidance and depend upon the results of the targeted investigation and may include, but not be limited to, the following:

- Stream Restoration: $400-$500 per linear foot
- Riparian Restoration: $2,500/acre
- Gulley Repair: Depends on Severity
- Livestock Exclusion Fencing: $1.80/linear foot
- Alternative Livestock Water Source: $3,500-$4,550 (well); $1.30/linear foot of pipeline
- Water Troughs: $195/each
- Livestock Stream Crossing: $4.07/square foot
- Use of Cover Crops: $55/acre
- Conservation Tillage: $16/acre

- Pave or improve dirt roads segments: $879,000/mile

Potential priority subwatersheds for targeted sediment investigations include:

- Unnamed tributary to Threemile Creek (south of I-10, north of U.S. Highway 90, West of Loxley)
- Upper Corn Branch (above Stapleton Road)
- Perone Branch
- Caney Branch
- Pensacola Branch
- Waterhole Branch
- Turkey Branch (lower)
- Upper Polecat Creek (above CR 55)
- Upper Baker Branch (above Davis Road)
- Upper Schoolhouse Branch
- Unnamed tributary to Magnolia River (north of CR 24, south of CR 32, west of Younce Road)
- Unnamed tributary to Magnolia River and mainstem (east of CR 49, north of Laurent Road, west of Grantham Road)

In addition two specific stream restoration projects were identified during preparation of this WBWMP: 1) unnamed tributary of Fish River near intersection of CR 9 and CR32, near Etta Smith Road, and 2) Magnolia River near powerline crossing east of CR 49 (see Figure 3.78). These two stream restoration projects are certainly not the only candidate projects within the Watershed, but serve as representative high priority restoration projects that could be addressed first, while additional analyses and field reconnaissance efforts are pursued to identify additional sediment reduction/stream restoration projects.

11.3.4.1 Unnamed Tributary to Fish River near Etta Smith Road

This site is located near the intersection of CR9 and CR 32, and is very close to the unpaved section of Etta Smith Road (latitude 30.473667°, longitude -87.796369°). The site has severe bank erosion in the drainage channel leading to Fish River (600 feet away), contributing significant quantities of sediment to the Fish River, and threatening a residence and privacy fence. The erosion/sedimentation problem was triggered by heavy rainfall and flooding on April 29-May 5, 2014. Left unchecked this erosional area will continue to contribute significant quantities to the Fish River and the stream headcut will likely progress upstream and threaten utilities and CR 9 (approximately 400 feet away). An analysis of the area was performed in July 2014 by the Baldwin County Highway Department. At that time, a rough cost estimate to stabilize the approximate 200 feet of stream headcut was approximately $85,000. Since that time additional bank erosion has taken place therefore an updated survey and design would be required, likely increasing the cost to at least $100,000.

11.3.4.2 Magnolia River Bank Erosion Site

This site on Magnolia River is located approximately 3,300 feet east of CR 49 near the overhead powerline crossing. The stream reach primarily affected by eroding banks is estimated to be approximately 1,000 feet long, with downstream significant sediment deposition estimated to be approximately 3,500 feet long. The major unstable bank area is located at latitude 30.399603°, longitude -87.7595°. Unlike the Fish River erosion site discussed in the previous paragraph, this area has not had any field analysis to determine quantifiable costs for bank stabilization and sediment deposit removal. Estimating the bank stabilization based on $500 per linear foot would put the estimate for that 1,000 foot reach to be $500,000, plus the cost for sediment removal based on $250 per linear foot for the 3,500 foot reach would be $875,000 – total cost $1,375,000.

11.3.5 Pave Six Priority Dirt Roads

Paving of the following six high priority dirt roads in the Watershed are recommended: Lipscomb Road, Norris Lane, Mannich Lane [S2], Mannich Lane [S4], Paul Cleverdon Road, and Sherman Road in order to reduce erosion and sedimentation problems.

1. Lipscomb Road has an unpaved reach 0.87 mile long from U.S. Highway 98 north almost to Mannich Lane, and has a wetland crossing with evidence of sediment impacts, with turnouts directing sediment to wetlands.
2. Norris Lane (South) begins at Laurent Road and runs south for a distance of 2.02 miles terminating at CR 12, and has sediment impacts at several stream crossings.
3. Mannich Lane [S2] runs 0.5 mile from Norris Lane (North) west to CR 49 (North), and has a significant amount of sediment deposition in wetlands and the braided Spring Branch stream channel.
4. Paul Cleverdon Road runs approximately 1.5 miles from CR 34 south to CR 32, and has some stream crossing erosion problems.
5. Mannich Lane [S4] runs 1.5 miles between Lipscomb Road and CR 9, and has significant sediment plumes at several culvert crossings and gully erosion in ROW ditches contributing sediment to Eslava Creek.
6. Sherman Road runs 1.0 miles from CR 16 to Weeks Road, crosses Weeks Creek, and has cross drains with significant sediment plumes.

A rough estimate paving cost would be $800,000 per mile (does not include utility relocations or design/construction of utilities), with a survey cost of $15,000 per mile, and engineering/design cost of $64,000 per mile. Therefore the rough cost estimates for paving of these six high priority roads are:

1. Lipscomb Road: $800,000

2. Norris Lane (South): $1,800,000
3. Mannich Lane [S2]: $450,000
4. Paul Cleverdon Road: $1,400,000
5. Mannich Lane [S4]: $1,400,000
6. Sherman Road: $900,000

11.3.6 Assess/Pave Other Dirt Roads in Watershed

Assessment and paving of the other dirt roads within the Weeks Bay Watershed would help reduce the amount of sediment entering nearby wetlands and streams. Section 3.4.5.1 identifies the current unpaved road segments in the Watershed. For the Upper Fish River Subwatershed there are approximately 8.6 miles of unpaved roads, and would cost an estimated $7,600,000 to pave. The Middle Fish River Subwatershed has approximately 10.5 miles of unpaved roads (excluding the 1.5 mile reach of Paul Cleverdon Road that is included in the previous paragraph discussion/estimate), and would cost an estimated $9,300,000 to pave. The Lower Fish River Subwatershed has approximately 2.6 miles of unpaved roads, and would cost an estimated $2,300,000 to pave. The Magnolia River Subwatershed has approximately 13.6 miles of unpaved roads (excluding the 5.8 mile reaches of Lipscomb Road, Norris Lane, Mannich Lane [S2 and S4], and Sherman Road that is included in the previous paragraph discussion/estimate), and would cost an estimated $12,000,000 to pave.

11.3.7 Identify/Reduce Nutrient Producing Hotspots

The GOMA/ADEM Source, Fate, Transport and Effects (SFTE) study (2013), ADEM Trend Station data and other data sources, indicate that nutrient concentrations and loadings are elevated and rising in both the Fish and Magnolia River watersheds. Although dissolved oxygen levels in the mainstem of the rivers and most of their tributaries are generally good, impacts are most noticeable in Weeks Bay, which by all accounts is considered eutrophic. The SFTE speculates that up to 28% of the loading may be anthropogenic.

Targeted reconnaissance, modelling (SWAT at HRU level) and sampling of subwatersheds identified with potentially high nutrient (nitrogen and/or phosphorus) yields and/or loadings to identify specific sources and contributing factors will initially be conducted. Based on the findings, develop and design site specific measures to reduce or eliminate nutrient sources and contributing factors such that subwatershed nutrient concentrations are within the range estimated natural concentrations based on ADEM and EPA ecoregion reference values (see Table 3.13) 90% of the time.

- Targeted subwatershed investigation: $75,000/each

- Implement appropriate subwatershed management measures in the following paragraph: TBD

Watershed appropriate management measures will be consistent with the ACNPCP and other published guidance and depend upon the results of the targeted investigation and may include, but not be limited to, the following:

- Stream Restoration: $400-$500 per linear foot
- Riparian Restoration: $2,500/acre
- Septic Tank Repair/Replacement: $4,000 - $6,000
- Livestock Exclusion: $1.80/linear foot
- Alternative Livestock Water Source: $3,500-$4,550 (well); $1.30/linear foot of pipeline
- Water Troughs: $195/each
- Livestock Stream crossing: $4.07/square foot
- Use of Cover Crops: $55/acre
- Conservation Tillage: $16/acre
- No Till Planting: TBD
- Precision Fertilizer Application: $23/acre

- Potential subwatersheds for targeted investigations include:
    - UT to Threemile Creek (south of I-10, north of U.S. 90, West of Loxley)
    - Upper Corn Branch (above Stapleton Road)
    - Upper Perone Branch
    - Upper Caney Branch (Picard Branch)
    - Upper Pensacola Branch
    - Upper Waterhole Branch (above Hwy 181)
    - Upper Green Branch (above Danne Road)
    - Turkey Branch (above Hwy 181)
    - Upper Polecat Creek (above CR 55)
    - Upper Baker Branch (above Davis Road)
    - Upper Schoolhouse Branch
    - Magnolia River

11.3.8 Identify/Reduce Pathogen Producing Hotspots

The ADEM TMDL (2013) indicates that a 68% reduction in bacteria loading is necessary for the Fish River (mainstem) to meet State water quality standards. The bacteriological conditions occurring in Fish River that are attributable to non-point sources are largely unknown and may have been exacerbated by anthropomorphic stressors within the watershed. These stressors include changes in land use and land cover, the use of on-site sewage disposal systems, biosolids application, and animal husbandry practices. A number of tributaries to both the Fish and Magnolia Rivers have also been noted as exceeding the State water quality standards.

Systematic targeted reconnaissance and sampling of subwatersheds identified with potentially high bacteria concentrations to identify specific sources and contributing factors (i.e. bacteria source tracking) will initially be conducted. Based on the findings, develop and design site specific measures to reduce or eliminate sources and contributing factors such that subwatershed bacteria concentrations (where elevated) are reduced by 68% and meet ADEM water quality criteria at least 90% of the time.

- Targeted subwatershed bacteria investigations: $175,000/each

- Implement subwatershed appropriate management measures as described in the following paragraph: TBD

Watershed appropriate management measures will be consistent with the ACNPCP and other published guidance and depend upon the results of the targeted investigation and may include, but not be limited to, the following:

- Stream Restoration: $400-$500 per linear foot
- Riparian Restoration: $2,500/acre
- Livestock Exclusion: $1.80/linear foot
- Septic Tank Repair/Replacement: $4,000 - $6,000
- Alternative On-Site Disposal System Installation: TBD
- WWTP Improvements: TBD
- Sewage Collection System Improvements (SSO reduction): TBD

- Potential subwatersheds for targeted investigations:

    - Threemile Creek
    - Corn Branch
    - Perone Branch
    - Caney Branch
    - Pensacola Branch
    - Waterhole Branch
    - Turkey Branch (lower)
    - Polecat Creek (above CR 55)
    - Baker Branch (above Davis Rd)
    - Schoolhouse Branch
    - Eslava Creek
    - Weeks Creek

11.3.9 Restore Degraded Streams, Wetlands, and Riparian Buffers

Restoration of degraded streams, wetlands, and riparian buffers are discussed in more detail in Sections 4.5 and 6.8.1. Riparian and wetland buffers with natural vegetation help maintain highly diverse and functional aquatic communities. Narrow and impaired riparian zones, such as those associated with roads, pasture, cropland, impervious surfaces, and urbanized areas often result in poor biological conditions in their associated wetlands, streams and rivers. Watershed catchments with relatively high nutrient and sediment loadings identified by the SWAT Model appear to correspond well with locations of poor quality riparian and wetland buffers identified with the landscape-scale condition analysis. These priority catchments will be the focus of initial riparian buffer restoration efforts. More detailed future analyses will diagnose site-specific stressors of aquatic resources, to identify specific restoration sites for both riparian buffers and wetlands. For creation or restoration of riparian buffers and wetlands, the Year 1 success criterion is at least 85% survivorship of tree plantings. Subsequent coverage should be 60-70% trees, with herbaceous ground cover in between. Information on the cost for implementation of this recommended management measure is shown in Table 11.3, at the end of Section 11.3.10, below.

11.3.10 Acquire Strategic Tidal and Headwater Habitats

Implementation of strategic acquisition of high quality coastal and headwater habitats are discussed in more detail in Sections 4.5 and 6.8.2. Natural wetland areas provide critical ecological habitat for important flora and fauna; filter contaminants from runoff to decrease pollutants entering Fish River and Magnolia River, their tributaries, and Weeks Bay; and attenuate the effects of stormwater and tropical storm surge. Due primarily to the destruction and degradation of wetlands, the ecosystem services under the most stress in coastal Alabama are biodiversity, wildlife habitat, and water quality enhancement. Protection of natural, high quality wetlands will help ensure that habitat conditions and water quality do not continue to degrade, and that important ecosystem services and environmental benefits provided by these areas are not lost.

Upland habitats constitute a high percentage of the landscape surrounding headwater wetlands. Many headwater areas in the watershed have been impacted by urbanization, forestry practices, or draining for agricultural production. Small, first-order streams and associated wetlands absorb significant amounts of rainwater and runoff. When a landscape is altered, runoff can exceed the absorption capacity of small streams and degrade natural water quality and quantity, causing degradation downstream. Management of headwater regions can therefore benefit the condition of entire catchments and stream systems. Protection of these areas is critical for securing long-term environmental benefits in urbanizing watersheds. Information on the cost for implementation of this recommended management measure is shown in Table 11.3, at the end of Section 11.3.10, below.

11.3.11 Increase Invasive Species Management

An aspect of riparian buffer and wetland restoration is invasive plant management. Exotic invasive plants degrade community structure and ecosystem function in infested areas, and can spread rapidly to outcompete native flora, with consequent losses of biodiversity and habitat degradation. Monitoring for invasive exotics typically involves ongoing management, due to difficulties in permanent eradication. For invasive plant management, the success criterion is achievement of less than 5% coverage of invasive plants within a treatment area. Unit costs for herbicidal management of invasive species are shown in Table 11.3.

Table 11.3 Cost Information for Ecological Evaluation Management Measures

Project Type	Project Name	Potential Project Locations	Sub-Watershed	Linear Feet	Acres	Number of Units	Estimated Cost per Acre	Total Estimated Cost
Strategic Acquisition of High Quality Habitats								
		Tidal Wetlands	Magnolia River	NA	100	100	$2,900[1]	$290,000
		Tidal Wetlands	Lower Fish River/Weeks Bay	NA	200	200	$2,900[1]	$580,000
Riparian Buffer Restoration[2]								
	RB-1	Upper Eslava Branch	Magnolia River	8,380	36	36	$2,500	$90,000
	RB-2	Upper Weeks Creek	Magnolia River	69,950	163	163	$2,500	$407,500
	RB-3	Baker Branch	Middle Fish River	16,400	78	78	$2,500	$195,000
	RB-4	Green Branch	Lower Fish River	15,250	76	76	$2,500	$190,000
	RB-5	Corn Branch	Upper Fish River	13,400	60	60	$2,500	$150,000
Invasive Plant Control, Monitoring, and Management								
		Overall Watershed	Upper Fish	NA	200	200	$12,000[3]	$2,400,000
			Middle Fish	NA	200	200	$12,000[3]	$2,400,000
			Lower Fish	NA	200	200	$12,000[3]	$2,400,000
			Magnolia	NA	200	200	$12,000[3]	$2,400,000

[1]Non-developable land
[2]Tree planting only; No land work/geomorphic alteration; monitoring not included
[3]Includes initial treatment and 25-yr follow-up period

11.3.12 Planning/Awareness of Potential Sea Level Rise

The potential for sea level to continue to rise as it has over the past 50 years (6.5 inches as measured at the Dauphin Island tide gage) makes it is important to adequately plan and prepare for sustainable coastal communities within the Watershed. The public (including policy makers) needs to understand the reality and implications of SLR. Therefore, it is important to promote programs/workshops to improve stakeholder awareness of:

- Recorded SLR in the greater Mobile Bay area over the last 50 years;
- SLR predictions based on various agencies and models;
- Potential effects on infrastructure, residential properties, and habitats in the Watershed due to future SLR; and
- Sea level rise adaptation options.

The WBNERR and other partners such as the Alabama Coastal Foundation have taken a proactive approach in the public awareness and education of potential SLR effects by providing workshops over the last couple of years such as "*Protecting Coastal Communities by Linking Science and Citizens: An Interactive Sea Level Rise Workshop*". Other partners in these workshops have included NOAA, The Nature Conservancy, Louisiana State University, and University of Central Florida. The issue of sea level rise was explained in layman's language, explaining the science behind SLR and what it means to people and communities along the Gulf Coast. Also the risk associated with potential future SLR was addressed for natural environments, e.g., islands, marshes, wetlands, and human environments, e.g., roads, sewage treatment plants, ports, bridges, historical buildings. The WMPIT should endorse such future public awareness/education efforts on the potential for SLR by the WBNERR and other agencies/organizations.

11.3.13 Restore Tidal Area Degraded Areas With Living Shoreline Measures

11.3.13.1 Background and Purpose

Management measures to address coastal erosion and the effects of sea level rise (see Section 6.9) were developed to (1) help protect and enhance coastal habitats, (2) increase public awareness of SLR, and (3) to encourage the incorporation of SLR into planning and design activities in coastal areas. However, in order to effectively achieve these goals, it is necessary to better understand the complex dynamics affecting coastal portions of the watershed.

For example, one of the more notable findings from the shoreline and climate change assessments (see Sections 3.8 and 3.9, respectively) was that over the last 60 years, the lower reaches of both Fish River and Magnolia River have experienced: (1) the loss of emergent marsh island area; and (2) marsh loss due to the widening of coastal streams. While erosion due to boat wake may be one factor leading to this observed loss of marsh, it does not explain the widening of small streams, which are protected from boat wake. As such, there may be other factors impacting not only the streams but perhaps exacerbating the effects of boat wake erosion. Some such factors may include (1) inundation and potential salinity fluctuations due to Sea Level Rise (SLR) potentially leading to the loss of bank stabilizing vegetation, and (2) possible decreases in accretion rates, which could effectively starve the marsh of necessary sediment deposition. Understanding the role each of these factors may or may not play in the observed loss of marsh, will be critical to design of effective restoration projects in this area.

A more detailed evaluation is needed to better understand the complex dynamics in these systems, and provide the most applicable information to designers. This information should significantly enhance their ability to design the most effective restoration projects possible. The proposed project would share a similar scope as the *Fowl River Marsh Health and Recovery Study*, currently underway by the Mobile Bay NEP. Although there are some similarities with the Fowl River study area, Fish River and Magnolia Rivers exhibit their own unique conditions individually as well as collectively, as they both discharge into a protected bay with a narrow mouth, unlike Fowl River.

With improved understanding, a *Weeks Bay Watershed Marsh Health and Recovery Study* will inform how to best effect marsh health, guiding future restoration activities in the Weeks Bay Watershed. Additionally, the study and ensuing restoration efforts will benefit two priority natural resources in coastal Alabama: water and fish.

11.3.13.2 Goal and Scope

The goal of this project is to understand and improve the ecosystem function of intertidal marshes in the transitional zone of both Fish River and Magnolia River. This goal will be achieved through the preparation of a comprehensive characterization of health of emergent marshes in the transitional zone of both rivers, including an examination of factors influencing marsh health and underlying its degradation.

This study will focus on fringing marshes (i.e. plant communities at the interface between the land and river and influenced by tidal forces and river flooding) throughout the brackish transitional zone between the saltier and the fresher portions of both rivers. A series of metrics indicative of marsh health will be monitored along the course of both rivers, which will provide a better understanding of hydrology, sediment transport and vegetation in the study area. As with the Fowl River Marsh Study, these metrics will likely include:

- Plant distribution, diversity, and density;
- Above and below-ground plant biomass;
- Plant growth rates;
- Sediment grain size;
- Sediment accrual and erosion rates;

- Sediment composition;
- Salinity dynamics;
- Water quality;
- Hydrologic variables;
- Wave/boat wakes energy
- Marsh elevation profiles, and
- Sediment core isotope analysis.

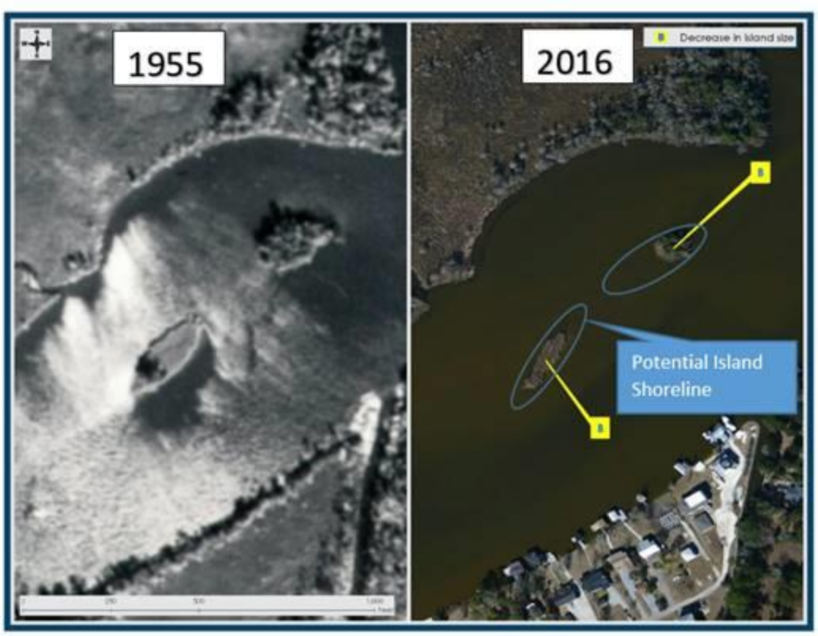
11.3.13.3 Schedule and Cost

Project schedule will be dictated by the season in which the study is initiated, but in general should be completed within 12 months. The anticipated cost of the *Weeks Bay Watershed Marsh Health and Recovery Study,* will be approximately $500,000.

11.3.13.4 Lower Fish River Degraded Marsh Islands Demonstration Project

11.3.13.4.1 Background and Purpose

As a result of the *Weeks Bay Watershed Marsh Health and Recovery Study,* shoreline assessment, and SLR analysis a demonstration project is recommended on the Lower Fish River to address impacts that are being observed on tidal islands in Fish and Magnolia Rivers. As a first step this demonstration project is recommended which would restore and stabilize two emergent marsh islands (see aerial photograph comparison below) located in the lower reaches of Fish River, approximately 1.3 miles upstream of the U.S. Highway 98 bridge.



11.3.13.4.2 Goal and Scope

This goal of the project is to restore two degrading islands, which serve as breakwaters for a nearby marsh on the western shore of Fish River, and provide designers with valuable information about the complex dynamics in this system. Information obtained during this demonstration project will provide a better understanding of hydrology, sediment transport and vegetation in the project area. Living shoreline concepts will be incorporated into the design of this demonstration project. It will also better our understanding of any effects to the system resulting from SLR, fluctuations in salinity levels and changing accretion rates. Such information would be very helpful in guiding future restoration activities in the brackish transitional zone between the saltier and the fresher portions of Fish and Magnolia Rivers, as well as similar portions of other coastal streams. Islands will likely be designed to:

- enhance accretion of sediment around the restored islands,
- enhance accretion in the marsh on the western shore of Fish River, and
- serve as a breakwater to limit erosion along the marsh on the western shore.

The project will consist of five phases:

1) Preliminary field investigation
2) Analysis of conceptual design alternatives
3) Design and Permitting
4) Implementation
5) Monitoring, and distribution of results to coastal planners and the public

11.3.13.4.3 Schedule and Cost

Table 11.4 Cost for Fish River Island Demonstration Project

Phase	Schedule	Cost Estimate
1 and 2. Field Investigation & Conceptual Alternatives Analysis	8 months	$200,000
3. Design & Permitting	14 months	$400,000
4. Implementation	16 months	$2,000,000
5. Monitoring	36 months	$100,000
		TOTAL COST: $2,700,000

11.3.13.5 Coastal Weeks Bay Watershed Living Shoreline Projects

As a result of completion of the above *Weeks Bay Watershed Marsh Health and Recovery Study* and the Lower Fish River Degraded Marsh Islands Demonstration Project, the WMPIT will identify the highest priority candidate living shoreline sites in the tidally influenced areas on Lower Fish River, Magnolia River, and Weeks Bay. For project estimation purposes we propose five (5) projects within each of these three areas, with each living shoreline being 200 feet in length.

11.4 Projects Previously Submitted on Deepwater Horizon Oil Spill Portals

Table 11.5 is a compiled list of proposed projects generated from different lists developed after the Deepwater Horizon Oil Spill by local resource management agencies and non-governmental organizations. Only projects that would directly affect improvements in water quality or ecosystem function were included in this compilation. Each row represents a proposed project with a brief description, the watershed(s) where it is located, the list(s) from which this project was derived, and a very broad restoration classification. Project cost estimates were included if they were reported on the project summary sheets. This compilation was generated to reflect the breadth of activities proposed for restoration, acquisition, or protection, and are supported by the findings of the WBWMP evaluations. Sources for this list included:

- **AL Portal** - Projects submitted to the Alabama RESTORE Council Portal for funding consideration (**http://www.alabamacoastalrestoration.org/View-Projects**)
- **NOAA Project Portal** - Projects submitted to NOAA for Natural Resource Damage Assessment consideration (**http://www.gulfspillrestoration.noaa.gov/restoration/give-us-your-ideas/view-submitted-projects**)
- **Draft Initial Funded Priorities List** - Projects approved Gulf Coast Ecosystem Restoration Council's Initial Funded Priorities List (**https://restorethegulf.gov/sites/default/files/Draft_Initial_FPL.pdf#overlay-context=draft-initial-funded-priorities-list-draft-fpl**)

Copies of summary sheets describing these projects are located in Appendix M.

Table 11.5 Ecosystem Restoration Project List Submitted on Deepwater Horizon Oil Spill Portals

Portal Information	Project Name	Contact Information	Primary Classification	Estimated Cost
PAGE 135 of Draft Initial Funded Priorities List: Project# DOC_RESTORE_001_006-008_Cat1	Marsh Restoration in Fish River, Weeks Bay, Oyster Bay and Meadows Tract	NOAA	Ecol./Environ.	$907,954
73 (AL Portal)	Fish River Watershed Restoration Project	Baldwin Co. Hwy. Dept.	Ecol./Environ.	$8,500,000
88 (AL Portal)	Floodplain conservation easements	WBF	Ecol./Environ.	$5,000,000
129 (AL Portal)	Harrod Tract Addition to the WBNERR	WBF	Ecol./Environ.	$2,700,000
267 (AL Portal)	New Stream-Gaging Station on Fish River at CR 32	Baldwin Co. Hwy. Dept.	Coastal Flood Protection	$87,250
293 (AL Portal)	Magnolia River Preservation Project – Holmes Property	WBF	Ecol./Environ.	$3,233,500
336 (AL Portal)	Weeks Bay East Gateway Tract	WBF	Ecol./Environ.	$3,000,000
337 (AL Portal)	Magnolia River North Gateway Tract	WBF	Ecol./Environ.	$2,000,000
396 (AL Portal)	Fairhope Sewer System Upgrades Phase I	Fairhope	Infrastructure* (Water Quality**)	$10,000,000
398 (AL Portal)	Fairhope Sewer System Upgrades Phase II	Fairhope	Infrastructure	$30,000,000
417 (AL Portal)	Pre-restoration Planning for Baker Branch - a Tributary of Fish River	MBNEP	Planning Assistance	$146,600
11602 in NOAA Project Portal	Fish River and Weeks Bay boat launchs and parking access.	Data Not Available	Public Access	Data Not Available
11786 in NOAA Project Portal	Improving Public Access to Alabama Coastal Waters-Viewpoint Park Public Access	Magnolia Springs	Public Access	$810,000
13072 in NOAA Project Portal	Predicting landscape-level impacts to in-stream sediment and nutrient flux to coastal waters	WBNERR, WBF	Water Quality	$350,000
2112 in NOAA Project Portal	Magnolia Springs Habitat Restoration	Magnolia Springs	Restoration	$500,000
NOAA NRDA Portal	Safe Harbor Marsh Restoration	WBNERR, DISL	Restoration	$822,375
NFWF GEBF Pre-Proposal	Strategic Land Acquisition in Weeks Bay Watershed	MBNEP, WBNERR, WBF	Ecol./Environ.	$6,500,000
NFWF GEBF Pre-Proposal	Bacterial Source Tracking, Upper Fish River	MBNEP, WBNERR, BCHD, ADPH, AWWA	Planning Assistance	$350,000
NFWF GEBF Pre-Proposal	Weeks Bay Watershed Turf Farm inventory and Assessment	MBNEP, WBNERR, NRCS, BCSWCD	Planning Assistance	$150,000

11.5 Implementation Schedule

Implementation of recommended management measures should begin immediately following approval of the WBWMP. Initial implementation should focus on the most critical issues and prioritized management measures identified in the WMP. The following steps should be given priority:

- Create a WMPIT within the first six months.
- Create/Hire Watershed Coordinator at BCSWCD within first eight months.
- Apply for and solicit funding within the first year.
- Establish Monitoring Program as soon as funding becomes available.
- Establish the Public Education and Outreach Program within the first year.
- Implement priority management measures as funding becomes available.

11.6 Indicators to Measure Progress

Criteria for determining the success of site specific management measures in improving watershed conditions will be established by the WMPIT as projects are funded and implemented. The criteria for success must include specific reduction goals for water-quality impairments. Establishing goals for load reductions also allows an adaptive management approach to reevaluate management measures and implementation plans if they fail to meet goals. Reduction goals for sediment, nutrients, and pathogens are stated within those sections (11.3.3, 11.3.6, and 11.3.7).

11.7 Education Program

The focal point for the education program within the Weeks Bay Watershed will continue to be the WBNERR, as they have"lead the charge" in this role since establishment in 1986. Management of any natural resource is enhanced by understanding, support, and participation of the stakeholders. Successful implementation of the recommended management measures may not be possible without public education and outreach, which is one of the EPA's nine key elements for watershed planning. A consistent and targeted education and outreach program will raise public awareness and support for the recommended management measures necessary to protect and improve the health of the Weeks Bay Watershed. The outreach program should include scheduled presentations to schools, civic organizations, the Baldwin County Commission, the nine municipality mayors/councils, and other organizations as necessary. Informational signage at watershed boundaries along roadways, boat landings and public access points should encourage the public to help preserve and protect the Weeks Bay Watershed through good stewardship. Trash containers and dumpsters with appropriate signage should be located at public access points and other strategic locations as a reminder to keep the Weeks Bay Watershed clean and free of trash.

The following goals have been identified for the public education and outreach plan

- Inform, educate, and engage key stakeholders in an effort to increase the public's awareness of both the benefits provided by Fish River, Magnolia River, tributaries, and Weeks Bay and the problems impacting the Bay, the Rivers and its Watershed.
- Develop the public's sense of ownership of Fish River, Magnolia River, and Weeks Bay, along with an understanding of the value of the Weeks Bay Watershed resources available to the community.
- Provide ways for the public to contribute to the restoration process, such as offering ideas for improving and preserving the Watershed.
- Educate community members so they increasingly value natural resources and recognize the importance of preserving and protecting the resource.
- Explore additional opportunities to engage the public in the restoration and protection of the Weeks Bay Watershed.

11.7.1 Targeted Audiences

Specific community stakeholders must become leaders in the WMP implementation process. These targeted audiences and the ways the WMP addresses the values important to each of those stakeholders are identified in this section. The following stakeholder groups have the ability to make changes through regulation or policy, participation in restoration activities, management of stormwater runoff, or communication of the Weeks Bay WMP goals and objectives.

11.7.2 Local Government Officials

Local elected officials and their staffs are responsible for establishing priorities for local programs, developing policies, and setting annual budgets. These roles can influence the successful implementation of the greater Weeks Bay WMP. This stakeholder group should be informed of the opportunity presented by the WMP to unify the public with the concept of protecting Weeks Bay Watershed with local engagement. Local government officials also have a role in providing access to the historic and productive waterway. In addition, the WMP provides useful information needed to make decisions about both recreational access and economic development while ensuring protection of environmental resources.

Local government officials can vote to support the Weeks Bay WMP, develop and implement WMP recommendations, and encourage stricter enforcement of regulations related to stormwater management. Local officials should be encouraged to work with state and federal agencies to facilitate WMP projects. They can also promote a sense of watershed community through community-wide activities such as trash collection and tree planting events. Local government may also provide funding for watershed signage such as:

- Historic and cultural signage to commemorate significant events or milestones in history.
- “Create a Clean Water Future” signage (as opposed to “Don’t Litter”) to positively connect residents with the Weeks Bay Watershed.
- Signage to identify the Weeks Bay Watershed’s historic biological diversity.

11.7.3 Private Industry

Success is closely tied to financial support. Support from an active and diverse group of private stakeholders is needed to attract and match sources of federal, state, and local funding. Major institutions within the Weeks Bay Watershed should be motivated to support the WMP, as all businesses within the Weeks Bay Watershed will benefit from its restoration. Local residents will enjoy improved surroundings, a better living environment, and increased satisfaction and pride in their community. Businesses can enhance their public image by demonstrating their support for preservation and restoration of a local resource. The WMP recommends engagement opportunities for private industry in the implementation of projects to support the surrounding community, local workforce, and economy while promoting their company image and fostering goodwill. Private industry can also seize opportunities to become involved in recommended projects such as installing stormwater retention ponds for their facilities or funding components of other projects and programs throughout the Watershed. Sponsors can be highlighted on signage or plaques.

11.7.4 Academia

Local schools and higher education institutions have an opportunity to inform students about issues in their community. Teachers and instructors can introduce students to the WMP goals and objectives. The extensive scientific and technical data presented in the WMP regarding the current status of the Weeks Bay Watershed and measures to improve conditions can be utilized as educational tools for all levels of curriculum. The WMP also identifies research opportunities for academic field work benefiting local resources.

The MBNEP developed educational resources to instruct 5th through 12th grade students about watersheds. The purpose of the program is to educate students about the environmental significance and the impact the community has on its watershed.

Academic institutions can develop multiple curriculums for grades K-12 and beyond; create grade school field trip opportunities throughout the Weeks Bay Watershed; identify research and implementation opportunities, including field work and/or data collection with relevant departments at local colleges and universities; and include preservation and restoration initiatives in curriculum when possible.

11.7.5 Local Resource Managers

Local resource managers provide services related to water supply and wastewater treatment to Weeks Bay Watershed residents and can assist in guiding water quality management within the Watershed. The actions recommended in this WMP will improve water quality of streams and Weeks Bay by reducing stormwater pollutants and trash in waterways and increasing public understanding of human impacts on water resources. Local resource managers can help by getting involved in Weeks Bay Watershed preservation and restoration efforts, assisting with outreach and communication, and sponsoring community events.

11.7.6 Media

Newspapers, television news programs, on-line news sources, and radio stations are significant sources of information for the public. The WMP sets the stage for a better future for the Weeks Bay Watershed and a vision, supported by the public, to preserve the area and provide community- wide access to a beautiful natural resource. Local media can help by publishing stories highlighting the WMP and its recommendations, creating news series describing accomplishments of the Weeks Bay WMPIT, advertising any cleanup or anti-littering events and campaigns, and sharing stories about the involvement of local leaders in the WMP.

11.7.7 Community Leaders

Community leaders have a vital role in implementing the WMP and its goals. They should be advocates of the WMP and encourage elected officials to prioritize the WMP recommendations. They should participate in education and outreach, watershed protection/restoration campaigns, and share restoration ideas. Community leaders should understand that the WMP represents a community-wide approach for protecting water quality, habitats, and living resources of the Weeks Bay Watershed through the goals of improving recreational opportunities, beautifying the area, and highlighting historical and cultural aspects of the Watershed. Community leaders can host events, promote recreational and outreach activities, create and launch neighborhood stormwater basin maintenance campaigns, and educate residents on the benefits of preservation and restoration to their properties.

Many leaders and stakeholders have been identified through the process of developing the WMP, and some are already involved. The task for the future is not necessarily to identify additional leaders, but to determine how the leaders should structure the existing group in moving forward into a WMPIT. While the MBNEP has led the effort to initiate the work, future efforts and project implementation must be rooted within the community of stakeholders.

The mission of the MBNEP is to promote wise stewardship of the water quality and living resources of Mobile Bay and the Mobile-Tensaw Delta. To support its mission and role in the community, the MBNEP chooses to promote watershed planning and the development of this WMP. The MBNEP recognizes the critical importance of preserving and improving the health of the Weeks Bay Watershed. However, an independent leadership organization should coordinate WMP implementation in close collaboration with the MBNEP.

The WMPIT must develop a vision, mission, bylaws, and leadership structure. It should work with local governmental officials and regulatory agencies to implement the WMP recommendations. The WMPIT should provide opportunities for public involvement and membership, organize the training of volunteer coordinators for a wide variety of environmental topics, host meetings with community groups and neighborhood associations to equip them with the knowledge and materials for promoting the WMP goals and objectives, and collaborate with citizen groups to promote stewardship efforts in preserving and restoring the Weeks Bay Watershed. The WMPIT should schedule recurring meetings with area media to educate the community about watershed management; provide information regarding upcoming events, photos, and other supporting materials; and update the community on new developments and opportunities for public engagement by generating press releases on watershed activities. As stated above, the WMPIT could consist of a consolidated group from the MBNEP collaborating with a local and active civic group.

11.8 Local Programs

11.8.1 Alabama Coastal Area Management Program

The Alabama Coastal Area Management Program (ACAMP) was approved by NOAA in 1979 as part of the National Coastal Zone Management Program. The Alabama Department of Conservation and Natural Resources (ADCNR), State Lands Division, Coastal Section is responsible for overall management of ACAMP. The purpose of ACAMP is to balance economic growth with the need for preservation of Alabama's coastal resources for future generations. The program promotes wise management of the cultural and natural resources of the state's coastal areas and fosters efforts to ensure the long-term ecological and economic productivity of coastal Alabama. ACAMP is implemented in the legislatively defined Alabama Coastal Area which extends from the continuous ten-foot contour seaward to the three-mile limit in Mobile and Baldwin Counties.

The ADCNR, State Lands Division, Coastal Section staff works jointly with staff from ADEM to implement the federally-approved program. ADCNR serves as the lead agency responsible for overall management of the program including planning, fiscal management, and education and dissemination of public information. ADEM oversees regulatory, permitting, monitoring, and enforcement responsibilities of the program. Based upon current federal legislation, the State of Alabama continues to administer the ACAMP as its Coastal Zone Management Program under the Coastal Zone Management Act (CZMA) of 1972. The CZMA also requires the state to develop and implement its ACNPCP, in order to deter potential impacts and enhance coastal waters, under Section 6217 of the Coastal Zone Act Reauthorization Amendment of 1990 (CZARA). These proposed Watershed Management Plan prioritizations and projects are developed to ensure implementation of the program measures and best management practices that support the ACNPCP and the ACAMP goals.

Annual program activities include Coastal Cleanup, implementation of public access construction projects, planning support for local governments, implementation of the Alabama Coastal Nonpoint Source Control Program measures, and providing grant funds and technical assistance to Alabama's coastal communities and partners. ACAMP's annual grant program supports projects that protect, enhance, and improve the management of natural, cultural, and historical coastal resources and that increase the sustainability, resiliency, and preparedness of coastal communities and economies.

As part of the implementation of this WBWMP, full and continued support of ACAMP is endorsed. More information on the Alabama Coastal Area Management Program can be found on the ADCNR website: http://www.outdooralabama.com/alabama-coastal-area-management-program and ADEM's Coastal Programs website: http://adem.alabama.gov/programs/coastal/

11.8.2 Clean Marina Program

Marinas and recreational boating are recognized as potential sources of nonpoint source pollution in coastal watersheds. The Alabama- Mississippi Clean Marina Program (AMCMP) is a voluntary, incentive-based program developed and implemented by the Mississippi-Alabama Sea Grant Consortium and partners to promote environmentally- responsible and sustainable marina and boating practices (http://masgc.org/clean-marina-program).

This program, created to reduce water pollution and erosion in state waterways and coastal zones, helps marina operators protect the very resource that provides them their livelihood – clean water. The AMCMP promotes boater education, coordination among state agencies, and better communication of existing regulations, as well as offers incentives to creative and proactive marina operators.

The AMCMP focuses on seven management measures identified by marina operators as priorities: (1) marina siting, design, and maintenance; (2) sewage management; (3) fuel management; (4) solid waste and petroleum recycling and disposal; (5) vessel operation, maintenance, and repair; (6) stormwater management and erosion control; and (7) marina management and public education.

Marinas in the Weeks Bay Watershed should be encouraged to participate in the AMCMP. Through participation, marina operators will receive technical assistance and promotional items identifying their facilities as "Clean Marinas." Studies have shown that the most important criteria in choosing a marina for boat owners is cleanliness, and designated "Clean Marinas" may have an advantage in appealing to more environmentally-conscious consumers.

Additional needs include the establishment of a cost-share program providing incentives to marinas to retrofit existing infrastructures, including stormwater and waste management systems, to meet "Clean Marina" standards.

11.8.3 Alabama Water Watch

An important part of the WMP implementation strategy is to create interest and encourage participation by watershed residents. One way to achieve this is to renew the interest in the local volunteer monitoring program that was established by the WBNERR. The Alabama Water Watch (AWW) organization is an outstanding example of this type of program. It is a citizen-volunteer water quality monitoring program that has data collection stations located in all of the major river basins in Alabama. Data collected through the Weeks Bay Chapter of AWW was instrumental in preparation of the water quality portion of the WBWMP.

The goals of the Weeks Bay Watershed volunteer monitoring program is to:

- Educate residents on water quality issues and create interest in the health of the Watershed;
- Train citizens to use standardized equipment and techniques to gather water quality information correctly;
- Enable citizens to maintain and improve the health of the Watershed by using their data for environmental education, restoration, protection, and stewardship; and
- Create a database of water quality data that can be used to help evaluate the effectiveness of management measures.

Volunteer monitoring locations should initially include all the data collection stations listed in Section 10. The volunteer monitoring program is primarily intended to collect field parameters as an ongoing reconnaissance to screen water quality for potential problems. Identified issues could then be more thoroughly investigated through in-depth sampling and analyses under the formal monitoring program addressed in Section 10.

11.8.4 Community Rating System

The Community Rating System (CRS) is a Federal Emergency Management Agency (FEMA) program that encourages community flood management to exceed the minimum National Flood Insurance Policy standards and can lead to discounted premiums depending on the level of community participation. The insurance premium rates for policyholders can be reduced as much as 45%. Technical assistance is available for designing and implementing the required activities. Additionally, implementing some of the CRS activities can aid in project qualification for other federal assistance programs.

11.8.5 Alabama Smart Yards

The Alabama Smart Yards (ASY) program is a cooperative alliance by the Alabama Cooperative Extension System, ADEM, Alabama Nursery and Landscape Association, Alabama Master Gardeners Association, and Auburn University's Department of Horticulture (ACES, 2016a). Its mission is to introduce environmental consciousness to homeowners and neighborhoods. The ASY provides an extensive handbook that contains a host of information including recycling lawn waste, reducing stormwater runoff, managing yard pests responsibly, efficient irrigation practices, etc. The program also includes a "Smart Yards" application for mobile telephones that serves as a pocket guide for environmentally responsible yard maintenance.

11.8.6 Create a Clean Water Future

The Create a Clean Water Future organization, (http://www.cleanwater future.com), seeks to improve the water quality of coastal Alabama through education of the general public and encouragement of the adoption of good stewardship practices. They have an active campaign oriented towards the general public, schools, restaurants, and businesses. Their website features tips to promote easy habits that will improve water quality through the reduction of trash and polluted runoff, and facilitates volunteer community cleanup activities.

11.9 Monitoring Program

A monitoring program must be developed and used to determine the overall health of the Weeks Bay Watershed. Specific monitored parameters, locations, and schedules are addressed in Section 10 of the WMP. A substantial database of information compiled in the development of this WMP can provide baseline conditions to evaluate future conditions determined by the monitoring program. The data collected will also be used to evaluate the success of implemented management measures and indicate where additional management measures are needed. The monitoring should be conducted on a regular schedule and should begin as soon as the necessary funding is secured.

11.10 Evaluation Framework

The evaluation framework for this WMP, its implementation, and its success, can be divided into three primary areas: inputs, outputs, and outcomes. Inputs include human resources of time and technical expertise, organizational structure, management, and stakeholder participation. Outputs include implementation of management measures, public outreach and education, and the monitoring program. Outcomes include increased public awareness, improved watershed conditions, and improved water quality.

An effective evaluation framework allows the WMP and implementation strategy to be modified as necessary to maximize efficiency and achieve stated goals. The evaluation framework for the WBWMP should focus on answering these questions during the indicated time frames. If the answer to any of these questions is negative, the implementation strategy should be reevaluated and revised.

11.10.1 Short-Term Milestone Period (0 – 2 years)

- Has the WMPIT assigned duties and responsibilities?
- Has the Watershed Coordinator position been created, funded, and position filled?
- Has the necessary funding been quantified, sources identified, and received?
- Has an inter-governmental partnership been formed for the nine municipalities and county to track compatibility of watershed regulations and handling of issues?
- Has a forum been created for periodic dialogue of municipality and county elected officials on broad watershed issues?
- Have the monthly municipal/county planners meetings been continued regarding regulatory/growth issues
- Has a municipality/county GIS layer been developed for the municipalities and county to track potential large residential and commercial projects?
- Has the use of LID/GI practices across the various jurisdictions been promoted and expanded use been realized?
- Has the Baldwin County flood model been rerun with updated land use forecasts?
- Has a HOA/POA Stormwater Inspection Guide/Checklist been developed, including training forum?
- Has a scope of work/cost estimate been developed, and funding sought for stormwater basin inventory and assessment for the Watershed?
- Have demonstration projects been designed/constructed for retrofitting of a few stormwater basins for water quality improvements?
- Has the Public Education and Outreach Program been organized and implemented?
- Has the Monitoring Program been established, a qualified entity identified to carry out the program identified/funded, and the field monitoring initiated?

11.10.2 Long-Term Milestone Period (2-20 years)

11.10.2.1 General Goal Questions

- Have specific projects and management measures proposed in the WMP been fully implemented and completed?
- Have there been reductions in the sediment, nutrient, and bacteria loading rates?

- Have water quality conditions improved?
- Have water quality improvements and loading rate reductions met stated goals?

11.10.2.2 Specific Goal Questions

- Have LID/GI regulations been adopted by more municipalities and by Baldwin County?
- Have LID/GI practices been increasingly utilized within the Watershed?
- Have additional retrofits of stormwater facilities (beyond the short-term demonstration projects) been installed within the Watershed?
- Has the use of conservation programs available for both public and private landowners through the NRCS and Farm Service Agency (FSA) programs been encouraged and more widely used by farmers and foresters?
- Has broader implementation of good agricultural/forestry practices been realized for farmers and foresters?
- Have site specific efforts been implemented to reduce sediment loading as a result of expanded SWAT data analysis/field review for subwatersheds?
- Have the high priority unpaved roads: Lipscomb Road, Norris Lane, Mannich Lane [S2], Mannich Lane [S4], Paul Cleverdon Road, and Sherman Road been paved?
- Have other Watershed unpaved roads been assessed and/or paved?
- Have site specific nutrient loading reduction management measures been implemented as a result of expanded SWAT data analysis for subwatersheds with the highest nutrient yields?
- Have site specific pathogen source location and remediation measures for human and livestock sources been implemented?
- Have degraded streams, wetlands, and riparian buffers been restored in the Watershed?
- Have strategic acquisitions of high quality coastal and headwater habitats been accomplished?
- Have increased invasive species detection and management programs been implemented?
- Has long term municipal and county planning activities been conducted to recognize uncertainties of potential future sea level changes?
- Have specific oyster reef and contiguous marsh areas been the subject of living shoreline or shoreline protection/restoration measures?
- Has the Public Education and Outreach Program continued long-term in the Watershed?
- Has the Monitoring Program been continued long-term in the Watershed?

12.0 REFERENCES

<u>**Section 2 Watershed Description References**</u>

Hydrology-Water Quality References

GOMA (Gulf of Mexico Alliance). 2013a. *Sources, Fate, Transport, and Effects (SFTE) of Nutrients as a Basis for Protective Criteria in Estuarine and Near-Coastal Waters: Weeks Bay, Alabama Pilot Study*. Prepared for the Gulf of Mexico Alliance, Nutrients Priority Issues Team (Alabama Department of Environmental Management, and the Mississippi Department of Environmental Quality) by Tetra Tech, Inc., Owings Mills, MD.

GOMA. 2013b. *Sources, Fate, Transport, and Effects (SFTE) of Nutrients as a Basis for Protective Criteria in Estuarine and Near-Coastal Waters. Weeks Bay, Alabama Pilot Study. Empirical Analysis of Monitoring Results.* Prepared for the Gulf of Mexico Alliance, Nutrients Priority Issues Team (Alabama Department of Environmental Management, and the Mississippi Department of Environmental Quality). Prepared by: Tetra Tech, Inc., Owings Mills, MD.

Alabama Department of Environmental Management. (1 April 2014). *2014 Integrated Water Quality Monitoring and Assessment Report- Water Quality in Alabama 2014-2014*.

Bianchette, T .A., K.-B. Liu, N. S.-N. Lam, L.M. Kiage. (2009). *Ecological Impacts of Hurricane Ivan on the Gulf Coast of Alabama: A Remote Sensing Study.* Journal of Coastal Research, SI 56.

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K, and Yoder, D.C., coordinators. (1987). *Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Soil Loss Equation (RUSLE).* U.S. Dept. of Agriculture, Agric. Handbook No. 703, 404 pp.

Rodgers III, J.C, A.W. Murrah, W.H. Cooke. (2009). *The Impacts of Hurricane Katrina on the Coastal Vegetation of the Weeks Bay Reserve, Alabama from NDVI Data.* Estuaries and Coasts 32:496-507.

Soils, Geology, Groundwater, Topography References

Davis, M.E. (1987). *Stratigraphic and Hydrogeologic Framework of the Alabama Coastal Plain*. U.S. Geological Survey Water-Resources Investigations Report.

Gillett, Blakeney, Raymond Dorothy E, Moore, James D, and Tew, Berry H. (2000). *Hydrogeology and Vulnerability to Contamination of Major Aquifers in Alabama.* Area 13.

McBride, E.H. and Burgess, L.H. (1964). *Soil Survey of Baldwin County, Alabama.* United States Department of Agriculture Soil Conservation Service, Series 1960, No. 12.

Murgulet, Dorina and Tick, Geoffrey R. (2008). *Assessing the Extent and Sources of Nitrate Contamination in the Aquifer System of Southern Baldwin County, Alabama.*

Soil Survey Staff. (2016). *Natural Resources Conservation Service*. United States Department of Agriculture. Web Soil Survey. Retrieved from http://websoilsurvey.sc.egov.usda.gov/.

Robinson, James L., Moreland, Richard S., and Clark, Amy E. (1996). *Ground-Water Resources Data for Baldwin County, Alabama.*

University of Alabama. (2017). *Physiographic Regions.* Department of Geography, Department of Arts and Sciences. Retrieved from http://alabamamaps.ua.edu/contemporarymaps/alabama/physical/al_physio.pdf

Floodplains and FEMA Flood Zones

ADECA. (August 2014). *Mapping the Risk, Flood Map Update: Baldwin County.* ADECA OWR. Public Outreach Flyer No. 2 of 6.

ADECA. (July 2012). *Mapping the Risk, Flood Map Update: Baldwin County.* ADECA OWR. Public Information Sheet No. 1 of 5.

Alabama Department of Economic and Community Affairs. (2015). *Floodplain Management.* Retrieved in 2016 from http://adeca.alabama.gov/Divisions/owr/floodplain/Pages/default.aspx.

Hydro Engineering Solutions, LLC. (October 2011). *Fish River and Magnolia River Watershed Study*. Prepared by Hydro Engineering Solutions, LLC, for Baldwin County.

Hydro Engineering Solutions, LLC. (2014). *Fish River Stages with Proposed Detention Ponds April 29, 2014 Rain Event*. PowerPoint Presentation prepared by Hydro Engineering Solutions, LLC for Baldwin County.

History and Culture References

Weeks Bay Foundation. (27 May 2016). *Weeks Bay Foundation: An Accredited Land Trust.* Alabama Department of Conservation and Natural Resources. Retrieved from <http://www.weeksbay.org/brochure/Weeks_Bay_Brochure.pdf>.

Baldwin County, Alabama. (N.d). Baldwin County, Alabama. Retrieved on 14 June 2016 from <http://www.centralbaldwin.com/baldwin/index.html>. (2016a)

Baldwin County, Alabama. (17 May 2016). Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Baldwin_County,_Alabama#Major_highways>. (2016b)

Baldwin County FacebookPages. (N.d). *Free Baldwin County Alabama Ancestry Records*. Retrieved on 27 May 2016 from <http://genealogytrails.com/ala/baldwin/>.

Borom, John, and Bill Hosking. (February 1987). *Weeks Bay National Estuarine Reserve Newsletter.* The Pelican Post. Retrieved on 3 June 2016 from <http://www.weeksbay.org/Pelican/The%20Pelican%20Post%20-%201987%20February.pdf>.

Causey, Donna R. (16 September 2014). *Pictures From The Past - Silverhill, Al.* Alabama Pioneers. Retrieved on 2 June 2016 from <http://alabamapioneers.com/silverhill-baldwin-county-alabama-immigrants-throughout-world-settled-small-community/#sthash.9oxBdLTQ.dpbs>.

The City of Foley Railroad Museum Archives. (2008). *Foley Alabama Railroad Museum*. Foley Train Museum. Retrieved on 23 May 2017.

City of Robertsdale, Alabama | Official Website. (N.d.). *City of Robertsdale, Alabama*. Retrieved on 27 May 2016 from <http://www.robertsdale.org/>.

Wikipedia. (28 March 2016). *Daphne, Alabama.* Wikimedia Foundation. Retried on 27 May 2016 from <https://en.wikipedia.org/wiki/Daphne,_Alabama#History>.

Fairhope, Alabama. (17 May 2016). Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Fairhope,_Alabama#History>.

Fish River(Alabama). (21 May 2016). Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Fish_River_(Alabama)>.

Outdoor Alabama. (16 July 2014). *Fish River.* Retrieved on 3 June 2016 from <http://www.outdooralabama.com/fish-river>.

Wikipedia. (28 Mar. 2016). *Foley, Alabama.* Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Foley,_Alabama#History>.

Foley Train Museum. (N.d.). *Foley Train Museum - History*. Retrieved on 27 May 2016 from <http://www.foleyrailroadmuseum.com/history.cfm>.

Freeman, Paul. (N.d.). *Abandoned & Little-Known Airfields: Alabama, Mobile Area*. Retrieved on 09 June 2016 from <http://www.airfields-freeman.com/AL/Airfields_AL_Mobile.htm#Magnolia>.

(N.d.). *Ft. Mims Massacre, Baldwin County, Alabama 1813*. Retrieved on 27 May 2016 from <http://www.canerossi.us/ftmims/massacre.htm>.

Gaston, Paul M. (4 May 2007). *Fairhope*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-1161>.

Gyllerstrom, Catherine Kim. (8 September 2011). *Turpentine Industry in Alabama.* Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-3137>.

Harper, Roland M. (1913). *Economic Botany of Alabama: Monograph 8, Part 1*. Geological Survey of Alabama. Montgomery, Alabama. 120+.

Historic Compilations Comprehensive History. (N.d.). Retrieved on 27 May 2016 from <http://baldwincountyal.gov/community/about-baldwin-county/history-of-baldwin-county/historical-compilations-comprehensive-history>.

(2012). *History of the City of Spanish Fort, AL*. Retrieved on 27 May 2016 from <http://www.cityofspanishfort.com/GettoKnowUs/History.aspx>.

Jackson, John. (25 Nov. 2013). *Historic Marlow Ferry, Part I.* GulfCoastNewsToday.com. Retrieved on 27 May 2016 from <http://www.gulfcoastnewstoday.com/people/history/article_69b44216-560d-11e3-b352-001a4bcf887a.html?mode=story>.

Jackson, John. (25 Nov. 2013). *Historic Marlow Ferry, Part II.* GulfCoastNewsToday.com. Retrieved on 14 June 2016 from <http://www.gulfcoastnewstoday.com/people/history/article_a5149bf8-560d-11e3-8475-001a4bcf887a.html>.

Kaetz, James P. (31 August 2012). *Loxley*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-3306>.

Kaetz, James P. (11 February 2013). *Magnolia Springs*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-3393>.

Kaetz, James P. (13 February 2012). *Robertsdale*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-3212>.

Kaetz, James P. (18 February 2013). *Silverhill*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-3398>.

Lawson, Thomas. (1996). *Logging Railroads of Alabama*. Birmingham, Alabama: Cabbage Stack Publication. Chapter 14/Mobile Bay, East and West. Pg. 178-92. Print.

Lee, J. Lawerce. (10 Aug. 2009). *Alabama Railroads*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-2390>.

Wikipedia. (N.d.). *Louisville and Nashville Railroad.* Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Louisville_and_Nashville_Railroad>.

Wikipedia. (1 Jan. 2016). *Loxley, Alabama.* Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Loxley,_Alabama#History>.

Wikipedia. (N.d.). *Magnolia Springs, Alabama.* Wikimedia Foundation. Retrieved on Web. 27 May 2016 from <https://en.wikipedia.org/wiki/Magnolia_Springs,_Alabama>.

Marlow Ferry. (7 Jan. 2016). Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Marlow_Ferry>.

Memory of the Good Old Days: Free Range Cattle. (2009). Baldwin County Cattle and Fair Association. Retrieved on 15 June 2016 from <http://baldwincofair.com/Product/14>.

Mitchell, Charles. (4 Dec. 2007). *Agriculture in Alabama.* Encyclopedia of Alabama. Retrieved on 31 May 2016 from <http://www.encyclopediaofalabama.org/article/h-1396>.

Morton, Patricia Hoskins. (23 Aug. 2007). *Baldwin County*. Encyclopedia of Alabama. Retrieved on 08 June 2016 from <http://www.encyclopediaofalabama.org/article/h-1303>.

National Register of Historic Places. Retrieved on 18 May 2017 from https://www.nps.gov/nr/research/index.htm

Oliver-Lee, Dallam. (1957). *OLF Summerdale*. Abandoned & Little-Known Airfields: Alabama, Mobile Area. Retrieved on 9 June 2016 from <http://www.airfields-freeman.com/AL/Airfields_AL_Mobile.htm#Summerdale>.

Pictures From The Past - Silverhill, Al. (2013). Alabama Pioneers. Retrieved on 27 May 2016 from <http://alabamapioneers.com/silverhill-baldwin-county-alabama-immigrants-throughout-world-settled-small-community/#sthash.9oxBdLTQ.dpbs>.

Wikipedia. *Silverhill, Alabama*. (N.d.). Wikimedia Foundation. Retrieved on 27 May 2016 from <https://en.wikipedia.org/wiki/Silverhill,_Alabama>.

Smith, E. A., Dr., and R. S. Hodges. (1902). Figure 54. *Bayou La Batre.* Economic Botany of Alabama. Montgomery: U of Alabama, 1913. 179. Print.

Sommer, David. (1944). *1944 L&N Southern States Route Map.* Photograph. Retrieved on 27 May 2016 from http://www.rrpicturearchives.net/showPicture.aspx?id=48454

Summerdale. (18 Feb). 2013*Encyclopedia of Alabama*. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-3399>.

Thompson-Messina, Jennifer. (7 Aug. 2009). *Daphne*. Encyclopedia of Alabama. Retrieved on 27 May 2016 from <http://www.encyclopediaofalabama.org/article/h-2379>.

United States Geological Survey. (1941). *Alabama (Baldwin County) Weeks Bay Quadrangle* [map]. 1:62,500. 15 Minute Series. In cooperation with the United States Department of the Army Corps of Engineers.

United States Geological Survey. (1941). *Alabama (Baldwin County) Foley Quadrangle* [map]. 1:62,500. 15 Minute Series. In cooperation with the United States Department of the Army Corps of Engineers.

United States Geological Survey. (1941). *Alabama (Baldwin County) Robertsdale Quadrangle* [map]. 1:62,500. 15 Minute Series. In cooperation with the United States Department of the Army Corps of Engineers.

United States Geological Survey. (1953). *Silverhill Quadrangle* [map]. Photorevised 1967. 1:24,000. 7.5 Minute Series.

United States Geological Survey. (1953). *Stapleton Quadrangle* [map]. Photorevised 1967. 1:24,000. 7.5 Minute Series.

Weeks Bay Alabama. (N.d.). National Estuarine Research Reserve System. Retrieved on 27 May 2016 from <http://www.weeksbay.org/brochure/Weeks_Bay_Brochure.pdf>.

Welcome To Magnolia Springs. Retrieved on 27 May 2016 from <http://www.townofmagnoliasprings.org/index.asp>.

Welcome To Magnolia Springs. (2013). Town of Magnolia Springs. Retrieved on 22 May 2017.

Population

Baldwin County Development Alliance. (2016). "*Baldwin By The Numbers 2016"*. Retrieved in April 2017 from http://blog.baldwineda.com/blog/2016-year-in-review-baldwin-county-economic-development.

Eastern Shore Metropolitan Planning Organization. (2015). "*2040 Long Range Transportation Plan (LRTP)".* Prepared for the Eastern Shore MPO in cooperation with the Baldwin County Commission, City of Spanish Fort, City of Daphne, City of Fairhope, and Town of Loxley and the Alabama Department of Transportation.

Land Use/Land Cover References

Ellis, J., J. Spruce, R. Swann, and J. Smoot. (December 2008). Land-Use and Land-Cover Change from 1974-2008 around Mobile Bay, Alabama. Final Report. Prepared for Mobile Bay National Estuary Program by NASA, Stennis Space Center, Mississippi.

Impervious Cover References

Alabama Department of Environmental Management in cooperation with the Alabama Cooperative Extension System and Auburn University. Undated. Low Impact Development Handbook for the State of Alabama. http://adem.alabama.gov/programs/water/waterforms/LIDHandbook.pdf Last accessed April 2017.

Alabama Cooperative Extension Service, Alabama Department of Environmental Management, and Auburn University, 2016. Planning for Stormwater: Developing a low impact solution. Alabama Cooperative Extension Service at Auburn University http://www.aces.edu/natural-resources/water-resources/watershed-planning/stormwater-management/documents/1467207286_lowimpactdistribution59.pdf Last accessed May 2017.

Center for Watershed Protection. (2003). *The Impacts of Impervious Cover on Aquatic Systems: Watershed Protection Research Monograph No. 1*. Center for Watershed Protection. Ellicott City, Maryland.

Center for Watershed Protection. (February 2005). *An Integrated Framework to Restore Small Urban Watersheds.* Version 2.0. Manual 1. Center for Watershed Protection. Ellicott City, Maryland.

Hirschman, D.J. and J. Kosco. (July 2008). *Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program.* EPA Publication No: 833-R-08-001. Center for Watershed Protection. Ellicott City, Maryland.

Homer, C.H., Fry, J.A., and Barnes C.A. (2012). *The National Land Cover Database, U.S. Geological Survey Fact Sheet 2012-3020.* 4 p. https://pubs.usgs.gov/fs/2012/3020/

Schueler, T. Undated. *Implications of the Impervious Cover Model: Stream Classification, Urban Subwatershed Management and Permitting.* CSN Technical Bulletin No. 3. Chesapeake Stormwater Network.

U.S. Environmental Protection Agency. (December 2009). Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act. EPA 841-B-09-001. Washington, D.C.

Xian, G., C. Homer, J. Dewitz, J. Fry, N. Hossain, and J. Wickham. (August 2011). "Change in Impervious Surface Area Between 2001 and 2006 in the Conterminous United States" in Photogrammetric Engineering & Remote Sensing, Vol. 77, Number 8.
https://www.mrlc.gov/nlcd2006.php
https://www.mrlc.gov/downloadfile2.php?file=September2011PERS.pdf

Section 3 Watershed Conditions - References

Water Quality

Alabama Department of Environmental Management. 2006 Monitoring Summary Magnolia River at Baldwin County Road 65. Montgomery, Alabama.

Alabama Department of Environmental Management. 2011 Monitoring Summary Magnolia River at Baldwin County Road 65. Montgomery, Alabama.

Alabama Department of Environmental Management. 2006 Monitoring Summary Fish River at AL Hwy 104 in Baldwin County. Montgomery, Alabama.

Alabama Department of Environmental Management. 2011 Monitoring Summary Fish River at AL Hwy 104 in Baldwin County. Montgomery, Alabama.

Alabama Department of Environmental Management. 2011 Monitoring Summary Cowpen Creek (at Baldwin County Road 33). Montgomery, Alabama.

Alabama Department of Environmental Management. August 2013. Final Total Maximum Daily Load (TMDL) for Fish River, Assessment Unit ID # AL03160205-0204-112 Pathogens (E. coli). Water Quality Branch, Water Division. Montgomery, Alabama. 36 pages.

Alabama Department of Environmental Management. September 29, 2015. ADEM Admin. Code r. 335-6-x-.xx, Water Division Water Quality Program Volume 1 Division 335-6. Montgomery, Alabama.

Alabama Department of Environmental Management. December 2016. 2016 Holiday Report for ACNPCP: December 2016 SWD Report -Coastal NPS PROJECTS. Electronic distribution by rcs@adem.state.al.us.

Alabama Department of Environmental Management. May 28, 2013. ADEM Admin. Code r. 335-8-x-.xx, Coastal Area Management Program, Division 335-8. Montgomery, Alabama.

Alabama Department of Environmental Management. April 1, 2014. 2014 Integrated Water Quality Monitoring and Assessment Report. Montgomery, Alabama.

Alabama Department of Environmental Management. September 2014. 2014 Alabama §303(d) List. Montgomery, Alabama. (http://adem.alabama.gov/programs/water/wquality/2014AL303cList.pdf)

Alabama Department of Public Health. 1995. Gulf of Mexico Program Demonstration Project in Sewage Management – Final Project Report, ADPH. January 13, 1995.

Alabama Department of Public Health. 1996. Demonstration Project in Onsite Wastewater Management in the Weeks Bay Watershed – Final Report, ADPH September 30, 1996.

Alabama Department of Public Health. June 2016. Alabama Fish Consumption Advisories 2016. Montgomery, Alabama.

Alabama Department of Transportation. January 26, 2016. MS4 Stormwater Management Program Annual Report Fiscal Year 2015. Montgomery, Alabama.

Alabama Forestry Commission. June 2007. *Alabama's Best Management Practices for Forestry*. Alabama Forestry Commission, 513 Madison Avenue, Montgomery, Alabama 36130.

Alabama Forestry Commission. April 2017. *2016 Annual Report*. Alabama Forestry Commission, 513 Madison Avenue, Montgomery, Alabama 36130

Alabama Water Watch. April 2001. *Citizen Volunteer Water Quality Monitoring on Alabama's Coast…protecting unique estuaries and streams*. Editor Dr. Bill Deutsch. Auburn University, Auburn, Alabama. 16 pp.

Alabama Water Watch. On-line Water Quality Data available from http://www.alabamawaterwatch.org/water-data

Baldwin County Commission. March 2016. Municipal Separate Storm Sewer System (MS4) Annual Report for 2015. Baldwin County Commission. Bay Minette, Alabama. 56 pp.

Basynat, P., L. D. Teeter, K. Flynn, and B. G. Lockaby. (1999). *Relationships Between Landscape Characteristics and Nonpoint Source Pollution Inputs to Coastal Estuaries*. Journal of Environmental Management 23: 539-549.

Chandler, R.V., P. E. O'Neil, V.L. Miller, S. S. DeJarnette, T. E. Shepard, and S.W. McGregor. 1998*. Monitoring of Surface-Water and Biological Conditions in the Fish River Watershed of Southwest Alabama*. Geological Survey of Alabama Circular 194. Tuscaloosa, Alabama.

Cook, Marlon R., N.E. Moss, D. Murgulet. (2009). *Analysis of Sediment Loading Rates for The Magnolia River Watershed, Baldwin County, Alabama*. Geological Survey of Alabama OPEN FILE REPORT 0914. Tuscaloosa, Alabama.

Cook, Marlon R.(December 2016). *Pre-Restoration Analysis of Discharge, Sediment Transport Rates, Water Quality, and Land-Use Impacts in the Fish River Watershed, Baldwin County, Alabama.* Polyengineering, Inc., Dothan, Alabama.

Daphne, City of. (March 2016). City of Daphne's 2015-2016 Phase II MS4-Annual Report's Goals and Achievements Compliance Charts and SWMPP update. City of Daphne. Daphne, Alabama.

Fairhope, City of. MS4 Program Phase II General Permit #ALR040040 2015 Annual Report. City of Fairhope. Fairhope, Alabama.

Gassman, P. W.,M. R. Reyes, C. H. Green, and J. G. Arnold. (2007). *The Soil and Water Assessment Tool: Historical Development, Applications, and Future Research Directions*. *Trans.* ASABE 50(4): 1211-1250

GOMA (Gulf of Mexico Alliance). (2013). *Sources, Fate, Transport, and Effects (SFTE) of Nutrients as a Basis for Protective Criteria in Estuarine and Near-Coastal Waters: Weeks Bay, Alabama Pilot Study.* Prepared for the Gulf of Mexico Alliance, Nutrients Priority Issues Team (Alabama Department of Environmental Management, and the Mississippi Department of Environmental Quality) by Tetra Tech, Inc., Ownings Mills, MD.

Haywick, D., M. Fearn, J. Kempton, L. Yokel, et.al. (2004). *Holocene Sedimentary History of Weeks Bay, AL: Human and Natural Impacts on Deposition in a Gulf Coast Estuary*. University of South Alabama. EPA Grant R83065101-0. March 31, 2004.

Hydro Engineering Solutions, LLC. (October 2011). *Fish River and Magnolia River Watershed Study*. Prepared by Hydro Engineering Solutions, LLC, for Baldwin County.

Hydro Engineering Solutions, LLC. (2014). *Fish River Stages with Proposed Detention Ponds April 29, 2014 Rain Event*. PowerPoint Presentation prepared by Hydro Engineering Solutions, LLC for Baldwin County.

Lehrter, J. C. (2006). *Effects of Land Use and Land Cover, Stream Discharge, and Interannual Climate on the Magnitude and Timing of Nitrogen, Phosphorus, and Organic Carbon Concentrations in Three Coastal Plain Watersheds*. Water Research Environment, Volume78, Number 12. DOI: 10.2175/106143006X102015.

Morrison, Andrew. (2011). *Spatial and Temporal Trends and the Role of Land Use/Cover on Water Quality and Hydrology in the Fish River Watershed.* Master's Thesis. Auburn University, Auburn, Alabama.

Mortazavi, B., A. A. Riggs, J. M. Caffrey, H. Genet, and S. W. Phipps. (2012). *The Contribution of Benthic Nutrient Regeneration to Primary Production in a Shallow Eutrophic Estuary, Weeks Bay, Alabama.* Estuaries and Coasts (2012) 35:862-877. DOI 10.1007/s12237-012-9478-y.

Monrreal, R. H. (2007). *Hydrology and Water Chemistry in Weeks Bay, Alabama: Implications for Mercury Bioaccumulation.* Master's Thesis Auburn University. Auburn, Alabama.

National Atmospheric Deposition Program (NADP) - Mercury Deposition Network (MDN) website: http://nadp.sws.uiuc.edu/mdn/

Niraula, R., L. Kalin, R. Wang, P. Srivastava. (2012). *Determining Nutrient and Sediment Critical Source Areas with SWAT: Effect of Lumped Calibration*. American Society of Agricultural and Biological Engineers, Vol. 55(1): 137-147.

NOAA National Estuarine Research Reserve System (NERRS). System-wide Monitoring Program. Data accessed from the NOAA NERRS Centralized Data Management Office website: http://www.nerrsdata.org/; *accessed* 13 March 2017.

O'Neil, Patrick, R.V. Chandler. (2003). *Water Quality and Biological Monitoring in Weeks Bay Watershed, Alabama 1994-1998*. Geological Survey of Alabama Bulletin 173. Tuscaloosa, Alabama.

Singh, H.V. (2010). *Modeling Impact of Land Use/ Cover on Water Quality and Quantity of Fish River Watershed*. Master Thesis Auburn University. Auburn, Alabama.

Spanish Fort, City of. (March 2016). Stormwater Management Program 2015 Annual Report. Matthew Hinton. Spanish Fort, Alabama.

Tetra Tech. (2016). Evaluating Nutrient Pulse Loads on Water Quality Weeks Bay, Alabama. Presentation to Alabama Water Resources Conference by E. Lincoln, September 8, 2016.

T. Miller-Way, M. Dardeau, G. Crozier. (1996). *Weeks Bay National Estuarine Research Reserve: An Estuarine Profile and Bibliography*. Dauphin Island Sea Lab Technical Report 96-01.

US Environmental Protection Agency. (2000). *Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion IX*. EPA 822-B-00-019. Office of Water. Washington, D.C. 32 pages plus appendices.

US Environmental Protection Agency. (2000). *Ambient Water Quality Criteria Recommendations, Information Supporting the Development of State and Tribal Nutrient Criteria, Rivers and Streams in Nutrient Ecoregion XII*. EPA 822-B-00-021. Office of Water. Washington, D.C. 24 pages plus appendices.

US Environmental Protection Agency ECHO (Environmental Compliance History Online) website (https://echo.epa.gov/?redirect=echo)

Weeks Bay National Estuarine Research Reserve (WBNERR). (2011). *Upper Fish River Bacterial Source Tracking Project October 2008 - March 2011.* Alabama Department of Conservation and Natural Resources. Fairhope, Alabama.

Ecology

Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries Division, 2016. Alabama's Comprehensive Wildlife Conservation Strategy. http://www.outdooralabama.com/alabama-cwcs

Alabama Natural Heritage Program. (2016). Alabama Natural Heritage Program Element Occurrences for Weeks Bay Watershed. September 20, 2016. Originator: M.S. Barbour, GIS Analyst.

Aldous, A., P. McCormick, C. Ferguson, S. Graham, and C. Craft. (2005). Hydrologic regime controls soil phosphorus fluxes in restoration and undisturbed wetlands. Restoration Ecology, 13:341-347.

Ardón, M., J.L Morse, M.W. Doyle, and E.S. Bernhardt. (2010). The water quality consequences of restoring wetland hydrology to a large agricultural watershed in the Southeastern Coastal Plain. Ecosystems, 13:1060-1078.

Aresco, M.J., and C. Guyer, 2004. Gopher tortoise (Daudin). Pp. 82 – 83 *In* R.E. Mirarchi, M.A. Bailey, T.M. Haggerty, and T.L. Best (eds). Alabama Wildlife. Volume 3. Imperiled Amphibians, Reptiles, Birds and Mammals. The University of Alabama Press, Tuscaloosa.

Ashton, R.E. and P.S. Ashton. (2008). The Natural History and Management of the Gopher Tortoise *Gopherus polyphemus* (Daudin). Kreiger Publishing Company, Malabar, FL. 288 pp.

Baldwin County Planning and Zoning Department. (2005). The Baldwin County Wetland Conservation Plan Final Summary Document. 115 pp.

Barry A. Vittor & Associates, Inc. (2016). Submerged Aquatic Vegetation Mapping in Mobile Bay and Adjacent Waters of Coastal Alabama in 2015. Prepared for the Mobile Bay National Estuary Program, Mobile, AL. 17 pp + appendices.

Barry A. Vittor & Associates, Inc. (2014). Calibrating a Biological Conditional Gradient Model to the Mobile Bay Estuary. Prepared for the Great Lake Environmental Center, Inc. and the Environmental Protection Agency Region 1. 7 pp + appendices.

Bartram, W., [1791] 1988. Travels Through North and South Carolina, Georgia, East and West Florida, The Cherokee County, the Extensive Territories of the Muscogulies or Creek Confederacy, and the Country of the Choctaws. Penquin Books, New York, NY.

Bortone, S.A. and J.L. Williams. (1986). Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (South Florida)--gray, lane, mutton, and yellowtai1 snappers. U.S. Fish Wildlife Service Biological Report, 82 (11.52). Coastal Ecology Group, Waterways Experiment Station, U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

Brinkley, E. (2013). eBird: An online database of bird distribution and abundance. Ithaca, NY. Accessed: October 26, 2016.

Carr, S.C., K.M. Robertson, and R.K. Peet. (2010). A vegetation classification of fire-dependent pinelands of Florida. Castanea, 75(2):153-189.

Castelle, A.J., A.W. Johnson, and C. Conolly. (1994). Wetland and stream buffer size requirements—a review. Journal of Environmental Quality, 23:878-882.

Christmas, J.Y. and R.S. Waller. (1973). Phase II: Estuarine vertebrates, Mississippi. pp. 320-406, *In* J.Y. Christmas (ed.), Cooperative Gulf of Mexico Inventory and Study, Mississippi. Gulf Coast Research Laboratory, Ocean Springs, MS.

Colvin, S., B. Helms, D. DeVries, and J. Feminella (2016). Environmental and fish assemblage differences between blackwater and clearwater streams of coastal Alabama. Research Symposium at Weeks Bay National Estuarine Research Reserve, August 4-5, 2016.

Conner, R.N., D.C. Rudolph, and J.R. Walters. (2001). The Red-cockaded Woodpecker: Surviving in a Fire Maintained Ecosystem. University of Texas Press, Austin. 363 pp.

Conservation International. (2014). http://www.conservation.org/How/Pages/Hotspots.aspx. Accessed March 14, 2017.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. (1979). Classification of Wetlands & Deepwater Habitats of the U.S. FWS/OBS-79/31. Washington, DC: Office of Biological Services, U.S. Fish and Wildlife Service.

Dauphin Island Sea Lab's Manatee Sighting Network. (2017). http://manatee.disl.org/sighting/map as of 05-03-2017

Duncan, R.S. (2013). Southern Wonder: Alabama's Surprising Biodiversity. University of Alabama Press. Tuscaloosa, Alabama. 436 pp.

Falcone, J.A., D.M. Carlisle, and L.C. Weber. (2010). Quantifying Human Disturbance in Watersheds: Variable Selection and Performance of a GIS-Based Disturbance Index for Predicting the Biological Condition of Perennial Streams. Ecological Indicators, 10(2):264-273.

Florida Natural Areas Inventory (FNAI). (2010). Guide to the natural communities of Florida: 2010 edition. Florida Natural Areas Inventory, Tallahassee, FL.

Frost, C. (2006). History and future of the longleaf pine ecosystem. Pages 9-48 *In* S. Jose, E.J. Jokela, and D.L. Miller (eds). The Longleaf Ecosystem: Ecology, Silviculture and Restoration. Springer, New York, NY.

Gergel, S.E., M.G. Turner, J.R. Miller, J.M. Melack, and E.H. Stanley. (2002). Landscape indicators of human impacts to riverine systems. Aquatic Science, 64:118-128.

Gulf of Mexico Fishery Management Council (GMFMC). (2005). Generic Amendment Number 3 for addressing Essential Fish Habitat Requirements, Habitat Areas of Particular Concern, and adverse effects of fishing in the following Fishery Management Plans of the Gulf of Mexico: Shrimp fishery of the Gulf of Mexico, United States waters red drum fishery of the Gulf of Mexico, reef fish fishery of the Gulf of Mexico, coastal migratory pelagic resources (mackerels) in the Gulf of Mexico and South Atlantic, stone crab fishery of the Gulf of Mexico, spiny lobster in the Gulf of Mexico and South Atlantic, coral and coral reefs of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL. 104 pp.

Gulf of Mexico Fishery Management Council (GMFMC). (1998). Generic Amendment for Addressing Essential Fish Habitat Requirements in the Following Fishery Management Plans of the Gulf of Mexico: Shrimp Fishery of the Gulf of Mexico, United States Waters, Red Drum Fishery of the Gulf of Mexico, Reef Fishery of the Gulf of Mexico, Coastal Migratory Resources (Mackerels) in the Gulf of Mexico and South Atlantic, Stone Crab Fishery of the Gulf of Mexico, Spiny Lobster Fishery of the Gulf of Mexico and South Atlantic, and Coral and Coral Reefs of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, FL, 238 pp.+app.

Gulf of Mexico and South Atlantic Fishery Management Councils (GMFMC and SAFMC). (1985). Final Amendment 1 to the fishery management plan and final environmental impact statement for the coastal migratory pelagic resources (mackerels). Prepared by the GMFMC and SAFMC, April 1985.

Gulf of Mexico and South Atlantic Fishery Management Councils (GMFMC and SAFMC). (1990). Amendment 3 to the fishery management plan for the coastal migratory pelagic resources (mackerels). Prepared by the GMFMC and SAFMC, April 1990. 37 pp + appendices.

Godwin, J.C. (2004). Eastern indigo snake *Drymarchon couperi* (Holbrook). Pp. 40-41 *In* R.E. Mirarchi, M.A. Bailey, T.M. Haggerty, and T.L. Best, (eds.), Alabama Wildlife. Volume 3. Imperiled amphibians, reptiles, birds and mammals. The University of Alabama Press. Tuscaloosa.

Gorecki, R. and M.B. Davis. (2013). Seasonality and spatial variation in nekton assemblages of the lower Apalachicola River. Southeastern Naturalist, 12:171-196.

Griffith, G.E., J.M. Omernik, J.A. Comstock, G. Martin, A. Goddard, and V.J. Hulcher. (2001). Ecoregions of Alabama. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, OR.

Guyette, R.P., M.C. Stambaugh, D.C. Dey, and R. Muzika. (2012). Predicting fire frequency with chemistry and climate. Ecosystems, 15:322-335.

Harper, R.M. (1922). Some pine-barren bogs in central Alabama. Torreya, 22(4):57-60.

Harper, R.M. (1914). A superficial study of the pine-barren vegetation of Mississippi. Bulletin Torrey Botanical Club, 41:551-567.

Harper, R.M. (1913). Economic Botany of Alabama, Part 1: Geographical report, including descriptions of the natural divisions of the state, their forests and forest industries, with quantitative analyses and statistical tables. Geological Survey of Alabama Monographs 8. 222 pp.

Hart, B. (2002). Status Survey of the Eastern Indigo Snake (*Drymarchon couperi* Holbrook), Black Pine Snake (*Pituophis melanoleucus lodingi* Blanchard), and Southern Hognose Snake (*Heterodon simus* Linnaeus) in Alabama. December 2002. Alabama Natural Heritage Program, The Nature Conservancy.

Hastings, Robert W. and F. M. Parauka. (2004). Gulf Sturgeon *Acipenser oxyrinchus* desotoi (Vladykov). Pp. 204-205 *In* R.E. Mirarchi, J.T. Garner, M.F. Mettee, and P.E. O'Neil, (eds.), Alabama Wildlife. Volume 2. Imperiled Aquatic Mollusks and Fishes. The University of Alabama Press, Tuscaloosa.

Haywick, D., W. Geers, and M. Cooper. (1994). Preliminary Report Of Grain Size Distribution In Weeks Bay, Baldwin County, Alabama. Unpublished Report To The Weeks Bay National Estuarine Research Reserve. 121 pp.

Hyland, J.L., L. Balthis, C.T. Hackney, G. McRae, A.H. Ringwood, T.R. Snoots, R.F. Van Dolah, and T.L. Wade. (1998). Environmental Quality of Estuaries of the Carolinian Province: 1995. Annual Statistical Summary for the 1995 EMAP-Estuaries Demonstration Project in the Carolinian Province. NOAA Technical Memorandum NOS ORCA 123.

Jones, S.C., D.K. Tidwell, and S.B. Darby. (2009). Comprehensive Shoreline Mapping, Baldwin And Mobile Counties, Alabama: Phase I. Geological Survey of Alabama, Open File Report 0921. 80 pp. + appendices.

Keener, B.R., A.R. Diamond, L.J. Davenport, P.G. Davison, S. L. Ginzbarg, C.J. Hansen, C.S. Major, D.D. Spaulding, J.K. Triplett, and M. Woods. (2016). Alabama Plant Atlas. [S.M. Landry and K.N. Campbell (original application development) Florida Center for Community Design and Research, University of South Florida]. University of West Alabama, Livingston, AL.

Leary, C.J., J.L. Dobie, T.M. Mann, P.S. Floyd, and D.H. Nelson. (2008). *Pseudemys alabamensis* Baur 1893 – Alabama red-bellied cooter, Alabama red-bellied turtle. *In* Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A., and Iverson, J.B. (Eds.). Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Monographs No. 5, pp. 019.1-019.9.

Mack, J.J. (2007). Developing a wetland IBI with statewide application after multiple testing iterations. Ecological Indicators, 7:864-881.

Marczak, L.B., T. Sakamaki, S.L. Turvey, I. Deguise, S.L.R. Wood, and J.S. Richardson. (2010). Are forested buffers an effective conservation strategy for riparian fauna? An assessment using meta-analysis. Ecological Applications, 20:126-134.

Mettee, M.F., T.E. Shepard, J.B. Smith, S.W. McGregor, C.C. Johnson, and P.E. O'Neil. (2009). A survey for the Gulf sturgeon in the Mobile and Perdido Basins, Alabama. Geological Survey of Alabama, Open-file Report 0903. Prepared in cooperation with the Alabama Department of Conservation and Natural Resources. Tuscaloosa, AL. 94 pp.

Mohr, C. (1901). Plant life of Alabama, an account of the distribution, modes of association, and adaptations of the flora of Alabama, together with a systematic catalogue of the plants growing in the state. Geological Survey of Alabama. Monograph 5. Brown Print Co. Montgomery, Alabama.

Moreno-Mateos, D., F.A. Comín, Pedrocchi, C., and J. Causapé. (2009). Effect of wetlands on water quality of an agricultural catchment in a semi-arid area under land use transformation. Wetlands, 29:1104-1113.

Napton, D.E., R.F. Auch, R. Headley, and J.L. Taylor (2010). Land changes and their driving forces in the Southeastern United States. Regional Environmental Change, 10(1):37-53.

National Audubon Society. (2010). The Christmas Bird Count Historical Results [Online]. Available http://www.christmasbirdcount.org [accessed on October 25, 2016]

NatureServe. (2015). NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 14, 2017).

Nelson, D. H. and W. M. Turner, Jr. (2004). Alabama red-bellied turtle *Pseudemys alabamensis* Baur. Pp. 54-55 *In* R. E Mirarchi, M. A. Bailey, T. M. Haggerty, and T. L. Best, (eds). Alabama Wildlife. Volume 3. Imperiled amphibians, reptiles, birds and mammals. The University of Alabama Press. Tuscaloosa.

National Marine Fisheries Service (NMFS). (2009). Final Amendment 1 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan Essential Fish Habitat. Highly Migratory Species Management Division, Office of Sustainable Fisheries, Silver Spring, MO.

Noss, R.F., W.J. Platt, B.A. Sorrie, A.S. Weakley, D.B. Means, J. Costanza, and R.K. Pee. (2015). How global biodiversity hotspots may go unrecognized: lessons from the North American Coastal Plain. Diversity and Distributions, 21:236-244.

Odum, W.E. (1988). Comparative ecology of tidal freshwater and salt marshes. Annual Review of Ecology and Systematics, 19:147-176.

O'Neil, P.E. and T.E. Shepard. (2012). Calibration Of The Index Of Biotic Integrity For The Southern Plains Ichthyoregion In Alabama. Geological Survey of Alabama, Open-File Report 1210. Prepared in cooperation with the Alabama Department of Environmental Management and the Alabama Department of Conservation and Natural Resources. Tuscaloosa, AL. 93 pp + appendices.

O'Neil, P.E., T.E. Shepard, M.F. Mettee, and S.W. McGregor. (2004). A Survey Of Alabama's Coastal Rivers And Streams For Fishes Of Conservation Concern. Geological Survey of Alabama, Open-File Report 0502. Prepared in cooperation with the Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries Division. Tuscaloosa, AL. 41 pp.

Outcalt, K.W. and R.M. Sheffield. (1996). The Longleaf Pine Forest: Trends and Current Conditions. Resource Bulletin SRS-9, U.S. Department of Agriculture, Forest Service, Southern Research Station, Asheville, NC.

Pattillo, M.E., T.E. Czapla, D.M. Nelson, and M.E. Monaco. (1997). Distribution and abundance of fishes and invertebrates in Gulf of Mexico estuaries. Vol. II: Species life history summaries. ELMR Rep. No. 11. NOAA/NOS Strategic Environmental Assessment Div., Silver Spring, MD. 377 pp.

Peet, R.K. and D.J. Allard. (1993). Longleaf pine vegetation of the southern Atlantic and eastern Gulf Coast regions: a preliminary classification. In: Proceedings of the Tall Timbers Fire Ecology Conference, 18:45-81.

Petersen, G.W. and R.E. Turner. (1994). The value of salt marsh edge vs. interior as a habitat for fish and decapod crustaceans in a Louisiana tidal marsh. Estuaries, 17:235-262.

Rheinhardt, R.D., M.C., Rheinhardt, and M.M. Brinson. (2002). A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains (No. ERDC/EL-TR-02-9). Engineer Research and Development Center, Vicksburg, MS Environmental Lab.

Rooney, R.C., S.E. Bayley, I.F. Creed, and M.J. Wilson. (2012). The accuracy of land cover-based wetland assessments is influenced by landscape extent. Landscape Ecology, 27:1321-1335.

Rosenberg, K.V., J.A. Kennedy, R. Dettmers, R.P. Ford, D. Reynolds, J.D. Alexander, C.J. Beardmore, P.J. Blancher, R.E. Bogart, G.S. Butcher, A.F. Camfield, A. Couturier, D.W. Demarest, W.E. Easton, J.J. Giocomo, R.H. Keller, A.E. Mini, A.O. Panjabi, D.N. Pashley, T.D. Rich, J.M. Ruth, H. Stabins, J. Stanton, and T. Will, 2016. Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and Continental United States. Partners in Flight Science Committee.

Rozas, L.P., C.W. Martin, and J.F. Valentine. (2013). Effects of reduced hydrological connectivity on the nursery use of shallow estuarine habitats within a river delta. Marine Ecology Progress Series, 492:9-20.

Shipp, R.L. (1979). Summary of Knowledge of Forage Fish Species of Mobile Bay and Vicinity, pp 167-176 *In* Symposium of the Natural Resources of the Mobile Estuary, US Army Corps of Engineers, Mobile District, Mobile Alabama.

Semlitsch, R.D. and J.R. Bodie. (2003). Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Conservation Biology, 17:1219-1228.

Smiley, P.C., K.W. King, and N.R. Fausey. (2011). Influence of herbaceous riparian buffers on physical habitat, water chemistry, and stream communities within channelized agricultural headwater streams. Ecological Engineering, 37:1314-1323.

Sorrie, B.A. and A.S. Weakley. (2001). Coastal Plain vascular plant endemics: Phytogeographic pattern. Castanea 66(1-2):50-82.

Stabile, J., J.R. Waldman, F. Parauka, and I. Wirgin. (1996). Stock structure and homing fidelity in Gulf sturgeon (*Acipenser oxyrinchus desotoi*) based on restriction fragment length polymorphism and sequence analysis of mitochondrial DNA. Genetics, 144:767-775.

Steinman, A.D. and M.E. Ogdahl. (2011). Does converting agricultural fields to wetlands retain or release P? Journal of the North American Benthological Society, 30:820-830.

Stout, J.P. and M.G. Lelong. (1981). Wetland habitats of the Alabama coastal zone: Part II. An inventory of wetland habitats south of the Battleship Parkway. Technical Publication No. 81-01. Dauphin Island: Alabama Coastal Area Board. 47 pp.

Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. (2009). eBird: a citizen-based bird observation network in the biological sciences. Biological Conservation, 142:2282-2292.

Swingle, H.A. and D.G. Bland. (1974). A study of the fishes of the coastal watercourses of Alabama. Alabama Marine Resources Bulletin, 10:17-102.

Tucker, J.W., Jr. and W.D. Robinson. (2004). Red-cockaded Woodpecker *Picoides borealis* (Vieillot). Pp. 112-113 *In* R. E Mirarchi, M.A. Bailey, T.M. Haggerty, and T.L. Best (eds). Alabama Wildlife. Volume 3. Imperiled Amphibians, Reptiles, Birds and Mammals. The University of Alabama Press. Tuscaloosa.

U.S. Fish and Wildlife Service (USFWS). (2016). Information for Planning and Conservation (IPaC) Trust Resources Report, Generated October 20, 2016.

Valentine, J.F., K.D. Kirsch, and D.C. Blackmon. (2006). An Analysis of the Long Term Fisheries Assessment and Monitoring Program Data Set Collected by the Marine Resources Division of the Alabama Department of Conservation and Natural Resources. Final Report To The Mobile Bay National Estuary Program. 17 pp.

Wenner, E.L. and H.R. Beatty. (1993). Utilization of shallow estuarine habitats in South Carolina, U.S.A., by post-larval and juvenile stages of *Penaeus* spp. (Decapoda: Penaeidae). Journal of Crustacean Biology, 13:280-295.

White, C.R. and G.L. Harley. (2016). Historical fire in longleaf pine (*Pinus palustris*) forests of south Mississippi and its relation to land use and climate. Ecosphere, 7(11):1-17.

Whitney, E.N., D.B. Means, and A. Rudloe. (2004). Priceless Florida: Natural Ecosystems and Native Species. Pineapple Press Inc., Sarasota, FL. 423 pp.

Zimmerman, R.J. and T.J. Minello. (1984). Densities of *Penaeus aztecus*, *Penaeus setiferus*, and other natant macrofauna in a Texas salt marsh. Estuaries, 7:421-433.

Shoreline Assessment and Climate Change References

Alabama Coastal Area Board (ACAB). (1980). Inventory of Alabama's coastal resources and uses. Alabama Coastal Area Board, Daphne, Alabama. 169 pp.

Alabama Coastal Foundation (ACF). (2009). Project Report – A Shoreline Assessment of the Upper Fish River. Prepared for the Mobile Bay National Estuary Program.

Blankenship, T. K. (2004). To repair or replace a bulkhead: that is the question: http://www.coastalsystemsint.com/pdf/Media/Bulkhead_Converted.pdf. Coral Gables, Florida,

Coastal Systems International, Inc.. http://www.coastalsystemsint.com/index.htm.

Carter, L.M., J.W. Jones, L. Berry, V. Burkett, J.F. Murley, J. Obeysekera, P.J. Schramm, and D. Wear. 2014. Ch. 17: Southeast and the Caribbean. Climate Change Impacts in the United States: The Third National Climate Assessment, J.M. Melillo, Terese (T.C.) Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, 396-417. doi:10.7930/J0N-P22CB. http://nca2014.globalchange.gov/report/regions/southeast.

Geselbracht, L., K. Freeman, A. Birch, D. Gordon, A. Knight, M. O'Brien, and J. Oetting. (2013). Modeling and Abating the Impacts of SLR on Five Significant Estuarine Systems in the Gulf of Mexico, Final Report to the U.S. Environmental Protection Agency – Gulf of Mexico Program, Project # MX95463410-2. The Nature Conservancy.

Jones, S.C., D.K. Tidwell, and S.B. Darby. (2009). Comprehensive Shoreline Mapping, Baldwin and Mobile Counties, Alabama: Phase I, Open File Report 0921, Geological Survey of Alabama, Geologic Investigations Program, Tuscaloosa, Alabama http://www.mobilebaynep.com/images/uploads/library/Shoreline-Mapping-Baldwin-Mobile-Counties-AL-PhaseI-JonesTidwell-Darby2009.pdf.

Kana, T.W., B.J. Baca, and M.L. Williams. (1995). Charleston case study, in Titus, J.G. and Narayanan, V.K., eds., The probability of SLR: Washington D.C., U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, EPA 230-R-95-008. pp. 37-55.

LaRoche, G. (2007). Shoreline armoring alternatives project, summary report submitted to the Jefferson County Marine Resources Committee: http://www.nwstraits.org/uploadBibliography/Shoreline%20Armoring%20Summary%20Report%20063007.pdf, Port Townsend, Washington, Florida, http://www.nwstraits.org/. 9 pp.

Melillo, J.M., T.C. Richmond, and G.W. Yohe, Eds. 2014a. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 841 pp. doi:10.7930/J0Z31WJ2. http://nca2014.globalchange.gov/downloads.

Melillo, J.M., T.C. Richmond, and G.W. Yohe, Eds. 2014b. Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 148 pp. http://nca2014.globalchange.gov/highlights

Moser, S.C., M.A. Davidson, P. Kirshen, P. Mulvaney, J.F. Murley, J.E. Neumann, L. Petes, and D. Reed. 2014. Ch. 25: Coastal Zone Development and Ecosystems. Climate Change Impacts in the United States: The Third National Climate Assessment, J.M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program. pp. 579-618. doi:10.7930/J0MS3QNW. http://nca2014.globalchange.gov/report/regions/coasts.

National Park Service (NPS). (2009). Bulkheads and shoreline erosion control: http://www.nps.gov/fiis/planyourvisit/bulkheads-and-shoreline-erosion-control.htm. Patchogue, New York. http://www.nps.gov.

National Oceanic and Atmospheric Association (NOAA). (2012). Incorporating Sea Level Change Scenarios at the Local Level, Prepared by NOAA Coastal Services Center, NOAA Center for

Operational Oceanographic Products and Services, NOAA National Geodetic Survey, NOAA Office of Coast Survey.

NOAA. 2016a. SLR and Coastal Flooding Impacts Viewer. https://coast.noaa.gov/slr/.

NOAA. 2016b. NOAA's Sea Levels Online website: www.tidesandcurrents.noaa.gov/sltrends.

Pennsylvania Department of Environmental Protection (PDEP). (2001). Pennsylvania-Lake Erie shoreline protection study. http://www.dep.state.pa.us/river/reference/Docs/ShorelineProtection StructuresStudy.pdf. Harrisburg, Pennsylvania. http://www.dep.state.pa.us/.

Smith, W.E. (1981). Geological features and erosion control in Alabama gulf coastal area: Alabama Geological Survey Information Series 57. 57 pp.

Stewart, C.J. (2001). Open coast reach delineations and re-attribution of shore classification mapping, Pennsylvania and New York shorelines, Lake Erie: British Columbia, Canada, prepared for the United States Army Corps of Engineers Buffalo District, Contract DACW39-97-D-0007, Delivery Order no. 10. 36 pp.

The Nature Conservancy (TNC) and the NOAA Coastal Services Center. (2011). Marshes on the Move: A Manager's Guide to Understanding and Using Model Results Depicting Potential Impacts of SLR on Coastal Wetlands. www.csc.noaa.gov/publications/Marshes_on_the_move.pdf.

Toft, J., C. Simenstad, C. Young, and L. Stamatiou. (2003). Inventory and mapping of city of Seattle shorelines along Lake Washington, the Ship Canal, and Shilshole Bay: http://www.fish.washington.edu/research/publications/pdfs/0302.pdf. Prepared for Seattle Public Utilities, City of Seattle, Washington, University of Washington, School of Aquatic & Fishery Sciences, SAFS-UW-0302, 33 pp.

United States Army Corps of Engineers (USACE). (2014). USACE Sea Level Curve Calculator (2015.46). http://www.corpsclimate.us/ccaceslcurves.cfm

Warren Pinnacle Consulting, Inc. (WPC, Inc.). (2016). Evaluation of Regional SLAMM Results to Establish a Consistent Framework of Data and Models. Published in June, 2015 with minor revisions in March 2016. Prepared for the Gulf Coast Prairie Landscape Conservation Cooperative (GCPLCC). www.warrenpinnacle.com/prof/SLAMM.

Section 6 Management Measures - References

Alabama Department of Conservation and Natural Resources, Wildlife and Freshwater Fisheries Division, 2016. Alabama's Comprehensive Wildlife Conservation Strategy. http://www.outdooralabama.com/alabama-cwcs

Alabama Natural Heritage Program. (2016). Alabama Natural Heritage Program Element Occurrences for Weeks Bay Watershed. September 20, 2016. Originator: M.S. Barbour, GIS Analyst.

Aldous, A., P. McCormick, C. Ferguson, S. Graham, and C. Craft. (2005). Hydrologic regime controls soil phosphorus fluxes in restoration and undisturbed wetlands. Restoration Ecology, 13:341-347.

Ardón, M., J.L Morse, M.W. Doyle, and E.S. Bernhardt. (2010). The water quality consequences of restoring wetland hydrology to a large agricultural watershed in the Southeastern Coastal Plain. Ecosystems, 13:1060-1078.

Moreno-Mateos, D., F.A. Comín, Pedrocchi, C., and J. Causapé. (2009). Effect of wetlands on water quality of an agricultural catchment in a semi-arid area under land use transformation. Wetlands, 29:1104-1113.

Smiley, P.C., K.W. King, and N.R. Fausey. (2011). Influence of herbaceous riparian buffers on physical habitat, water chemistry, and stream communities within channelized agricultural headwater streams. Ecological Engineering, 37:1314-1323.

Steinman, A.D. and M.E. Ogdahl. (2011). Does converting agricultural fields to wetlands retain or release P? Journal of the North American Benthological Society, 30:820-830.

Section 7 Regulatory Review - References

Clean Water Act, 33 USC § 1251, et seq.

Alabama Water Pollution Control Act, Ala. Code § 22-22-1, et seq.

ADEM Administrative Code R. 335-6-6 (NPDES)

ADEM Administrative Code R. 335-6-10 (water quality)

ADEM Administrative Code R. 335-8 (coastal area management)

ADEM Construction Stormwater NPDES General Permit ALR10 (April 1, 2016)

ADEM Low Impact Development Handbook for the State of Alabama (http://www.adem.state.al.us/programs/water/waterforms/LIDHandbook.pdf)

Baldwin County Zoning Ordinance (May 17, 2016)

Baldwin County Subdivision Regulations (May 19, 2015)

City of Fairhope Subdivision Regulations (March 8, 2007)

City of Fairhope Code of Ordinance, Chapter 7 Article VII (Erosion) (September 23, 1996)

City of Fairhope Code of Ordinance, Chapter 7 Article IX (Wetlands) (October 13, 2008)

City of Daphne Ordinance No. 2014-14, CBMPP Ordinance (April 21, 2014)

City of Daphne Land Use and Development Ordinance (July 18, 2011)

City of Spanish Fort Zoning Ordinance, Article VIII (May 31, 1996)

City of Spanish Fort Subdivision Regulations (February 8, 2016)

Town of Loxley Zoning Ordinance (July 14, 2014)

Town of Loxley Subdivision Regulations (April 13, 2009)

City of Robertsdale Land Use Ordinance (January 23, 2012)

Town of Silverhill Zoning Ordinance (January 17, 2000)

Town of Magnolia Springs Zoning Ordinance (June 22, 2010),

Town of Magnolia Springs Subdivision Regulations (January 12, 2012)

Town of Summerdale, Alabama Zoning Ordinance (April 9, 2012)

Town of Summerdale Building Code Ordinance 521-13 (March 11, 2013)

City of Foley Code of Ordinance, Chapter 6.5 Article III (Erosion Control) (March 16, 2015)

City of Foley Code of Ordinance, Chapter 4 Article IV (Construction) (October 1, 2007)

City of Foley Code of Ordinance Chapter 4 Article VIII (Shorelines) (January 21, 2008)

Georgia Environmental Protection Division. (April 2009) Coastal Stormwater Supplement to the Georgia Stormwater Management Manual. First Edition. Prepared by Center for Watershed Protection, Ellicott City, MD. 542 pages. (https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Georgia_Coastal_Stormwater_Supplement_2009.pdf)

Hydro Engineering Solutions, LLC. (October 2011). *Fish River and Magnolia River Watershed Study*. Prepared by Hydro Engineering Solutions, LLC, for Baldwin County.

Hydro Engineering Solutions, LLC. (2014). *Fish River Stages with Proposed Detention Ponds April 29, 2014 Rain Event*. PowerPoint Presentation prepared by Hydro Engineering Solutions, LLC for Baldwin County.

Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation. (1999) Virginia Stormwater Management Handbook. First Edition. Volume I, 619 pages. (http://www.deq.virginia.gov/Portals/0/DEQ/Water/Publications/HndbkVolumeI.pdf)

Section 8 Financing Alternatives - References

Kania, John and Mark Kramer. (2011) Collective Impact. Stanford Social Innovative Review. Accessed July 2017. (https://ssir.org/articles/entry/collective_impact)

Section 10 Monitoring - References

Homer, C.H., Fry, J.A., and Barnes C.A. (2012). *The National Land Cover Database, U.S. Geological Survey Fact Sheet 2012-3020.* 4 p. https://pubs.usgs.gov/fs/2012/3020/

Section 11 Implementation Plan - References

Alabama Cooperative Extension System, Alabama Department of Environmental Management, Alabama Nursery and Landscape Association, Alabama Master Gardeners Association, and Auburn University Department of Horticulture. 2016a. *The Alabama Smart Yards*.

Alabama Cooperative Extension Service, Alabama Department of Environmental Management, and Auburn University, 2016b. Planning for Stormwater: Developing a low impact solution. Alabama Cooperative Extension Service at Auburn University http://www.aces.edu/natural-resources/water-resources/watershed-planning/stormwater-management/documents/1467207286_lowimpactdistribution59.pdf Last accessed May 2017.

Alabama Department of Environmental Management. August 2013. Final Total Maximum Daily Load (TMDL) for Fish River, Assessment Unit ID # AL03160205-0204-112 Pathogens (E. coli). Water Quality Branch, Water Division. Montgomery, Alabama. 36 pages.

Alabama Department of Environmental Management in cooperation with the Alabama Cooperative Extension System and Auburn University. Undated. Low Impact Development Handbook for the State of Alabama. http://adem.alabama.gov/programs/water/waterforms/LIDHandbook.pdf Last accessed April 2017.

Cook, Marlon R.(December 2016). *Pre-Restoration Analysis of Discharge, Sediment Transport Rates, Water Quality, and Land-Use Impacts in the Fish River Watershed, Baldwin County, Alabama.* Polyengineering, Inc., Dothan, Alabama.

GOMA (Gulf of Mexico Alliance). 2013a. *Sources, Fate, Transport, and Effects (SFTE) of Nutrients as a Basis for Protective Criteria in Estuarine and Near-Coastal Waters: Weeks Bay, Alabama Pilot Study*. Prepared for the Gulf of Mexico Alliance, Nutrients Priority Issues Team (Alabama Department of Environmental Management, and the Mississippi Department of Environmental Quality) by Tetra Tech, Inc., Owings Mills, MD.

GOMA. 2013b. *Sources, Fate, Transport, and Effects (SFTE) of Nutrients as a Basis for Protective Criteria in Estuarine and Near-Coastal Waters. Weeks Bay, Alabama Pilot Study. Empirical Analysis of Monitoring Results.* Prepared for the Gulf of Mexico Alliance, Nutrients Priority Issues Team (Alabama Department of Environmental Management, and the Mississippi Department of Environmental Quality). Prepared by: Tetra Tech, Inc., Owings Mills, MD.

U.S. Environmental Protection Agency. (December 2007). *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*. EPA 841-F-07-006. Washington, D.C. https://www.epa.gov/green-infrastructure/stormwater-costs

This Page Intentionally Left Blank

WEEKS BAY WATERSHED MANAGEMENT PLAN GIS DATA SOURCES/CITATION BY FIGURE							
FIGURE	REPORT MAP TITLE	Digital File Name	DATASETS	SOURCE	SOURCE WEBSITE (If applicable)	NOTES	CONSULTANT/AUTHOR
1.1	**Weeks Bay Watershed**	Weeks Bay Watershed	USGS NHD HUC-12s, Flowlines*	USGS NHD	https://nhd.usgs.gov/data.html		
			Baldwin County Jurisdictions, Feb. 2016*	Baldwin County	N/A Provided by County		Thompson Engineering (TE)
2.3	**Stream Network within Weeks Bay Watershed**	Hydrology	USGS NHD HUC-12s, Flowlines, Waterbodies*	USGS NHD	https://nhd.usgs.gov/data.html		Thompson Engineering
			ESRI Roads, Edited*	ESRI		Modified for Foley Beach Express, HWY 181 to 98	
2.5	**Public Groundwater Wells and Acquifer Recharge Areas**	Geology_Aquifers_Water Supply	Aquifer Recharge Areas	Alabama Coastal Resources Comprehensive GIS Inventory		Thumb drive provided by NEP	Thompson Engineering
			ADEM 2013 Public Water Supply Wells	Alabama Coastal Resources Comprehensive GIS Inventory			
2.7	**Topographic Relief**	Topographic Relief	2005 LiDAR - 1Ft. Contours	Baldwin County	N/A Provided by County		Thompson Engineering
2.8	**Geologic Formations**	Geologic Formations	USGS Digital Geologic Map of Alabama	USGS	https://ngmdb.usgs.gov/ngmdb/ngmdb_home.html		Thompson Engineering
2.9	**Major Soil Types within Weeks Bay Watershed**	Soil Map Units	Soil Survey Geographic Database (SSURGO)	USDA NRCS	https://datagateway.nrcs.usda.gov/		Thompson Engineering
2.10	**Soil Erodibility K Factors within Weeks Bay Watershed**	Soil K-Factor	Soil Survey Geographic Database (SSURGO)	USDA NRCS	https://datagateway.nrcs.usda.gov/		Thompson Engineering
2.11	**FEMA Flood Zones within Weeks Bay Watershed**	FEMA Flood Zones	FEMA	FEMA-NFHL 200602017 Publication, Edition Version 1.1.1.0. Location and attributes for boundaries of flood insurance risk zones shown on the FIRM. FEMA FIRM Database Technical Reference (available in the FEMA Library at http://www.fema.gov/media-library/assets/documents/34519	https://msc.fema.gov/portal		Thompson Engineering
2.13	**Longleaf Pine Distribution**			Alabama Gap Analysis Program (ALGAP, 2001)			Vittor
2.14	**Wetlands in the Weeks Bay Watershed**		ADID 2005, Modified	Baldwin County Planning and Zonning Department	Baldwin County 2005 Wetland Advanced Identification Map (ADID)	Modified as outlined in Section 2.5.3	Vittor
2.16	**Incorporated Areas in Weeks Bay Watershed**	Political Map	Baldwin County Jurisdictions, Feb. 2016	Baldwin County	N/A Provided by County		Thompson Engineering
2.17	**Extra Territorial Jurisdiction In Weeks Bay**	ETJ Political Map	Baldwin County Jurisdictions, Feb. 2016	Baldwin County	N/A Provided by County		Thompson Engineering
			Baldwin County Planning Jurisdictions, Feb. 2016	Baldwin County	N/A Provided by County		
2.18	**County Planning Districts in the Weeks Bay Watershed**	Baldwin County Planning Districts	Baldwin County Planning Districts, May 2017	Baldwin County	N/A Provided by County		Thompson Engineering
			Baldwin County Jurisdictions, Feb. 2016	Baldwin County	N/A Provided by County		
2.33	**Public Access Locations within Weeks Bay Watershed**	Public Access Sites	Public Access Locations, 2014	ADCNR-State Lands Division Coastal Stewardship Office - Five Rivers			Thompson Engineering
2.36	**2010 Population Density Per Square Mile, US Census Blocks**	2010 PopDensity_Blocks	2010 Census Block, Modified	US Census		Modified as described in Section 2.7.4	Thompson Engineering
2.38	**Eastern Shore MPO LRTP 2040 Population Density Projection, TAZ**	MPO 2040 POP	ESMPO TAZ 2040 Population Projections	ESMPO		Shapefile provided by ESMPO	Thompson Engineering
2.39	**2040 Population Density Projections Per Square Mile, TAZ and US Census Blocks**	2040 PopDensity_TAZ_Blocks	ESMPO TAZ 2040 Population Projections	ESMPO		Shapefile provided by ESMPO	Thompson Engineering
			2010 Census Block with 2040 Projections	US Census		Modified as described in Section 2.7.4	
2.40	**Major Roads**	Major Roads	ESRI Roads, Edited	ESRI		Modified for Foley Beach Express, HWY 181 to 98	
2.41	**Fish River Watershed Land Use and Cover Decadal Change**	NASA-LU-LC MAP	fish_river_landsat-mss_19741112_classification.tif fish_river_landsat-mss_19840906_classification.tif fish_river_landsat-tm_19960127_classification.tif fish_river_landsat-tm_20080316_classification.tif	NEP		Data simply used to recreate at higher resolution figure in NASA "Land-Use and Land-Cover from 1974-2008 around Mobile Bay, AL" report (pg. 46).	Thompson Engineering
2.43	**1992 Land Cover in Weeks Bay Waterhed**	1992_LULC	NLCD 1992 Land Cover	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.44	**2001 Land Cover in Weeks Bay Waterhed**	2001_LULC	NLCD 2001 Land Cover (2011 Edition)	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering

FIGURE	REPORT MAP TITLE	Digital File Name	DATASETS	SOURCE	SOURCE WEBSITE (If applicable)	NOTES	CONSULTANT/AUTHOR
2.45	**2006 Land Cover in Weeks Bay Waterhed**	2006_LULC	NLCD 2006 Land Cover (2011 Edition)	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.46	**2011 Land Cover in Weeks Bay Waterhed**	2011_LULC	NLCD 2011 Land Cover	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.47	**2040 Medium Land Cover Projection**	2040 Medium LUCU Projections	NLCD 2011 Land Cover, Modified	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/	Modified as described in Section 2.8.2.2	Thompson Engineering
2.48	**2040 High Land Cover Projection**	2040 High LUCU Projections	NLCD 2011 Land Cover, Modified	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/	Modified as described in Section 2.8.2.2	Thompson Engineering
2.53	**2001 Percent Developed Imperviousness**	2001 Percent Developed Imperviousness	NLCD 2001 Percent Developed Impervoiusness (2011 Edition)	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.54	**2006 Percent Developed Imperviousness**	2006 Percent Developed Imperviousness	NLCD 2006 Percent Developed Impervoiusness (2011 Edition)	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.55	**2011 Percent Developed Imperviousness**	2011 Percent Developed Imperviousness	NLCD 2011 Percent Developed Impervoiusness	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.56	**2001-2006 Change in Percent Develped Imperviousness**	2001-2006 Change in Percent Developed Imperviousness	NLCD 2001to 2006 Percent Developed Imverousness Change (2011 Edition)	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
2.57	**2006-2011 Change in Percent Develped Imperviousness**	2006-2011 Change in Percent Developed Imperviousness	NLCD 2006 to 2011 Percent Developed Imverousness Change	Multi-Resolution Land Characteristics Consortium (MRLC)	https://www.mrlc.gov/		Thompson Engineering
3.1	**ADEM Stream Classifications and 303(d) Stream Segments**	ADEM 303D	303d Lines and Polygons (2016)	ADEM	http://www.adem.state.al.us/programs/water/waterquality.cnt		Thompson Engineering
3.2	**NPDES Permits in Weeks Bay Watershed**	NPDES Permits	Shapefile generated from data download from EPA's Enforcement and Compliance History Online (ECHO) site. Includes all permits through June 2016.	EPA	https://echo.epa.gov/		Thompson Engineering
3.3	**Sanitary Sewer Overlow Inventory in Weeks Bay Watershed**	SSO Inventory	Shapefile generated from data download from ADEM eFile System.	ADEM	http://app.adem.alabama.gov/eFile/	Dowloaded tabular data was mapped by manually obtaining lat/longs for locations based on address or cross street.	Thompson Engineering
3.4	**MS4 Permit Coverage Areas in Weeks Bay Watershed**	MS4 Areas	MS4 Areas shapefile	ALDOT			Thompson Engineering
3.5	**On-Site Sewage Disposal Systems**	OSDS Septic Tanks	OSDS Inventory shapefile generated from tabular data.	AL Department of Public Health, Baldwin County Health Deparment (BCHD)		Data provided in 3 tables. Data was plotted lat/longs or by geocoding addresses after extensive cleanup of both.	
3.6	**Livestock and Turf Farm Inventory**	Livestock_Turf_Inventory	Livestock and Turf farm inventories shapefiles.	Thompson Engineering		Livestock and turf farm inventory conducted by roadside survey and aerial photograph inspection.	Thompson Engineering
3.13	**SWAT Model Sediment Yield Map - 2011, 2040 Med, 2040 High**	SWAT Model Sediment Yield	SWAT Model sub-watersheds with joined SWAT model sediment yield data.	Latif Kalin			Latif Lakin (Data), Thompson Engineering (Map)
3.14	**Major Unpaved Roads in the Weeks Bay Watershed**	Unpaved Road Inventory	Shapefile	Baldwin County, Thompson Engineering Inventory		Baldwin County unpaved and county maintained road inventory was updated by Thompson Engineering to remove/add roads that had been paved or were not part of the original data due ot not being county maintained road.	Thompson Engineering
3.15	**Dirt pits in the Weeks Bay Watershed**	Dirt Pit Inventory	Potential erosion sites shapefile.	Thompson Engineering inventory.		Inventory generated through imagery analysis.	Thompson Engineering
3.16	**SWAT Model Total Nitrogen and Phosphorus Map - 2011, 2040 Med, 2040 High**	SWAT Model Nitrogen Yield	SWAT Model sub-watersheds with joined SWAT model nitrogen yield data.	Latif Kalin			Latif Lakin (Data), Thompson Engineering (Map)
		SWAT Model Phosphorus Yield	SWAT Model sub-watersheds with joined SWAT model phosphorus yield data.	Latif Kalin			Latif Lakin (Data), Thompson Engineering (Map)
3.40	**Predicted wetland conditions by NHD Catchment**		Vittor	Vittor			Vittor
3.41	**Predicted riparian buffer condition by NHD catchment.**		Vittor	Vittor			Vittor
3.42	**Riparian and Wetland field check points**		Vittor	Vittor			Vittor
3.45	**Location of Shoreline Assessment Areas**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.47	**Geographic Distribution of shoreline Types, Upper Portion of Fish River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)

FIGURE	REPORT MAP TITLE	Digital File Name	DATASETS	SOURCE	SOURCE WEBSITE (If applicable)	NOTES	CONSULTANT/AUTHOR
3.48	**Geographic Distribution fo Shoreline Types, Middle Portion of Fish River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.49	**Geographic Distribution fo Shoreline Types, Lower Portion of Fish River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.51	**Distribution of Shoreline Protection Types, Upper Portion of Fish River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.52	**Distribution of Shoreline Protection Types, Middle Portion of Fish River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.53	**Distribution of Shoreline Protection Types, Lower Portion of Fish River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.55	**Geographic Distribution of Shoreline Types, Magnolia River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.57	**Geographic Distribution of Shoreline Protection Types, Magnolia River Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.59	**Geographic Distribution of Shoreline Types, Weeks Bay Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.61	**Geographic Distribution of Shoreline Protection Types, Weeks Bay Study Area**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
3.79	**Boundaries of All Four 12-Digit HUCs Comprising Greater Weeks Bay Watershed**		Ecology and Environment (E&E)	Ecology and Environment (E&E)			Ecology and Environment (E&E)
6.1	**Storm Water Basin/Detention Pond Inventory**	Detention StormWaterBasin Inventory	Detention ponds inventory shapefile.	Thompson Engineering		Inventory generated through imagery analysis.	Thompson Engineering
6.2	**Protected Lands**	WBW Protected Lands	Shapefile	Weeks Bay Foundation, County Parcel Data			Thompson Engineering
6.3	**Tidal Marshes Inside and Outside Existing Protection in the Weeks Bay Watershed**	Tidal Marshes Protected and Unprotected	Vittor	Vittor			Vittor
7.1	**Jurisdictional Zoning Districts in the Weeks Bay Watershed**	**WBW Simplified Zoning**	**Consolidated zoning geodatabase generated by Thompson Engineering**	**Various (listed below)**		Thompson Engineering generated a compilation of various jurisdictional zoning data. Similarly zoned districts were grouped into generalized (simplified) zoning districts for analysis and representation purposes. Original jurisdiction zoning codes and descriptions were retained for reference. Zoning data accuracy is based upon source data and its originating date as outlined below.	Thompson Engineering
			City of Daphne Zoning Map Approved 11/02/15 (PDF)	City of Daphne	http://www.daphneal.com/residents/community-development/documents-information/	TE generated spatial data based on City map and Zoning Ordinance.	
			City of Fairhope C.O.F. Zoning Map Dated 08/2016 (PDF)	City of Fairhope	http://www.cofairhope.com/departments/planning-and-zoning	TE generated spatial data based on City map and Zoning Ordinance.	
			City of Foley Zoning shapefile dated 04/08/16	City of Foley			
			City of Loxley Zoning shapefile dated 12/17/14	South Alabama Regional Planning Commission (SARPC)			
			City of Robertsdale shapefile dated 08/2016	City of Robertsdale		As of 08/2016 per City Engineer.	
			City of Silverhill shapefile dated (received) 8/18/2016	South Alabama Regional Planning Commission (SARPC)			
			City of Summerdale dated (received) 08/10/2016	Baldwin Conty Planning & Zoning			
			City of Magnolia Springs Zoning Map Amended 10/28/2010 (PDF)	City of Magnolia Springs		TE generated spatial data based on City map and Zoning Ordinance	
			City of Spanish Fort Zoning Map dated 09/24/2015 (PDF)	City of Spanish Fort	http://www.cityofspanishfort.com/Portals/spanishfort/Planning/Zoning.pdf	TE generated spatial data based on City map and Zoning Ordinance	
			Baldwin County GIS shapefile - 08/04/2016	Baldwin Conty Planning & Zoning			

FIGURE	REPORT MAP TITLE	Digital File Name	DATASETS	SOURCE	SOURCE WEBSITE (If applicable)	NOTES	CONSULTANT/AUTHOR
10.1	**Monitoring Station Locaiton Map**	Water Monitoring Stations	Monitoring Locations Inventory	USGS	https://waterdata.usgs.gov/al/nwis/rt		Thompson Engineering
				NERR	https://coast.noaa.gov/nerrs/reserves/weeks-bay.html		
				ADEM	http://www.adem.state.al.us/programs/water/waterquality.cnt		
				AWW	http://www.alabamawaterwatch.org/water-data/AWWmap/		
Appx. G Figure 5	**LULC Distributions in the Fish River Watershed**	SWAT MODEL FISH RIVER AGG MAPS_LATIF REPORT	Fish_LULC1992.tif	Latif Kalin			Latif Lakin (Data), Thompson Engineering (Map)
			Fish_LULC2011.tif				
			Fish_LULC2040Mdd.tif				
			Fish_LULC2040Agg.tif				
Appx. G Figure 6	**LULC Distributions in the Magnolia River Watershed**	SWAT MODEL MAGNOLIA AGG MAPS_LATIF REPORT	Magnolia_LULC1992.tif	Latif Kalin			Latif Lakin (Data), Thompson Engineering (Map)
			Magnolia_LULC2011.tif				
			Magnolia_LULC2040.tif				
			Magnolia_LULC2040Agg.tif				
Appx. G Figure 7	**SSURGO Soil Distribution in the Fish River and Magnolia River Watersheds**	SWAT MODEL SSURGO MAPS_LATIF REPORT	Fish_Soil.tif	Latif Kalin			Latif Lakin (Data), Thompson Engineering (Map)
			Magnolia_Soil.tif				
*** This dataset consistently used in multiple figures and may not be cited for each instance.**							