DOG RIVER WATERSHED MANAGEMENT PLAN

Submitted to:
Mobile Bay National Estuary Program
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planning NEXT

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ACKNOWLEDGEMENTS

In recent years, the Mobile Bay National Estuary Program (MBNEP) has facilitated efforts to address problems in watersheds within the Mobile Bay estuary. This involved establishing watershed working groups, which are a coalition of federal, state, and local agencies; county and local governments; property owners; developers; and commercial interests. These entities work together to complete comprehensive watershed management plans (WMPs). The greater Dog River Watershed is the fourth watershed within the Mobile Bay system to be evaluated in the past five years. Preparation of this WMP was made possible by collaborative funding provided by the National Fish and Wildlife Foundation (NFWF) through the MBNEP.

Goodwyn, Mills and Cawood, Inc. (GMC) was selected to organize and manage the work of the consultant team. The GMC team was responsible for helping with the characterization of the watershed, studying current conditions, evaluating the critical area and issues, developing conceptual management measures to address the issues, and identifying possible funding sources to finance the implementation of the management measures contained in this WMP. Other members of the Watershed Management Team (WMT) included the following personnel: Dr. David Tomasko and Doug Robison of Environmental Science Associates (ESA), Cherie Arceneaux, and Jamie Greene and Sarah Kelly of Planning Next. The consultant team would like to recognize the following individuals, organizations, and agencies that assisted in the various phases of work on the WMP:

The greater Dog River Watershed steering committee and public involvement participants:

Cherie Arceneaux	Debi Foster	Mark Ornelas
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Charles Finkley	Amy Newbold	

The consulting team would also like to recognize the following individuals and entities for their diligent efforts and contributions: Marlon Cook and Steve Jones of the Geological Survey of Alabama (GSA), Dog River Clearwater Revival (DRCR), Shorecombers, Peninsula of Mobile, Dave Armstrong of the Alabama Department of Conservation and Natural Resources (ADCNR), Mobile County, City of Mobile, Debi Foster, and Dr. Miriam Fearn. Finally, the WMT wishes to acknowledge Roberta Swann and the entire MBNEP team for their dedicated efforts during the preparation of this WMP.

EXECUTIVE SUMMARY

The greater Dog River Watershed is one of several intertidal watersheds along the Alabama coast identified for restoration by the Mobile Bay National Estuary Program (MBNEP). The greater Dog River Watershed Management Plan (WMP) presents a conceptual course for improving and protecting the natural resources of the Watershed, thereby preserving what people living along the Alabama coast value most: access to the resource, the shorelines, water quality, fish and biological resources, environmental health and resiliency, and culture and heritage (Comprehensive Conservation and Management Plan for Alabama's Estuaries and Coast 2013- 2018, MBNEP).

THE WATERSHED

Located in Mobile County, Alabama, the greater Dog River Watershed, as defined by this WMP, is the geographical area identified by the following U.S. Geological Survey (USGS) 12-digit hydrologic unit codes (HUCs): HUC 031602050101 (Upper Dog River), HUC 031602050102 (Halls Mill Creek), and HUC 031602050103 (Lower Dog River) (USGS, 2017). The greater Dog River Watershed encompasses approximately 93.29 square miles and 174 miles of streams and waterways (USGS, 2017). The boundary of the greater Dog River Watershed begins just inland from Mobile Bay, runs west through the City of Mobile, sweeps north then runs south just east of the Mobile Airport before turning east again towards Mobile Bay and curving back to the north to encompass most of the commercial and much of the residential portions of the City of Mobile.

According to the 2011 National Land Cover Database (NLCD) (Homer et al., 2015), land use and land cover within the greater Dog River Watershed is predominantly developed: the three greatest land uses are urban (60.4%), upland forests (17.7%), and woody wetlands (13.3%). Together, these three-major land use and land cover classifications comprise 91.4% of the greater Dog River Watershed.

CRITICAL ISSUES AND AREAS

Critical issues affecting the health of the greater Dog River Watershed were identified through Steering Committee input, public workshops, inspection of existing water quality data, field reconnaissance by the Watershed Management Team (WMT), scientific modeling, and analysis of historical aerial photography and maps.

Residents of the greater Dog River Watershed and other stakeholders were engaged in public outreach and education efforts, a critical part of the WMP process. In addition to the purpose and specific goals of the WMP, stakeholders identified the following 11 priority issues with the number of responses shown in parenthesis: litter (31), pollution (23), trash (21), access (13), sediment and siltation (12), stormwater (11), preservation and conservation (10), dredging (10), water quality (9), erosion (6), and restoration (5).

The WMT identified nutrient loading, sedimentation, excessive stormwater runoff, and trash as critical issues affecting the health of the greater Dog River Watershed. Excessive nitrogen and phosphorous loading could have negative impacts on water quality within the streams, rivers, and estuary of Dog River. Modeling of nutrient loading identified urbanized areas within the Watershed as primary source areas for nutrients. In addition to nutrient loading, stormwater management was determined to be a critical issue. Altered hydrology, intense rainfall events, and impervious surfaces created by urban development have resulted in large volume stormwater flows. The loss of wetlands and the channelization of streams have also altered the natural hydrologic regime of the Watershed increasing runoff, stormwater flows, and flooding, and negatively affecting the water quality of the Watershed. Therefore, new urban development must be properly managed to control stormwater runoff from urbanized land and impervious surfaces.

While best management practices are more routinely utilized today, older developments were not built to the same standards. For this reason, it is recommended to implement stormwater best management practices during retrofits of existing developments. In addition, excessive stormwater flows have contributed to habitat loss in the greater Dog River Watershed. Islands, spits, marshes, and shorelines have been receding over the past 50 years and need to be protected.

Stormwater runoff, water quality, and sediment transport within the greater Dog River Watershed were identified as priority issues based on studies by the Geological Survey of Alabama (GSA), data provided by the Alabama Department of Environmental Management (ADEM) and the Alabama Water Watch (AWW) and Dog River Clearwater Revival (DRCR) organizations, public perception, and input from the Steering Committee. Investigations completed by GSA indicate that erosion and sediment transport rates within the greater Dog River Watershed were highest in East Eslava Creek and Spencer Branch within the Upper Dog River Watershed, and Spring Creek was highest within the Halls Mill Creek Watershed.

Stormwater runoff carrying trash, nutrients, sediment, and chemicals from developed areas into waterways is a critical issue throughout the entire greater Dog River Watershed. The greater Dog River Watershed contains critical habitats that serve as feeding grounds, refuges, and nurseries for many species. Therefore, stormwater runoff, sediment loads, and sanitary sewer overflow (SSO) events are serious issues that must be addressed. Stormwater runoff is greatest in urbanized areas with impervious surfaces. According to the 2011 NLCD Percent Developed Imperviousness dataset (Xian et al., 2011), impervious surfaces cover an estimated 16.08% of the greater Dog River Watershed. Stream degradation begins if as little as 10% of a watershed is covered by impervious surfaces (Schueler, 2003). The Upper Dog River and the Halls Mill Creek watersheds have the greatest sediment loads, the most concentrated urban land use, and the greatest impervious surface percentages.

RECOMMENDED MANAGEMNET MEASURES

Working in cooperation with stakeholders, the WMT developed the following management measures to address the purpose of the WMP, its specific goals, and its priority issues.

1. Improve water quality.
   - Reduce sediment rates in increments of 25% until they are no more than 1.5 times the estimated background geologic erosion rate as determined by the GSA.
   - Reduce trash by implementing additional litter traps, stormwater inlet screens, catch basin filters, volunteer clean-ups, and by addressing human behavior through public education and awareness. A preliminary goal of reducing trash recovery tonnages by 50% over 10 years can be established.
   - Implement stormwater runoff management techniques that mimic natural systems to reduce runoff.
   - Reduce concentrations of individual nutrient components until the concentrations are within the "good" to "fair" range 90% of the time.
   - Reduce bacterial counts to be less than ADEM's standards for Fish and Wildlife Coastal Maximum and Swimming Coastal Maximum 90% of the time.

2. Protect and restore critical habitats.
   - Acquire 1,000 acres of existing natural wetlands and ecologically-significant land.
   - Restore 6,000 linear feet of streams.
   - Employ 5 acres of bioretention.
   - Employ 20 acres of constructed stormwater wetlands.
   - Restore 20,000 linear feet of riparian buffer.
   - Employ living shoreline techniques to at least 3,000 linear feet of shorelines.

3. Improve resiliency.
   - Acquire at least 50% of the 95 acres of land identified for habitat migration.
   - Develop an adaptation action area designation for low-lying zones that may experience flooding due to high tides and storm surge and are vulnerable to the impacts of sea level rise. Designation criteria may include, but may not be limited to: areas with land elevations below, at, or near mean higher high water; with land having a hydrologic connection to coastal waters; or lands that are designated storm surge evacuation zones.

4. Improve access.
   - Add at least six new access points.

- Improve access points through signage with maps.
- Increase interpretative signage with historic and cultural themes.
- Develop a boaters' guide to highlight local waterways and access points.

Implementation of the recommended management measures should begin immediately after approval of this WMP. Initial implementation should focus on the most critical issues and the prioritized management measures identified in this WMP. Many of the management measures can occur concurrently as soon as the necessary funding is available.

IMPLEMENTATION OF MANAGEMENT MEASURES

Successful implementation of the recommended management measures will require the long-term commitment of significant financial resources and community support. The jurisdictional areas of political entities that might provide funding do not follow or encompass the Watershed boundaries; therefore, a public-private partnership may be the most effective way to accomplish the management goals. To acquire the funding necessary to undertake significant restoration, preservation, and 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 greater Dog River Watershed. However, increases in watershed recovery efforts by communities around the nation have substantially increased the competition for these resources. The following funding sources were identified and discussed in the WMP and should be pursued through project implementation.

- Stormwater utility fees (10.2)
- Property, sales, or other taxes (general funds) (10.3)
- Federal grants, loans, and revenue sharing (10.4)
- State of Alabama Revolving Loan Fund (10.4.3)
- "Green" stimulus funding (10.5)
- Non-governmental organization and other private funding (10.6)
- Mitigation banks (10.7)
- Impact fees (10.8)
- Special assessments (10.9)
- System development charges (10.10)
- Environmental tax shifting (10.11)
- Capital improvement cooperative districts (10.12)
- Alabama improvement districts (10.13)
- Regional collaboration opportunities (10.14)
- RESTORE Act (10.15)
- Natural Resource Damage Assessment (10.16)
- National Fish and Wildlife Foundation Gulf Coast Benefit Fund (10.17)
- Gulf Coast Conservation Grants Program (10.18)
- Coastal Ecosystem Resiliency Grants Program (10.19)
- Gulf of Mexico Energy Security Act (GOMESA) (10.20)
- EPA Healthy Watersheds Consortium Grant (10.21)
- Five Star Restoration Program (10.22)
- Clean Water Act Section 319(h) (10.23)
- Wetlands Program Development Grants (10.24)

1.0 INTRODUCTION

In 2015, Goodwyn, Mills and Cawood (GMC) was contracted by the Mobile Bay National Estuary Program (MBNEP) through its Project Implementation Committee (PIC), to conduct a comprehensive Watershed Management Plan (WMP) for the greater Dog River Watershed located in Mobile County, Alabama. The greater Dog River Watershed as defined by this WMP is the geographical area identified by the following U.S. Geological Survey (USGS) 12-digit hydrologic unit codes (HUCs): HUC 031602050101 (Upper Dog River), HUC 031602050102 (Halls Mill Creek), and HUC 031602050103 (Lower Dog River). The greater Dog River Watershed encompasses approximately 93.29 square miles within Mobile County as shown in Figure 1.1 (USGS, 2017). The headwaters of Dog River begin at the lower tip of the City of Mobile.

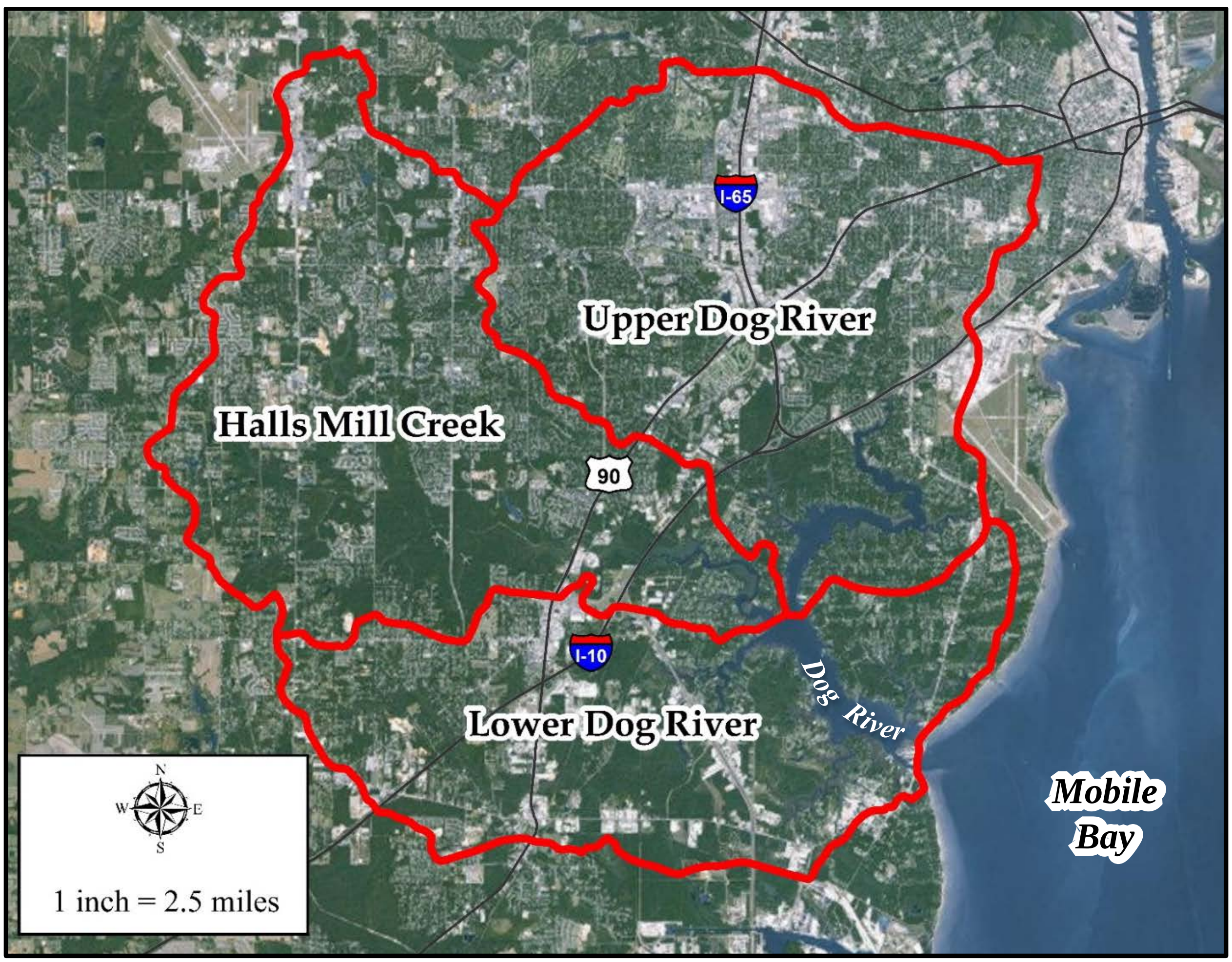

Figure 1.1: The greater Dog River Watershed boundary (USGS, 2017)

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1.1 PLAN OVERVIEW

The MBNEP developed a Comprehensive Conservation and Management Plan (CCMP) for the Mobile Bay estuary, an estuary of national significance that is at risk of impact by pollution, development, or overuse. The initial CCMP, published in 2002, included the following five areas identified as issues that need to be addressed:

1. Water Quality
2. Living Resources
3. Habitat Management
4. Human Uses
5. Education and Public Involvement

After the completion of several goals and objectives, the CCMP was revised in 2012. The basis of the revised plan's foundation was the result of analysis from community input. Six values were recognized by the community as most important to the quality of life in coastal Alabama:

1. Access to water/open spaces for recreation and vistas (Human Uses);
2. Beaches and shoreline protection, economy, and beauty (Habitat Management);
3. Fish habitats, abundance, and livelihood (Living Resources);
4. Heritage/ Culture - This is a new value aimed at protecting the legacy of the coast;
5. Resiliency - The capacity of human and natural physical systems to rebound from unforeseen events protecting beauty (Human Uses/Habitat Management); and
6. Water Quality – Whether drinkable, fishable, or swimmable, the public places high value on quality rivers, creeks, and bays (Water Quality).

The MBNEP PIC identified three goals in the current (2013-2018) CCMP as part of its five-year strategy to support these six values. The goals identified include:

1. Improving trends in water quality in priority watersheds that discharge into priority fishery nursery areas;
2. Improving ecosystem function and resilience through protection, restoration, and conservation of habitats, including beaches, bays, backwaters, and rivers; and
3. Restoring and/or expanding human connections to Alabama's coastal resources.

To achieve these goals, the PIC identified a need for comprehensive watershed planning within the Mobile Bay estuary. To assist the PIC in achieving this objective, the MBNEP received funding from the National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund (GEBF) to develop a comprehensive WMP for the greater Dog River Watershed. The Garrow's Bend watershed was originally included within the project area intended to be covered by the WMP. However, due to its significant differences with the Upper Dog River, Lower Dog River and Halls Mill Creek watersheds (it's position along Mobile Bay's shoreline, the Port, etc.), the MBNEP determined that the Garrow's Bend Watershed be studied separately and a WMP be developed specifically for Garrow's Bend. Efforts are currently underway to secure funding for this WMP.

The greater Dog River Watershed's population, traffic, and impervious surfaces collectively affect the health of the Mobile Bay estuary. Realizing this, the greater Dog River Watershed was identified as a high priority for watershed planning in order to preserve and improve its existing environmental quality and the quality of the Mobile Bay estuary.

1.2 PLAN PURPOSE

The purpose of the greater Dog River WMP is to guide watershed resource managers, policy makers, community organizations, and citizens to protect the chemical, biological, and cultural integrity of the greater Dog River 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.

1.3 PLAN VISION

The vision of the greater Dog River WMP is a healthy watershed environment by fostering the coordinated effort to protect, restore, and enhance the overall quality of life by preserving and restoring water quality, natural habitats, biological resources, and recreational resources.

1.4 GOALS AND OBJECTIVES

Goals initially identified by the MBNEP for the greater Dog River WMP include:

1. Improving water quality to support healthy populations of fish and shellfish;
2. Improving habitats necessary to support healthy populations of fish and shellfish;
3. Protecting continued customary uses of biological resources to preserve culture, heritage, and ecology of the Watershed;
4. Improving watershed resiliency to sea level rise and changing climate impacts; and
5. Expanding opportunities for community access to the natural resources and waters of the greater Dog River Watershed.

Building off of the initial goals provided above, the collective inputs gathered from several sources (residents, stakeholders, the greater Dog River WMP Steering Committee, results from previous studies, and the analysis of collected data) were used to develop the management goals for the greater Dog River WMP. The specific goals identified for the greater Dog River Watershed include:

1. Improving water quality by addressing:
   - Sediment
   - Trash
   - Nutrients
   - Pathogens

2. Protecting and restoring critical habitats to support:
   - Good water quality
   - Healthy populations of fish and wildlife

3. Improving resiliency to address:
   - Habitat migration
   - Increased flooding and critical infrastructure

4. Improving access points:
   - New water access locations
   - Access signage
   - Interpretive signage of historic and culture themes
   - Guides to local waterways and access points

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Determining the success or failure of implementing management efforts to improve water quality, resiliency, access, and to restore critical habitats requires a reasonable means of measurement. The objectives of the greater Dog River WMP are to conform to the nine key elements of watershed planning defined by the U.S. Environmental Protection Agency (EPA) given in Section 1.6.1. The proposed objectives, including metrics for success, identified in this WMP include:

1. Improving water quality:
    - Reduce sediment rates in increments of 25% until they are no more than 1.5 times the estimated background geologic erosion rate as determined by the Geological Survey of Alabama (GSA).
    - Reduce trash by implementing additional litter traps, stormwater inlet screens, catch basin filters, volunteer clean-up, and by addressing human behavior through public education and awareness. A preliminary goal of reducing trash recovery tonnages by 50% over 10-years can be established.
    - Implement stormwater runoff management techniques that mimic natural systems to reduce runoff.
    - A reduction of concentrations of the individual components that comprise nutrients until the concentrations are within the good to fair range 90% of the time.
    - Reductions of the bacteria counts to be less than the Alabama Department of Environmental Management's (ADEM) standards for Fish and Wildlife Coastal Maximum and Swimming Coastal Maximum 90% of the time.

2. Protecting and restoring critical habitats:
    - Acquire 1,000 acres of existing natural wetlands and ecologically significant land.
    - Restore 6,000 linear feet of streams.
    - Employ 5 acres of bioretention.
    - Employ 20 acres of constructed stormwater wetlands.
    - Restore 20,000 linear feet of riparian buffer.
    - Employ living shoreline techniques to at least 3,000 linear feet of shorelines.

3. Improving resiliency
    - Acquire at least 50% of the 95 acres of land identified for habitat migration.
    - Develop an adaptation action area designation for low-lying zones that may experience flooding due to high tides, storm surge, and that are vulnerable to the impacts of sea level rise. Designation criteria may include, but may not be limited to, areas with land elevations below, at, or near mean higher high water, have a hydrologic connection to coastal waters, or are designated storm surge evacuation zones.

4. Improving access
    - Add at least six new access points.
    - Improve access points through signage and mapping.
    - Increase interpretative signage on historic and cultural themes.
    - Develop a boater's guide to highlight local waterways and access points.

1.5 STEERING COMMITTEE

A Steering Committee comprising diverse stakeholders was established to guide the planning process. This group represented a cross-section of the community and included residents from different geographic locations across the greater Dog River Watershed as well as representatives from businesses, civic groups, environmental organizations, and government agencies. The Steering Committee acted as a working group serving as advocates and helped to make recommendations about the process and the substance of the vision.

The greater Dog River WMP Steering Committee was established to be a working group with a number of critical responsibilities related to 1) the planning process and 2) development of recommendations for the plan. These responsibilities include:

- Attend committee meetings.
- Represent residents and other stakeholders in the planning process.
- Provide guidance and direction to the staff and consultants.
- Act as spokespersons for the planning effort.
- Serve as hosts at public events during the process.
- Identify volunteers to support the process (i.e., distributing promotional materials, serving on outreach sub-committees, etc.).
- Volunteer to assist with community meetings.
- Disseminate information during the planning process (using individual networks).
- Participate in formalizing and presenting the recommendations.
- Serve as stewards of the WMP once it is adopted.

The Greater Dog River Watershed Steering Committee Members:

Jim Adkins, Bel Air Mall
Nick Amerberger, City of Mobile
Robbie Baker, Hancock Bank
James Barber, City of Mobile Public Safety Director
Kelley Barfoot, Mobile Bay National Estuary Program
Jim Barton, Lobbyist, former state legislator
Gavin Bender, Bender Real Estate Group
Tom Bender, Tembotec Asphalt Company
John T. Bender, McFadden, Lyon and Rouse LLC
Bob Bender, Springdale Travel
Mark Berte, Alabama Coastal Foundation
Val Blankenship
Todd Boatman, U.S. Army Corps of Engineers
Ben Brenner, Mobilians on Bikes
Will Bridges, Landowner
Ben Brooks (Judge), former elected official
Donna Brown, River Park Community Action Group President
David Buckhaults
Casi Callaway, Mobile Baykeeper
Matthew Capps, City Parks
Bruce Coldsmith, Dog River Clearwater Revival
TJ Collins, Grand Mariner Marina
Marlon Cook, Geological Survey of Alabama
Lewis Copeland, Principal of Davidson High School
Rick Courtney, Patrick Courtney LLC
Ben Cummings, Architect
Monty Dees, Dees Paper
David Delaney, AL Capitol

David Dexter, NAI Commercial Real Estate Services
Joshua Dindo, White-Spunner Construction
Melvin Dunn
Lee Echols, Dog River Clearwater Revival
Michael Farmer, Mobile Archdiocese
Miriam (Mimi) Fearn, Dog River Clearwater Revival
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CJ Finkley, City of Mobile
Debi Foster, The Peninsula of Mobile
Pat Garmeson, Alabama Coastal Fishing Association
Tony Gibson, Dog River Park Athletic Assoc.
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Tracy McClure, Dog River Clearwater Revival
Shannon McGlynn, Alabama Department of Environmental Management
Lee Metzger, Realtor
Sonny Middleton, Dog River Marina
Christian Miller, Mobile Bay National Estuary Program
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Larry Moons
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Peggy Olive
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Colvice Parker, Lloyd's Station Community Group
Drew Perrin
Terry Plauche, Plauche Landscape Architecture
Jon Porthouse, National Fish and Wildlife Foundation
Bess Rich, Mobile City Council
Ray Richardson, City of Mobile Environmental Manager
Doug Robinson, Environmental Science Associates
Mike Rogers, Rogers and Willard Builders
Rosemary Ginn Sawyer, City of Mobile
Bob Schwarz, Dog River Marina
Randy Shaneyfelt, Alabama Department of Environmental Management
Barbara Shaw, Mobile Area Water and Sewer System
CJ Small, Mobile City Council
BJ Smith, Shorecombers
William Smith, Principal of Murphy High School
Jill Stork, Alabama Power
Roberta Swann, Mobile Bay National Estuary Program
Merrill Thomas, Realtor
Jody Thompson, Auburn University Marine Extension and Research Center
David Tunstall, McAleer Tunstall Commercial Real Estate
Roger Wehner, formerly with the Mobile Airport Authority
Matt White, White-Spunner Realty
John Williams, Mobile City Council
Claire Wilson, Dog River Clearwater Revival
John Windley, Retired City of Mobile Public Works
Ron Wright, Golf Course Superintendents Association of America
Representative, Government St. Baptist Church
Representative, Dauphin Way Baptist Church
Representative, Large Commercial Property Manager
Representative, Arch Diocese of Mobile

1.6 PLANNING ALIGNMENT

1.6.1 EPA Nine Elements

The EPA has identified nine key elements of watershed planning that are critical for achieving improvements in water quality. These nine elements and their relevant chapters in this WMP are as follows:

1. Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in this watershed plan (Chapters 1, 5, and 6);

2. An estimate of the load reductions expected from management measures (Chapter 7);
3. A description of the nonpoint source management measures that need to be implemented to achieve load reductions, and a description of the critical areas in which those measures will be needed to implement this plan (Chapters 6, 7, and 9);
4. Estimate of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan (Chapters 8, 9, and 11);
5. An information and education component used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented (Chapter 9);
6. Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious (Chapters 9 and 11);
7. A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented (Chapter 9);
8. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards (Chapters 9 and 11); and
9. A monitoring component to evaluate the effectiveness of implementation efforts over time, measured against criteria established under item 8 immediately above (Chapter 11).

1.6.2 Dog River Watershed Management Plan of 2000

The 2000 Dog River Watershed Management Plan is based on studies conducted by ADEM and the U.S. Army Corps of Engineers (USACE) in 1994 and 1997, respectively. Thereafter, the South Alabama Regional Planning Commission (SARPC) initiated stakeholder meetings followed by the assignment of the Watershed Plan development to Auburn University in 1998. The intent of the Plan was to reduce flooding, improve water quality, and to promote and inspire similar endeavors in other coastal watersheds.

The major recommendations from USACE and ADEM are as follows:

1. Control runoff and sediment from entering Dog River;
2. Control runoff from cleared land and impervious surfaces;
3. Habitat restoration at Rabbit Creek, Alligator Bayou, and Rattlesnake Bayou;
4. Initiate an improved and expanded land use management plan; and
5. Implement an educational awareness program.

The following ten goals were developed by stakeholders in a 1999 meeting:

1. Reduce loss of aquatic and riparian habitats. Conserve existing habitat by establishing greenways and other natural areas to improve wildlife habitat and water quality;
2. Promote limited home rule legislation for the Mobile County Commission for environmental issues, including planning and zoning authority;
3. Reduce nonpoint source urban stormwater runoff, including: trash, and run off from construction, industrial, and residential areas;
4. Reduce nonpoint source pollution from septic tank seepage and work with Mobile Area Water and Sewer System (MAWSS) to reduce sanitary sewer overflows (SSO);
5. Encourage enforcement of regulations pertaining to best management practices (BMPs);
6. Promote and encourage land clearing requirements and planning;
7. Pursue the development of a watershed management authority;
8. Encourage and enforce management of no wake zones to prevent erosion;
9. Implement a public outreach program; and
10. Coordinate and partner with other agencies to achieve the above.

1.6.3 Dog River Scenic Blueway Master Planning Workbook

The Dog River Scenic Blueway (DRSB) is a partnership created by Dog River Clearwater Revival (DRCR) and the National Park Service (NPS) through a Rivers, Trails, and Conservation Assistance (RTCA) grant. This venture relies on a collaborative effort by several partners and allies including: 1) The Coastal Program, Alabama Department of Conservation and Natural Resources (ADCNR) - State Land Division (SLD); 2) MBNEP; 3) Alabama Coastal Foundation (ACF); 4) Smart Coast; and 5) Mobile Baykeeper.

The vision and mission of the Dog River Scenic Blueway Planning Workbook includes:

1. Identify river and coastal access points;
2. Encourage cultural and historical awareness;
3. Provide recreational opportunities for water activities such as boating and paddling; and
4. Promote the stewardship of sensitive environments.

The workbook provides information on various current and potential access points including locations and a desired inventory of amenities, improvements, and enhancements.

1.6.4 Peninsula of Mobile Corridor Master Plan

The Mobile Peninsula Corridor Master Plan, developed by Peninsula of Mobile, is a plan that focuses on the Dauphin Island Parkway corridor (the roadway's surrounding area south of Interstate 10 to the confluence of Dog River and Mobile Bay) and is based on the seven principles (Section 1.6.7) of the *Map for Mobile* Plan. The overall goals are to:

1. Revitalize the area by redevelopment;

2. Reduce flooding potential through aesthetic and stormwater improvement with the introduction of low impact development (LID) techniques; and
3. Enhance community awareness of its unique environment.

The plan includes potential considerations for inclusion in plans such as the greater Dog River WMP, the Garrow's Bend WMP, and/or the *Map for Mobile* Plan. The plan identifies several strategies that include residential (re)development, business growth, and corridor access in specific areas.

The Mobile Peninsula Corridor Master Plan elements include:

1. Built environment: zoning and future land use patterns;
2. LID: stormwater management techniques and applications;
3. Mobility and connectivity: walking, bicycling, and driving along the corridor;
4. Neighborhoods: development centers and gateways;
5. Infrastructure: assets that promote economic and recreational activity; and
6. Economic development: strategic investment opportunities.

1.6.5 Dog River Clearwater Revival Work Plan

The goal of the DRCR Work Plan is to "facilitate successful action targeted at immediate solutions for clean, healthy water." The work plan includes water quality, public awareness, and public access projects and activities. The goals of the work plan include:

- Increase public awareness of the local water quality and its bacterial levels;
- Develop improved water quality baseline data;
- Obtain "Outstanding Waterway" status;
- Build a connection between the young population and Dog River;
- Improve and enhance the desirability of Dog River Park;
- Create public access to Dog River;
- Promote the environmental and financial benefits of conservation easements to private owners;
- Prevent litter from east of I-65 from entering the River;
- Secure the purchase or conservation of key undeveloped wetland properties;
- Improve Rochon Landing for public access; and
- Perform a wetland restoration or living shoreline project.

1.6.6 City of Mobile Storm Water Management Program Plan

The City of Mobile was issued a National Pollutant Discharge Elimination System Permit (NPDES) Permit Number ALS000007 and, to fulfill the NPDES requirement, developed a Storm Water Management Program (SWMP). Ten program elements are included in the plan:

1. Storm Water Collection System Operations;

2. Public Education and Public Involvement on Storm Water Impacts;
3. Illicit Discharges Detection and Elimination (IDDE);
4. Construction Site Storm Water Runoff Control;
5. Post-Construction Storm Water Management in New Development and Re-development;
6. Spill Prevention and Response;
7. Pollution Prevention / Good Housekeeping for Municipal Operations;
8. Application of Pesticide, Herbicide, and Fertilizer (PHFs);
9. Oil, Toxics, and Household Hazardous Waste Control; and
10. Industrial Storm Water Runoff (City of Mobile, 2016c).

The plan is a Municipal Separate Storm Sewer System (MS4) specific comprehensive program to accomplish the following goals (City of Mobile, 2016c):

1. Reduce discharge of pollutants from MS4 to the maximum extent practicable (MEP);
2. Monitor stormwater collection system operations;
3. Identify and eliminate illicit discharges and improper disposal into the storm sewer;
4. Develop, implement, and enforce controls to minimize pollutants from construction activities;
5. Develop and implement pollution prevention/good housekeeping practices for municipal operations;
6. Develop and implement stormwater management practices for new developments and re-developments;
7. Reduce discharges of pollutants from the application of pesticides, herbicides, and fertilizers;
8. Prevent, contain, and respond to spills that may discharge into the MS4;
9. Monitor and control pollutants in stormwater discharges from industrial facilities (such as municipal landfills, hazardous waste treatment, sewage treatment, storage, disposal and recovery facilities subject to Emergency Planning and Community Right to Know Act (EPCRA) Title III, Section 313; and
10. Implement public education activities regarding the stormwater management program, recycling programs, household hazardous waste and proper disposal, etc.

1.6.7 Map for Mobile – Framework for Growth

Map for Mobile is a comprehensive, long-term plan for preservation, revitalization, and growth of the City of Mobile. It embraces the ideas, themes, and conditions from previous plans to direct and further develop future goals for the City.

Map for Mobile contains seven principles as core values. These principles were identified and refined by citizens during a robust public outreach campaign as part of the overall planning process. The seven principles are reflected in the goals, policies, and action items of the Plan and include:

1. Strong neighborhoods with:
    - Unique identity and sense of place;

- A mix of housing types that provide for residents' diverse needs; and
- Community amenities within walkable distances.

2. Functional roadway corridors with:
   - An attractive and welcoming public realm;
   - Safe accommodations for people and vehicles; and
   - A variety of thriving businesses that support a robust economy.

3. Strategic infill and redevelopment with:
   - A mix of uses that serve the needs of the community;
   - A focus on vacant properties and blighted areas; and
   - Concentrated activity that creates vibrancy.

4. A connected community with:
   - Ease of mobility for pedestrians, automobiles and bicyclists;
   - Safe and appealing transportation options; and
   - Access to businesses, parks and open spaces, cultural amenities, local waters, and other destinations.

5. High-quality design of the built environment with:
   - An attractive and distinctive streetscape and public realm;
   - Maintenance of existing private property to minimize degradation and blight; and
   - New private property development that is distinguishing yet in keeping with city and neighborhood character.

6. A strong downtown with:
   - A greater intensity of uses and activities;
   - Pedestrian-friendly streets and interesting restaurants and entertainment options; and
   - Accommodations for tourists as well as those who live and work in Mobile.

7. Greater opportunities to enjoy natural and recreational assets with:
   - Quality parks and open spaces; and
   - Appropriate and inviting development at key waterfront and riverfront locations.

8. Proximity and connections to residential and commercial areas.

To reinforce the principles, *Map for Mobile* includes the following plan elements which organize policy recommendations for the City to grow and develop. Each of the plan elements contain goals and policies which could be applicable to the greater Dog River WMP. The seven plan elements include:

1. Built environment;
2. Mobility and connectivity;
3. Neighborhoods;
4. City facilities and services;
5. Economic development;
6. Natural resources; and
7. Collaboration and cooperation.

The following is a brief summary of the plan's goals:

1. Incorporate mixed-used designs that are people-focused, enhance the community and its connectivity and access, minimizes development sprawl, and in strategic locations;
2. Decrease congestion by accommodating walking, cycling, and the use of public transit;
3. Development and revitalization of diverse, well-designed residential areas near jobs and services and which also provide access to recreational amenities;
4. Provide high quality public services in well-maintained and well-connected facilities and infrastructure;
5. Diversify the tourism and technology economic base and retain and attract new businesses by developing and expanding industries, and cultivating a skilled workforce; and
6. Protect and conserve sensitive natural environments as well as offer access to trails and waterways, develop resiliency and sustainability, and improve the quality of the water.

1.6.8 Map for Mobile: Future Land Use Plan and Major Streets Plan

The Future Land Use Plan (FLUP) is the City of Mobile's primary guide to future physical development. The Future Land Use Map (FLUM) and corresponding land use designations describe the desired types, intensity, and spatial arrangement of the City's land uses to achieve the vision described in Map for Mobile.

The principles and guidelines provided by the FLUM are implemented through the City's Zoning Ordinance, specifically the zoning districts and related regulations. The FLUM specifies the desired development pattern for Mobile through a categorical land use system, which describes the location, type, and intensity of development and redevelopment for each land use district.

The Major Streets Plan (MSP) represents the City's vision for a coordinated land use and transportation strategy in accordance with present and anticipated needs. The MSP recognizes key existing and future street corridors within the City's overall transportation network, based primarily on analyses of traffic volumes and character of traffic movements that could be generated by future development of land according to the FLUM.

1.6.9 Other Relevant Watershed Studies

The Dog River and Mobile Bay estuaries have been studied and assessed on many different occasions. Numerous studies have been conducted relating to the greater Dog River Watershed including several at the University of South Alabama. Under the guidance of Dr. Miriam Fearn in the Department of Earth Sciences, students conducted research, involving such things as stream flows and the ecotone within the greater Dog River Watershed.

The USACE conducted an environmental assessment as part of a navigation improvements project in 1985 (USACE, 1985). In 2012, one of the most significant studies relating discharge and sediment was released by the GSA (Cook and Moss, 2012). This study identifies areas of major sediment concern in Dog River. A comprehensive assessment of the shorelines was also conducted by the GSA (Jones and Tidwell, 2011). The report, published in 2011, classifies the type of shoreline and the type shoreline protection, if any.

A land use and land cover (LULC) assessment study, released in a multi-agency effort in 2009 (Spruce et al., 2009), assessed LULC change from 1974 to 2008. Another study on the impact of LULC change for the Mobile Bay estuary was concluded in 2015 (Estes et al., 2014). This study uses historical data to evaluate the impact of change as well as possible future impacts. In 2016, a new dynamic modeling framework was published to assist in evaluating the effects of climate change and sea level rise on storm surge for the Gulf of Mexico including Mobile Bay (Bilskie et al., 2016).

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2.0 PUBLIC PARTICIPATION AND EDUCATION

2.1 COMMUNITY OUTREACH

Stakeholder involvement in the greater Dog River Watershed was important to the development of the Watershed Management Plan (WMP) because it allowed the community to share its aspirations for the future. This is critical to generating a shared understanding about the value of this WMP, informing its priorities, and providing the broad base of support necessary to ensure its implementation. Stakeholder involvement included leadership from a Steering Committee (Chapter 1 Section 5) that guided the process from start to finish, input from the general public through stakeholder meetings, a survey, and an open house that will take place at a future date.

Early in the planning process, the greater Dog River WMP Steering Committee felt it was important to establish an identity for this effort. The "Making Watersheds Work" logo, shown in Figure 2.1.1, was created and used in all marketing and/or outreach efforts. Building a brand for this WMP would aid in generating consensus through the unified appearance of all collateral material.

Figure 2.1.1: Watershed brand logo

2.2 STAKEHOLDER INVOLVEMENT

Using the leadership of the greater Dog River WMP Steering Committee, key community members were identified for targeted stakeholder involvement. Because of the size and scale of the greater Dog River Watershed, these targeted stakeholder groups allowed for focused discussion around key topics of importance in the Watershed. On November 11 and 12, 2015, three focus group meetings were conducted with three interest-based groups:

1. Builders, Developers, and Engineers;
2. Recreation Users; and
3. Businesses.

These targeted stakeholders became important distribution points for a community survey. Each targeted group meeting is summarized in the Sections that follow.

2.2.1 Builders, Developers, and Engineers

This meeting, shown in Figure 2.2.1, brought together builders, developers, and engineers who conduct work in the greater Dog River Watershed. Attendees were each invited by three Steering Committee members who are part of this community. The invitations were based on a conviction that these individuals would have relevant interest and perspective on the Watershed and the development of this WMP. After a brief exercise in which participants were asked to summarize the Watershed in one word, they shared their concern on its conditions, as well as on the Plan's prioritization. Each participant has a deep connection to the greater Dog River Watershed not only through their professional activities, but many are also recreational users of the Watershed and demonstrated an interest in helping improve the Watershed. The input from these stakeholders was considered in the development of the Watershed's goals and management measures.

Figure 2.2.1: Participants during the builders, developers, and engineers stakeholder meeting

2.2.2 Recreational Users

This meeting, shown in Figure 2.2.2, brought together recreational users of the greater Dog River Watershed. Attendees were invited by Steering Committee members, Watershed Management Team (WMT) members, and the Mobile Bay National Estuary Program (MBNEP). These users represented a variety of recreational aspects within the greater Dog River Watershed including, but not limited to, kayaking, recreational motor boating, sailing, fishing, golfing, running, and team sports. After a short exercise in which participants were asked to summarize the Watershed in one word, they identified perceived issues and shared thoughts about positive activities in the Watershed. These users understood the impact their recreational activities have on the watershed and understood the dynamics other user groups have created. Going forward, these users committed to staying involved with the WMT and MBNEP to help improve the Watershed. The input from these stakeholders was considered in developing the Watershed's goals and management measures.

2.2.3 Businesses

Through the Mobile Chamber of Commerce, individuals from businesses in or near the greater Dog River Watershed were invited to participate in a stakeholder group meeting. However, based upon the lack of response, this meeting revealed that business owners and operators do not understand the relationship between their work and the issues being addressed through this WMP. An informal general discussion was posed on concerns regarding the Watershed so as to reinforce that relationship. The input from these stakeholders was considered in developing the Watershed's goals and management measures.

Figure 2.2.2: Participants during the recreational users stakeholder meeting

2

2.2.4 Mobile County Public Schools

As part of the effort to increase educational awareness around the greater Dog River Watershed, an educational program was designed and implemented in conjunction with the MBNEP and the Mobile County School System. The educational program was created for all high school and middle school students located in the greater Dog River Watershed. The list of those schools is included in Table 2.2.1.

The purpose of the educational program was to educate students on the environmental significance of the greater Dog River Watershed and the impact that the community has on it. The educational program included two segments; the first was a three-week in-class video and question competition, and the second was a video production competition as part of the Mobile County School System Academy Awards program.

During the first segment of the educational program, all students watched two videos produced by the MBNEP. The videos, Watershed's 101 and Red Fish Tales, were shown to students using system-wide broadcasting capabilities.

Following the video segments each week, students would then receive pre-recorded questions from the MBNEP tailored to the segment previously watched. Responses would be collected and students' correct answers would be entered into a competition with the other participating students. At the end of this first three-week educational program segment, a random drawing was held amongst the students with the highest scores and the winner received a Clean Water Future packet of gifts from the MBNEP. For this segment, 933 students participated through the schools.

The second segment of the educational program was a video production competition between the students in those same schools. This segment was a voluntary competition, with a winner chosen based upon the content and quality of their submission. Three individual groups participated in the video production competition, each producing a video with a different perspective of the greater Dog River Watershed. The final winner was recognized during the 2016 Mobile County School System Academy Awards program.

Table 2.2.1: High schools and middle schools located in the greater Dog River Watershed

High School(s)	Murphy High School	B.C. Rain High School	Davidson High School	Williamson High School
Feeder Middle School(s)	• Burns • Calloway Smith • Phillips	• Pillans	• Clark-Shaw • Denton	• Eans • Scarborough

2.2.5 Geographic Outreach

Due to the large physical size of the greater Dog River Watershed, additional geographic outreach was conducted. This outreach was focused on distributing information on the greater Dog River Watershed and directing people to complete an online survey (Section 2.4). To accomplish this outreach, existing contact networks were leveraged from the Mobile County Commission and the Mobile City Council. Elected officials in both of these municipalities maintain contact lists of constituents for regular communication. Information regarding the Watershed and the planning effort were placed in the correspondence and emphasis was placed on completing the online survey. Elected officials also shared the Watershed information and online survey on their social media communications.

2.3 MAP FOR MOBILE – FRAME WORK FOR GROWTH

The City of Mobile recently adopted the *Map for Mobile* the City's comprehensive plan. Through the *Map for Mobile* planning effort, valuable, additional insight was gained about the general public's understanding and opinions about the greater Dog River Watershed. This insight is useful to the public participation and education component of this WMP. A summary of the relevant input follows.

2.3.1 Comments Relevant to the greater Dog River WMP

During the "Focus on the Future Workshop" of the Map for Mobile planning effort, there was an exercise to identify strong places and weak places in the City. During that exercise, less than 1% of "Ideas for the Future" developed by workshop participants specifically referenced the greater Dog River Watershed area, however, many comments were directly relevant to Dog River, including the following:

- **Waterfront access and amenities.**
  A strong desire for more waterfront access and amenities was expressed by many participants, including a desire for more retail, restaurants, parks, walking trails, bicycle lanes, and access points for boating.

- **Litter and recycling.**
  Many comments focused on the need to clean up and control litter and to improve recycling services.

- **Stormwater.**
  System improvements and innovations to improve drainage were mentioned by numerous individuals who believe that these are related to stormwater management in Mobile.

2.3.2 Comments Relevant to Dog River

During the "Ideas for the Future Workshop" of *Map for Mobile*, participants were asked to think about specific "strong" or "weak" places in Mobile. Dog River was generally considered a "strong" place with more potential and was one of the top seven places mentioned, as judged by a composite map (Figure 2.3.1) and comments at the workshop. However, most comments about Dog River indicated that people believe that it is a "strong" place because of its potential rather than its current condition.

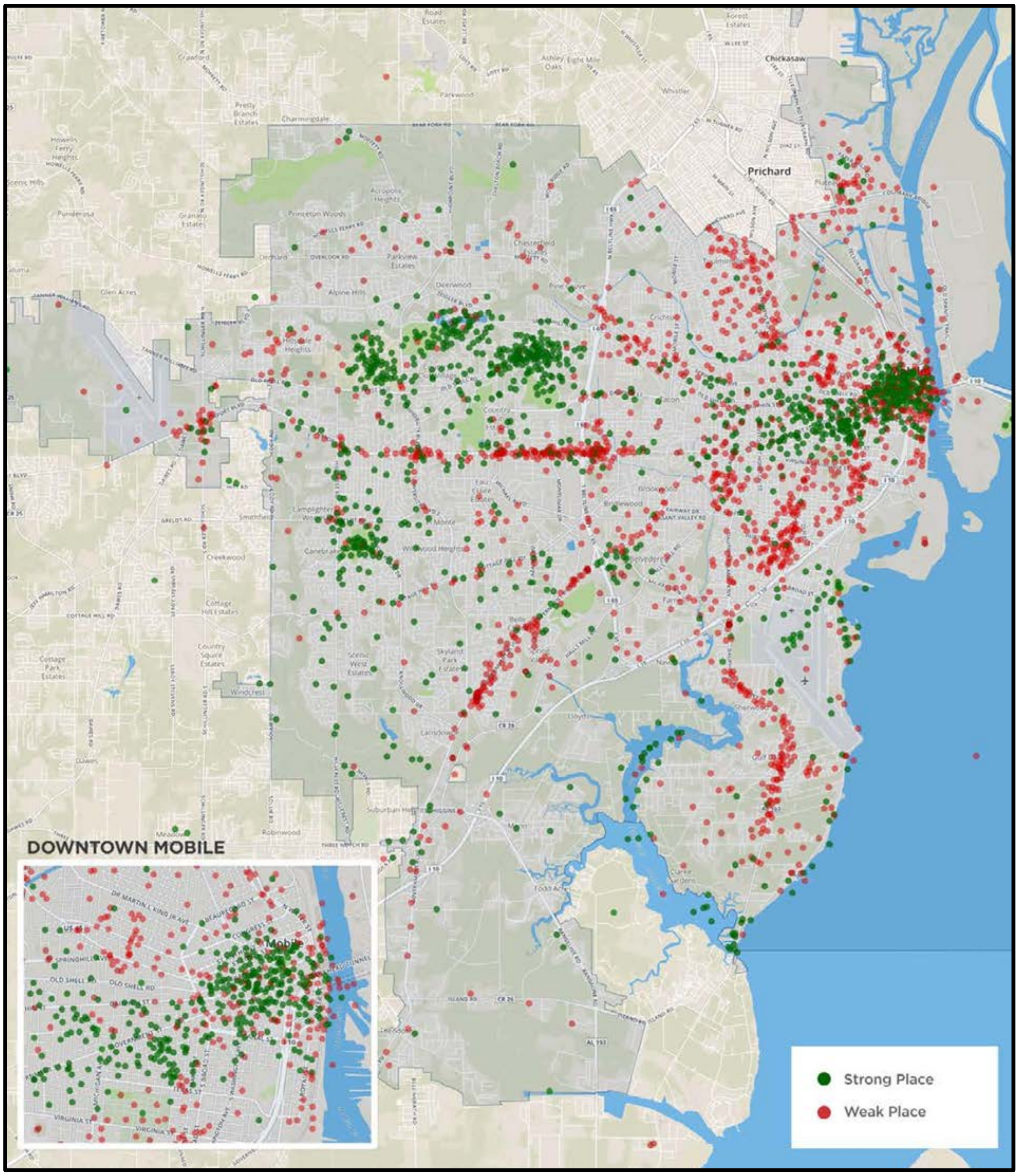

Figure 2.3.1: Strong places and weak places (from *Map for Mobile*)

Although most people who mentioned Dog River identified it as a "strong" place, approximately 20% of the people who mentioned Dog River identified it as a "weak" place. Negative qualities mentioned included stormwater runoff, illegal dumping, litter, blighted conditions near the River, lack of boat access, lack of well-maintained parks nearby and along the River, and lack of bicycle and pedestrian access.

2.4 ONLINE SURVEY

In addition to the stakeholder groups, *Map for Mobile* input, and geographic outreach, the greater Dog River Steering Committee advertised and provided an online survey to stakeholders in the Watershed. During the online survey period of 6 months, multiple outlets were used to advertise and promote the survey to the general public for additional input.

Survey participants were asked a series of questions regarding the Watershed. The following are some representative examples of the input those responses provided in relation to these questions:

"What are the top three issues the greater Dog River WMP should focus on?"

A wide array of responses was provided by participants. The word-cloud shown on Figure 2.4.1 represents the frequency of those responses. This word-cloud is composed of words used in response to this survey question with the size of each word indicating how often the word appeared. The larger the word, the more frequently it was identified in survey responses.

Litter and trash, siltation, and stormwater issues have been an ongoing problem for the entire Watershed because of the vast amount of developed land. Access has been a common theme throughout all aspects of public participation, as everyone would like to take advantage of the Watershed as a natural resource.

"Do you think the condition of the area is better or worse today compared to how you first remember it?"

Of the responses, over two-thirds of responders reported the condition of the area being "worse" than they first remembered it. The remainder stated that it was only "slightly better" or "much the same" condition. Those who stated that it was in "worse" condition, attribute that condition to many of the top issues facing the Watershed, including trash and litter along with sedimentation.

Figure 2.4.1: Word-cloud representing intensities of word responses

2

2.5 KEY THEMES

During the stakeholder meetings and online survey period, these key themes were prominently featured from a variety of different perspectives. Ultimately, they all revolve around the significance of improving the Watershed.

- **Conduct proactive education.** Educational campaigns, especially targeting youth, are critical to creating a shared sense of commitment to improving water quality and the environmental conditions of the Watershed.
- **Take a multifaceted approach to litter.** Litter issues should be addressed through a multifaceted strategy focusing on regular clean-ups, stringent enforcement, recycling programs, and education based on a message of community pride.
- **Build connections**. The prioritization of physical connections including public access to the waterways, thereby ensuring that the community—including pedestrians and cyclists—can take full advantage of the Watershed as a scenic and recreational amenity.
- **Focus on long-term land uses.** Map for Mobile emphasizes redevelopment of properties; these activities are likely to have the greatest impact on water quality; temporary construction-related sediment should be addressed as a secondary issue.
- **Improve conditions along the river.** Improving conditions and continued maintenance along the water bodies including trail systems, marshes, and beaches—should also be a priority to ensure that a range of desired recreational activities are supported.
- **Coordinate with partners.** Ensuring communication between regulatory agencies, user groups, property owners, and others is important to solving complex watershed issues.
- **Education about the watersheds' boundaries is needed.** The general public is unaware of the greater Dog River Watershed's boundaries; it is unlikely that many people know that they live, work, or spend time in the Watershed. For this reason, educating the public about the Watershed and the relationship between activities and water quality is critically important.

3.0 WATERSHED CHARACTERIZATION

The Halls Mill Creek, Upper Dog River, and Lower Dog River watersheds collectively comprise the greater Dog River Watershed, encompassing approximately 59,705 acres (93.29 square miles) (USGS, 2017). The greater Dog River Watershed's reach is approximately 12 miles inland from the western shore of Mobile Bay, spans 10.8 miles from north to south, and is shown in Figure 3.1.1. In total, the greater Dog River Watershed encompass approximately 36,094 acres (60.4%) of urban land use (Homer et al., 2015) and approximately 174 miles of streams and waterway networks (USGS, 2017). Major transportation routes include Interstate 10, Dauphin Island Parkway, Government Street, Airport Boulevard, Old Pascagoula Road, Cottage Hill Road, South University Boulevard, Halls Mill Road, and Range Line Road.

3.1 WATERSHED BOUNDARY

Located in Mobile County, Alabama, the greater Dog River Watershed, as defined by this Watershed Management Plan (WMP), is the geographical area identified by the following U.S. Geological Survey (USGS) 12-digit hydrologic unit codes (HUCs): HUC 031602050101 (Upper Dog River) HUC 031602050102 (Halls Mill Creek), and HUC 031602050103 (Lower Dog River) (USGS, 2017).

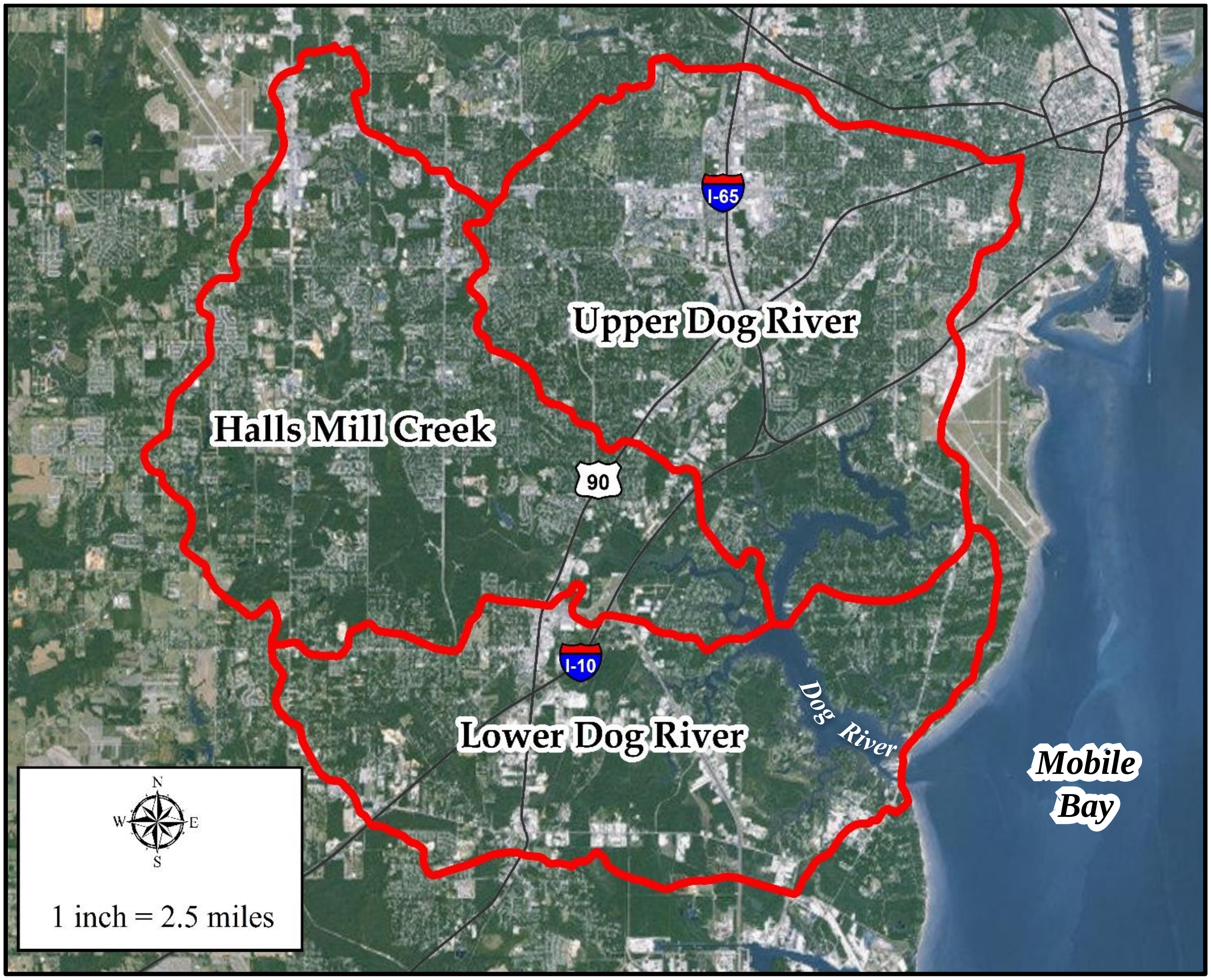

Figure 3.1.1: Watersheds comprising the greater Dog River Watershed (USGS, 2017)

3.2 PHYSICAL SETTING

3.2.1 Physiography

The greater Dog River Watershed is located within the East Gulf Coastal Plain physiographic section, and lies within two physiographic districts: the Coastal Lowlands and the Southern Pine Hills (Sapp and Emplaincourt, 1975). The Coastal Lowlands is a flat to gently undulating plain with localized swamps. It is underlain by sediments of Holocene and late Pleistocene age. Streams are tidally influenced and fringed by tidal marshes with significant saltwater influence. The landward boundary between the Coastal Lowlands district and the Southern Pine Hills is defined by the Pamlico marine scarp at an elevation of 25 to 30 feet above sea level, as shown in Figure 3.2.1.

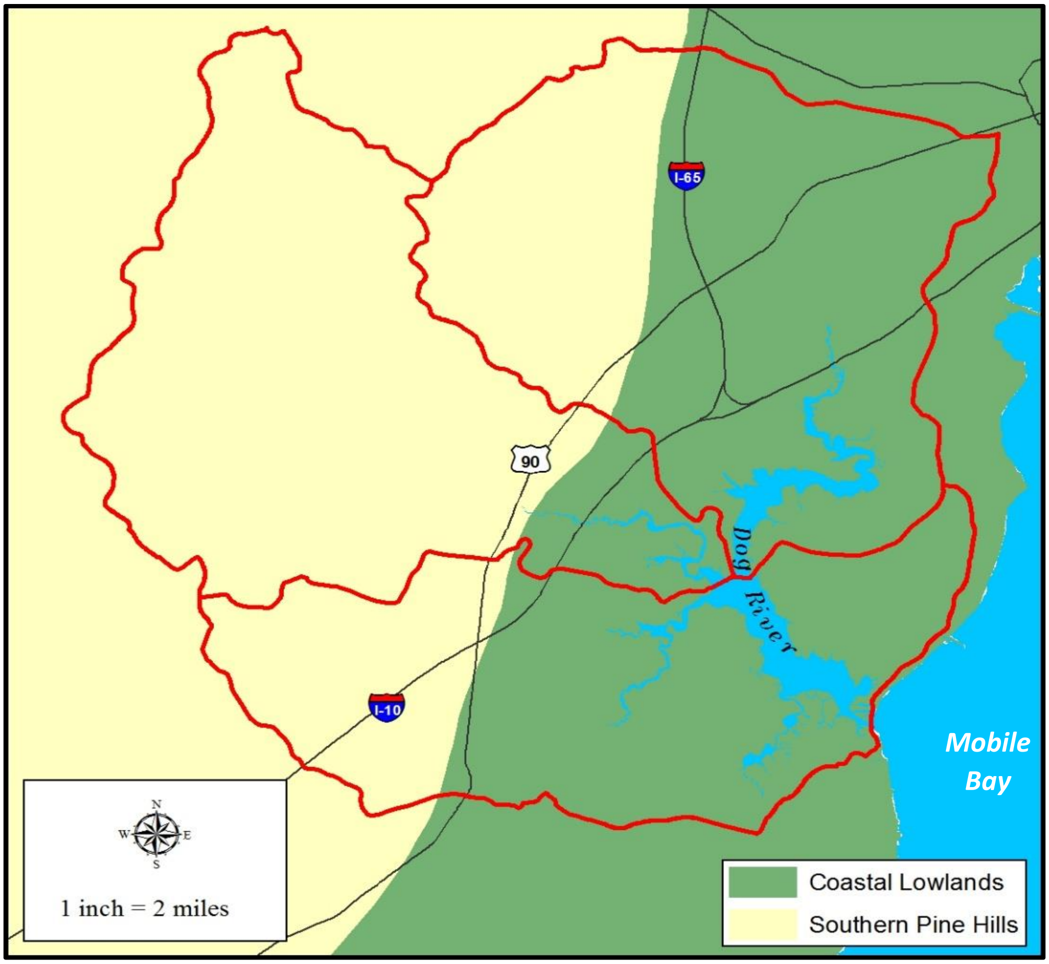

Figure 3.2.1: Physiography in the greater Dog River Watershed (EPA, 2012)

The Halls Mill Creek Watershed lies primarily within the Southern Pine Hills district. About 10% of this Watershed, primarily floodplain in its lower reaches, lies within the Coastal Lowlands district. The Upper Dog River Watershed is located within parts of two districts: the Coastal Lowlands and the Southern Pine Hills. The boundary roughly bisects the Watershed. The Lower Dog River Watershed is also located within parts of the same two districts: the Coastal Lowlands and the Southern Pine Hills. It is also bisected by the boundary of the two districts.

3.2.2 Geology

The greater Dog River Watershed is underlain by a thick sequence of consolidated and unconsolidated sediments to depths in excess of 15,000 feet (Davis, 1987). The near-surface sediments are part of the Tertiary and Quaternary systems. They are primarily composed of sand, silt, clay, and gravel. As shown in Figure 3.2.2, the geologic units exposed at land surface within the greater Dog River Watershed include the Alluvial, Coastal, and Low Terrace deposits, the Citronelle Formation, and the Miocene Series undifferentiated. Beneath the coastal deposits lie sediments of the Miocene Series.

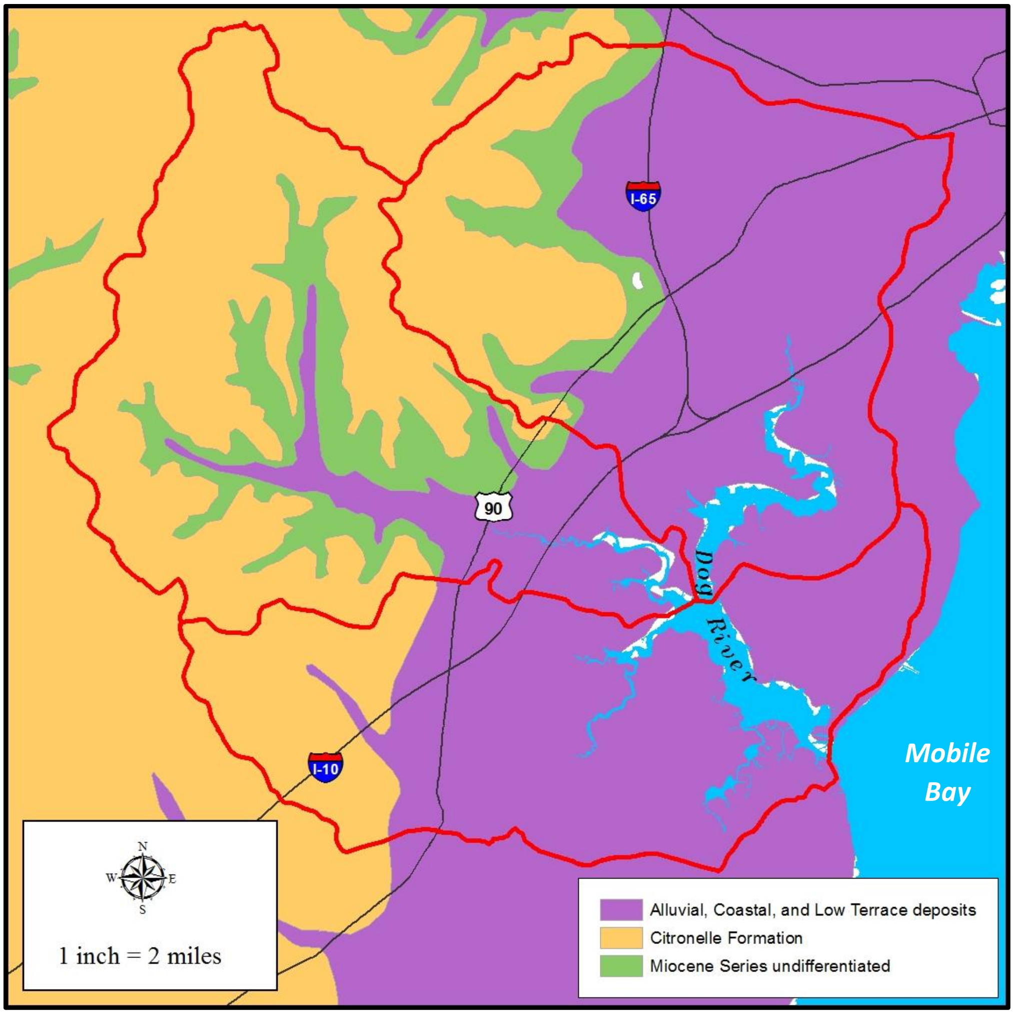

Figure 3.2.2: Geology in the greater Dog River Watershed (GSA, 2006)

The Alluvial, Coastal, and Low Terrace deposits are present at land surface in the eastern half of the greater Dog River Watershed and in the floodplains of the major surface water drainages. These sediments consist of up to 200 feet of white, gray, orange, and red sand with gravel and sandy clay. The Citronelle Formation is present at land surface in the western half of the study area (Cook and Moss, 2012). The Citronelle Formation near Mobile is composed of about 200 feet of brown, red, and orange sand; locally, gravel beds occur, and there are gray, orange, and brown lenses of sandy clay (Mooty, 1988). Sediments of the Miocene Series are exposed where streams have eroded through the overlying Citronelle Formation, and along eastward facing hillside slopes (Figure 3.2.2). The Miocene sediments are up to 3,400 feet thick in Mobile County and consist of clay, sand, and sandy clays (Mooty, 1988). The Miocene deposits are wedge shaped, and dip towards the south between 40 feet per mile near the base of the formation and 15 feet per mile at the contact with the overlying formations.

The Citronelle Formation is the surficial geologic unit throughout the majority of the Halls Mill Creek Watershed. The Miocene Series sediments are exposed in the valley walls of Halls Mill Creek and its major tributaries (Cook and Moss, 2012). The Alluvial, Coastal, and Low Terrace deposits are the surficial geologic unit in the lower portion of the Watershed, primarily east of Interstate 10.

The western half of the Upper Dog River Watershed is underlain by the Citronelle Formation, while the eastern half of the Watershed is underlain by Alluvial, Coastal, and Low Terrace deposits (Cook and Moss, 2012). Underlying the Citronelle Formation and Coastal deposits are sediments of the Miocene Series undifferentiated. The Miocene sediments are exposed where Eslava and Moore creeks have eroded through the overlying Citronelle Formation, and along eastward facing hillside slopes.

The western third of the Lower Dog River Watershed (west of Interstate 10) is underlain by the Citronelle Formation (Cook and Moss, 2012). The eastern two-thirds of the watershed are underlain by Alluvial, Coastal, and Low Terrace deposits. The Miocene sediments are not exposed in the Lower Dog River Watershed (Figure 3.2.2).

3.2.3 Soils

The geologic sediments underlying the greater Dog River Watershed have developed into numerous soils. Soils are grouped into soil associations and soil complexes. A soil association is made up of soil types that are geographically associated and are shown as one unit on a map (Hickman and Owens, 1980). Soil associations have regularity in geographic pattern and in the kind of soils that are present. A soil complex consists of two or more soil types that are intermixed and cannot be shown separately on a map. Soils present in the greater Dog River Watershed include the Urban Land- Smithton-Benndale, Bayou-Escambia-Harleston, Notcher-Saucier-Malbis, and the Troup-Heidel- Bama soil associations as shown in Figure 3.2.3.

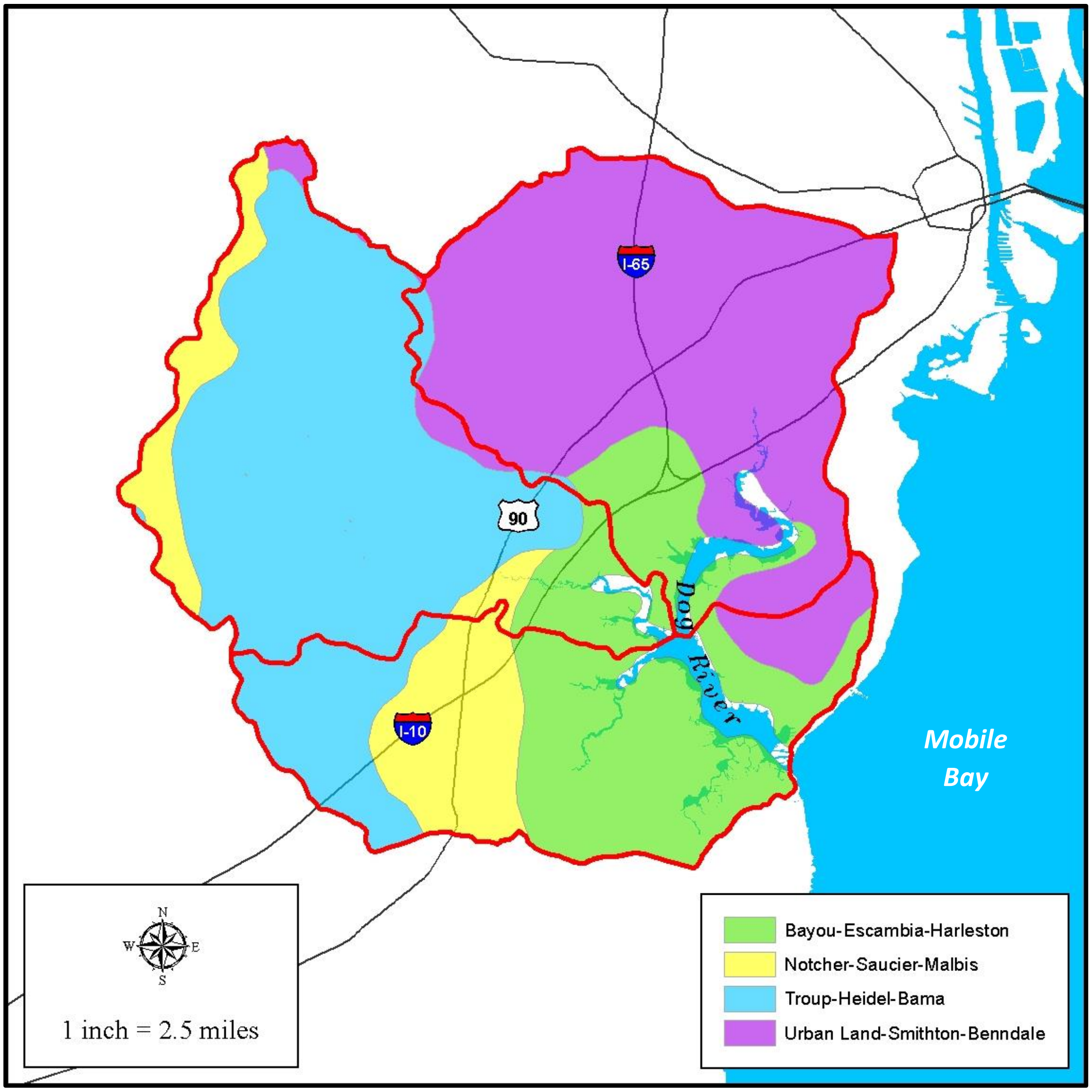

Figure 3.2.3: Soils in the greater Dog River Watershed (NRCS, 2006)

The majority of the greater Dog River Watershed is underlain by Urban Land-Smithton-Benndale and Troup-Heidel-Bama soils. Bayou-Escambia- Harleston soils are present in the southern portion of the greater Dog River Watershed located near Dog River and along Mobile Bay, while the Urban Land-Smithton-Benndale soils are present in the north and northeastern portion of the Watershed. The Urban Land-Smithton-Benndale soil association consists of nearly level to gently rolling urban land areas that are intermingled with poorly-and well-drained soils that have loamy subsoils, and are formed in loamy marine and fluvial sediments on uplands. The Urban Land soil complex includes sidewalks, streets, parking lots, buildings, and other structures that obscure the soils such that identification is not feasible. Poorly-drained Smithton soils are located on broad flats and along streams. The well-drained Benndale soils are located on ridgetops and upper side slopes. Minor soils in this unit include the well-drained Heidel and Troup soils located on ridgetops and side slopes.

The Bayou-Escambia-Harleston soil association consists of nearly-level to gently-undulating, poorly- to moderately-well-drained soils with loamy subsoils formed in marine and fluvial sediments located on uplands and terraces. Bayou soils are located on broad flats adjacent to poorly-defined drainage ways. Escambia and Harleston soils are located on slightly higher, gently-undulating ridges. Minor soils in this unit include well- and moderately-well-drained Benndale, Malbis, and Poarch soils located on knolls and low-ridges.

The Halls Mill Creek Watershed encompasses soils from the Notcher-Saucier-Malbis, the Troup-Heidel-Bama, Urban Land-Smithton- Benndale, and the Bayou-Escambia-Harleston associations. The Notcher-Saucier-Malbis soils are present in the eastern and western portion of the Watershed in a relatively narrow area along Dawes Road. Troup-Heidel-Bama soils are present in most of the Halls Mill Creek Watershed, except for an area east of Interstate 10, where Bayou-Escambia-Harleston soils are present near Dog River.

Soil associations present in the Upper Dog River Watershed include the Urban Land-Smithton- Benndale, Bayou-Escambia-Harleston, and Troup-Heidel-Bama soil associations. Most of the soils present in the Upper Dog River Watershed are classified as Urban Land-Smithton-Benndale soils. Soils of the Bayou-Escambia-Harleston association are present in a small area south of Interstate 10 and near the main channel of Dog River.

In the Lower Dog River Watershed, Troup-Heidel-Bama, Notcher-Saucier-Malbis, and Bayou-Escambia-Harleston, and Urban Land- Smithton-Benndale soils are present. This Watershed is roughly divided into three unequal parts, with the western third being underlain by Troup-Heidel-Bama soils, a central 20% being underlain by Notcher-Saucier-Malbis soils, and the eastern half being underlain by Bayou-Escambia-Harleston soils.

3.2.4 Topography

From the western and northern boundaries of the Upper Dog River and Halls Mill Creek watersheds to the shore of Mobile Bay, the relief within the study area encompasses less than 230 feet. The majority of that relief occurs in the western half of the area within the Southern Pine Hills physiographic district. Tributary drainages are well defined within the Southern Pine Hills district because of its greater topographic relief. The gentle topography of the Coastal Lowlands district is more favorable to the creation of floodplains and wetland areas along drainages.

The Halls Mill Creek Watershed, west of U.S. Highway 90, is topographically variable uplands with elevations ranging from 40 to 220 feet above sea level. Incised streams have created as much as 100 feet of relief from hilltop to floodplain. In the floodplain of Halls Mill Creek, east of U.S. Highway 90, total relief is approximately 40 feet. Total change in elevation across this Watershed is approximately 220 feet.

The northwestern portion of the Upper Dog River Watershed, north and west of U.S. Highway 90, is an upland area exhibiting as much as 100 feet of relief in incised drainages. A north-south-oriented, sinuous line marks hillsides that form the boundary between the upland areas and the eastern half of the Watershed, which is lower and exhibits much less relief. The Pamlico marine scarp roughly bisects the Upper Dog River Watershed. Total change in elevation across this Watershed is approximately 210 feet.

The Lower Dog River Watershed consists of a moderately-elevated upland west of Interstate 10 and a lowland area to the east near Mobile Bay and Dog River. Total relief along drainages in the western part of this Watershed are approximately 70 feet and typically less than 30 feet east of Interstate 10. The Pamlico marine scarp roughly bisects the Lower Dog River Watershed. Total change in elevation across this Watershed is approximately 165 feet.

3.3 HYDROLOGY

3.3.1 Rainfall and Climate

Mobile County has a hot, humid, subtropical climate with abundant rainfall. Rainfall and climate data from March 1900 through April 2012 are available from the Southeast Regional Climate Center database for the Weather Forecast Office (WFO) located at the Mobile Regional Airport, Weather Station 015478. Precipitation is usually in the form of showers with long periods of continuous rain being rare. Exceptions occur during tropical storms and hurricanes, when rainfall may be long and intense. Thunderstorms may occur at any time of the year. Annual rainfall totals for the last seven years are given in Table 3.3.1. Every year for the past seven years has included at least one month when precipitation exceeded 10 inches (NOAA, 2009-2015).

Table 3.3.1: Monthly precipitation data from the Mobile Airport WFO station number 015478 (from NOAA, 2009-2015)

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Year	**Precipitation in inches**												
2009	3.54	3.81	**12.34**	1.73	5.29	2.45	5.68	**10.18**	6.69	4.91	4.48	**15.37**	76.47
2010	**11.03**	5.51	4.06	1.72	8.98	3.45	4.42	7.25	2.06	4.08	5.92	1.39	59.87
2011	3.38	2.94	4.74	1.02	0.42	1.85	8.92	6.49	**15.80**	0.09	2.89	1.88	50.42
2012	2.24	7.25	6.69	2.51	7.82	**13.50**	6.74	**13.12**	4.13	0.19	1.43	3.48	69.1
2013	2.87	**11.31**	0.80	5.48	7.99	4.20	9.10	9.95	4.59	2.19	3.43	7.37	69.28
2014	2.92	4.20	6.50	**18.09**	9.79	5.15	7.92	2.83	5.53	3.03	1.48	5.27	72.71
2015	3.89	2.16	3.96	**13.90**	8.05	5.06	6.84	3.21	9.88	6.69	5.35	**12.38**	81.37

3.3.2 Surface Water Resources

The surface water system within the greater Dog River Watershed has been extensively altered by urbanization. Surface water drainages are heavily modified. Many are channelized and concrete lined, and those with natural channels often are eroded with heavy sediment loads. Extensive impervious surfaces within the greater Dog River Watershed creates flashy hydrographs with rapid rise and fall of discharge and velocity. The Geological Survey of Alabama (GSA) completed a study of discharge and sediment loading rates in tributaries of the greater Dog River

Watershed (Cook and Moss, 2012). Cook and Moss concluded that stream flow characteristics of tributaries varied widely due to a wide range of landforms and channel types and flow regimes influenced by urbanization, channel modifications, and floodplain structures. Measured stream velocities were greatest where extensive channelization was present and were not related to stream gradient.

3.3.3 Groundwater Resources

Along the coastal margins of Mobile County, the Alluvial-Coastal (USGS) or Watercourse (GSA) aquifer comprises recent alluvial and marine sedimentary deposits of sand and gravel. The Tertiary System (Citronelle Formation and the Miocene Series undifferentiated) directly underlie the alluvial-coastal sediments. The Miocene-Pliocene aquifer comprises permeable layers of sand and gravel within these older formations.

The relative permeability of the sediments in Mobile County allows rapid infiltration of rain water. Annual estimated runoff is approximately 30 inches (Kopaska-Merkel and Moore, 2002). The balance of the annual average precipitation (65 – 30 = 35 inches) enters the underlying aquifers as recharge, or it is returned to the atmosphere via evaporation and transpiration of trees and other plants. Some shallow groundwater flows towards and discharges to the nearest body of surface water. This groundwater seepage is included in the estimated 30 inches of runoff. Some groundwater moves deeper into the subsurface to recharge the aquifers underlying the greater Dog River Watershed. One of the first European settlements in Mobile County, Belle Fontaine, was established because a fresh water spring was discovered on the western shore of Mobile Bay by French explorers in the early 1700s.

Both the USGS and the GSA report that no continuous confining layers are present to create hydraulic separation between the deeper Miocene-Pliocene aquifer and the shallow Watercourse aquifer. When pumped, these two units act as a single hydraulic unit. There are discontinuous lenses of clay in the formations which retard the vertical movement of water on a local basis but do not hydraulically separate the various aquifers. In the deeper portions of the Miocene Series, clayey sediments are semi-confining and reduce the vertical infiltration of water which causes this aquifer to respond to short-term pumping as a confined system (Mooty, 1988). Wells constructed in the Miocene-Pliocene aquifer typically yield 0.5 to 2.0 million gallons per day. Wells constructed in the Alluvial-Coastal aquifer yield from 0.5 to 1.0 million gallons per day (Mooty, 1988).

3.4 FLOODPLAINS

Floodplains and their flood hazard area designations are identified in Figure 3.4.1. The flood hazard areas shown are designated by the Federal Emergency Management Agency (FEMA) and include: Zone A (subject to inundation by the 1% annual-chance flood event with no base flood elevation (BFE) determined), Zone AE (subject to inundation by the 1% annual-chance flood event with BFE determined), Zone VE (subject to inundation by the 1% annual-chance flood event with additional hazards due to storm waves with BFE determined), and Zone X (minimal risk areas outside the 1% and 0.2% annual-chance floodplains with no BFE or base flood depths determined).

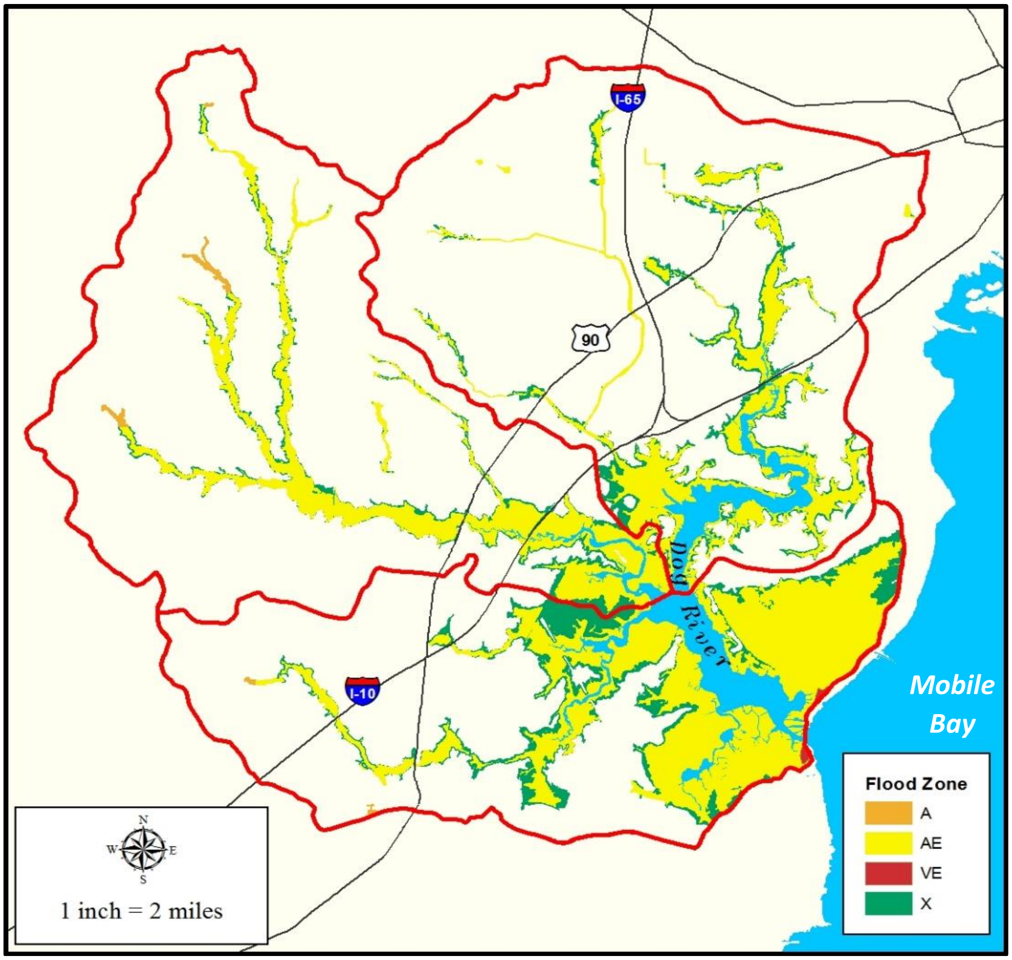

Figure 3.4.1: Floodplains in the greater Dog River Watershed (FEMA, 2015)

The flood designations within the greater Dog River Watershed include Zone A, Zone AE, Zone VE, and Zone X. The Halls Mill Watershed includes Zone A, Zone AE, and Zone X. Approximately 0.29% consists of Zone A and approximately 11.44% consists of Zone AE. The FEMA flood hazard designations within the Upper Dog River Watershed include Zone AE, consisting of approximately 12% of the area, and Zone X. Flood hazard areas within the Lower Dog River Watershed include Zone A, Zone AE, Zone VE, and Zone X. Approximately 0.07% consists of Zone A, approximately 33.82% consists of Zone AE, and approximately 0.16% consists of Zone VE.

3.5 WETLANDS

National Wetland Inventory (NWI) data (USFWS, 2010) were used to classify the wetlands within the greater Dog River Watershed. This NWI data was developed from satellite imagery in the 1980's. The greater Dog River Watershed contains approximately 5,223 acres or 8.75% of the Watershed's area that comprises wetlands (Figure 3.5.1) (USFWS, 2010). However, if wetland acreage were to be calculated from the 2011 National Land Cover Database land use data (Homer et al., 2015) then alternate wetland acreage values and percentages would be obtained. This is because of differences in the technologies and methods used to derive the datasets.

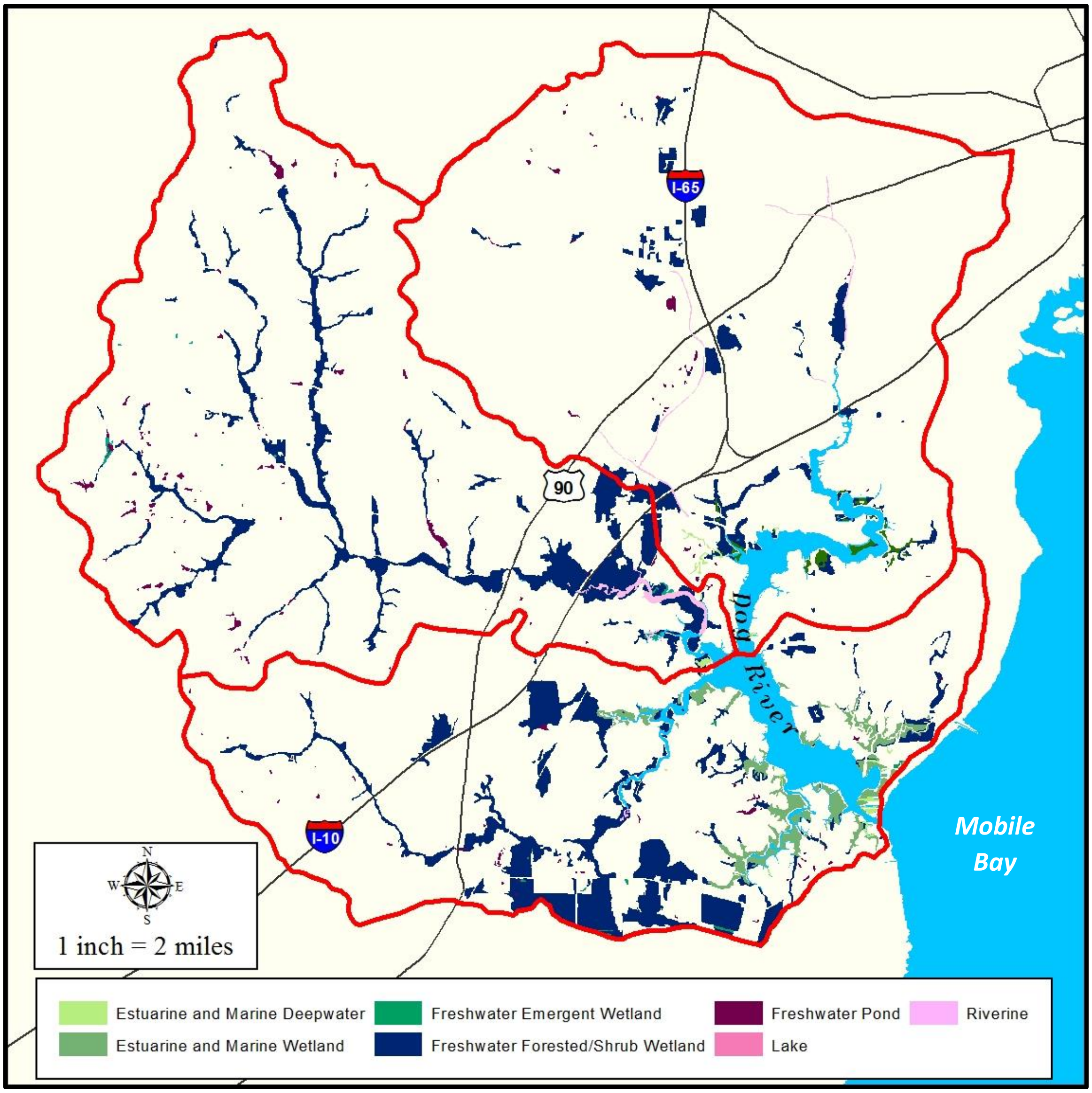

Figure 3.5.1: Wetlands in the greater Dog River Watershed (USFWS, 2010)

The overall health of the greater Dog River Watershed depends upon the existence of its wetlands, which contribute to the vitality of an ecosystem by storing, changing, and transmitting surface water and groundwater. Through these processes, pollution is removed, nutrients are recycled, groundwater is recharged, and biodiversity is enhanced. Wetland composition varies extensively, with five distinct categories for classification: Estuarine, Lacustrine, Marine, Palustrine, and Riverine systems (Cowardin, 1979). Wetlands within the greater Dog River Watershed include: Palustrine (Freshwater Emergent, Freshwater Forested/Shrub, Freshwater Pond, and Lake), Riverine, Estuarine and Marine (Deepwater and Wetland). Table 3.5.1 illustrates the acreage of each wetland type and the percentage of each type within the watersheds that comprise the greater Dog River Watershed.

Table 3.5.1: Wetlands types in the greater Dog River Watershed (USFWS, 2010)

	Wetland Type	Acreage	Percent of Watershed
Greater Dog River Watershed	Freshwater Emergent	42.56	0.07%
	Freshwater Forested/Shrub	4178.72	7.00%
	Freshwater Pond	210.86	0.35%
	Lake	2.61	0.00%
	Riverine	159.67	0.27%
	Estuarine and Marine Deepwater	47.7	0.08%
	Estuarine and Marine	581	0.97%
	Total	**5223.12**	**8.75%**
Halls Mill Creek Watershed	**Wetland Type**	**Acreage**	**Percent of Watershed**
	Freshwater Emergent	22.82	0.11%
	Freshwater Forested/Shrub	1678.16	8.04%
	Freshwater Pond	129.76	0.62%
	Lake	-	-
	Riverine	86.64	0.41%
	Estuarine and Marine Deepwater	-	-
	Estuarine and Marine	8.69	0.04%
	Total	**1926.07**	**9.22%**
Upper Dog River Watershed	**Wetland Type**	**Acreage**	**Percent of Watershed**
	Freshwater Emergent	0.97	0.00%
	Freshwater Forested/Shrub	641.11	2.94%
	Freshwater Pond	38.72	0.18%
	Lake	-	-
	Riverine	69.01	0.32%
	Estuarine and Marine Deepwater	20.48	0.09%
	Estuarine and Marine	76.17	0.35%
	Total	**846.46**	**3.88%**
Lower Dog River Watershed	**Wetland Type**	**Acreage**	**Percent of Watershed**
	Freshwater Emergent	18.77	0.11%
	Freshwater Forested/Shrub	1859.45	10.93%
	Freshwater Pond	42.38	0.25%
	Lake	2.61	0.02%
	Riverine	4.02	0.02%
	Estuarine and Marine Deepwater	27.22	0.16%
	Estuarine and Marine	496.14	2.92%
	Total	**2450.59**	**14.41%**

The Palustrine System

The Palustrine (freshwater) system, as shown in Figure 3.5.2, includes all non-tidal wetlands dominated by trees, shrubs, persistent emergent plants, emergent mosses or lichens, and all such wetlands that occur in areas where salinity due to ocean-derived salts is below 0.5%. The Palustrine system is bounded by upland.

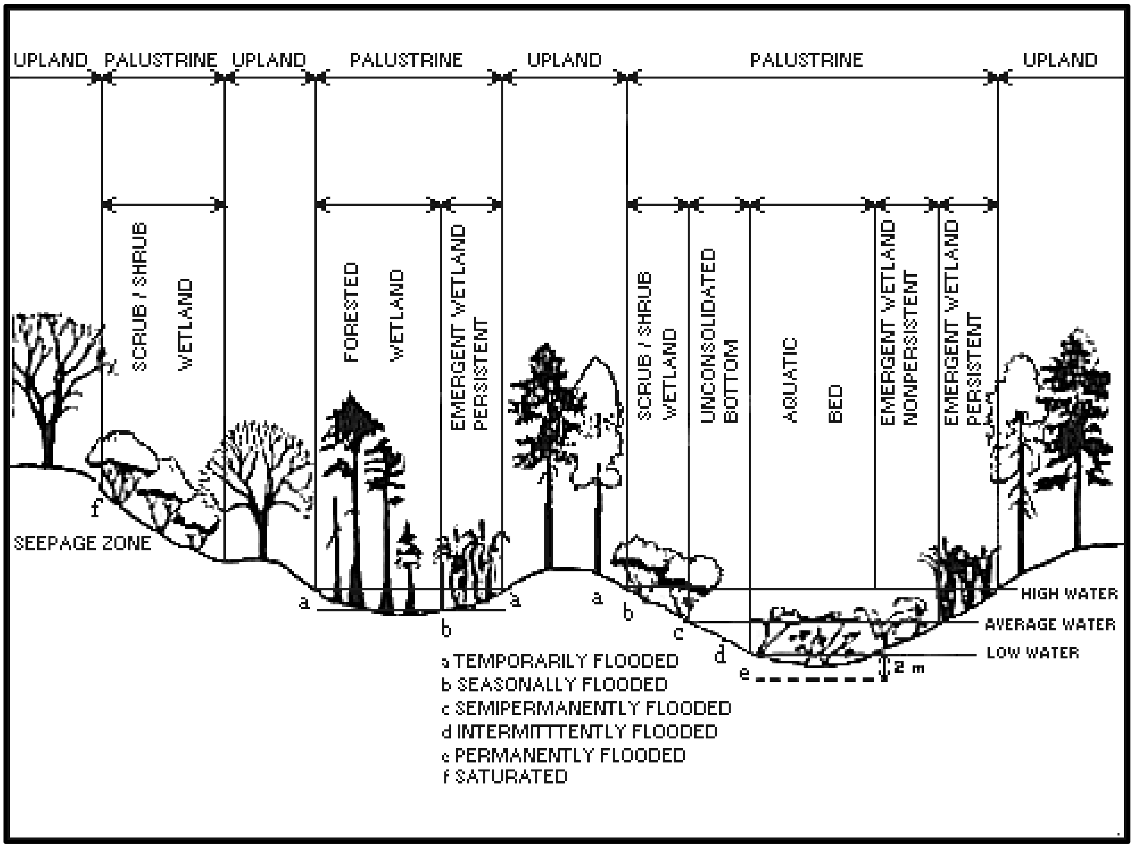

Figure 3.5.2: The Palustrine wetland system (from Cowardin, 1979)

The Estuarine System

The Estuarine system, shown in Figure 3.5.3, consists of deepwater tidal habitat and adjacent tidal wetlands that are usually semi-enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The Estuarine system extends (1) upstream and landward to where ocean-derived salts measure less than 0.5% during the period of average annual low flow; (2) to an imaginary line closing the mouth of a river, bay, or sound; and (3) to the seaward limit of emergent wetlands, shrubs, or trees where they are not included in (2). It also includes offshore areas of continuously diluted sea water. It contains two sub-systems: subtidal (where the substrate is continuously submerged) and intertidal (where the substrate is exposed and flooded by tides including the associated splash zone).

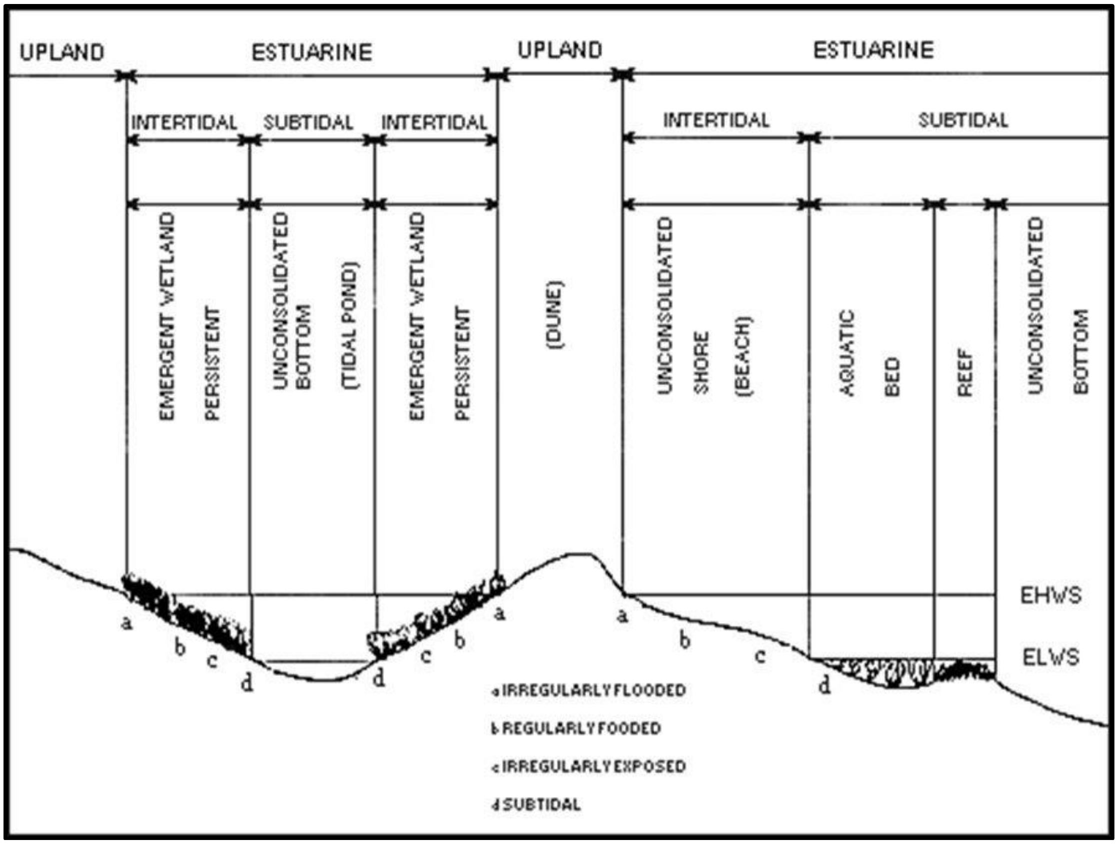

Figure 3.5.3: The Estuarine wetland system (from Cowardin, 1979)

The Riverine System

The Riverine system, shown in Figure 3.5.4, includes all wetlands and deepwater habitats contained within a channel with two exceptions: (1) wetlands dominated by trees, shrubs, emergent vegetation, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5%. The Riverine system is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetlands dominated by trees, shrubs, emergent vegetation, emergent mosses, or lichens. In braided streams, the system is bounded by the banks forming the outer limits of the depression within which the braiding occurs.

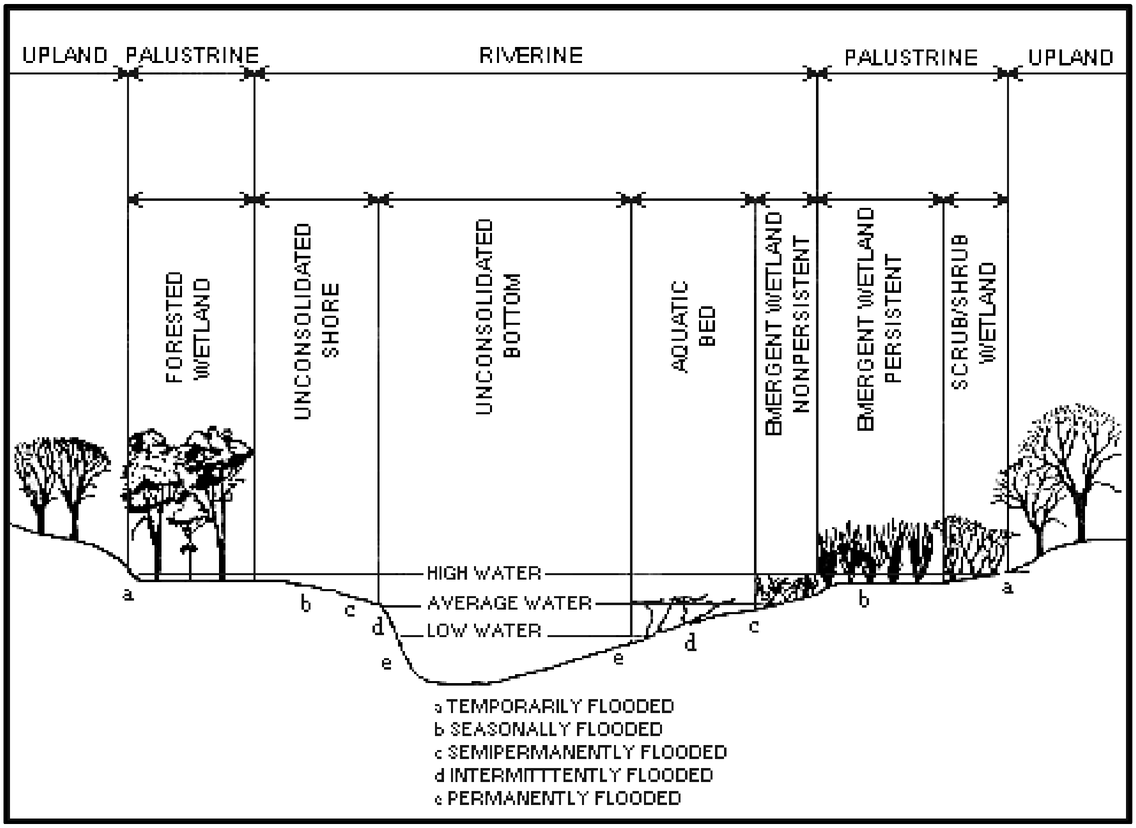

Figure 3.5.4: The Riverine wetland system (from Cowardin, 1979)

3.6 STREAMS

Table 3.6.1 and Figure 3.6.1 reveal that the greater Dog River Watershed contains approximately 174 miles (918,653.98 linear feet) of stream network systems (USGS, 2017). Approximately 65.17 miles (344,072.92 linear feet) of surface drainage systems occur in the Halls Mill Creek Watershed (USGS, 2017). The Halls Mill Creek Watershed includes the following named surface drainages: Campground Branch, Halls Mill Creek, Milkhouse Creek, Second Creek, and Spring Creek (USGS, 2017). Approximately 57.72 miles (304,761.79 linear feet) of surface drainage systems occur in the Upper Dog River Watershed and flow to Dog River (USGS, 2017). Named streams in this Watershed include Bolton Branch (East and West), Dog River, Eslava Creek (East and West), Montlimar Canal, Moore Creek, Robinson Bayou, and Spencer Branch. The Lower Dog River Watershed drains through 51.1 miles (269,819.27 linear feet) of stream network systems that include the following named streams: Alligator Bayou, Dog River, Perch Creek, Rabbit Creek, Rattlesnake Bayou, and Whiskey Branch (USGS, 2017).

Table 3.6.1: Named surface water drainages in the greater Dog River Watershed (USGS, 2017)

	Surface Water Drainages	Linear Feet (ft)	Miles (mi)
Halls Mill Creek Watershed	Campground Branch	10,731.20	2.03
	Halls Mill Creek	59,711.28	11.31
	Milkhouse Creek	38,179.88	7.23
	Second Creek	24,684.11	4.68
	Spring Creek	17,962.20	3.40
	Unnamed Drainages	192,804.25	36.52
	Total	**344,072.92**	**65.17**
Upper Dog River Watershed	East Bolton Branch	12,880.18	2.44
	West Bolton Branch	13,938.99	2.64
	Dog River	35,189.8	6.66
	East Eslava Creek	16,746.31	3.17
	West Eslava Creek	9,861.89	1.87
	Montlimar Canal	21,403.71	4.05
	Moore Creek	20,950.76	3.97
	Robinson Bayou	10,323.2	1.96
	Spencer Branch	14,109	2.67
	Unnamed Drainages	149,357.95	28.29
	Total	**304,761.79**	**57.72**
Lower Dog River Watershed	Alligator Bayou	23,585.1	4.47
	Dog River	16,172.6	3.06
	Perch Creek	19,244.9	3.64
	Rabbit Creek	55,472	10.51
	Rattlesnake Bayou	7,874	1.49
	Whiskey Branch	6,594.93	1.25
	Unnamed Drainages	140,875.74	26.68
	Total	**269,819.27**	**51.1**
Greater Dog River Watershed	**Total**	**918,653.98**	**173.99**

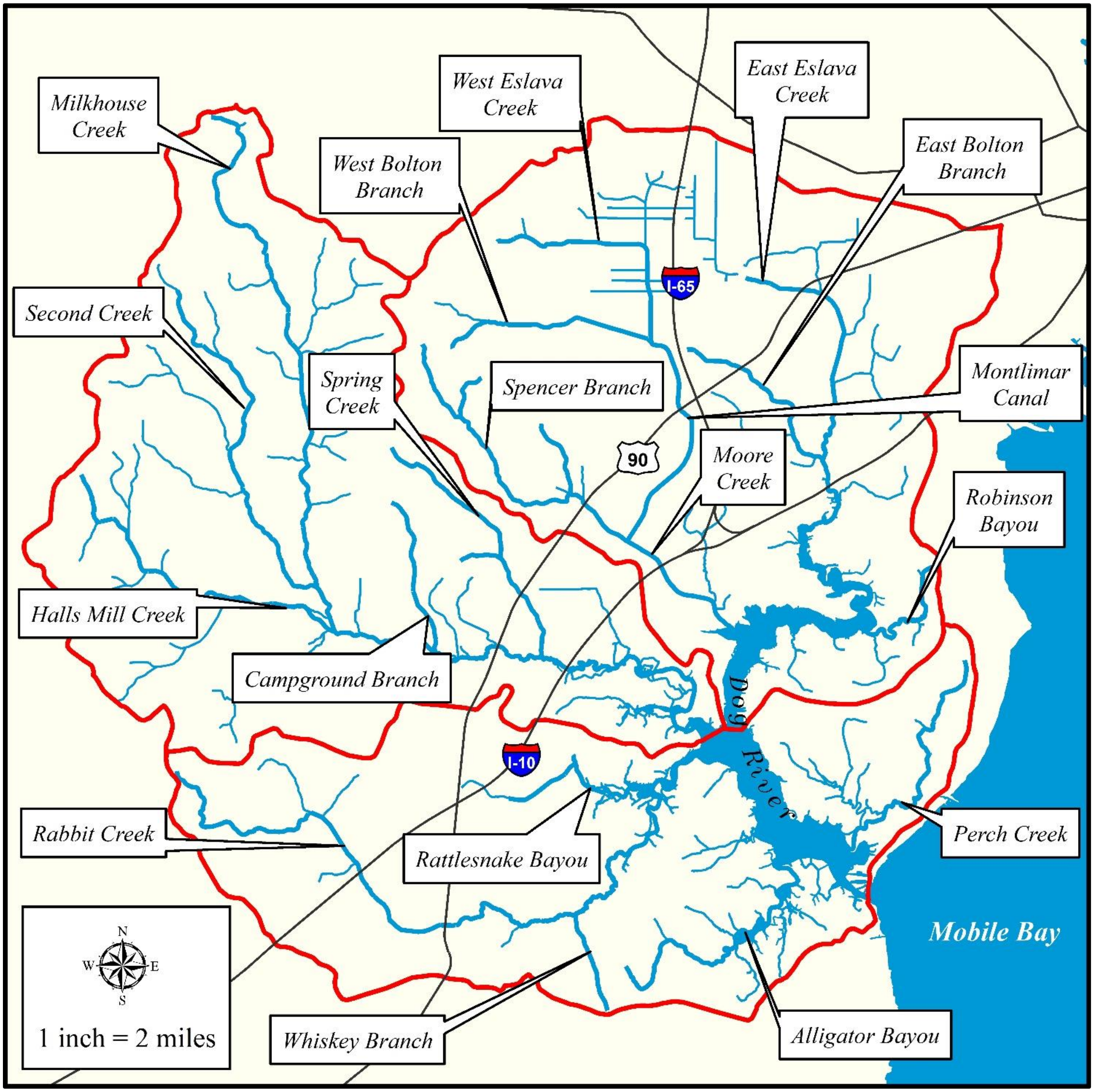

Figure 3.6.1: Major stream network systems in the greater Dog River Watershed (USGS, 2017)

3.7 BIOLOGICAL RESOURCES

There is great species diversity of both flora and fauna within the greater Dog River Watershed. The Dog River ecosystem is part of the Mobile Bay estuary, which provides habitat for more than 300 species of birds, 310 species of fish, 68 species of reptiles, 57 species of mammals, 40 species of amphibians, and 15 species of shrimp (Handley et al., 2013). Chapter 5 Section 2 of this WMP provides additional complimentary discussion for topics briefly discussed in the subsections of this section (Sections 3.7.1-3.7.3).

3.7.1 Flora

Mobile County's environmental inventory includes pine forest vegetation, freshwater, brackish water, and saltwater marsh vegetation; flora data specific to the greater Dog River Watershed is currently unavailable. Major tree species include longleaf pine and slash pine, as well as, bottomland and swamp forests comprising bald cypress (*Taxodium distichum*), water tupelo (*Nyssa aquatica*), swamp black gum (*Nyssa biflora*), overcup oak (*Quercus lyrata*), water oak (*Quercus nigra*), pumpkin ash (*Fraxinus profunda*), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), and river birch (*Betula nigra*). The understory primarily consists of chalky bluestem (*Andropogon sp.),* Indian grass (*Sorghastrum nutans*), and several species of panicum (*Panicum sp*.). Dominant woody shrubs include Palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), and waxmyrtle (*Myrica cerifera*). The freshwater and intermediate water vegetation includes, common reed (*Phragmites australis*), bulltongue (*Sagittaria lancifolia*), maidencane (*Panicum hemitomon*), cutgrass (*Leersia sp*.), and alligatorweed (*Alternanthera philoxeroides).* Saltwater vegetation includes saltgrass (*Distichlis spicata*), marshhay cordgrass (*Spartina patens*), smooth cordgrass (*Spartina alterniflora*), and black needlerush (*Juncus roemerianus*) (USDA, 2006; Schotz, 2009). Approximately 68 plant species in the area are considered rare, threatened, or endangered species (ALNHP, 2012).

Additional discussion on flora occurring in the greater Dog River Watershed can be found in Chapter 5 Section 2.1.1 of this report.

3.72 Fauna

Some of the major wildlife species in Mobile County include "white-tailed deer, feral hog, gray fox, red fox, bobcat, raccoon, skunk, opossum, otter, rabbit, squirrel, turkey, bobwhite quail, and mourning dove" (USDA, 2006). The species of fish in the greater Dog River Watershed include largemouth bass, channel catfish, bullhead catfish, bluegill, redear sunfish, spotted sunfish, warmouth, black crappie, chain pickerel, gar, bowfin, sucker, spotted trout, croaker, striped mullet, founder, and red drum (USDA, 2006).

In addition, Dave Armstrong, Fisheries Supervisor for the Alabama Division of Wildlife and Freshwater Fisheries, provided fish data for the greater Dog River Watershed. The data were collected in 2010 in response to potential fishery impacts caused by the Deepwater Horizon Oil Spill and included a group consisting of Auburn University, Alabama Department of Conservation and Natural Resources (ADCNR), and GSA. Species documented included bluegill sunfish (*Lepomis macrochirus*), pinfish (*Lagodon rhomboides*), sheephead (*Archosargus probatocephalus*), striped mullet (*Mugil cephalus*), menhaden (*Brevoortia tyrannus*), warmouth (*Lepomis gulosus*), largemouth bass (*Micropterus salmoides*), orange-spotted sunfish (*Lepomis humilis*), croaker (*Sciaenidae*), flounder (*Paralichthys*), atlantic needlefish (*Strongylura marina*), bay anchovy (*Anchoa mitchilli*), black crappie (*Pomoxis nigromaculatus*), bigmouth buffalo (*Ictiobus cyprinellus*), chain pickerel (*Esox niger*), golden shiner (*Notemigonus crysoleucas*), gizzard shad (*Dorosoma cepedianum*), redear sunfish (*Lepomis *microlophus*), spot (*Leiostomus xanthurus*), spotted seatrout (*Cynoscion nebulosus*), spotted gar (*Lepisosteus oculatus*), and white trout (*Cynoscion arenarius*) (ADCNR, 2010).

Additional discussion on fauna occurring in the greater Dog River Watershed can be found in Chapter 5 Section 2.1.1 of this report.

3.7.3 Protected Species

Mobile County provides habitat for approximately 200 rare, threatened, and endangered species (ALNHP, 2012). Of these species, the U.S. Fish and Wildlife Service (USFWS) listed 16 federally threatened or endangered species in 2017 that may occur in Mobile County. This includes 3 birds, 2 fish, 2 clams, 1 mammal, and 8 reptiles. Table 3.7.1 provides a list of these protected species.

Table 3.7.1: Federally threatened or endangered species that may occur in Mobile County (from USFWS, 2017)

Group	Common Name	Scientific Name	Status
Birds	Piping Plover	*Charadrius melodus*	Threatened
Birds	Red knot	*Calidris canutus rufa*	Threatened
Birds	Wood stork	*Mycteria americana*	Threatened
Fishes	Alabama sturgeon	*Scaphirhynchus suttkusi*	Endangered
Fishes	Atlantic Sturgeon (gulf Subspecies)	*Acipenser oxyrinchus (=oxyrhynchus) desotoi*	Threatened
Clams	Alabama (=inflated) heelsplitter	*Potamilus inflatus*	Threatened
Clams	Southern clubshell	*Pleurobema decisum*	Endangered
Mammals	West Indian Manatee	*Trichechus manatus*	Threatened
Reptiles	Alabama red-belly turtle	*Pseudemys alabamensis*	Endangered
Reptiles	Black pine snake	*Pituophis melanoleucus lodingi*	Threatened
Reptiles	Eastern indigo snake	*Drymarchon corais couperi*	Threatened
Reptiles	Gopher tortoise	*Gopherus polyphemus*	Threatened
Reptiles	Hawksbill sea turtle	*Eretmochelys imbricata*	Endangered
Reptiles	Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Reptiles	Leatherback sea turtle	*Pituophis melanoleucus lodingi*	Endangered
Reptiles	Loggerhead sea turtle	*Caretta caretta*	Threatened

In addition to the federally protected species, 32 birds, 3 fishes, 4 reptiles, and 5 amphibians are protected by the State of Alabama. According to the Alabama Natural Heritage Program (ALNHP), there are approximately 6 amphibians, 40 birds, 26 fishes, 4 mammals, and 15 reptile species that are considered rare, threatened, or endangered species (ALNHP, 2012).

Additional discussion on protected species occurring in the greater Dog River Watershed can be found in Chapter 5 Section 2.1.2 of this report.

3.7.4 Invasive Species

Invasive species are plants or animals that have been introduced to an area (terrestrial or aquatic) outside of their original range. Typically, these species spread incredibly fast due to their quick reproduction rates and ability to outcompete native species for resources. In many cases, the ecological integrity and biodiversity of an area is threatened when homogenous stands of invasive species are established. Managing invasive species can be a significant cost to forestry, fisheries, and agricultural industries. According to the University of Georgia Center for Invasive Species and Ecosystem Health (CISEH) (CISEH, 2016), with 360 species, Mobile County has reported the most invasive species of any county in Alabama. The top four (4) reported invasive species in Mobile County are Cogongrass (*Imperata cylindrical*), Chinese Privet (*Ligustrum sinense*), Japanese Climbing Fern (*Lygodium japonicum*), and Chinese Tallow tree (*Triadica sebifera*) (CISEH, 2016). Common invasive aquatic species include: Hydrilla (*Hydrilla verticillata*), Dotted Duckweed (*Landoltia punctata*), Alligatorweed (*Alternanthera philoxeroides*), and Common Reed (*Phragmites australis*).

Additional discussion on invasive species occurring in the greater Dog River Watershed can be found in Chapter 5 Section 2.1.3 of this report.

3.8 DEMOGRAPHIC AND SOCIOECONOMIC ENVIRONMENT

The U.S. Census captures data every ten years, and this information is available for a variety of geographic units including counties, cities, tracts, and census blocks. Five-year estimates are also calculated by the American Community Survey (ACS) for differing geographic units - many at the tract level. The population for the greater Dog River Watershed has been estimated using the tract level estimations from the 2014 ACS. The population of the tracts that were only partially contained in the greater Dog River Watershed boundary were determined by using the percentage of population for the part of the tract that fell within the Watershed and/ or by weighing the distribution and density of the population within those areas. According to this method, the 2014 population within the greater Dog River Watershed was estimated to be approximately 146,237.

The City of Mobile metropolitan area had a population growth rate of 3.3% between 2000 and 2010. This modest growth rate is similar to the growth rate experienced since 1980. Data given in Table 3.8.1 reveal that between 1980 and 1990, there was a population increase of 3.7%, and between 1990 and 2000, the population increased by 5.6%.

Table 3.8.1: Past, current, and projected population the City of Mobile metropolitan area (1980-2040)

Year	1980	1990	2000	2010	2020 Projected	2030 Projected	2040 Projected
Population	364,980	378,643	399,843	412,922	426,597	434,968	438,667
Percent Change	-	3.7%	5.6%	3.3%	3.3%	2.0%	0.9%

Note: Data from the Center for Business and Economic Research at the University of Alabama, 2014

Population projections by tract were acquired from the Center for Business and Economic Research at the University of Alabama. The tract projection data was used to determine a percent increase, or decrease, in population over the next twenty-six years (2014 to 2040). The percent change was then calculated from the tracts in which the area is contained to estimate the totals. The greater Dog River Watershed is projected to have a 2.8% population increase by the year 2020. Thereafter, the forecast is for smaller increases in population of 1.5% by 2030 and 0.4% by 2040 (Table 3.8.2). The results for estimated population expansion for the greater Dog River Watershed are presented in Table 3.8.2. Data presented in Table 3.8.2 projects a population of 150,320 in 2020 to 153,210 by 2040. The slowly increasing population will continue to place pressure on the natural ecosystem, and require continued and deliberate efforts to preserve and protect the natural resources of the greater Dog River Watershed.

Table 3.8.2: Current and projected population for the greater Dog River Watershed (2014 - 2040)

	Year	2014 Estimated	2020 projected	2030 projected	2040 projected
Greater Dog River Watershed	Population	146,237	150,320	152,627	153,210
	Percent Change	-	2.8%	1.5%	0.4%
Halls Mill Creek Watershed	Population	*48,728*	*48,994*	*50,399*	*51,271*
	Percent Change	-	*0.6%*	*2.9%*	*1.7%*
Upper Dog River Watershed	Population	*79,061*	*82,722*	*83,373*	*83,047*
	Percent Change	-	*4.6%*	*0.8%*	*-0.4%*
Lower Dog River Watershed	Population	*18,449*	*18,604*	*18,856*	*18,892*
	Percent Change	-	*0.8%*	*1.4%*	*0.2%*

Note: Data from the Center for Business and Economic Research at the University of Alabama, 2014

Socioeconomic statistics were also acquired from the 2014 ACS at the tract level geographic unit. Distributions are provided as percentages for the following socioeconomic designations: income below poverty level (Figure 3.8.1); median household income (Figure 3.8.2); owner occupied housing units (Figure 3.8.3); renter occupied housing units (Figure 3.8.4); high school educational attainment (Figure 3.8.5); bachelor's degree educational attainment (Figure 3.8.6); graduate or professional degree educational attainment (Figure 3.8.7); median age (Figure 3.8.8); and race and ethnicity distribution (White or Caucasian, Black or African American, Hispanic or Latino, Asian, American Indian or Alaskan Native, Native

Hawaiian or Pacific Islander) (Figures 3.8.9 - 3.8.14, respectively).

Figures 3.8.1-3.8.14 were developed for individual assessment of data distribution and trends and are not intended for comparative analysis.

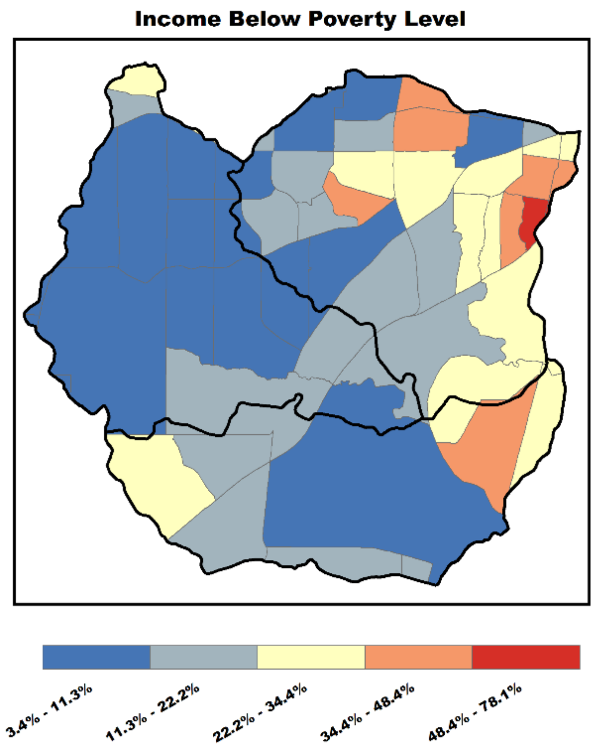

Figure 3.8.1: Income below poverty level (ACS, 2014)

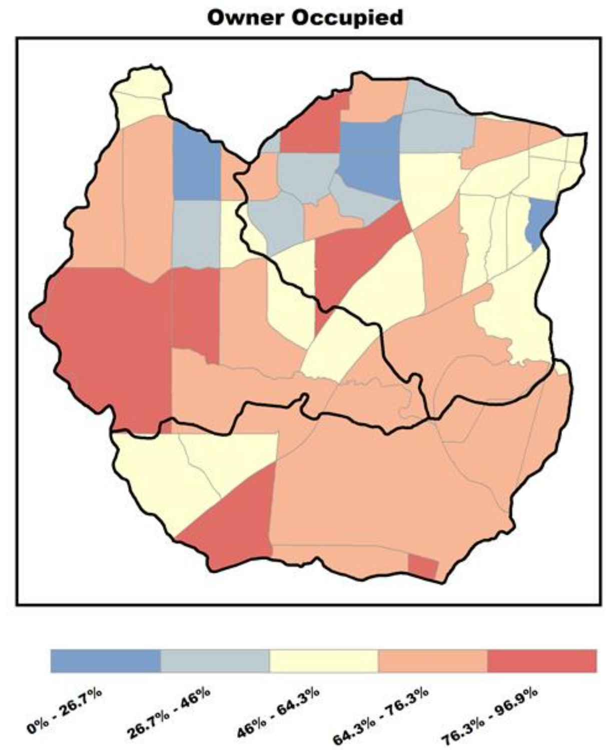

Figure 3.8.3: Owner occupied housing units (ACS, 2014)

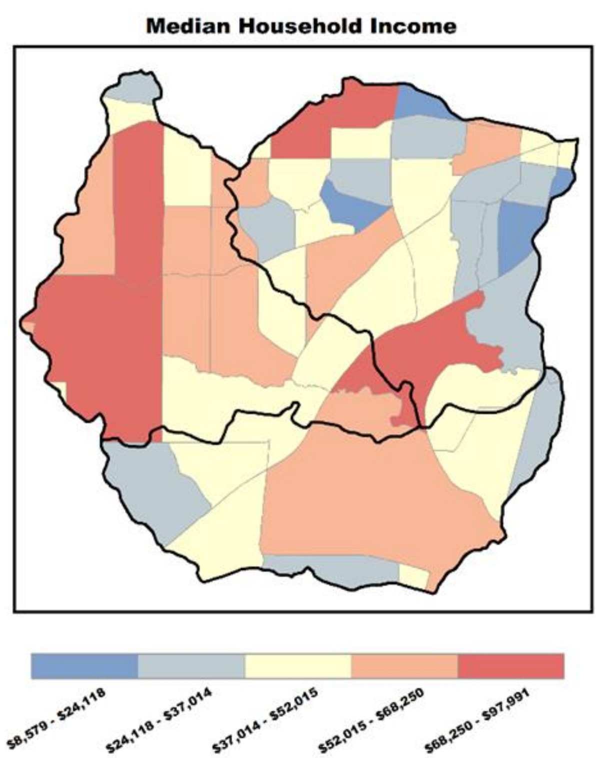

Figure 3.8.2: Median household income (ACS, 2014)

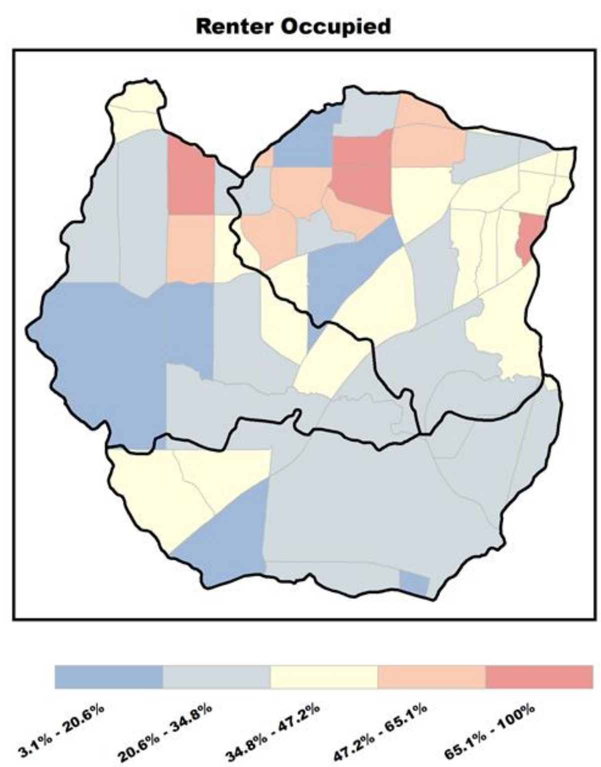

Figure 3.8.4: Renter occupied housing units (ACS, 2014)

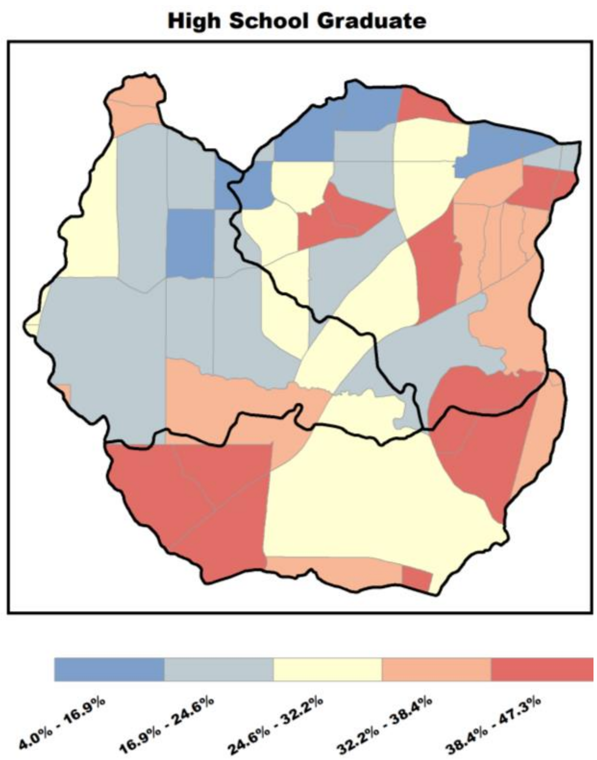

Figure 3.8.5: High school educational attainment (ACS, 2014)

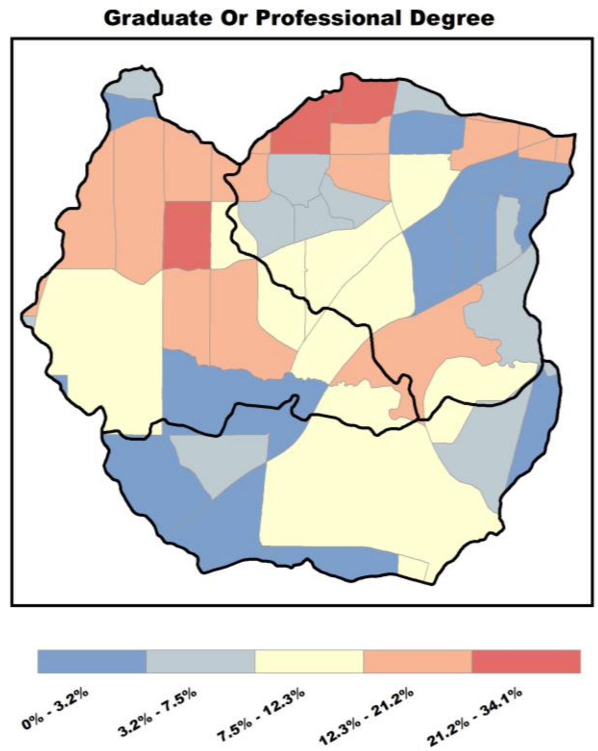

Figure 3.8.7: Graduate or professional degree educational attainment (ACS, 2014)

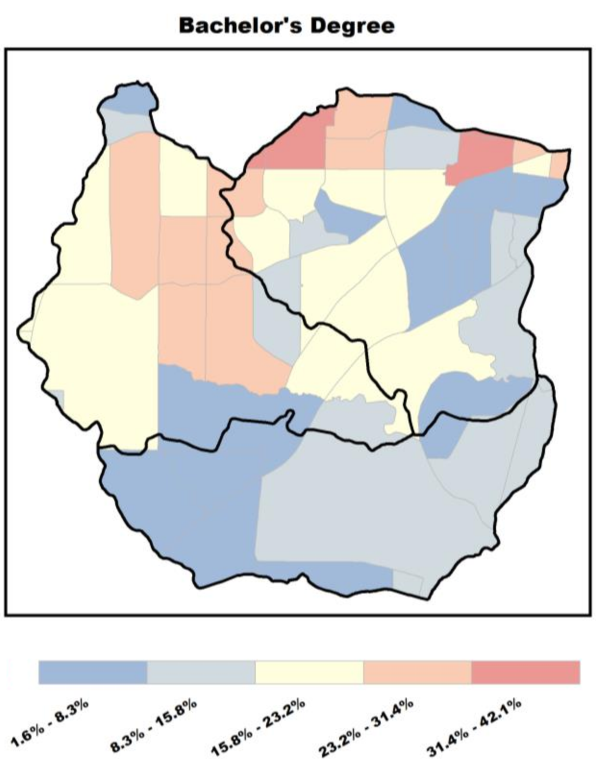

Figure 3.8.6: Bachelor's degree educational attainment (ACS, 2014)

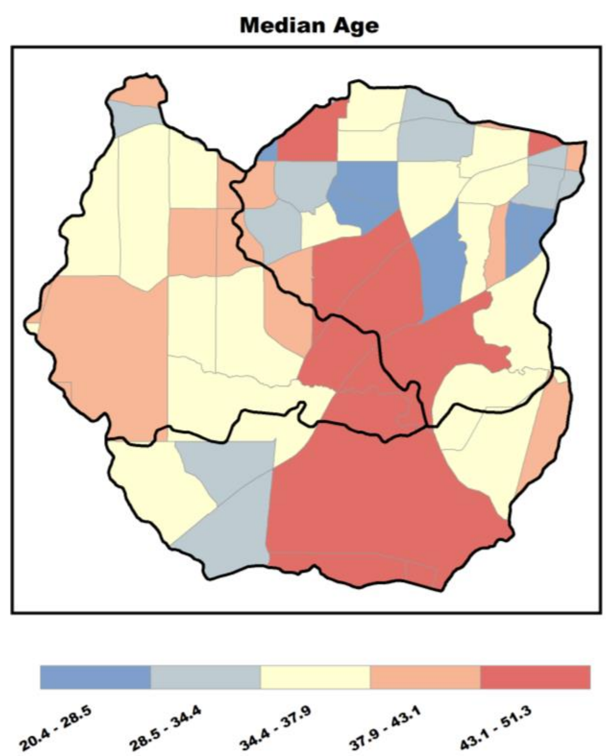

Figure 3.8.8: Median age (ACS, 2014)

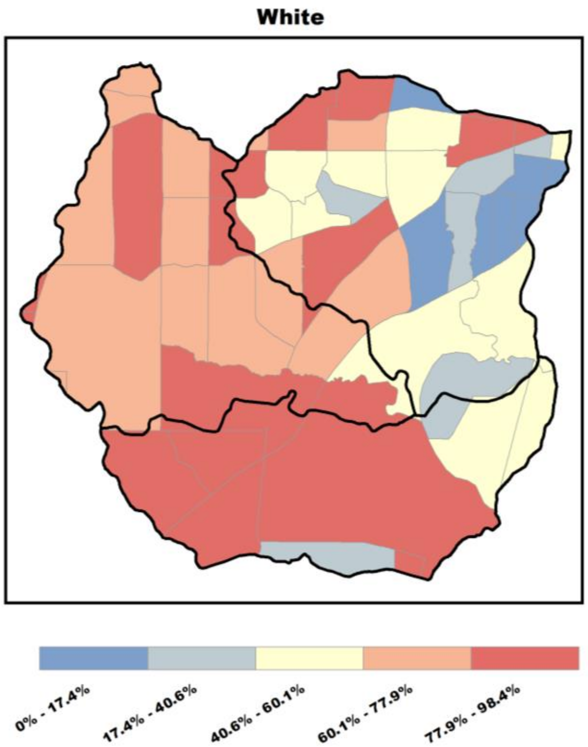

Figure 3.8.9: White or Caucasian race and ethnicity distributions (ACS, 2014)

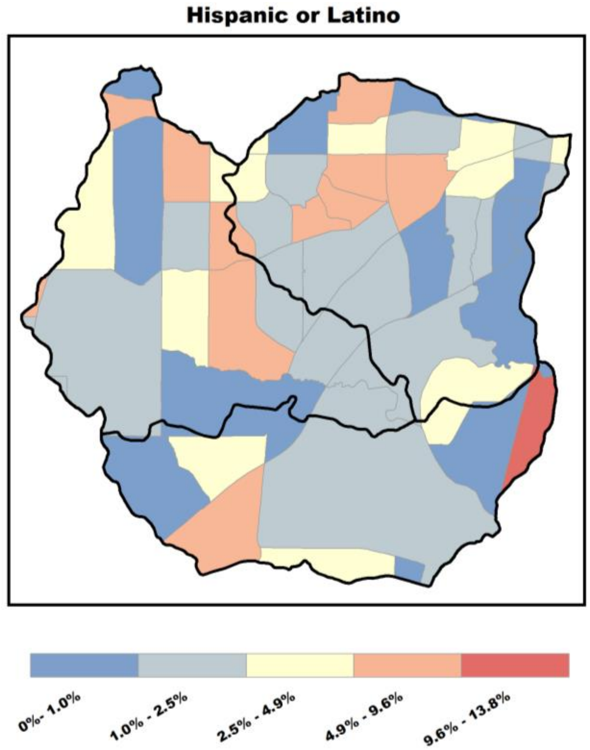

Figure 3.8.11: Hispanic or Latino race and ethnicity distributions (ACS, 2014)

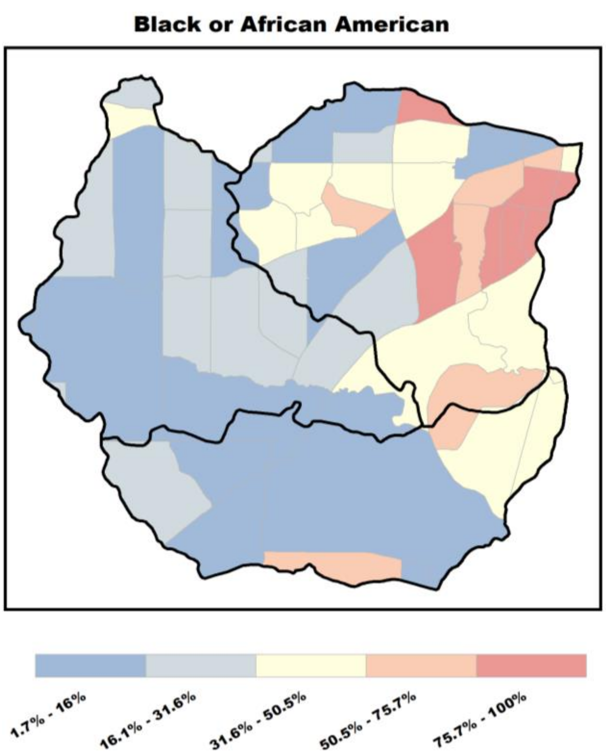

Figure 3.8.10: Black or African American race and ethnicity distributions (ACS, 2014)

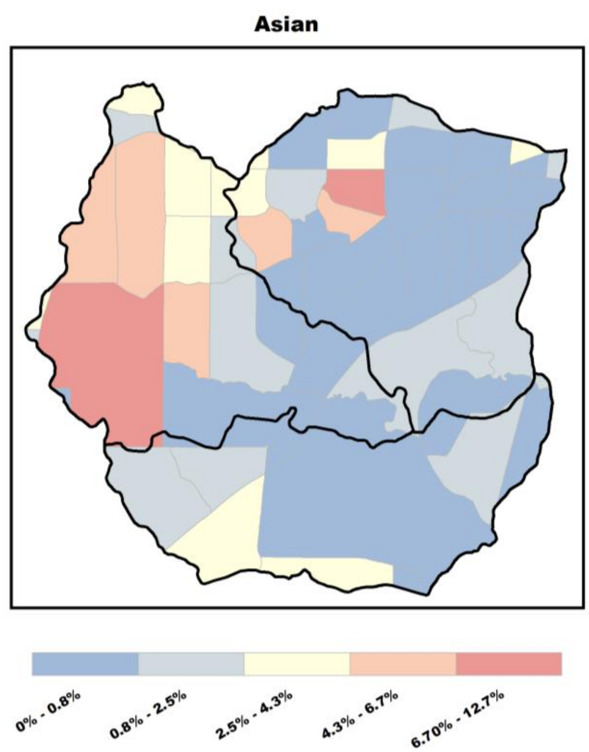

Figure 3.8.12: Asian race and ethnicity distributions (ACS, 2014)

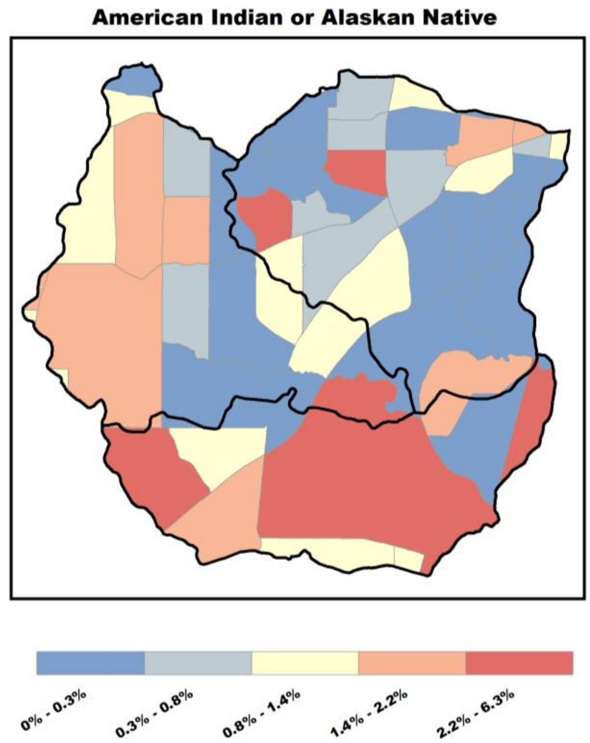

Figure 3.8.13: American Indian or Alaskan Native race and ethnicity distributions (ACS, 2014)

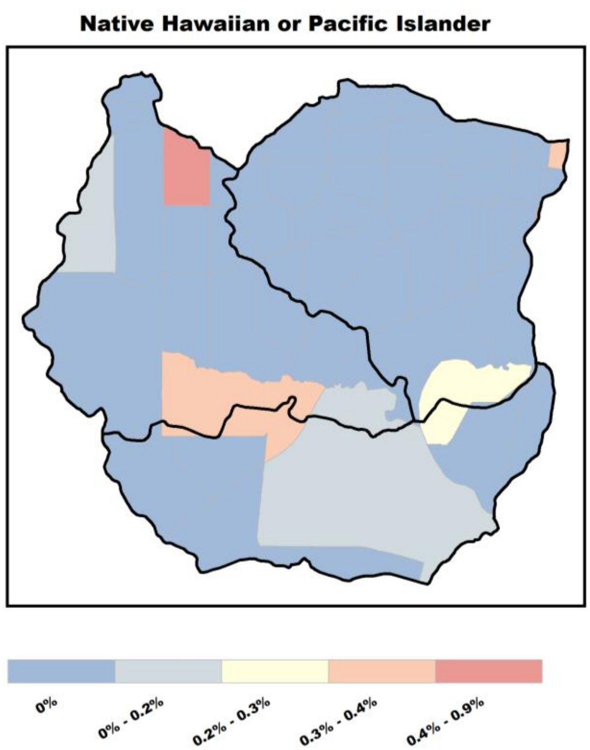

Figure 3.8.14: Native Hawaiian or Pacific Islander race and ethnicity distributions (ACS, 2014)

3.9 CULTURE AND HERITAGE

From pre-Columbian times to the modern era, Mobile is acclaimed as one of the most historically significant cities in the United States. With over three centuries of recorded history, Mobile reflects its early influences including French, English, and Spanish. Immigrants who settled in Mobile brought diversity and have contributed to the multi-culturalism that makes Mobile unique today.

Since its early history as a port, Mobile has been a key asset to the development of the economy of the entire Gulf Coast region. The city continues to serve a crucial economic role as a major port facility, industrial production center for shipbuilding, and aircraft assembly. Mobile emphasizes the importance of education, and is the home of the University of South Alabama, the University of Mobile, and Springhill College. As the regional headquarters for various state and federal agencies, Mobile also serves as a transportation hub for air, rail, and maritime shipping.

3.9.1 History of Mobile

Prehistoric Mobile was originally inhabited by Native Americans as indicated by artifacts attributed to three major cultural periods: Gulf Formational, Woodland, and Mississippian (Alchin, 2017). The most recent, the Mississippian Culture, is well documented, but evidence for the preceding cultural periods is not as abundant. Within documented historical times, Mobile was inhabited by members of the Muscogee Creek Confederacy.

Legend has it that Prince Madoc, or Madog ab Owain Gwynedd, a Welsh prince fleeing power struggles in his native land (Fritze, 2011), was the first European to visit Mobile when he landed at present day Fort Morgan in 1170.

General consensus among scholars and professional archaeologists, however, rejects this and other versions of the Madoc story as implausible, if not impossible. The Spanish were the first documented European explorers of the Alabama Gulf Coast. They began sailing into the area of Mobile Bay in the early 1500's (Kirkland, 2008). The bay is marked on early Spanish maps as the Bahía del Espíritu Santo (Bay of the Holy Spirit). The area was explored in more detail by Diego de Miruelo in 1516 and by Alonso Álvarez de Pineda in 1519. Pánfilo de Narváez traveled through what was likely the Mobile Bay area in 1528. It is reported that resident Native Americans burned their homes and fled their towns at the approach of the de Narváez expedition.

Hernando de Soto explored the area of Mobile Bay and beyond in 1540, and found the area inhabited by a Muscogee Native American people. De Soto's men were often at war with the Native Americans and destroyed the fortified town of Mauvila or Maubila from which the name Mobile was later derived (Weddle, 2007). It is reported that they fought with Chief Tuscaloosa and his warriors somewhere north of the current site of Mobile. The next large expedition was led by Tristán de Luna y Arellano in an unsuccessful attempt to establish a permanent colony for Spain during 1559-1561 (Weddle, 2007). Tristán de Luna established a short-lived settlement near Mobile. A hurricane devastated the expedition, and the Spanish government abandoned its search for gold in the area. A European country would not explore the Alabama Gulf Coast for another century.

French naval hero Pierre Le Moyne d'Iberville and his younger brother, Jean-Baptiste Le Moyne de Bienville, founded the fortified village of Mobile in 1702 near Mt. Vernon (Kirkland, 2008).

That officially makes Mobile Alabama's oldest city, although that settlement was located on the Mobile River near Twenty-Seven Mile Bluff - not at present day Mobile. Life at the original settlement was difficult. The colonists endured frequent floods, epidemics, and raids from Alabama Indians. These raiders attacked both the colonists and the local Mauvila Indians who lived near their fort. After an attack damaged the fort at Old Mobile beyond repair, the colonists moved the city closer to the mouth of Mobile Bay. Many of the Mauvila Indians relocated with the colonists in a move that highlights the economic partnership between the two peoples.

Mobile was occupied by the French from 1702-1763, by the British from 1763-1780, and by the Spanish from 1780-1813 (Kirkland, 2008). Mobile served as the capital of French Louisiana until 1720 and, for a short time in the 1760s, served as the temporary capitol of British West Florida. Because of this diverse history, the population of Mobile was multicultural, a trait that has distinguished it among other Alabama cities throughout its history. Mobile became a United States territory in 1813 by proclamation of Governor Holmes of the Mississippi Territory.

Colonial Mobile was a city of limited size and potential because of the stagnant economic prospects of early settlements in the New World (Kirkland, 2008). Mobile was, however, strategically located along the Gulf of Mexico near deep waters coveted by the European powers. This strategic location has always made Mobile a focal point in American history, either as a battleground or as an area of economic opportunity and innovation.

Mobile was a key battleground during the American Revolution and the War of 1812. Fort Charlotte, originally built as Fort Conde by the French in 1711, was attacked by an allied army commanded by Spanish General Bernardo de Galvez (Kane, 2016). The British surrendered, and Mobile once again became a Spanish territory. During the War of 1812, American troops under the command of General James Winchester occupied Mobile, and repelled a British attack (McRae, 2014) at Fort Bowyer (now Fort Morgan). Andrew Jackson headquartered at Mobile prior to marching to the American victory at New Orleans in 1814.

After Mobile became a United States territory in 1813, Americans invested much needed capital to make improvements and strengthened the area's economic standing (Kirkland, 2008). Wealthy businessmen financed new building projects that enhanced the potential of the city's port. By the 1820s, Mobile became a major exporting center for Alabama and the South to markets in the northeast and Europe. Cotton proved to be the most profitable export of antebellum Mobile, and the city's economic fortunes prospered. The Civil War ended Mobile's prosperity when the U.S. Naval blockade stifled foreign trade. In August 1864, a fleet of Union ships broke through Confederate defenses, entered Mobile Bay, and invaded the City. The city was spared the devastation of some other southern ports, but in late May 1865, a waterfront armory with 200 tons of ordnance exploded. Approximately 300 workers were killed, and waterfront facilities were devastated. The necessary reconstruction of a large portion of the port slowed postwar recovery (Kirkland, 2008).

The early years after the war were a disaster for the port city. The population fell as the cotton-dependent economy failed (Kirkland, 2008). In 1879, the city was on the verge of complete economic collapse and bankruptcy. The Alabama legislature repealed the City's charter. This action effectively put the city under the control of a state-appointed committee. This arrangement lasted until 1886, by which time timber had replaced cotton as the chief export, and bananas became a major import from South America.

By 1911, the City economy was again healthy; streetcar and telephone service were expanded. The City adopted the commission form of government in 1911 (Kirkland, 2008). War again slowed progress for the City of Mobile. Countries recalled trade vessels for military service at the start of World War I, and the port grew stagnant. People were forced to leave Mobile in search of work because of the decline in port activity. As a result, when the United States entered the war, the City was confronted with a job deficit of 10,000 skilled port workers. Mobile's shipyards were able to produce only one ship before the end of the war.

Following World War I, a consortium of Mobile's wealthy businessmen invested heavily in port improvements. Leading the effort were John B. Waterman, C. W.

Hempstead, and Walter D. Bellingrath (Kirkland, 2008). These men founded the Waterman Steamship Corporation in 1919; the corporation became one of the largest shipping companies in the region. In 1922, the Waterman Steamship Corporation and other entrepreneurs lobbied successfully for the creation of the Alabama State Docks. In 1927, the Cochran Bridge was constructed. This 10-mile structure spans the five rivers that flow into Mobile Bay. The bridge allowed easier access and quicker travel time between Mobile and the western shore of Baldwin County. This brought added economic and civic benefits.

The Great Depression did not affect Mobile as badly as most other Alabama cities because the Port City's two largest exports—cotton and timber—were less vulnerable to the fluctuations of the stock market than other products (Kirkland, 2008). There were still economic hardships, and President Franklin D. Roosevelt's works program brought much-needed jobs to the area in 1938 when the Works Progress Administration began building the Bankhead Tunnel. It was completed in 1941 on the eve of World War II, and Mobile's economic future looked promising.

Wartime mobilization and the military and maritime need for ships during World War II transformed Mobile into a major shipbuilding city. Between 1940 and 1943, 89,000 war workers moved to the city. The population of Mobile County increased by more than 60 percent by the end of World War II. Mobile shipyards completed hundreds of ships. Brookley Field, which was established in 1941 as an air supply depot, and expanded after the U.S. entered the war, became the city's largest postwar employer. The economic boom, created by World War II and the presence of Brookley Field, became a new bust when the base closed in the 1960s. Too great of an economic dependency on Brookley Field, and failure to recruit additional industry, contributed to Mobile's stagnating economy for more than a decade (Kirkland, 2008).

The violent protests that characterized some southern cities during the civil rights movement were not experienced in Mobile (Kirkland, 2008). The political movements by two local grassroots organizations: the Non-Partisan Voters' League and later the Neighborhood Organized Workers, used legal and political means to create change. The League pursued important legal suits, including the desegregation suit for Mobile's public schools and the case Bolden v. Mobile, which held that the at-large election of representatives was inherently discriminatory to minorities. The Bolden v. Mobile suit resulted in the first female and African American commissioners in the city's long history. In 2005, the city elected Samuel Jones as its first African American mayor.

3.9.2 Culturally Significant Resources

Mobile's more than 300-years of history have created a great wealth of culturally significant resources. Many of these originate from the wars fought over the strategic location of Mobile, and from the rich cultural diversity of the inhabitants of the area. A detailed discussion of every landmark, building, or person is beyond the scope of this study. A brief summary of cultural and historical resources is presented instead (see Table 3.9.1), and the reader is referred to the Explore Southern

History website (http://www.explore southernhistory.com/Alabama1.html), the Alabama Department of Archives and History (http://www.archives. alabama.gov /), the Historic Mobile Preservation Society (http://www.historicmobile.org), the Mobile Public Library (http://www.mpl online.org/local-history-and-genealogy. html), and the Alabama Historical Association (http://www. alabamahistory. net/home.html).

Table 3.9.1: Culturally significant dates, events, and resources in the Mobile area

Date of Origin	Resource	Description	Location
1702	Fort Louis	Original French Fort, damaged by flood	27-mile Bluff
1703	Mardi Gras	Started by Nicholas Langlois	Mobile
1711	Fort Louis	Temporary wooden Stockade	Mobile
1723 - 1813	Fort Conde'	Original French Fort	Mobile
1763	Fort Charlotte	Fort Conde' renamed by British in 1763	Mobile
1780	Fort Carlota	Forte Charlotte renamed by Spanish in 1780	Mobile
1813	Fort Charlotte	Fort Carlota renamed by Americans in 1813	Mobile
1725-1850	Dog River Plantation	French plantation discovered at the mouth of Dog River	Dog River
1821	Fort Gaines	Historic Fort built to guard passage into Mobile Bay	Dauphin Island
1829	Government Street Presbyterian Church	Example of Greek Revival Architecture, National Historic Landmark	Mobile
1830's	Searcy Hospital	Served as mental hospital for care of Black citizens. Treatment for all citizens began 1969. Nine of structures dating from 1830's are still in use. Enclosing wall dates from 1830's.	Mt. Vernon
1833	Oakleigh House	Antebellum mansion. Historic American Building Survey and the National Register of Historic Places.	Mobile
1836	Magnolia Cemetery	Final resting place for more than 100,000, including 1,100 Confederate Soldiers	Mobile
1850	Cathedral of Immaculate Conception	In 1962, Pope John XXIII elevated the cathedral to a minor basilica, a title bestowed, only by the pope, on churches of historical and spiritual importance.	Mobile
1855	Bragg-Mitchell Mansion	A 13,000 square foot Greek Revival structure. Placed on the National Register of Historic Places in 1972	Mobile
1855 - 1857	Old City Hall	Historic Complex that served as City Hall and marketplace, National Historic Landmark	Mobile
1860	Richards-DAR House	One of Mobile's finest examples of the Italianate style. National Historic Landmark	Mobile

3

Date of Origin	Resource	Description	Location
1864	Battle of Mobile Bay	Pivotal battle in the Civil War	Mobile Bay
1865	Mobile National Cemetery	Final resting place for thousands of American soldiers and sailors from the War of 1812 to the modern era. Contains the grave of Chappo, son of the famous Apache Chief Geronimo.	Mobile
1876	Grave of General Braxton Bragg	Magnolia Cemetery	Mobile
1965	Battleship Memorial Park	USS Alabama, USS Drum, military aircraft, vehicles, and equipment on display	Mobile Causeway

4.0 LAND USE AND LAND COVER

Land use describes how people use the landscape (farming, forestry, residential development, commercial development, etc.), while land cover describes the landscape or surface of the land (water, wetlands, forest, impervious surfaces, etc.). Examining land use and land cover (LULC) is useful in assessing change over time. By comparing present LULC maps with those generated in the past, officials and resource managers can evaluate previous decisions and gain insight into possible effects of proposed decisions before they are implemented. LULC maps can be used to measure urban and industrial growth, determine population changes, visualize impacts from floods and storm surges, track wetland losses, and predict potential impacts of climate change. Understanding LULC changes for landscapes at the watershed level are important because differing LULC can significantly impact local water resources including sediment and pollutant loads of streams as well as stormwater runoff velocities, volumes, and timing within watersheds.

Four (4) LULC datasets were used to evaluate LULC changes within the greater Dog River Watershed and include: 1) National Aeronautics and Space Administration (NASA) Stennis Space Center (SSC) Landsat-based datasets for the years 1974, 1979, 1984, 1988, 1991, 1996, 2001, 2005, and 2008 (Spruce et al., 2009); 2) Universities Space Research Association at NASA Marshall Space Flight Center (MSFC) datasets for the years 1948, 1992, 2001, and 2030 (projected) (Estes et al., 2014); 3) Multi- Resolution Land Characteristics Consortium (MRLC) 2011 National Land Cover Database (NLCD) (Homer et al., 2015); and 4) MRLC 2011 Percent Developed Imperviousness dataset (Xian et al., 2011).

These original LULC datasets of interest for this Watershed Management Plan (WMP) were clipped to the watershed boundary as defined in Chapter 3 Section 1. This data editing process facilitated the uniform assessment of the spatial data. However, all datasets were not developed to a uniform spatial reference system, limiting the comparison of the various sources and years of data. Relatedly, despite all efforts to assess and interpret spatial data through a uniform process, discrepancies among the various LULC datasets still exist. For example, quantitative information presented in the following sections regarding total land area (acres) from different sources over the years do not match each other or the total acreage for the watershed as defined in Chapter 3 Section 1. This discrepancy is suggested to be the result of the various mapping and remote sensing technologies used over the years by various sources.

In order to straightforwardly compare older years of LULC data with newer datasets, LULC classes were collapsed to seven simplified classes. Table 4.1.1 provides the "simplified classification" scheme used to evaluate LULC data presented throughout this Chapter. Reclassification of LULC datasets are based on the methods and groupings used by the NASA MSFC study (Estes et al., 2014). This simplification allowed for the uniform assessment of the NASA MSFC LULC datasets (Estes et al., 2014), the NASA SSC datasets (Spruce et al., 2009), and the 2011 NLCD dataset (Homer et al., 2015).

Table 4.1.1: Remapping LULC classes to a simplified classification (Estes et al., 2014)

1992 Land Use Classification	2001 Land Use Classification	Simplified Classification
Water	Water	Water
Low-Intensity Residential, Urban Recreational Grasses	Developed Open Space, Developed Low Intensity	Urban
High-Intensity Residential	High-Density Residential	
Commercial/Industrial/ Transportation	Developed High Intensity	
Bare Rock/Sand/Clay Quarries/Strip Mines/Gravel Pits Transitional	Barren Land	Barren
Deciduous Forest	Deciduous Forest	Upland Forest
Evergreen Forest	Evergreen Forest	
Mixed Forest, Shrubland	Mixed Forest, Shrubs/Scrub	
Grassland/Herbaceous, Fallow, Orchards, Pasture/Hay, Row Crops	Grassland, Pasture Hay, Cultivated Crops	Upland Herbaceous
Woody Wetlands	Woody Wetlands	Woody Wetland
Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands	Non-Woody Wetland

4.1 HISTORIC LAND USE AND LAND COVER

Landsat-Based Assessment of Mobile Bay LULC

In 2008, NASA SSC led a pilot project to measure LULC changes from 1974 to 2008 in the Mobile Bay region (Spruce et al., 2009). The project involved analyzing nine Landsat satellite mapping efforts undertaken over a 34-year period. A simplified classification system was developed to categorize types of land cover as: upland herbaceous, upland forest, barren, woody wetland, non-woody wetland, open water, and urban. The overall accuracy of the LULC data provided by Spruce et al. (2009) ranges between 83% and 89%, depending on the year. Analysis of the Mobile Bay Watershed, which includes most of Baldwin and Mobile counties, indicates an urban increase of 1.63% per year from 96,688 to 150,227 acres, or a 55.37% increase over the project duration (Spruce et al., 2009).

Urban development in the greater Dog River Watershed, shown in Figures 4.1.1 through 4.1.4 reveal that urbanization has increased 65.7% from 1974 to 2008 (Spruce et al., 2009). This is an average increase of 1.93% per year over a 34-year period. The data from the NASA SSC study reveal an increase in urbanization over the 34-year period, except with a small decline between 1984 and 1988. Following 1988, urbanization continued to increase from 43.2% to 53.1% by 2008.

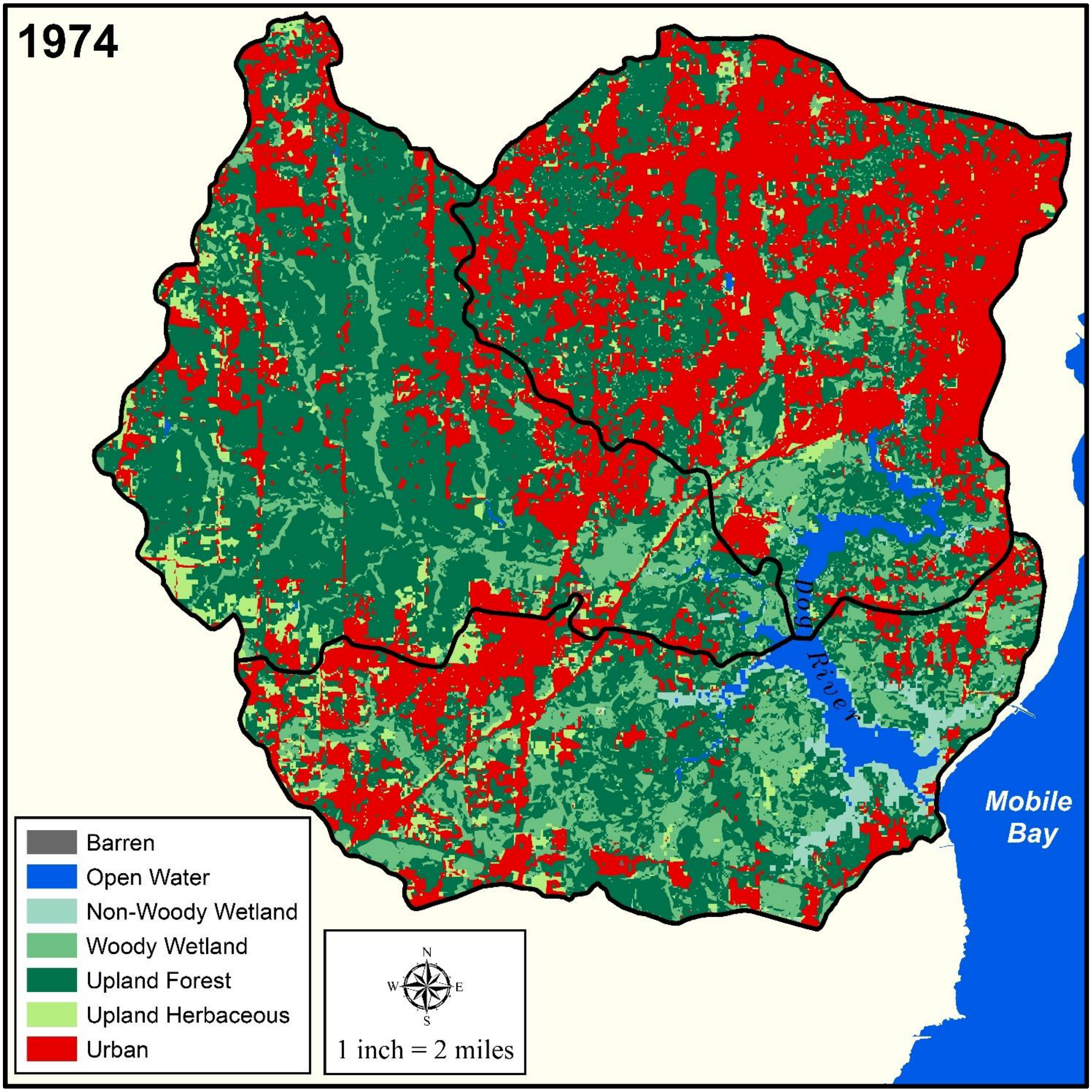

Figure 4.1.1: LULC for the greater Dog River Watershed - 1974 (Spruce et al., 2009)

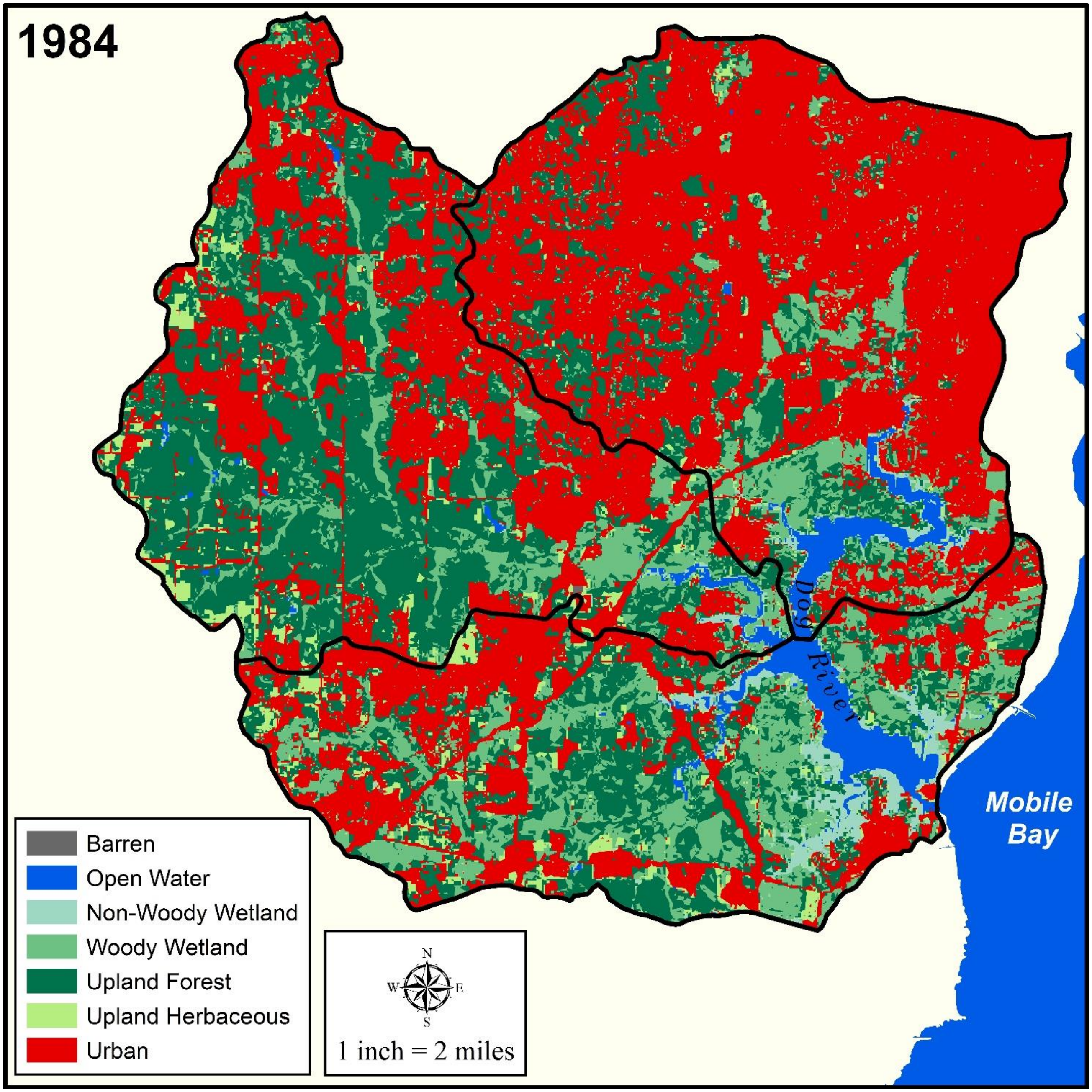

Figure 4.1.2: LULC for the greater Dog River Watershed - 1984 (Spruce et al., 2009)

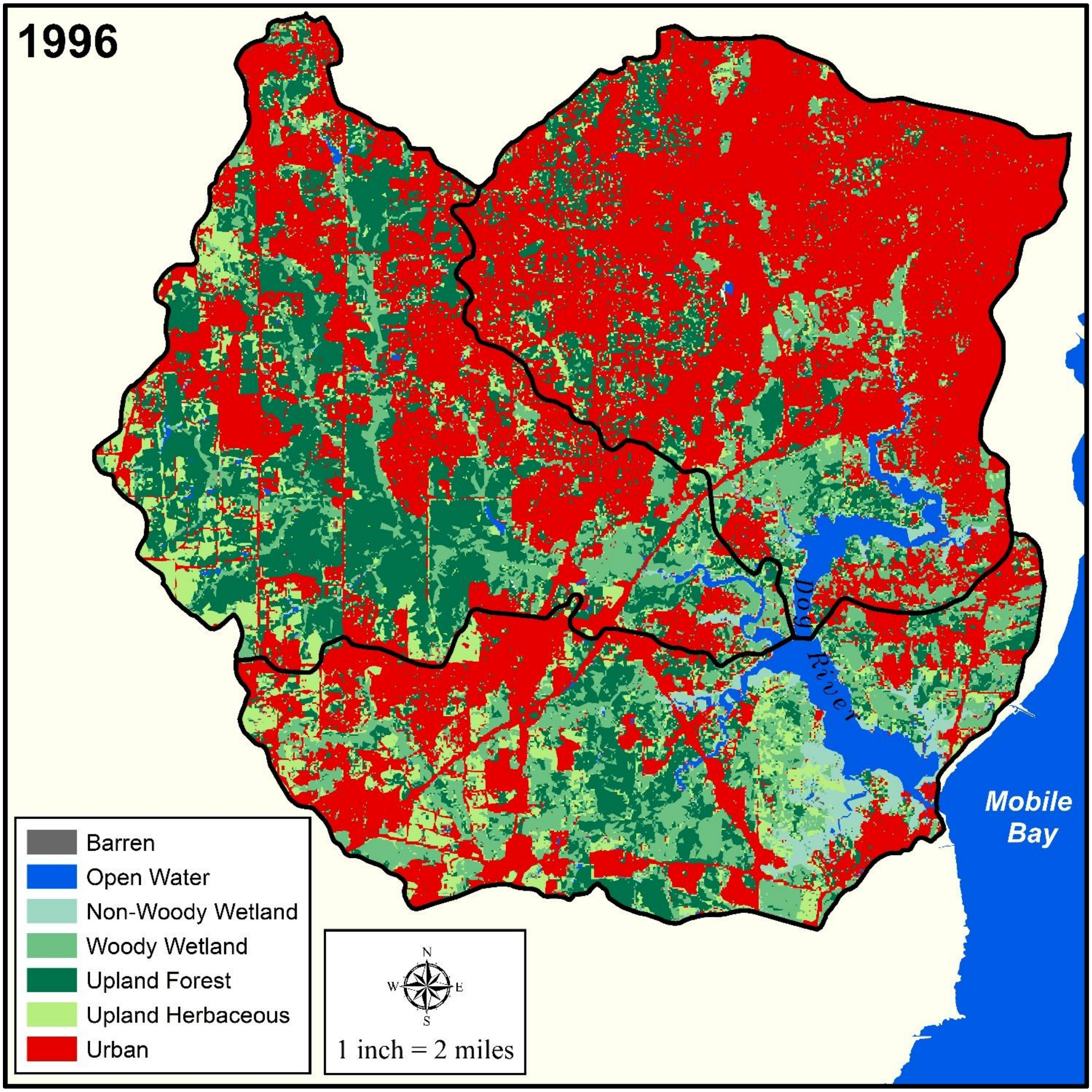

Figure 4.1.3: LULC for the greater Dog River Watershed - 1996 (Spruce et al., 2009)

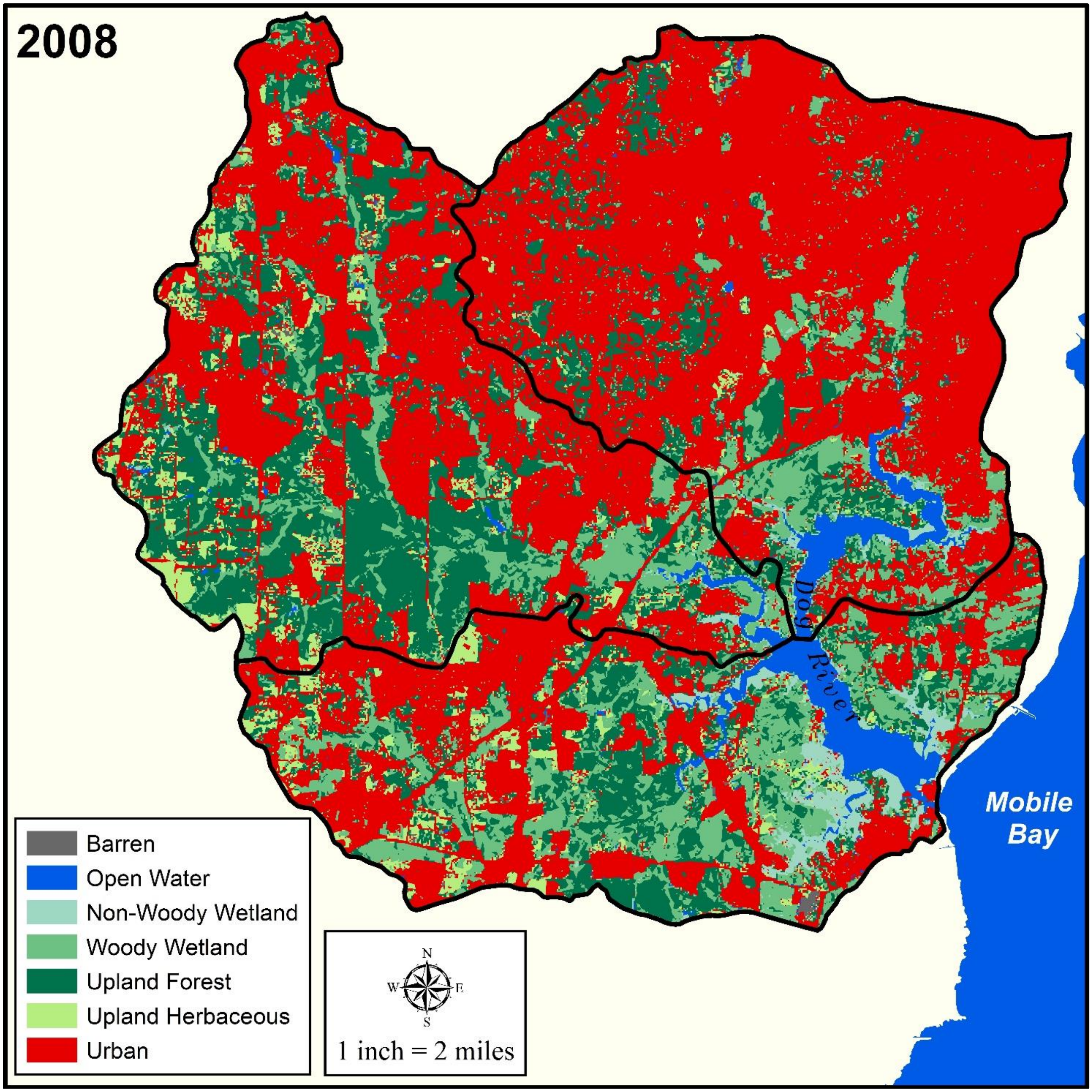

Figure 4.1.4: LULC for the greater Dog River Watershed - 2008 (Spruce et al., 2009)

Figure 4.1.5 shows that there is an inverse relationship in the greater Dog River Watershed between upland herbaceous and upland forest landscapes, with one increasing as the other decreases (Spruce et al., 2009). Figure 4.1.5 also shows that the combined percentage of upland forest and herbaceous cover has declined from 49.4% to approximately 26.9%, while urban land use has increased from 32.1% to 53.1% from 1974 to 2008, respectively. A fluctuation in non-woody and woody wetland acreage is also indicated by Figure 4.1.5. A decline in woody wetlands between 1984 and 1988 coincides with the drought of 1988, and could have been misclassified. In addition, non-woody wetlands appear to decline from 1996 to 2001 and increase from 2001 to

2005. Relatedly, the non-woody wetland class was not included in the 2001 dataset, and therefore appears as 0% coverage in Figure 4.1.5.

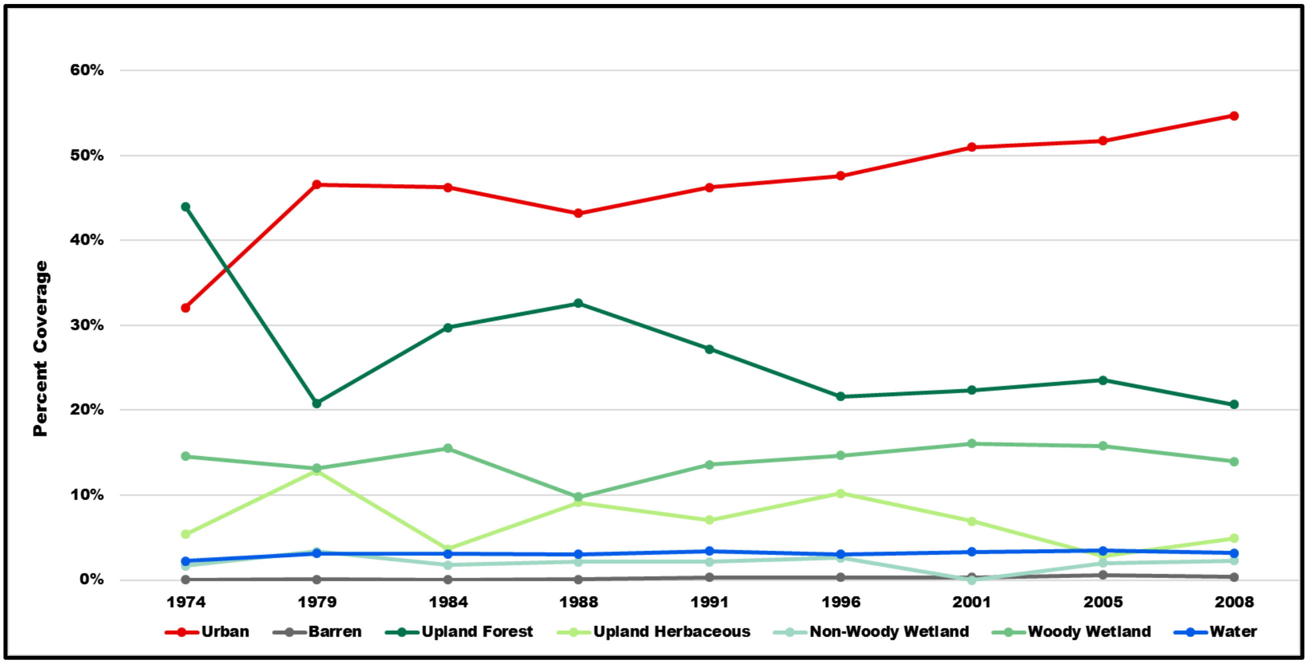

Figure 4.1.5: LULC trends for the greater Dog River Watershed - 1974 to 2008 (Spruce et al., 2009)

Table 4.1.2 further summarizes the Spruce et al. (2009) LULC datasets for 1974, 1984, 1996, and 2008 for the greater Dog River Watershed and the individual watersheds that comprise it, which include Halls Mill Creek, Upper Dog River, and Lower Dog River. Table 4.1.2 reveals that the Halls Mill Creek Watershed outpaces the Upper Dog River and Lower Dog River watersheds in growth with an average annual increase of 3.66% over a 34-year period, as compared to 1.3% and 1.8%, respectively (Spruce et al., 2009).

4

Table 4.1.2 Summary of LULC percent coverage – 1974 to 2008 (Spruce et al., 2009)

Watershed	Class	1974	1984	1996	2008
Greater Dog River Watershed	Urban	32.07%	46.23%	47.58%	53.14%
	Non-Woody Wetland	1.68%	1.79%	2.63%	2.04%
	Upland Forest	43.98%	29.72%	21.60%	21.80%
	Upland Herbaceous	5.37%	3.65%	10.19%	5.07%
	Woody Wetland	14.59%	15.51%	14.66%	14.39%
Halls Mill Creek Watershed	Urban	20.56%	34.96%	37.81%	46.14%
	Non-Woody Wetland	0.24%	0.46%	1.06%	0.60%
	Upland Forest	59.60%	45.81%	34.93%	31.88%
	Upland Herbaceous	6.26%	4.40%	11.80%	7.32%
	Woody Wetland	12.83%	13.28%	13.06%	12.46%
Upper Dog River Watershed	Urban	49.84%	68.58%	67.88%	71.85%
	Non-Woody Wetland	0.59%	0.86%	1.63%	1.03%
	Upland Forest	34.00%	15.66%	12.26%	12.62%
	Upland Herbaceous	3.74%	1.32%	4.98%	1.37%
	Woody Wetland	9.52%	10.58%	10.14%	9.92%
Lower Dog River Watershed	Urban	23.42%	31.41%	33.56%	37.73%
	Non-Woody Wetland	4.84%	4.61%	5.84%	5.09%
	Upland Forest	37.59%	28.00%	17.21%	21.21%
	Upland Herbaceous	6.38%	5.71%	14.91%	7.07%
	Woody Wetland	23.27%	24.58%	22.41%	22.50%

A Modeling System to Assess LULC Change Effects

In 2012, a study was undertaken by the Universities Space Research Center at NASA MSFC to evaluate LULC changes in the Mobile Bay watershed from 1948 to 2001 (Estes et al., 2014). This study also projects future land cover for 2030 (discussed in Section 4.3). The goals of Estes et al. (2014) were to: 1) develop and employ the LULC scenarios as prediction model inputs; and 2) predict the effects of LULC on submerged aquatic vegetation (SAV) in the Mobile Bay estuary. The resulting datasets from this study were also used for a variety of watershed modeling studies in order to understand human impacts on natural ecosystems, including SAV/seagrass (Estes et al., 2014).

The 1948 dataset was originally digitized from the State of Alabama Land Capability Map (1948), a paper map that was limited to four major classes: 1) predominantly row crop land; 2) predominantly row crop or pasture land; 3) urban areas; and 4) predominantly timber or range pasture or timber land only. The lack of wetland information for 1948 led to merging the 1992 wetland dataset (USFWS, 1992) with the digitized 1948 dataset. National Wetlands Inventory (NWI) data from the U.S. Fish and Wildlife Service (USFWS) is available for time periods following the NWI program inception in the 1970s. Consequently, the distribution of wetlands was normalized to the 1992 data; this is, likely, an underestimation of coverage (Estes et al., 2014). Moreover, the 1948 LULC inventory lacks the water and barren land classifications.

A bar chart of the 1948, 1992, and 2001 data, presented in Figure 4.1.6, indicate a decrease in upland herbaceous land cover over the years in the greater Dog River Watershed (Estes et al., 2014). The forests that once covered the Watershed and the County were continuously harvested in the 1800s and early 1900s. Harvested timberland was also repeatedly burned, so in many areas trees did not immediately return. However, by 1992, upland forests and urbanization increased to nearly 39.7% and 35.4%, respectively, of the total land coverage of the greater Dog River Watershed (Estes et al., 2014).

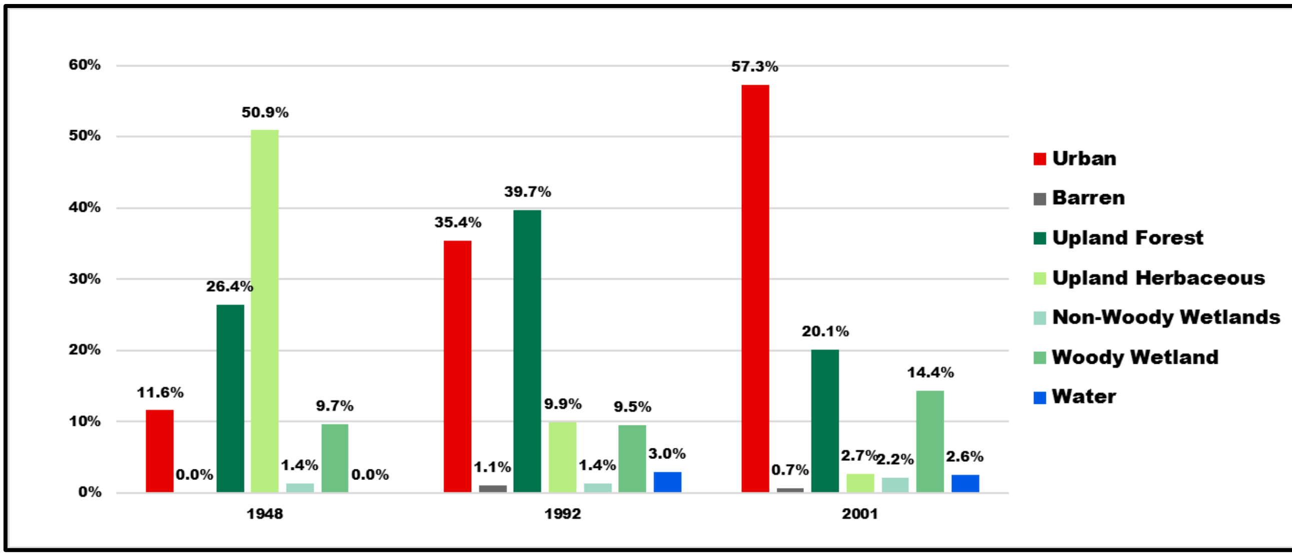

Figure 4.1.6: LULC trends for the greater Dog River Watershed – 1948 to 2001 (Estes et al., 2014)

Continued development in the greater Dog River Watershed by increased urbanization (urban land use classification) accounts for 57.3% of the total Watershed land coverage by 2001. The increase in urbanization in the greater Dog River Watershed is shown in Figures 4.1.7 through 4.1.9 (Estes et al., 2014).

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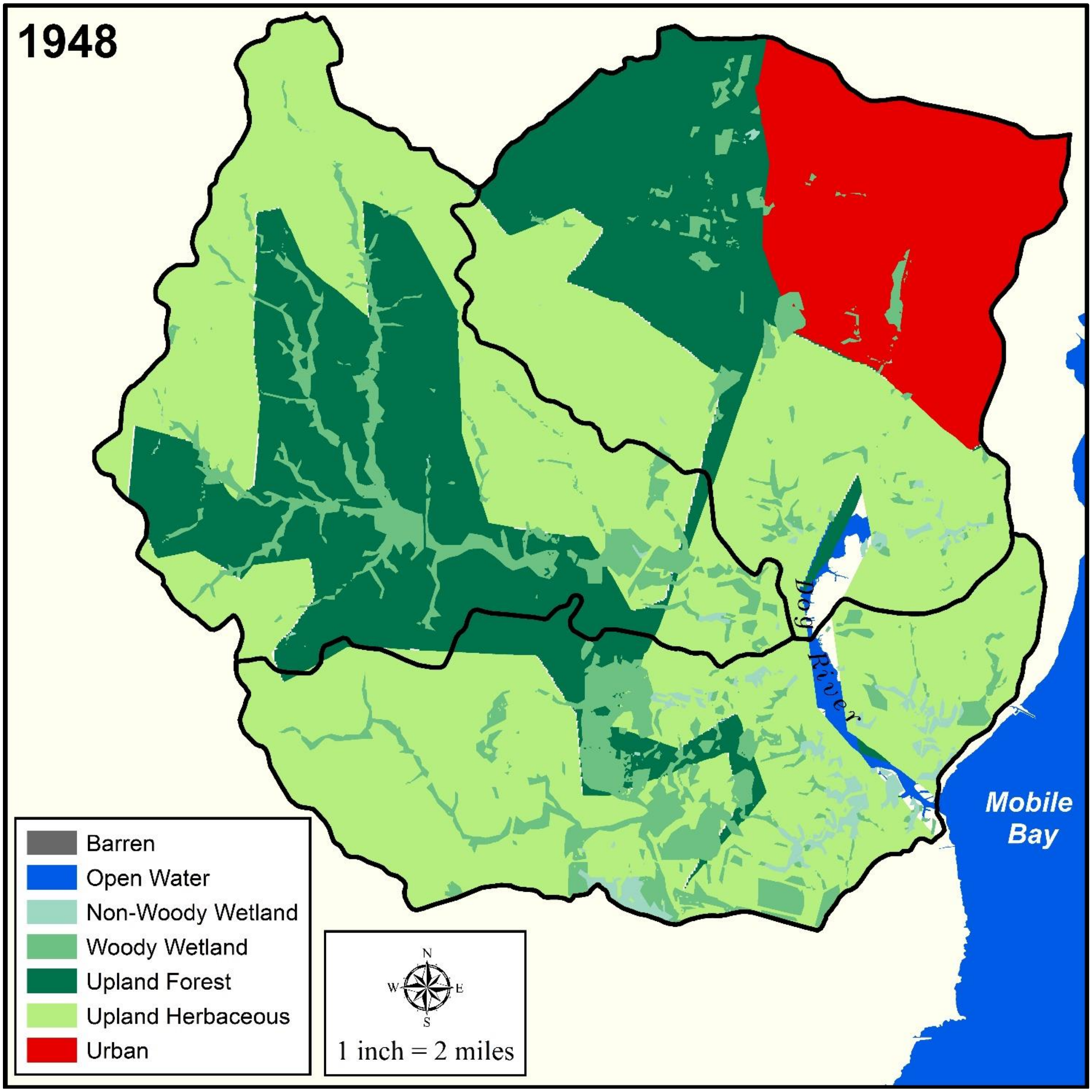

Figure 4.1.7: LULC for the greater Dog River Watershed - 1948 (Estes et al., 2014)

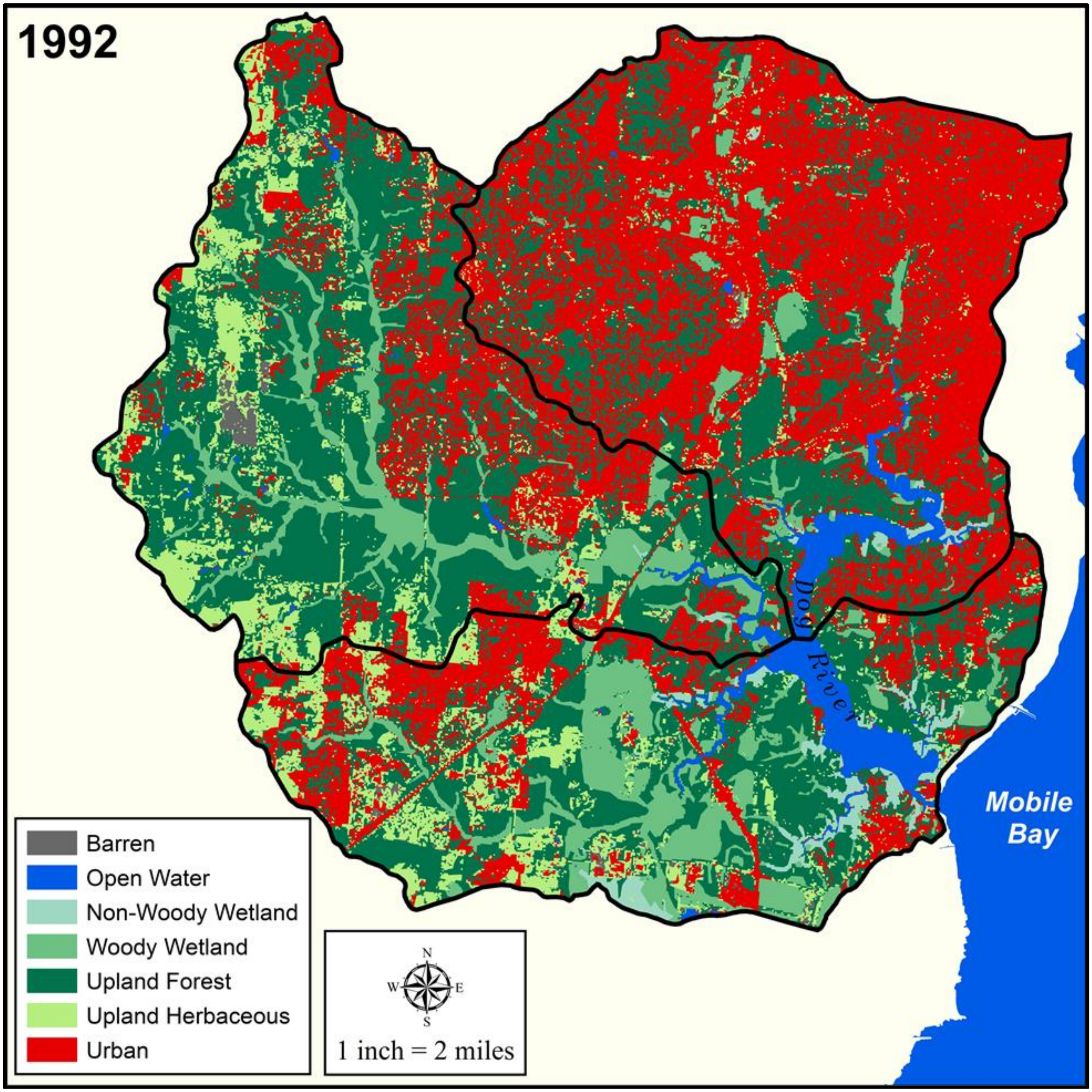

Figure 4.1.8: LULC for the greater Dog River Watershed - 1992 (Estes et al., 2014)

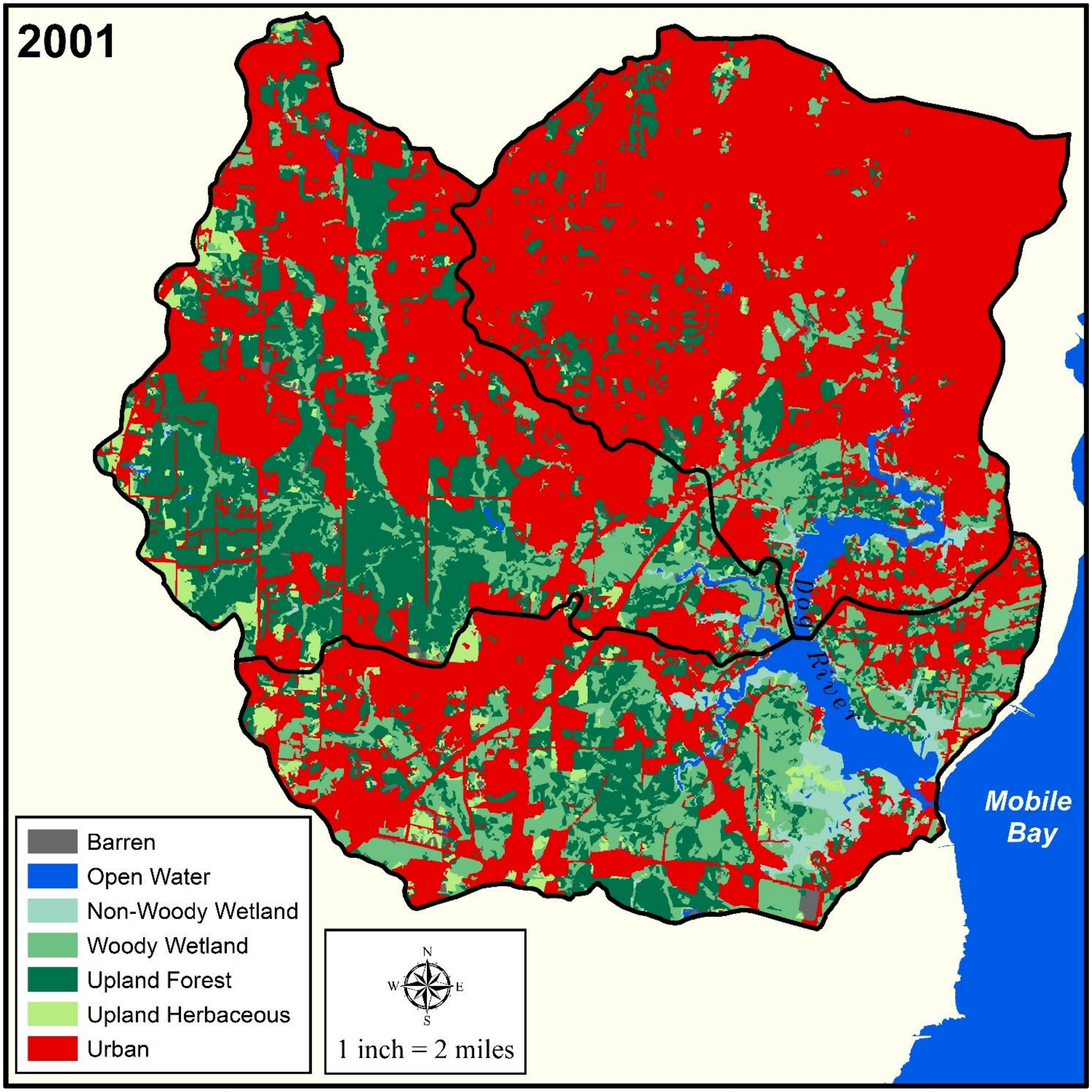

Figure 4.1.9: LULC for the greater Dog River Watershed - 2001 (Estes et al., 2014)

A summary of the LULC classes is provided in Table 4.1.3 for the greater Dog River Watershed and its individual watersheds. The Halls Mill Creek and Lower Dog River watersheds have had the largest increases in urban development from nearly zero in 1948 to over 40% in 2001. The upland forest and upland herbaceous land covers experienced major declines in all three watersheds.

Table 4.1.3: Summary of LULC percent coverage – 1948 to 2001 (Estes et al., 2014)

Watershed	Class	1948	1992	2001
Greater Dog River Watershed	Urban	11.6%	35.4%	57.3%
	Non-Woody Wetland	1.4%	1.4%	2.2%
	Upland Forest	26.4%	39.7%	20.1%
	Upland Herbaceous	50.9%	9.9%	2.7%
	Woody Wetland	9.7%	9.5%	14.4%
Halls Mill Creek Watershed	Urban	0.0%	19.5%	48.6%
	Non-Woody Wetland	0.2%	0.2%	0.5%
	Upland Forest	40.7%	52.1%	33.1%
	Upland Herbaceous	48.2%	14.9%	3.6%
	Woody Wetland	10.9%	10.9%	12.8%
Upper Dog River Watershed	Urban	31.8%	60.8%	78.9%
	Non-Woody Wetland	0.5%	0.5%	1.1%
	Upland Forest	26.9%	29.4%	8.3%
	Upland Herbaceous	37.0%	2.2%	0.4%
	Woody Wetland	3.8%	3.7%	8.3%
Lower Dog River Watershed	Urban	0.0%	22.4%	40.3%
	Non-Woody Wetland	4.1%	4.0%	5.7%
	Upland Forest	7.9%	37.7%	19.1%
	Upland Herbaceous	72.2%	13.8%	4.6%
	Woody Wetland	15.8%	15.4%	24.0%

The Estes et al. (2014) data reveal similar historical trends for the greater Dog River Watershed as did Spruce et al. (2009). Both datasets show urban land increasing to over 50% along with a loss of herbaceous upland and upland forest and increases in wetland coverages (Tables 4.1.2 and 4.1.3).

4.2 CURRENT LAND USE AND LAND COVER

Current LULC data within the greater Dog River Watershed is not available. The most recent source of LULC information for the Watershed is the 2011 MRLC NLCD (Homer et al., 2015) dataset. This dataset was developed by a consortium named the MRLC, that includes the U.S. Geological Survey (USGS), National Oceanic and Atmospheric Administration (NOAA), and the U.S. Forestry Service. Figures 4.2.1 and 4.2.2 and Table 4.2.1 present the NLCD 2011 LULC data (Homer et al., 2015) for the greater Dog River Watershed.

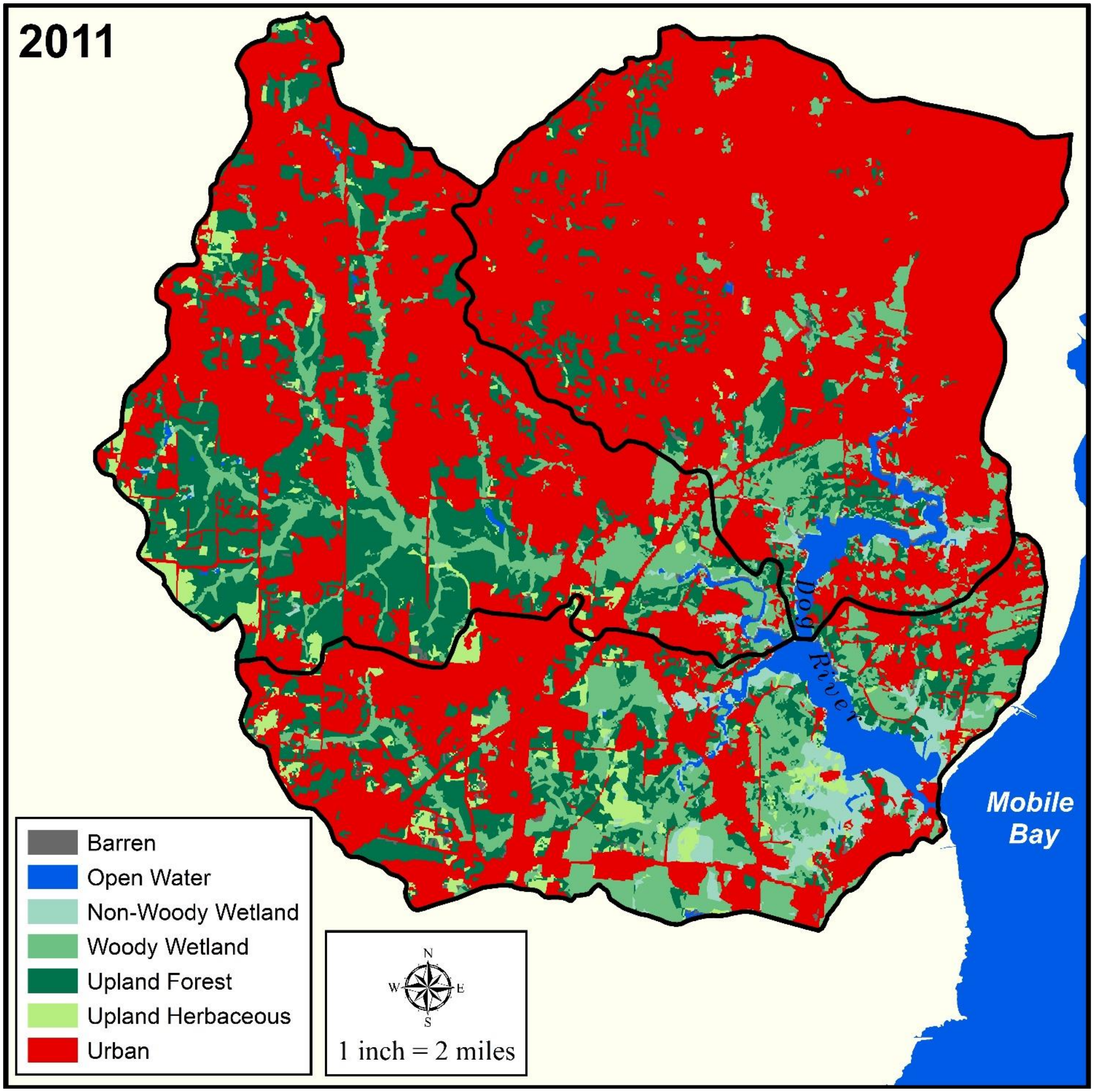

Figure 4.2.1: Current LULC for the greater Dog River Watershed - 2011 (Homer et al., 2015)

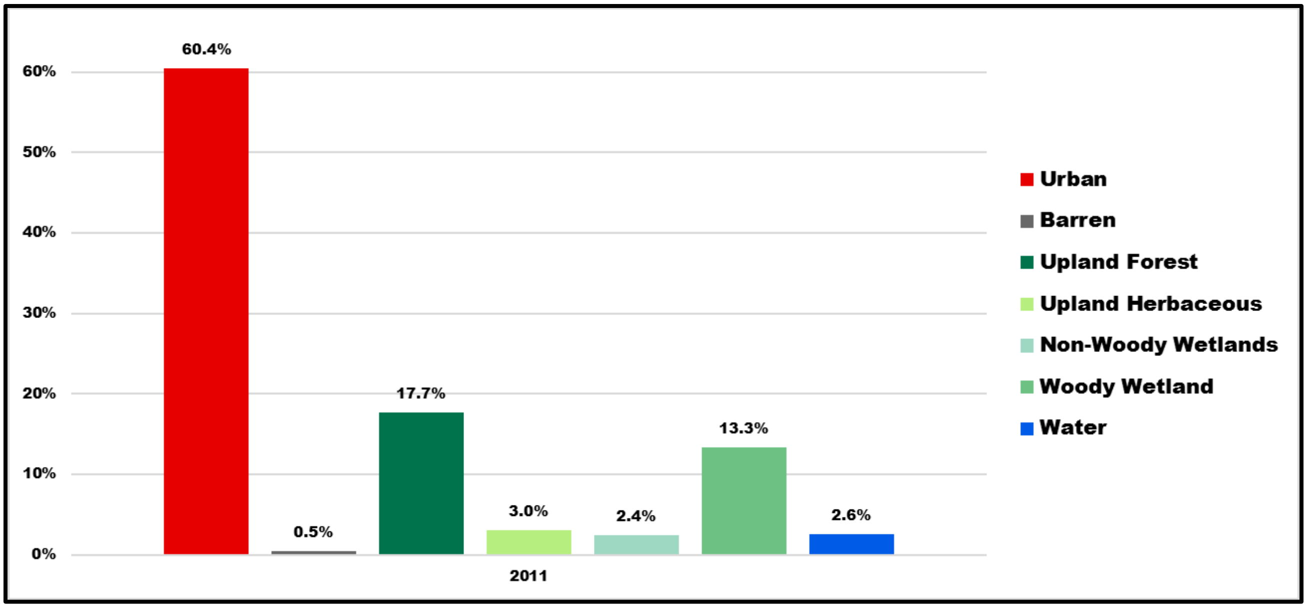

Figure 4.2.2: Current LULC trends for the greater Dog River Watershed - 2011 (Homer et al., 2015)

Table 4.2.1: Summary of LULC percent coverage – 2011 (Homer et al., 2015)

Watershed	Class	Percent Coverage
Greater Dog River Watershed	Urban	60.4%
	Non-Woody Wetland	2.4%
	Upland Forest	17.7%
	Upland Herbaceous	3.0%
	Woody Wetland	13.3%
Halls Mill Creek Watershed	Urban	54.1%
	Non-Woody Wetland	0.6%
	Upland Forest	28.0%
	Upland Herbaceous	3.8%
	Woody Wetland	12.3%
Upper Dog River Watershed	Urban	79.6%
	Non-Woody Wetland	1.1%
	Upland Forest	7.9%
	Upland Herbaceous	0.3%
	Woody Wetland	8.0%
Lower Dog River Watershed	Urban	43.5%
	Non-Woody Wetland	6.4%
	Upland Forest	17.6%
	Upland Herbaceous	5.5%
	Woody Wetland	21.1%

The Upper Dog River Watershed has the highest percentage of urban land use, followed by the Halls Mill Creek Watershed, while the Lower Dog River and Halls Mill Creek watersheds have higher percentages of upland forest land cover. Overall, urban land use in 2011 covered 60.4% of the greater Dog River Watershed (Figures 4.2.1 and 4.2.2) (Homer et al., 2015). Upland forest, the next largest LULC classification category, covered 17.7% of the greater Dog River Watershed area (Homer et al., 2015). Woody wetland covered 13.3%, upland herbaceous covered 3.0%, and non-woody wetlands covered 2.4% of the greater Dog River Watershed (Homer et al., 2015). Table 4.2.1 provides the percent coverage for each of the watersheds that comprise the greater Dog River Watershed (Homer et al., 2015).

Urbanization

Stress on a watershed's health depends on the degree and the extent of urbanization. Research relating to general watershed dynamics shows that shifts from natural to urban land "increases the velocity flows and potential erosion of sediments into waterways, whereas decreases in agricultural and pasture land in favor of urbanization or forests, reduce the available sediment load" (Estes et al., 2014). Other research shows that increased rates of urbanization are associated with larger volumes of runoff, and land coverage consisting of predominantly agriculture and pasture is associated with increased sediment loads (Thom et al., 2001). Therefore, identifying the distribution of urbanization and its intensity is essential to determining the best management, conservation, and monitoring practices to undertake in order to improve and/or preserve water resources within watersheds.

The NLCD 2011 data presented in Figure 4.2.1 for urban land use represents a simplified classification of land use categories for ease of comparison with other data sources. For the 2011 NLCD data (Homer et al., 2015), urban land use is a combination of four categories: 1) developed open-space; 2) developed low-intensity; 3) developed medium-intensity; and 4) developed high-intensity. Table 4.2.2 provides definitions for the 2011 NLCD urban land use categories.

Table 4.2.2: 2011 NLCD urban land use categories (from Homer et al., 2015)

Land Cover Category	Description
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 the total cover. Examples include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Developed, low intensity	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% of the total cover. These areas usually include single-family housing units.
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 usually include single-family housing units.
Developed, high intensity	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial and industrial properties. Impervious surfaces account for 80% to 100% of the total cover.

Approximately 60.4% of the greater Dog River Watershed is urban land use (Homer et al., 2015). Urban land use, illustrated in Figure 4.2.1, is most intense in the Upper Dog River Watershed, but is spread out uniformly across the entire greater Dog River Watershed. It is also widespread throughout the Halls Mill Creek and Lower Dog River watersheds, but more natural land cover remains in those watersheds. Developed open space comprises approximately 30.9% (18,472 acres) of the urban land use category within the greater Dog River Watershed (Homer et al., 2015). Approximately 18.1% of the greater Dog River Watershed is classified as developed low-intensity (Homer et al., 2015). Developed open-space and developed low-intensity are likely single family residential areas. Developed medium-intensity and developed high-intensity account for 8.3% and 3%, respectively, of the total greater Dog River Watershed area (Homer et al., 2015). Common examples of medium- and high-intensity development include small industrial areas and small commercial areas.

Figure 4.2.3 compares urban land use and other land use categories from 1948, 1992, and 2001 (Estes et al., 2014) to the current LULC dataset provided by the 2011 NLCD (Homer et al., 2015).

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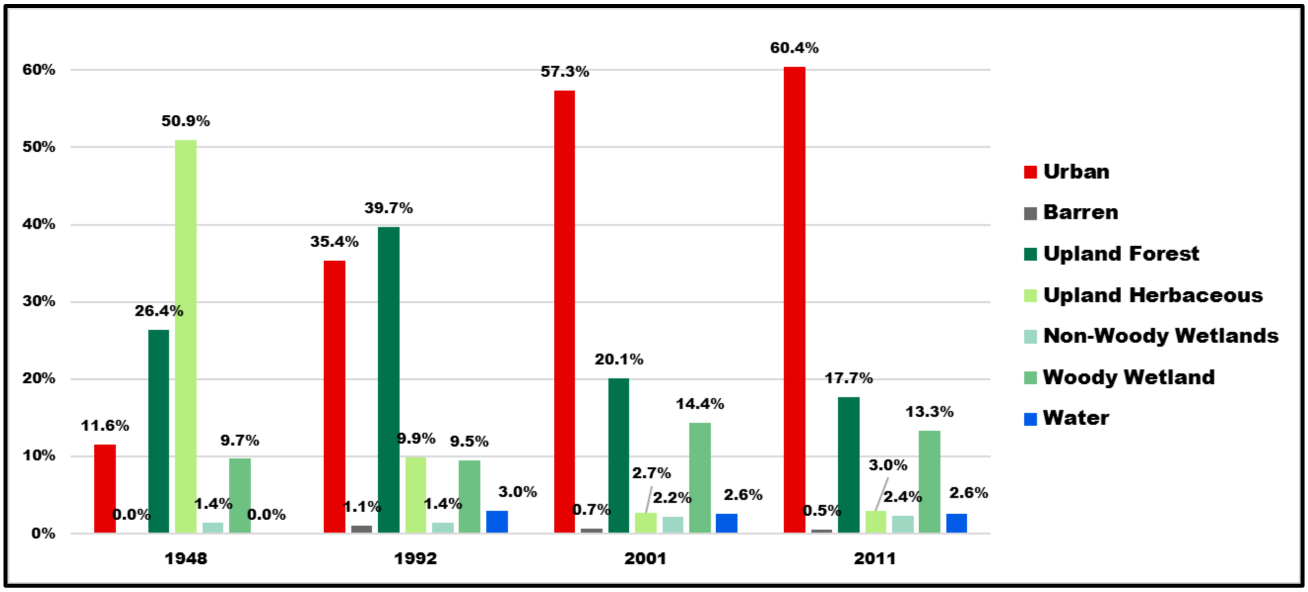

Figure 4.2.3: LULC trends for the greater Dog River Watershed – 1948 to 2011 (Estes et al., 2014; Homer et al., 2015)

Comparison of Estes et al. (2014) and Homer et al. (2015) LULC data given in Figure 4.2.3 reveals that urbanization has only increased slightly since 2001 (57.3%) while upland forest land use coverage has continued to decrease.

4.3 FUTURE LAND USE AND LAND COVER

Historic land use was analyzed as part of the NASA MSFC study to project future LULC for 2030 (Estes et al., 2014). Estes et al. (2014) applied the Prescott Spatial Growth Model (PSGM) using 1948 as a pre-existing LULC scenario, and 1992 and 2001 NLCD LULC datasets to evaluate class changes and to provide input for the hydrodynamic modeling of Mobile Bay watersheds.

> *"The Prescott Spatial Growth Model (PSGM) is an Arc geographic information system (ArcGIS) - compatible application that allocates future growth into available land based on user-defined parameters. The purpose of the PSGM is to help users develop alternative future patterns of LCLU based on socio-economic projections such as population, employment, and other controlling factors. When creating scenarios based on future development, the PSGM requires several inputs:*
>
> ***Developable land** must be provided as an input grid that represents areas suitable for accepting future growth.*
>
> ***Growth projections** quantify the demand for land area to be developed for each time horizon for each LULC type. These projections are derived from socio-economic drivers using a PSGM utility that determines the growth for each urban LULC category (industrial, high-density residential, etc.).*
>
> ***Suitability rules** for location of future growth are specified using a PSGM*

table interface. When the PSGM runs, it allocates the new growth onto the developable land grid, in the order of most to least-suitable land. The output of the PSGM is a series of growth grids, one for each time step and LULC type, showing the anticipated future growth pattern" (Estes et al., 2014).

The NASA MSFC study also utilized 1990 and 2000 census population data as well as projections for 2005, 2010, 2015, 2020 and 2025 as inputs into the PSGM to project future residential development. Projections for future commercial land use demands were developed by identifying the number of jobs for each decade and using employment data for 1990 and 2000 as a stimulus for commercial growth. Other assumptions in this study were: 1) the current LULC trends remaining constant; 2) more growth along shorelines; and 3) banning development in wetland areas. Nevertheless, the projected availability of land sufficiently met with the projected demand, so the model's projected rate of change was not restricted (Estes et al., 2014).

The projected 2030 dataset is a product of several inputs, including reclassified NLCD LULC datasets. The 2030 dataset maintains the same classification scheme as the reclassified 1992 and 2001 datasets in the NASA MSFC study. The urban land categories from NLCD 2011 dataset were also merged for comparison with previous and projected years of data. This normalizes the data and allows for collective analysis of the 1992, 2001, 2011, and projected 2030 LULC.

Figure 4.3.1 shows that by 2030, the projection for upland herbaceous land use declines from 3.0% to 1.7% (Estes et al., 2014; Homer et al., 2015); non-woody wetlands feature the second highest decline, from 2.4% to 2.2% (Estes et al., 2014; Homer et al., 2015); upland forest increases from 17.7% to 18.3% (Estes et al., 2014; Homer et al., 2015); and barren classification accounts for 1% or less and is not displayed on the graph (Estes et al., 2014; Homer et al., 2015). Figure 4.3.1 reveals that there is less than a 1% projected increase in the urban land category from 2011 to 2030 (Estes et al., 2014; Homer et al., 2015). Figure 4.3.1 also reveals the land use percentage of woody wetlands slightly increases from 13.3% to 14.1% over this time period.

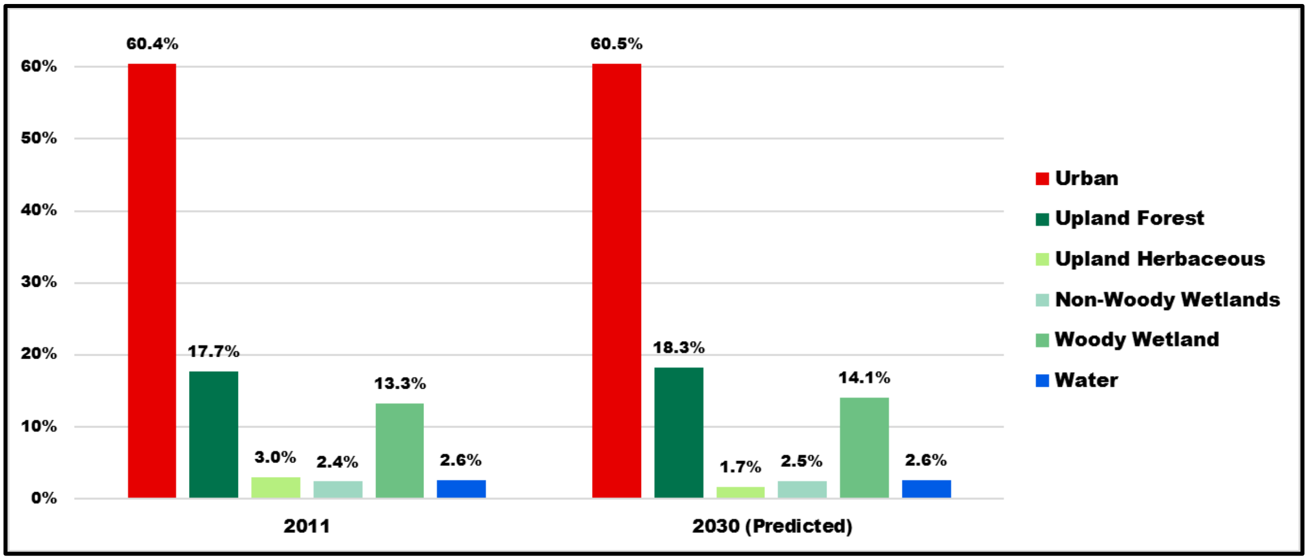

Figure 4.3.1: Comparison of 2011 and 2030 (predicted) LULC trends for the greater Dog River Watershed (Estes et al., 2014; Homer et al., 2015)

The predicted LULC spatial distribution for the greater Dog River Watershed in 2030 is shown in Figure 4.3.2. Figure 4.3.2 shows that urban land use remains the dominant land use type in the 2030 projection (Estes et al., 2014). Overall, the largest projected changes are the decline of upland herbaceous and non-woody wetlands and the increase of woody wetlands.

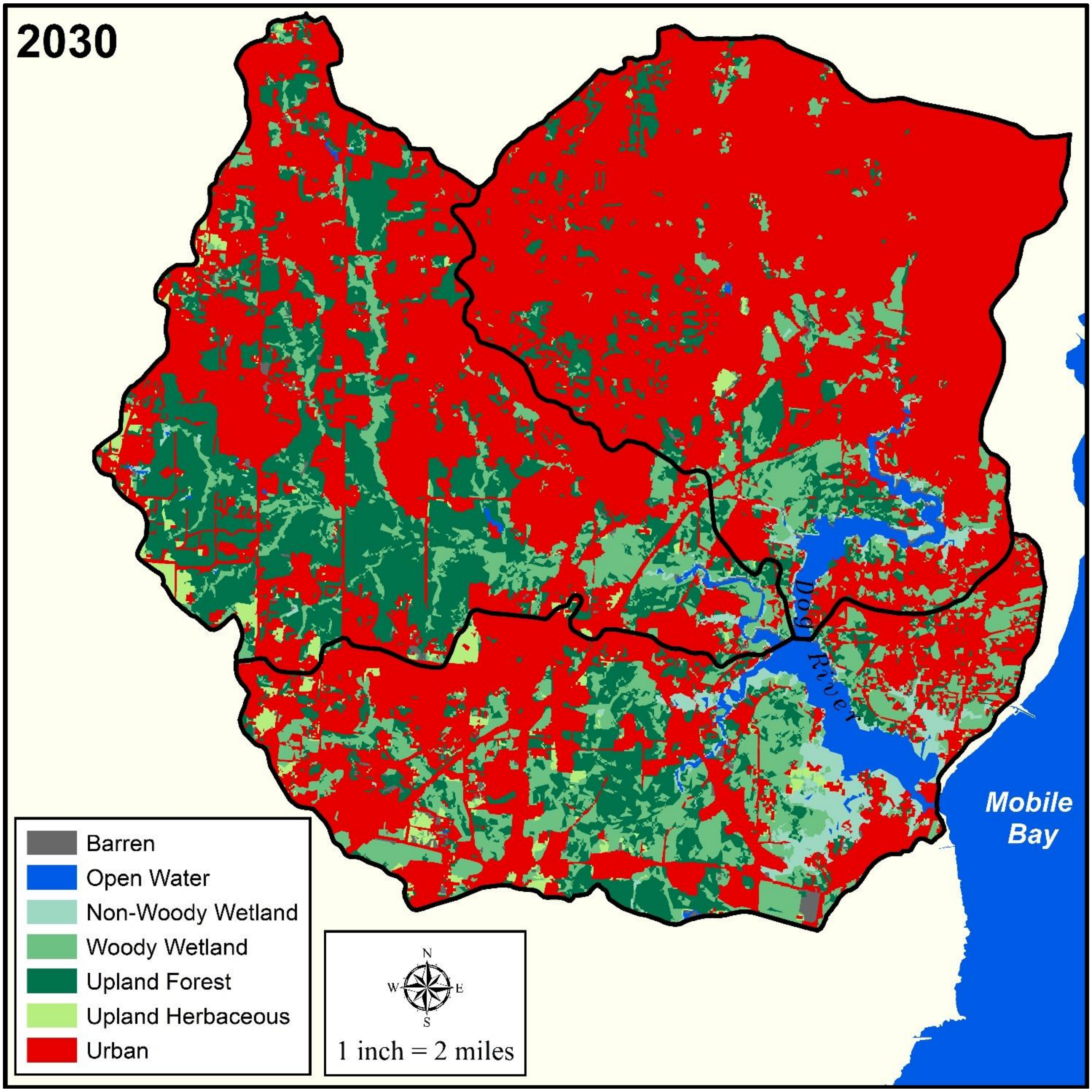

Figure 4.3.2: Projected 2030 LULC for the greater Dog River Watershed (Estes et al., 2014;)

In 2011, upland herbaceous and upland forest accounted for approximately 20.7% of the greater Dog River Watershed (Homer et al., 2015). The model predictions, summarized in Table 4.3.1, reveal increases of upland forest and woody wetlands in the greater Dog River Watershed by 2030 with decreases in upland herbaceous and non-woody wetlands. Urban land use remains practically unchanged.

Table 4.3.1: Comparison of LULC Percent Coverage (Estes et al., 2014; Homer et al., 2015)

Watershed	Class	2011	2030
Greater Dog River Watershed	Urban	60.4%	60.5%
	Non-Woody Wetland	2.4%	2.2%
	Upland Forest	17.7%	18.3%
	Upland Herbaceous	3.0%	1.7%
	Woody Wetland	13.3%	14.1%
Halls Mill Creek Watershed	Urban	54.1%	52.7%
	Non-Woody Wetland	0.6%	0.5%
	Upland Forest	28.0%	30.8%
	Upland Herbaceous	3.8%	2.0%
	Woody Wetland	12.3%	12.6%
Upper Dog River Watershed	Urban	79.6%	79.4%
	Non-Woody Wetland	1.1%	1.1%
	Upland Forest	7.9%	8.0%
	Upland Herbaceous	0.3%	0.3%
	Woody Wetland	8.0%	8.2%
Lower Dog River Watershed	Urban	43.5%	45.7%
	Non-Woody Wetland	6.4%	5.6%
	Upland Forest	17.6%	16.1%
	Upland Herbaceous	5.5%	3.0%
	Woody Wetland	21.1%	23.4%

4.4 IMPERVIOUS COVER

Impervious cover (IC) includes elements in the urban landscape that limit water penetration, such as roads, parking lots, sidewalks, rooftops, and other surfaces. Increases in the quantity of impervious surfaces in a watershed are associated with increases in the volume and velocity of stormwater, increases in pollutant loading, loss of both terrestrial and aquatic habitats, and decline of water quality. The effects of impervious surfaces on stormwater are displayed in Figure 4.4.1. "Depending on the degree of impervious cover, the annual volume of stormwater runoff can increase by two to 16 times its predevelopment rate, with proportional reductions in groundwater recharge" (CWP, 1998).

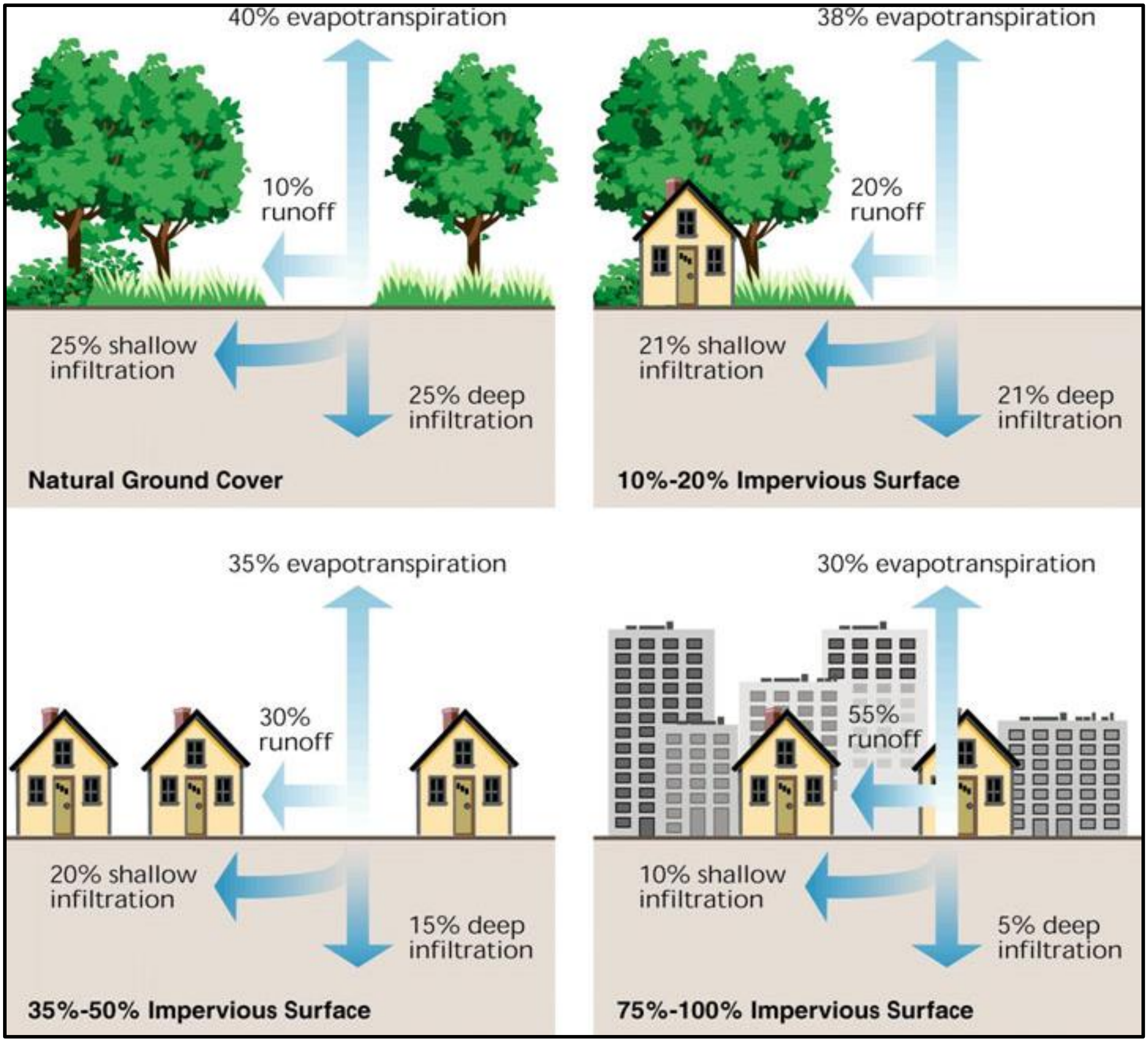

Figure 4.4.1: Effects of imperviousness on runoff and infiltration (from Arnold and Gibbons, 1996)

Impervious cover is a good 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 IC in a watershed is closely linked to the specific LULC cover types that reflect intensive land uses traditionally associated with urban growth. Typically, increases in IC 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. Relatedly, the potential for sediment erosion is known to increase in developing watersheds as natural vegetation is replaced by impervious cover.

Impervious Cover Model

The Impervious Cover Model (ICM) was first introduced by Schueler (1994), at The Center for Watershed Protection, as a tool to detect future stream issues in urban watersheds. The ICM, shown in Figure 4.4.2, classifies streams as "impacted" when a watershed features 11% to 25% IC. The level of stream degradation at IC levels exceeding 25% are classified as "non-supporting", and indicate a loss of the stream's normal function with regard to habitat, water quality, hydrology, biological diversity, or channel stability (Schueler, 1994). Although IC is a robust and reliable indicator of overall stream quality beyond the 10% IC threshold, several studies cited in Scheuler (2003) have documented stream degradation at levels of watershed imperviousness below the 10% threshold. Nonetheless, for watersheds with low levels of IC, other metrics should be examined in conjunction with IC such as forest cover, road density, riparian continuity, and cropping practices.

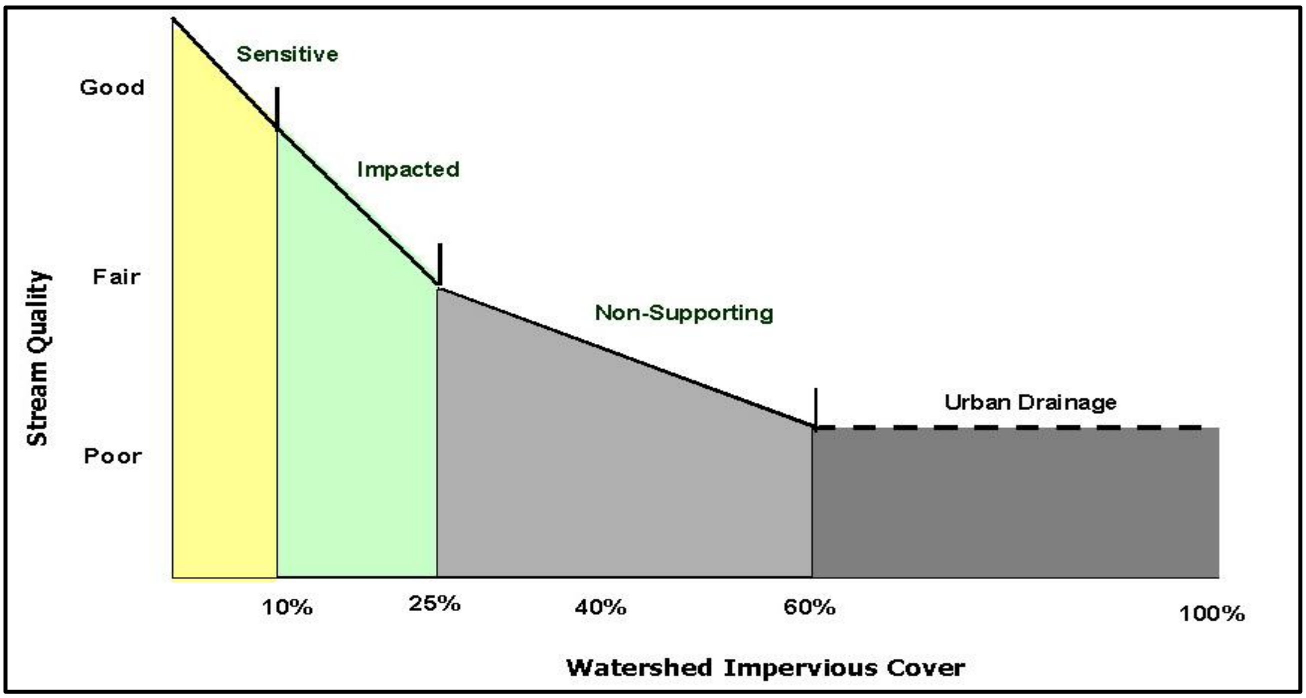

Figure 4.4.2: ICM (from Scheuler, 2003)

In a 2009 study, a suggested ICM reformulation attempts to more closely reflect the average behavior of hydrologic, physical, chemical, and biological response to a range of IC (Scheuler et al., 2009). In this structure, the ICM classifications (Figure 4.4.3) are expressed as a band of transition; from sensitive to impacted is 5% to 10% IC; from impacted to non-supporting is 20% to 25% IC; and from non-supporting to urban drainage is 60% to 70% IC. This structure acknowledges the variability amid stream hydrologic, physical, chemical, and biological responses and stream quality classifications and allows the flexibility to distinguish among stream categories based on the ecoregion's monitoring, the indicators of most concern, and the prevailing regional land cover prior to development (Scheuler et al., 2009).

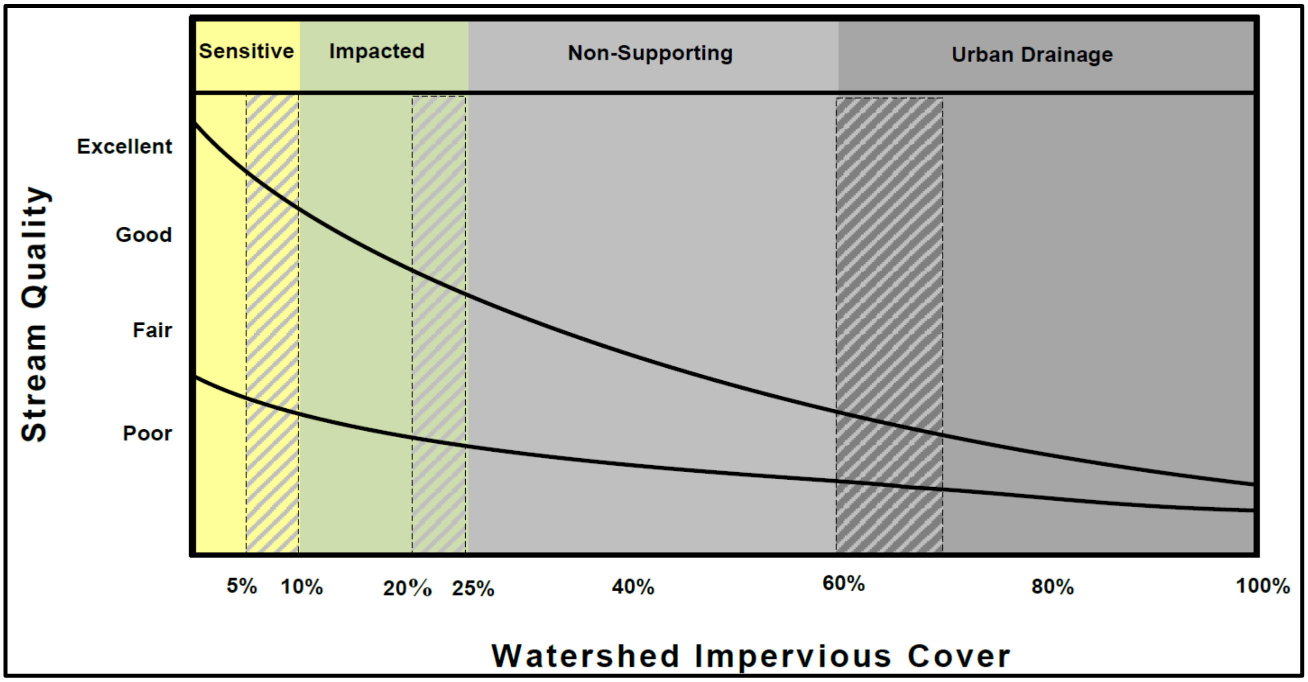

Figure 4.4.3: Reformulated ICM (from Scheuler et al., 2009)

NLCD 2011 Percent Developed Impervious

The impervious surface coverage within the greater Dog River Watershed is given in Figure 4.4.4 and was extracted from the 2011 NLCD Percent Developed Imperviousness dataset (Xian et al., 2011). This raster dataset is made up of 30m by 30m pixels where each pixel is assigned a value of 0 to 100. These values represent percent imperviousness. A pixel with a value of zero has no impervious surface, while one with a value of 100 is entirely impervious. Certain pixels may only be partially impervious, covering less area than a 30m by 30m pixel. Consequently, it is classified with an intermediate value such as 30 or 50.

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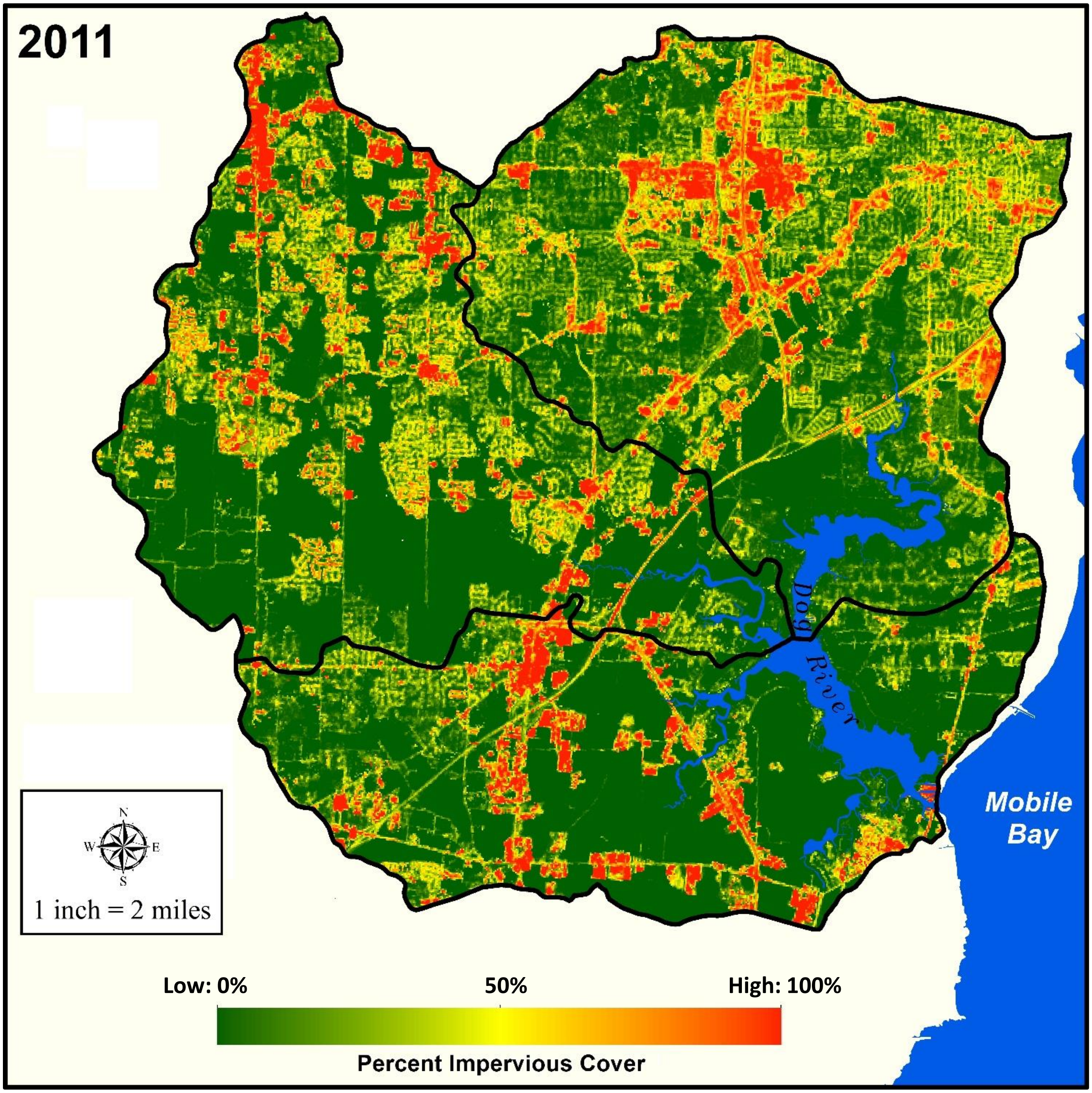

Figure 4.4.4: Percent IC for the greater Dog River Watershed (Xian et al., 2011)

Figure 4.4.4 and Table 4.4.1 reveal that approximately 16.08% (9,593 acres) of the total area of the greater Dog River Watershed is classified as impervious cover (Xian et al., 2011). Comparison of the greater Dog River Watershed's IC percentage (16.08%) with the ICM (Scheuler, 2003) reveals that the stream quality in greater Dog River Watershed would classify as "impacted". Likewise, each of the watersheds that comprise the greater Dog River Watershed, when evaluated individually, would all classify as having "impacted" stream health. Table 4.4.1 reveals that the Upper Dog River Watershed features the highest percentage of IC out of the three individual watersheds that comprise the greater Dog River Watershed, following a similar trend as the urbanization of the watersheds described in Section 4.2.

Table 4.4.1: IC for the greater Dog River Watershed (Xian et al., 2011)

Watershed Name	Acres of Impervious Cover (ac)	Percent Impervious Cover of the Watershed (%)
Greater Dog River Watershed	9,592.92	16.08
Halls Mill Creek Watershed	2,833.45	13.58
Upper Dog River Watershed	4,763.17	21.86
Lower Dog River Watershed	1,996.29	11.74

There are assumptions and limitations of the ICM. Several of these to note are:

1. Most research conducted involved subwatersheds of 10 square miles or less, so that other land use, pollution sources, and disturbances can dictate the stream and river quality and dynamics in larger watersheds and basins;
2. The ICM predicts probable, rather than definite, conditions and some stream segments may deviate from the predicted indicator; and
3. The model estimates the stream groupings average behavior over an array of IC (CWP, 1998).

Moreover, the NLCD IC data (Xian et al., 2011) rely on satellite imagery taken at night of light signatures. IC is then determined by classifying pixels with certain light signatures as impermeable, to varying degrees, for the urban landscape such as roads, parking lots, sidewalks, rooftops, and other surfaces. This method underestimates the percentage of impervious surface coverage.

IC of over 10% (Schueler, 1994) for a watershed is a good indicator that streams are at a higher risk of impact, as increased levels of imperviousness lead to greater runoff of contaminates into the streams. Approximately 16.08% of the total area within the greater Dog River Watershed is classified as IC. Streams within those areas are at a great risk of degrading water quality and overall stream health. However, research indicates that the influence of IC on hydrology, water quality, and biodiversity is stronger and readily apparent at watershed scales of 50 km^2 (roughly 12,355 acres) or less, and that IC may not be the ideal metric at levels below 10% impervious cover (Schueler et al., 2009).

One of the benefits of conducting an evaluation at a local watershed level includes the narrowing of the myriad pollutant sources, which can produce less ambiguous management decisions. The total acreage for the greater Dog River Watershed is about 93 square miles (59,705 acres). Consequently, evaluating the influence of IC at this scale may not reveal a representative stream indicator classification. However, it is still the best tool available for initial assessment of the condition of the Watershed and serves as a gage of the cumulative damage, and, ultimately, to target the reduction of the impacts (CWP, 1998).

The Center for Watershed Protection's *Rapid Watershed Planning Handbook* emphasizes that "while there are some limitations to the application of the urban stream impervious cover model, impervious cover still provides us with one of the best tools for evaluating the health of a watershed. Impervious cover serves not only as an indicator of urban stream quality but also as a valuable management tool in reducing the cumulative impacts within watersheds" (CWP, 1998). Research has found that, with the same degree of urbanization, forested riparian stream areas have higher habitat and diversity than areas lacking intact riparian zones. It is becoming evident that restoring and conserving of riparian zones is vital to protecting the ecosystem of streams (CWP, 1998).

4.5 CONCLUSIONS

There is an inverse relationship between the extent of IC within a watershed and the overall health or quality of its waters. Although IC itself does not produce pollution, it generates hydrologic changes within a watershed that encourage many physical and biological changes influencing urban streams (May et al., 1997). New development can potentially increase the volume of stormwater runoff by two to 16 times and, at the same rate, decrease groundwater infiltration affecting groundwater supplies (Schueler, 1994).

Streams begin to demonstrate significant impairment when impervious cover exceeds 10%. The greater Dog River Watershed's current IC percentage (16.08%) surpasses this threshold. With this level of impervious surface coverage, increased stormwater runoff, and an average annual rainfall of over 65-inches, a tremendous amount of stress is exerted on the greater Dog River Watershed. The effects caused by these changes can be far reaching and include not only biological (habitat loss, lack of ecological diversity) but also human health (water quality and flooding) effects.

5.0 WATERSHED CONDITIONS

5.1 WATER QUALITY OVERVIEW AND PROCESS

The status and trends of the ambient surface water quality of Dog River and its tributaries were assessed through the compilation and analysis of available data. Ambient surface water quality has generally been well studied over the past several decades, and sufficient recent and historic data exist to adequately analyze water quality conditions.

5.1.1 Previous Studies and Existing Data

The data sources reviewed and analyzed to characterize ambient surface water quality in this Dog River Watershed Management Plan (WMP) included the following:

- Alabama Department of Environmental Management (ADEM) (ADEM, 2015) – routine programmatic ambient monitoring;
- Alabama Water Watch (AWW)/ Dog River Clearwater Revival (DRCR) (AWW/DRCR, 2012) - volunteer monitoring;
- Mobile Area Water and Sewer System (MAWSS) (MAWSS, 2009) - special study;
- Geological Survey of Alabama (GSA) (Cook and Moss, 2012) - special study; and
- Mobile Bay National Estuary Program (MBNEP) (MBNEP, 2008) - baseline survey.

The available numeric data analyzed were obtained from the first three sources. Table 5.1.1 summarizes the number of stations, sampling period, and general parameters included in these datasets. During the period in which this WMP was produced, AWW/DRCR has initiated a monitoring effort at several new locations throughout the Dog River Watershed. While that data has not been incorporated into this WMP, it should be evaluated prior to project implementation.

Table 5.1.1: Summary of primary ambient surface water quality data sources (ADEM, 2015; AWW/DRCR, 2012; MAWSS, 2009)

Source	No. Stations	Sampling Period		General Parametric Coverage
		First	Last	
ADEM	28	3/29/1978	3/26/2015	D.O., temp/pH, secchi depth, salinity, sp. conductance, chlorophyll-a, BOD, TSS, nutrients, bacteria, metals, organics, other
AWW/DRCR	44	4/12/1993	8/27/2012	D.O, temp/pH, secchi depth, turbidity, bacteria
MAWSS	16	6/10/2003	6/21/2009	D.O, temp/pH, salinity, rainfall, flow, bacteria

It should be noted that the temporal, spatial, and parametric coverage of ADEM and AWW/DRCR monitoring programs vary substantially over the period of record, since some stations were only monitored for certain dates or for certain parameters. There are relatively few stations in the greater Dog River Watershed where consistent data have been collected over a long period. Therefore, the characterization of the status and trends in surface water quality presented relies on multiple sources and lines of evidence. Appendix D includes time series plots of data for key parameters at all stations.

5.1.2 Data Collection

Although stakeholders expressed concern that existing water quality data was somewhat dated and scattered and that a comprehensive current assessment of water quality conditions was needed to better understand existing conditions, new ambient surface water quality data was not collected as part of the development of this WMP. Instead, it was determined that additional water quality data collection would best be conducted under a long-term monitoring program to be developed as a management measure.

5.1.3 Water Quality Standards

5.1.3.1 Designated and Desired Uses

Code of Alabama Section 335-6-11 establishes the designated use classification system for Alabama surface waters. There are seven basic classifications including:

1. Outstanding Alabama Water
2. Public Water Supply
3. Swimming and Other Whole Body Water-Contact Sports
4. Shellfish Harvesting
5. Fish and Wildlife
6. Limited Warmwater Fishery
7. Agricultural and Industrial Water Supply

In addition to these classifications, there are two additional special designations: Outstanding National Resource Waters and Treasured Alabama Lakes. Designated use classifications essentially define the existing and/or intended use of a particular water body. Code of Alabama Section 335-6-10 defines the water quality criteria that corresponds with specific designated uses. These criteria establish water quality standards and other measures developed to protect designated uses of each waterbody.

All surface waters in the greater Dog River Watershed have a default water use designation of Fish and Wildlife (F&W). However, the lower segment of Dog River, from Rabbit Creek to Mobile Bay, as well as the nearshore waters of Mobile Bay adjacent to Garrow's Bend are also designated for Swimming and Other Whole Body Water-Contact Sports. Table 5.1.2 lists the specific water quality criteria for water use classifications within the greater Dog River Watershed.

Table 5.1.2: ADEM water quality criteria for water use classifications in the greater Dog River Watershed

Swimming and Other Whole Body Contact Water Sports:	
Criteria	**Standard**
pH	6.0 to 8.5 standard unit (s.u.)
Water Temperature	‹ 90°F
Dissolved Oxygen	› 4.0 to 5.0 mg/L (at mid depth or 5 ft dependent on total depth) depending on water type
Fecal Coliform Bacteria	‹ 200 colonies/100 mL (geometric mean)
Fecal Coliform Bacteria	‹ 100 colonies/100mL (geometric mean)
Turbidity	‹ 50 nephelometric turbidity units (NTU) above background
Fish and Wildlife:	
Criteria	**Standard**
pH	6.0 to 8.5 s.u.
Water Temperature	‹ 90°F
Dissolved Oxygen	› 4.0 mg/L to 5.0 mg/L (at mid depth or 5 ft dependent on total depth) depending on water type
Fecal Coliform Bacteria	‹ 200 colonies/100mL (geometric mean June – Sept.)
	‹ 1000 colonies/100mL (geometric mean Oct. - May)
	‹ 2000 colonies/100mL (single sample max.)
Fecal Coliform Bacteria	‹ 1000 colonies/100mL (geometric mean Oct. - May)
	‹ 2000 colonies/100mL (single sample max.))
	‹ 100 colonies/100mL (geometric mean June –Sept.)
Turbidity	‹ 50 NTU above background

*Pre - 2004 criteria and standards
Source: ADEM Admin. Code R. 335-6-10-.09

5.1.3.2 Clean Water Act (CWA) Section 303(d) and Total Maximum Daily Loads (TMDLs)

Under Section 303(d) of the Federal Clean Water Act 9 (CWA), waterbodies that are determined to not meet water quality criteria for their respective designated uses are required to be listed as "impaired waters". Section 303(d) of the CWA requires states to submit a list of surface waters that do not meet applicable water quality standards (impaired waters) where implementation of technology-based effluent limitations alone did not ensure attainment of applicable water quality standards. The 303(d) list is submitted to the U.S. Environmental Protection Agency (EPA) for approval after an opportunity for public comment. The list includes the causes and sources of water quality impairment for each waterbody listed and a schedule for development of total maximum daily loads (TMDLs) for each pollutant-causing impairment identified (ADEM, 2017a).

TMDLs determine the amount of each pollutant causing water quality impairments that can be allowed without resulting in exceedances of prescribed water quality standards for the waterbody. A TMDL is the sum of the allowable loads of a single pollutant from every contributing point and nonpoint source, including a margin of safety to account for uncertainty. TMDLs also address reductions needed to meet water quality standards and allocates those reductions among the point and non-point sources in a watershed. Therefore, development of TMDLs is an important step in restoring surface waters to their designated uses.

The greater Dog River Watershed is composed of three separate 12-digit hydrologic unit codes (HUCs) and their associated named tributaries and/or canals. The three HUCs and their respective tributaries that comprise the greater Dog River Watershed include the following (USGS, 2017):

Upper Dog River (HUC 031602050101)

- East Bolton Branch
- West Bolton Branch
- Dog River
- East Eslava Creek
- West Eslava Creek
- Montlimar Canal
- Moore Creek
- Robinson Bayou
- Spencer Branch
- Unnamed Drainages

Halls Mill Creek (HUC 031602050102)

- Campground Branch
- Halls Mill Creek
- Milkhouse Creek
- Second Creek
- Spring Creek
- Unnamed Drainages

Lower Dog River (HUC 031602050103)

- Alligator Bayou
- Dog River
- Perch Creek
- Rabbit Creek
- Rattlesnake Bayou
- Whiskey Branch
- Unnamed Drainages

ADEM is responsible for the implementation of the Section 303(d) program in Alabama (ADEM, 2017b). To date, five waterbody identification units (WBIDs) in the greater Dog River Watershed have been identified as impaired for different parameter classes, and four have approved TMDLs. Table 5.1.3 provides a status summary of the 303(d) listed WBIDs in the greater Dog River Watershed (ADEM, 2017b).

Table 5.1.3: Relative water quality summary assessment of the greater Dog River Watershed (ADEM, 2017b)

Water Body	Impairment	Regulatory Status
Halls Mill Creek	Siltation (sediment)	303(d) list (2012); TMDL pending (2018)
East Bolton Branch	Pathogens (bacteria)	Approved TMDL (2009)
West Bolton Branch	Pathogens (bacteria)	Approved TMDL (2009)
Montlimar Canal*	Pathogens (bacteria)	Approved TMDL (2009)
East Eslava Creek	Pathogens (bacteria)	Approved TMDL (2009)
Rabbit Creek	Organic enrichment (nutrients, Chlorophyll-a, DO)	Approved TMDL (2005)
Rabbit Creek	Pathogens (bacteria)	Approved TMDL (2005)
Upper Dog River	Organic enrichment (nutrients, Chlorophyll-a, DO)	Approved TMDL (2005)
Upper Dog River	Pathogens (bacteria)	Approved TMDL (2005)

*Also referred to as West Bolton Branch by ADEM

Responsibility for the implementation of the approved TMDLs in the greater Dog River Watershed falls primarily on the owners of permits for the operation of municipal separate storm sewer systems (MS4 permits), including both Mobile County and the City of Mobile. In addition, MAWSS is responsible for compliance related to domestic wastewater treatment infrastructure.

5.1.4 Water Quality Data

In assessing existing water quality conditions in the greater Dog River Watershed, it is important to make distinctions between fresh water, ecotone (transitional), and salt water (coastal) communities. For the purposes of this WMP, ecotone is defined as a transitional area between fresh water and salt water ecosystems. In Dog River and its tributaries, the dividing lines between the fresh water and salt water ecosystems have been generally delineated by the DRCR, a local stakeholder group, and are shown in Figure 5.1.1.

Green sections of the Watershed, shown in Figure 5.1.1, are considered tidally influenced locations where water salinity is elevated (salt water); yellow sections are tidally influenced some duration of time where water salinity is elevated but not as much or as frequently as the stream reaches represented by green (ecotone); and blue segments, which are not considered tidally influenced (fresh water). These designations allow ecosystems to be identified into general salinity classification ranges; however, defining specific salinity regime boundaries is difficult because salinity zones can vary based on the varying inland extent of a salt water wedge as well as in response to surface water discharges or tides.

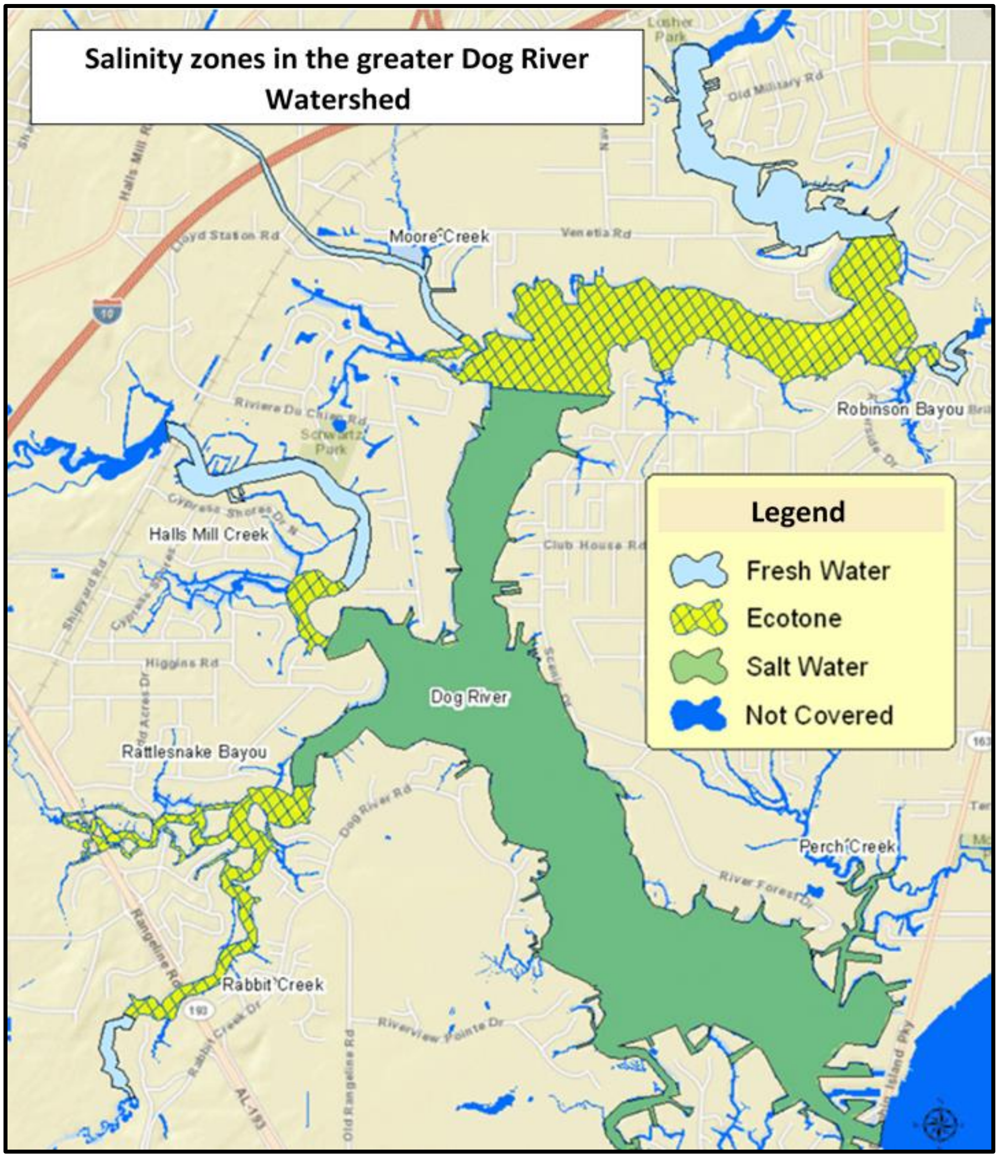

Figure 5.1.1: A representation of the fresh water, ecotone (transitional), and salt water zones in the greater Dog River Watershed (from Griffin, 2013)

Distinctions based on salinity regimes are important for two reasons. First, because the chemistry and biology of fresh water streams and rivers are very different from those of tidal estuaries, the ecosystem functions and services provided by these systems are also distinctly different. However, there is also a close relationship between fresh water and tidal portions of a water body because the quality, quantity, and timing of fresh or salt water deliveries controls the type of ecosystem which will be present. Second, regulatory guidance concentrations and standards differ between fresh water and salt water segments for many water quality parameters. Therefore, the applicable criteria for comparing existing water quality data of each of the different ecosystems will also vary.

In addition to distinguishing between fresh water and salt water segments of a waterbody, characterization of a waterbody's existing water quality is divided into other general classes of water quality parameters including:

- Physiochemical parameters – measures of the general physical and chemical properties of a waterbody related to water column mixing, density stratification, and light transmittance in estuaries, including:
  - Temperature
  - Salinity
  - Turbidity (Secchi depth)

- Geochemical parameters – measures of geological inputs into a waterbody that affect water clarity and sedimentation, including:
  - Total suspended solids (TSS)
  - Turbidity
  - Specific conductance
  - pH

- Trophic parameters – measures of primary production (e.g., algal and macrophytic photosynthesis), related processes (e.g., respiration), and drivers (nutrients) in a waterbody, including:
  - Dissolved oxygen (DO)
  - Chlorophyll-a
  - Nitrogen – both total and inorganic
  - Phosphorus - both total and inorganic

- Pathogens – bacterial constituents that are used as indicators to detect and estimate the level of fecal contamination in water, including:
  - Fecal coliform
  - Enterococci

- Contaminants – chemical constituents that are potentially toxic to aquatic organisms and humans, including:
  - Heavy metals
  - Organics

While there is some overlap in the classes of water quality parameters listed above, they are individual measures and/or indicators for different characteristics. The cumulative assessment of these parameters can be used to determine the overall water quality of a particular waterbody with regard to its designated uses.

5.1.4.1 Stormwater Runoff

The surface water system within the greater Dog River Watershed has been extensively altered by urbanization. Surface water drainages are heavily modified. Many have been channelized and concrete-lined, and those with natural channels often are eroded and carry heavy sediment loads. Mobile County has a hot, humid, subtropical climate with abundant rainfall. As noted in Table 3.3.1 of this document, every year for the past seven years has experienced at least one month when precipitation exceeded 10 inches. Precipitation typically comes in the form of thunderstorms and intense showers. All of these conditions create the potential for stormwater runoff to be a major issue within the greater Dog River Watershed.

Extensive impervious surfaces create flashy hydrographs with rapid rise and fall of surface water discharge and velocity due to runoff. As documented in Chapter 4, the greater Dog River Watershed contains a large percentage of urban-developed land use. Approximately 16.08% of the land in the greater Dog River Watershed is covered with impervious surfaces (Xian et al., 2011).

Stormwater runoff is greatest in developed areas with impervious surfaces. Developed areas are primary sources of trash, nutrients, sediment, and introduced chemicals. Maps of land use and land cover (LULC) within the greater Dog River Watershed were created using the GIS database (Chapter 4). Urbanized lands with impervious surfaces are critical areas where control and mitigation of runoff should be addressed.

There are 2,830 permitted stormwater outfalls in the greater Dog River Watershed: 2,044 in the Upper Dog River Watershed, 571 in the Halls Mill Creek Watershed, and 215 in the Lower Dog River Watershed (City of Mobile, 2014a). These outfalls convey stormwater runoff from streets and parking lots to surface water drainages. This runoff can carry petroleum-related substances, trash, metals, and other pollutants to the surface water drainages in the greater Dog River Watershed and eventually into Mobile Bay.

Illicit discharges are defined as unpermitted and unregulated outflows that place pollutants into the surface water system. The City of Mobile has records of 537 illicit discharges within the greater Dog River Watershed in the past three years (2013 - 2015) (City of Mobile, 2014b); of these, 449 occurred in the Upper Dog River Watershed, 63 occurred in the Halls Mill Creek Watershed, and 25 occurred in the Lower Dog River Watershed (City of Mobile, 2014b).

5.1.4.2 Halls Mill Creek Watershed

The Halls Mill Creek Watershed encompasses approximately 32.63 square miles with approximately 342,293 feet (or 65 miles) of surface water drainages (USGS, 2017). From the western and northern boundaries of the Halls Mill Creek Watershed to the confluence with Dog River near Mobile Bay, relief within the study area is approximately 230 feet. The majority of that relief occurs in the western half of the Watershed, within the Southern Pine Hills physiographic district. Tributary drainages are well defined within the Southern Pine Hills district because of the greater topographic relief. However, the gentle topography of the Coastal Lowlands district is favorable to the creation of floodplains and wetland areas along drainages. In the floodplain of Halls Mill Creek east of U.S. Highway 90, total relief is approximately 40 feet.

Water quality sampling stations in the Halls Mill Creek Watershed are shown in Figure 5.1.2. In terms of spatial coverage, the Watershed has been intensely sampled by AWW/DRCR. However, the MAWSS dataset represents the most complete long-term temporal coverage with a greater range of analyses. The MAWSS data encompass a period of record from 2003 to 2009. At the time this report was prepared, the only station being sampled on a routine basis was ADEM station 7330, which began in April of 2011. During the production of this document, AWW/DRCR initiated routine sampling at three new locations within the Halls Mill Creek Watershed. Those data are not included in the characterization of this Watershed.

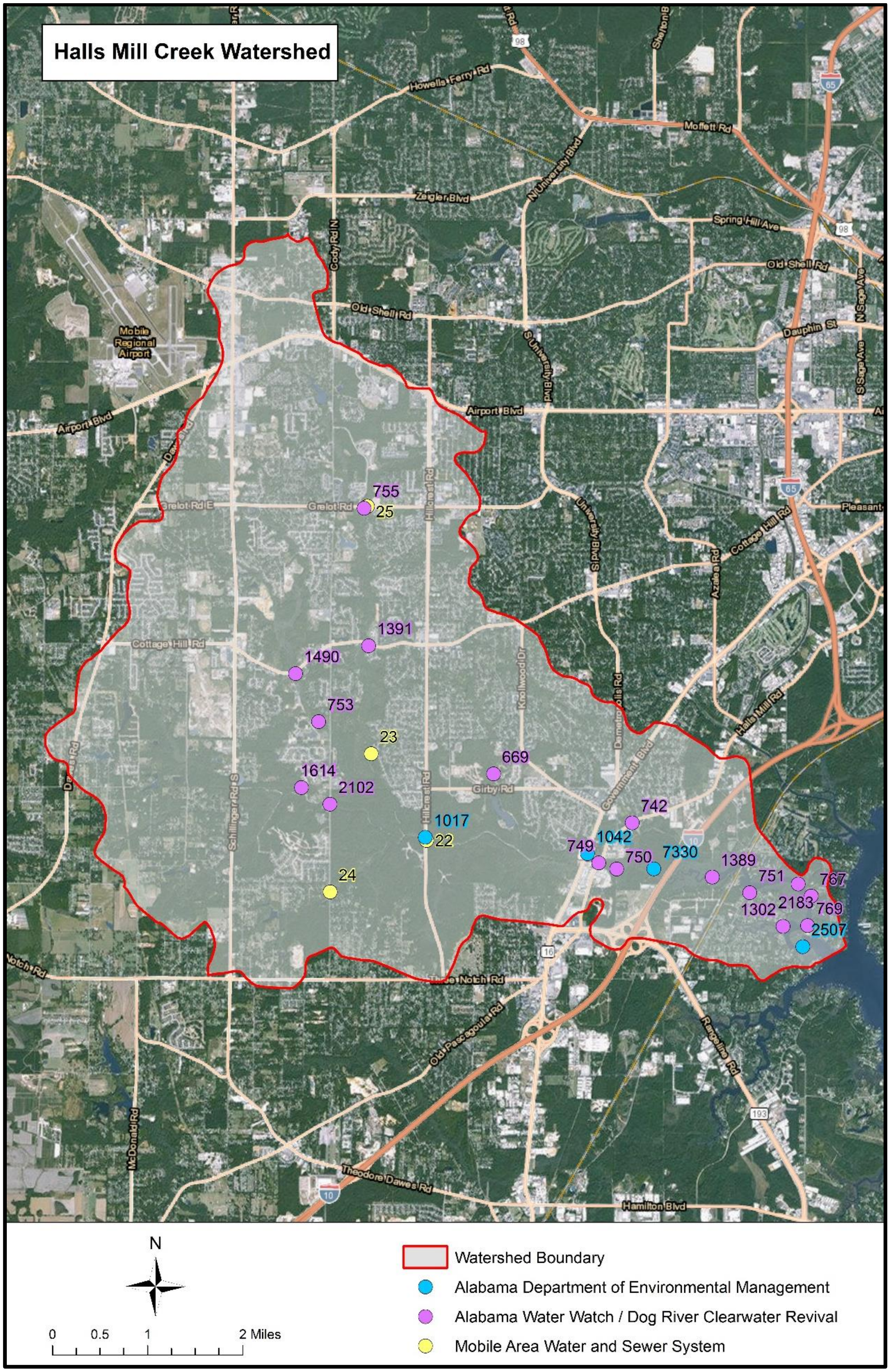

Figure 5.1.2: Water quality sampling stations in the Halls Mill Creek Watershed

Dissolved Oxygen

Dissolved oxygen (DO) is necessary for the healthy respiration of all aquatic organisms. DO concentration in streams fluctuates naturally as a result of many factors including water temperature, sunlight intensity and duration, plant growth, and stream flow characteristics such as turbulent versus laminar flow (WRWC, 2014). DO concentrations below regulatory criteria (5 mg/L for coastal waters; 4 mg/L for fresh waters) are considered to be stressful to fish, shellfish and other benthic invertebrates. Additionally, low DO levels contribute to the release of nutrients and metals from the sediments to the water column, further exacerbating water quality problems. Phosphate attaches to sediments in the stream channel. "The solubility of trace metals in surface waters is predominately controlled by the water pH, the type and concentration of ligands on which the metal could adsorb, and the oxidation state of the mineral components and the redox environment of the system" (Connell and Miller, 1984). When the DO concentration is lowered to anoxic levels the phosphate is released back into the water (Indiana University, 2017). Phosphate is a nutrient that encourages the growth of algae.

Figure 5.1.3 shows a time series plot of DO data from multiple AWW/DRCR stations in both the tidally-influenced and fresh water segments of Halls Mill Creek, compared to ADEM's coastal and freshwater criteria thresholds. This plot shows that dissolved oxygen concentrations rarely violate the regulatory criteria, and that the frequency of violations appears to have declined since the early 2000's.

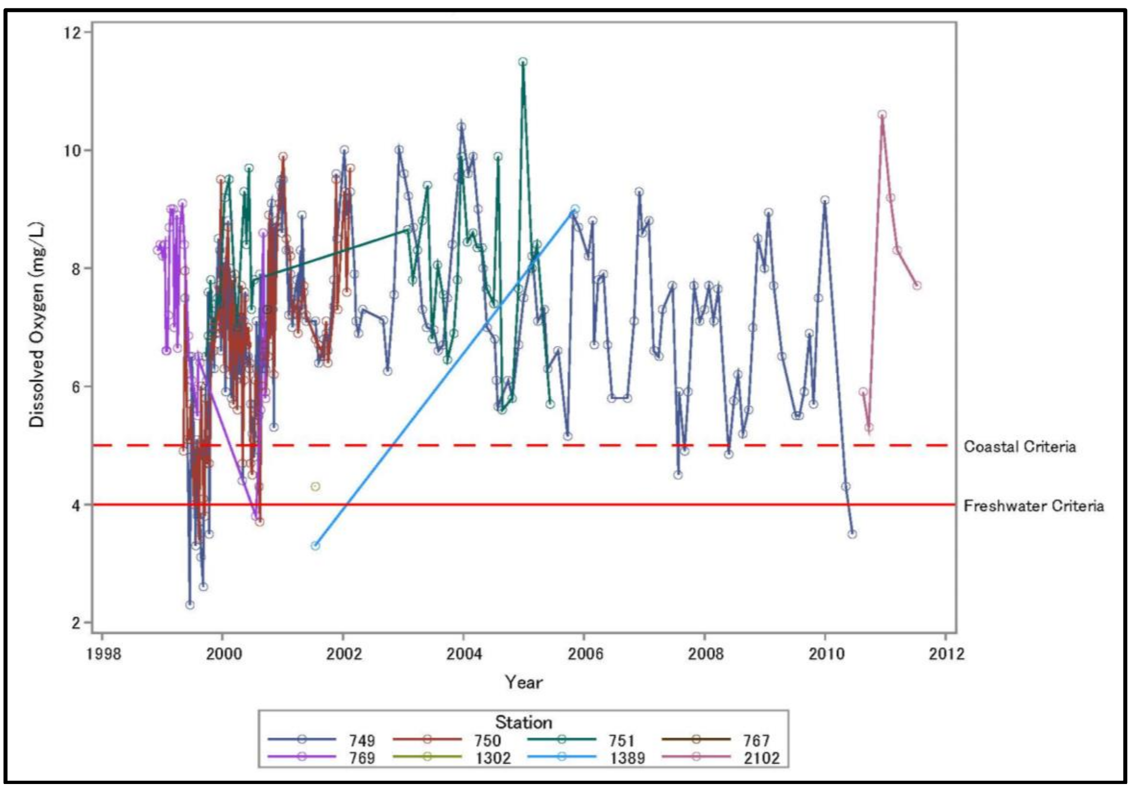

Figure 5.1.3: Composite time series of DO concentrations at AWW/DRCR data stations in Halls Mill Creek

Figure 5.1.4 shows a data series of vertical DO profiles taken at ADEM station 2507 in the tidally-influenced portion of Halls Mill Creek. These profiles show that DO concentrations are generally evenly mixed throughout the water column and do not decrease substantially below the salinity stratification depth. These patterns indicate a healthy oxygen environment for fish and shellfish with normal levels of organic enrichment and associated microbial respiration.

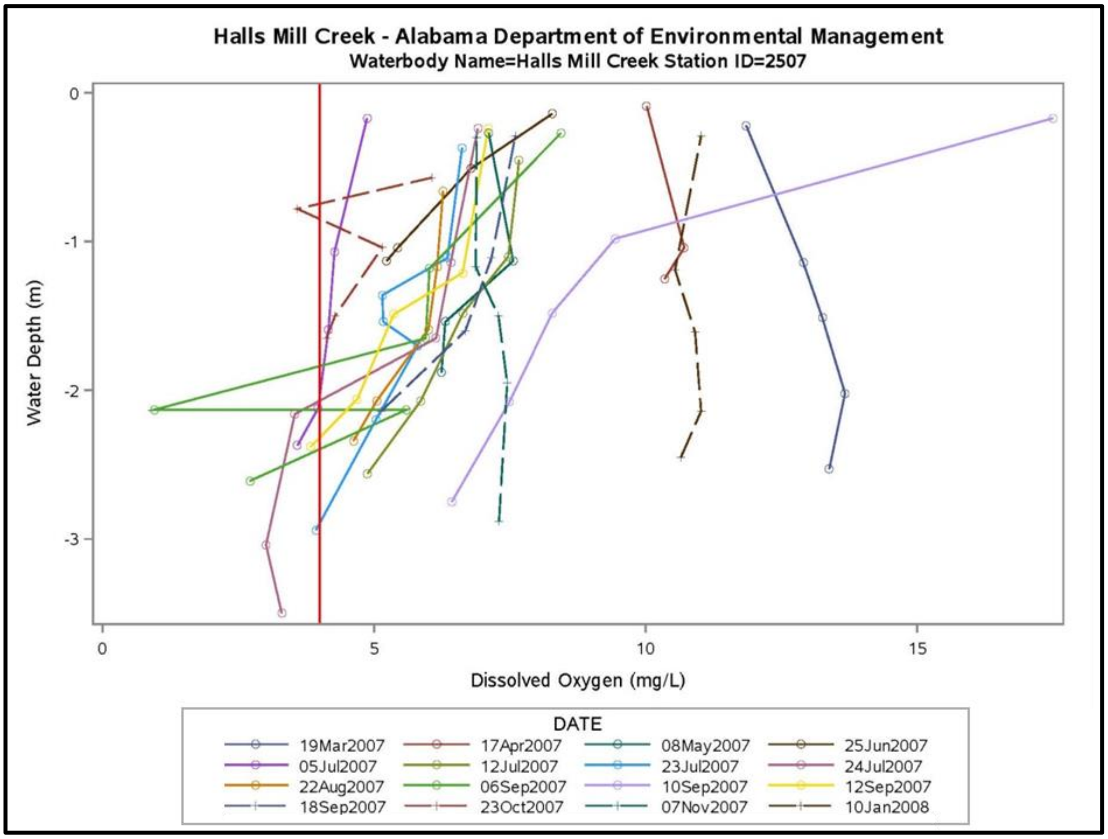

Figure 5.1.4: Data series of DO profiles at ADEM Station 2507 in the tidally-influenced portion of Halls Mill Creek

Chlorophyll-a

Chlorophyll-a is a pigment contained in algae cells and is a measure of algal productivity in waterbodies. Algal productivity is driven by dissolved nutrients, primarily nitrogen and phosphorus compounds in the water column. Excessive algal production also results in organic enrichment causing depressed DO concentrations.

Figure 5.1.5 shows a time series plot of chlorophyll-a data from multiple ADEM stations in the tidally-influenced segments of Halls Mill Creek with National Coastal Assessment (NCA) criteria for good (< 5µg/L), fair (5-20 µg/L), and poor (> 20µg/L) conditions (MBNEP, 2008). This plot shows that chlorophyll-a concentrations in Halls Mill Creek are almost always in the fair to good range, with only one measured value in the poor range. Although chlorophyll-a data from Halls Mill Creek is limited, available data appear to show a substantially decreasing trend.

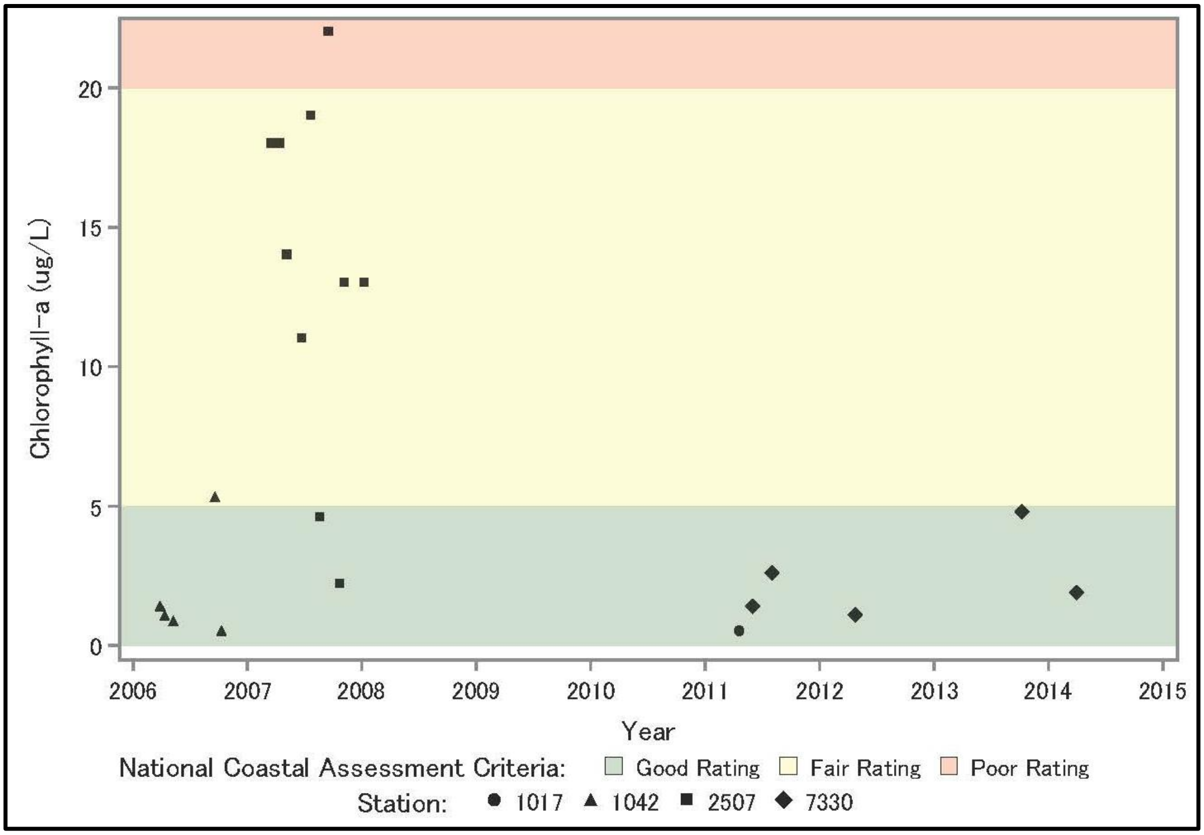

Figure 5.1.5: Composite time series of chlorophyll-a concentrations at ADEM stations in the tidally-influenced portion of Halls Mill Creek

Note: Station 1017 is located in the freshwater reach not the tidally-influenced portion of Halls Mill Creek.

Nutrients

As noted earlier, chlorophyll-a concentrations are driven by nutrients, primarily nitrogen and phosphorus, in the water column. Nutrients enter surface waterbodies from a number of sources including: stormwater runoff from fertilized agricultural areas; golf courses; urban green spaces; domestic wastewater discharges; and even pet waste.

Threshold values (good, fair, poor) for evaluating concentrations of total nitrogen (TN) and total phosphorus (TP) in this WMP were established by using “swapped” criteria thresholds from those published in MBNEP (2008) for TN and TP [i.e., MBNEP (2008) described threshold values for TN are used herein to assess TP, while MBNEP (2008) described threshold values for TP are used herein to assess TN]. After consultation with ADEM and the EPA, it was concluded that the threshold criterion for TN and TP provided in MBNEP (2008) were likely reversed; therefore, to correct for this discrepancy, threshold values were inversely applied for TN and TP in this report.

Figures 5.1.6 and 5.1.7 show time series plots of TN and TP data, respectively, from multiple stations in the tidally-influenced segments of the Halls Mill Creek Watershed. The threshold criteria for TN include good (<0.4 mg/L), fair (0.4 – 0.8 mg/L), and poor (>0.9 mg/L), while the threshold criteria for TP include good (<0.02

mg/L), fair (0.02 – 0.04 mg/L), and poor (>0.04 mg/L).

Figure 5.1.6 shows TN concentrations in Halls Mills Creek to be almost always in the fair range with a few excursions into both the poor and good ranges. Figure 5.1.6 shows TP concentrations measured from 2006 to 2008 ranged from good to poor with the majority in the poor range. However, TP concentrations measured from 2011 to 2015 showed a substantial decrease from the previous sampling period with virtually all measurements falling within the good and fair ranges. In conclusion, these findings show that Halls Mill Creek is not excessively nutrient-enriched and that phosphorus concentrations appear to have declined significantly in recent years.

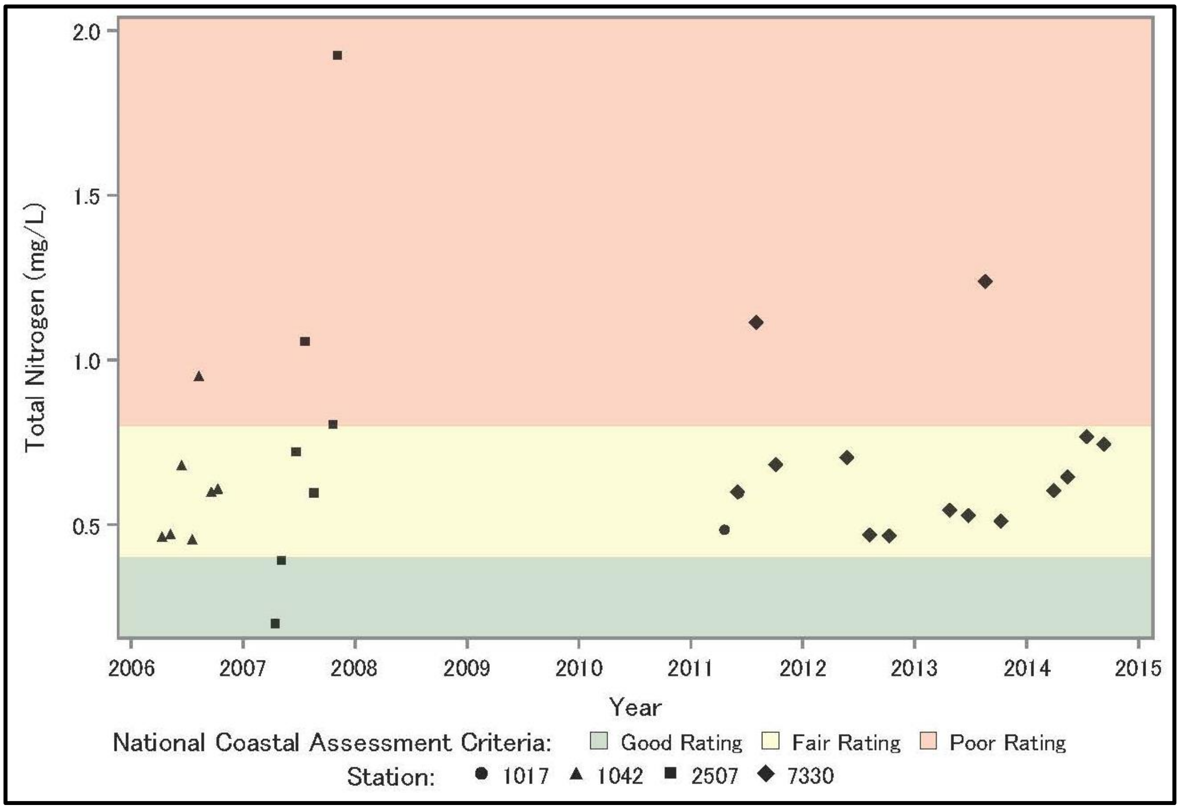

Figure 5.1.6: Composite time series of TN concentrations in the tidally-influenced portion of Halls Mill Creek

Note: Station 1017 is located in the freshwater reach not the tidally-influenced portion of Halls Mill Creek.

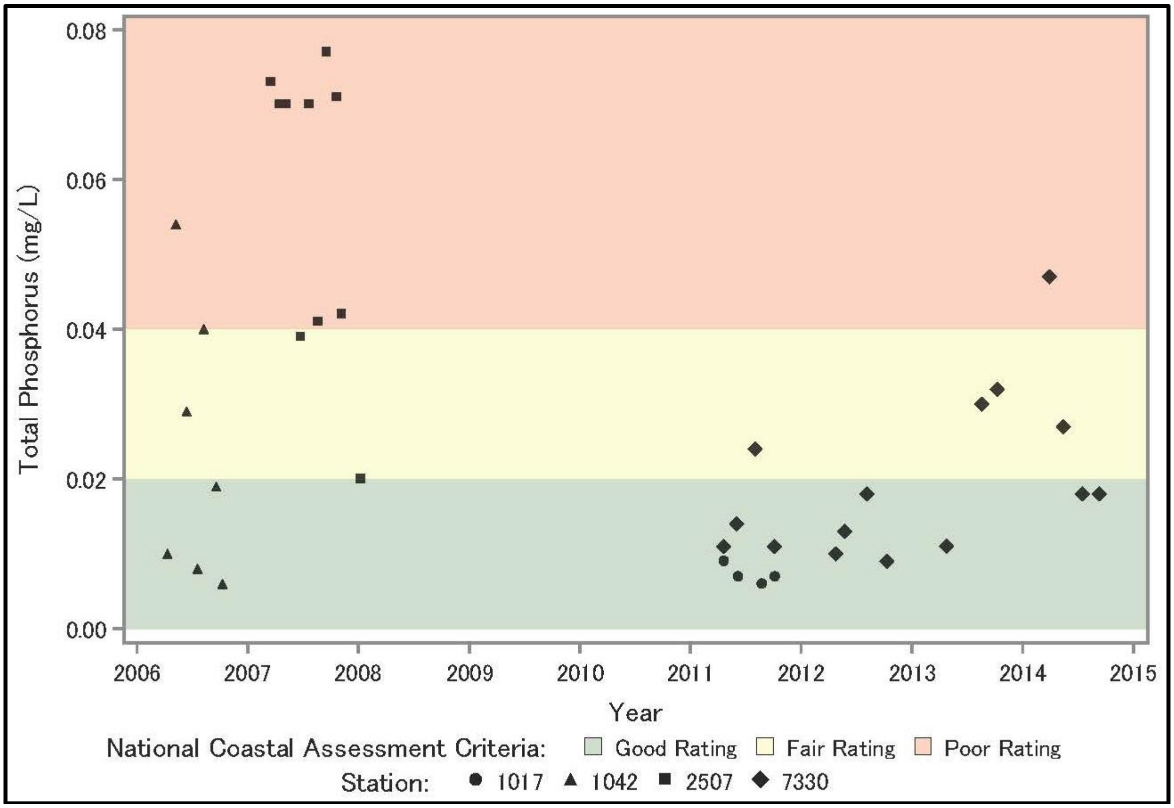

Figure 5.1.7: Composite time series of TP concentrations in the tidally-influenced portion of Halls Mill Creek

Note: Station 1017 is located in the freshwater reach not the tidally-influenced portion of Halls Mill Creek.

Bacteria

All healthy surface waters contain a wide range of naturally-occurring bacteria. However, when bacterial concentrations become excessive and are dominated by bacterial indicator species, excessive organic enrichment and the presence of human pathogens, such as disease-causing bacteria and viruses, are possible. Sources of excessive and potentially harmful bacteria in surface waters include untreated domestic wastewater discharges from sanitary sewer overflows (SSOs) or septic tank seepage; animal waste from livestock farms, pets, and bird colonies; and even decaying grass clippings and other organic matter.

Figure 5.1.8 shows a time series plot of bacteria concentrations measured as most probable number (MPN) of enterococcus cells at ADEM Stations 2507 and 7330. ADEM Station data in Figure 5.1.8 are compared to applicable Code of Alabama Section 335-6-11 designated and desired uses categories for Fish and Wildlife and Swimming and Other Whole Body Water-Contact Sports regulatory criteria thresholds. This plot shows bacteria concentrations in the 2011 to 2015 period frequently exceeded the coastal thresholds for Fish and Wildlife and Swimming and Other Whole Body Water-Contact Sports uses, and have increased compared to the previous 2007-2008 sampling period.

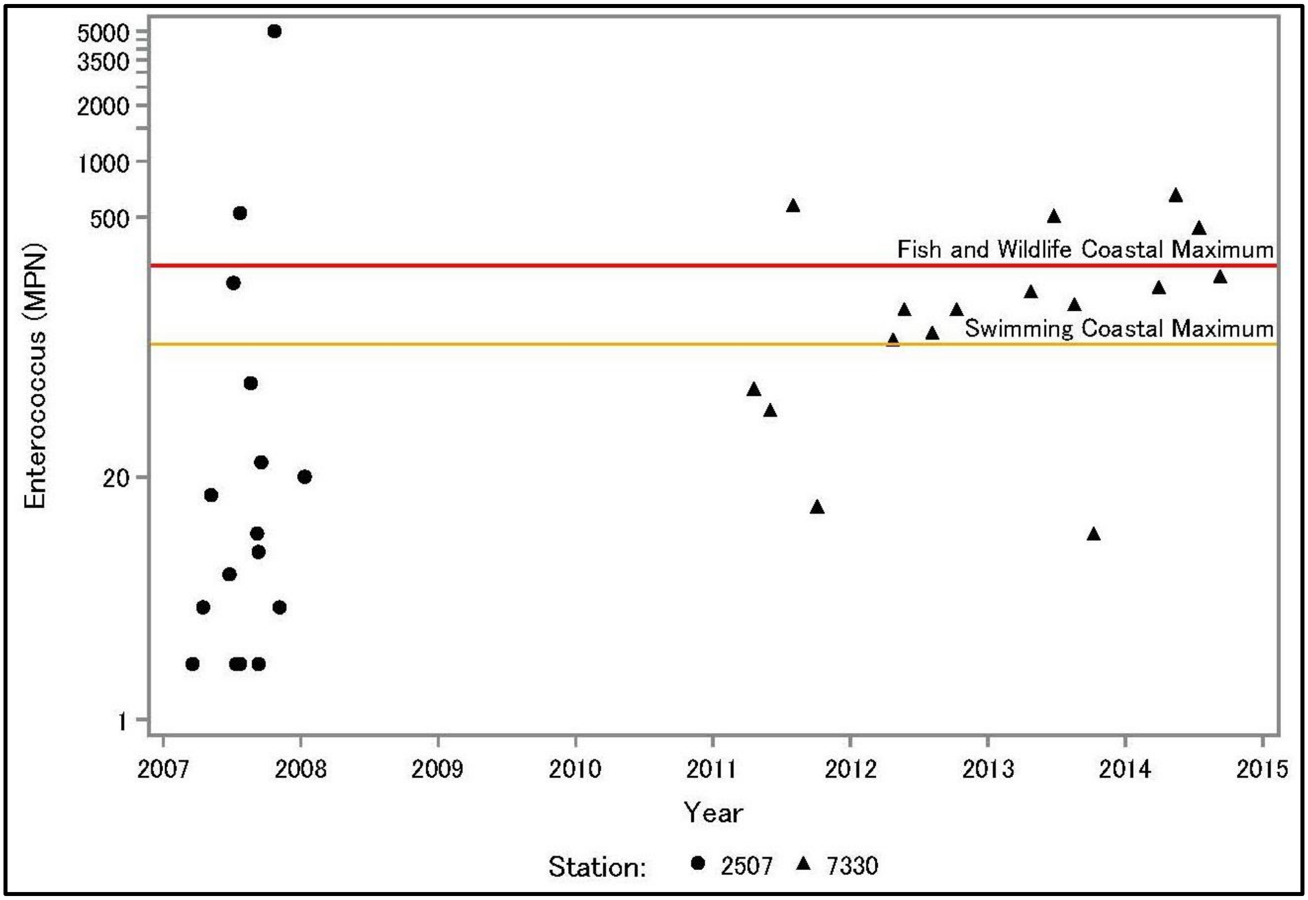

Figure 5.1.8: Composite time series of bacteria concentrations for ADEM Stations 2507 and 7330 in Halls Mill Creek

Note: Y-axis is plotted using a Log-10 scale.

5.1.4.3 Upper Dog River Watershed

The Upper Dog River Watershed encompasses 34.08 square miles with approximately 304,762 feet (or 58 miles) of surface water drainages (USGS, 2017). From the western and northern boundaries of the Watershed to the confluence with Dog River, the relief is approximately 210 feet. The majority of that relief occurs in the western and northern portions of the area within the Southern Pine Hills physiographic district where tributary drainages are well-defined because of the greater topographic relief. The northwestern portion of this Watershed, north and west of U.S. Highway 90, is an upland area exhibiting as much as 100 feet of relief in incised drainages. The gentle topography of the Coastal Lowlands district is favorable for the creation of floodplains and wetland areas along drainages. East of U.S. Highway 90, the total relief is roughly 40 feet.

Water quality sampling stations in the Upper Dog River Watershed are shown in Figure 5.1.9. ADEM station 541 provides the most long-term data from the upper portion of Dog River with a period of record dating from 1978 to present. During the production of this document, AWW/DRCR initiated routine sampling at new locations within the Upper Dog River Watershed. Those data are not included in the characterization of this Watershed.

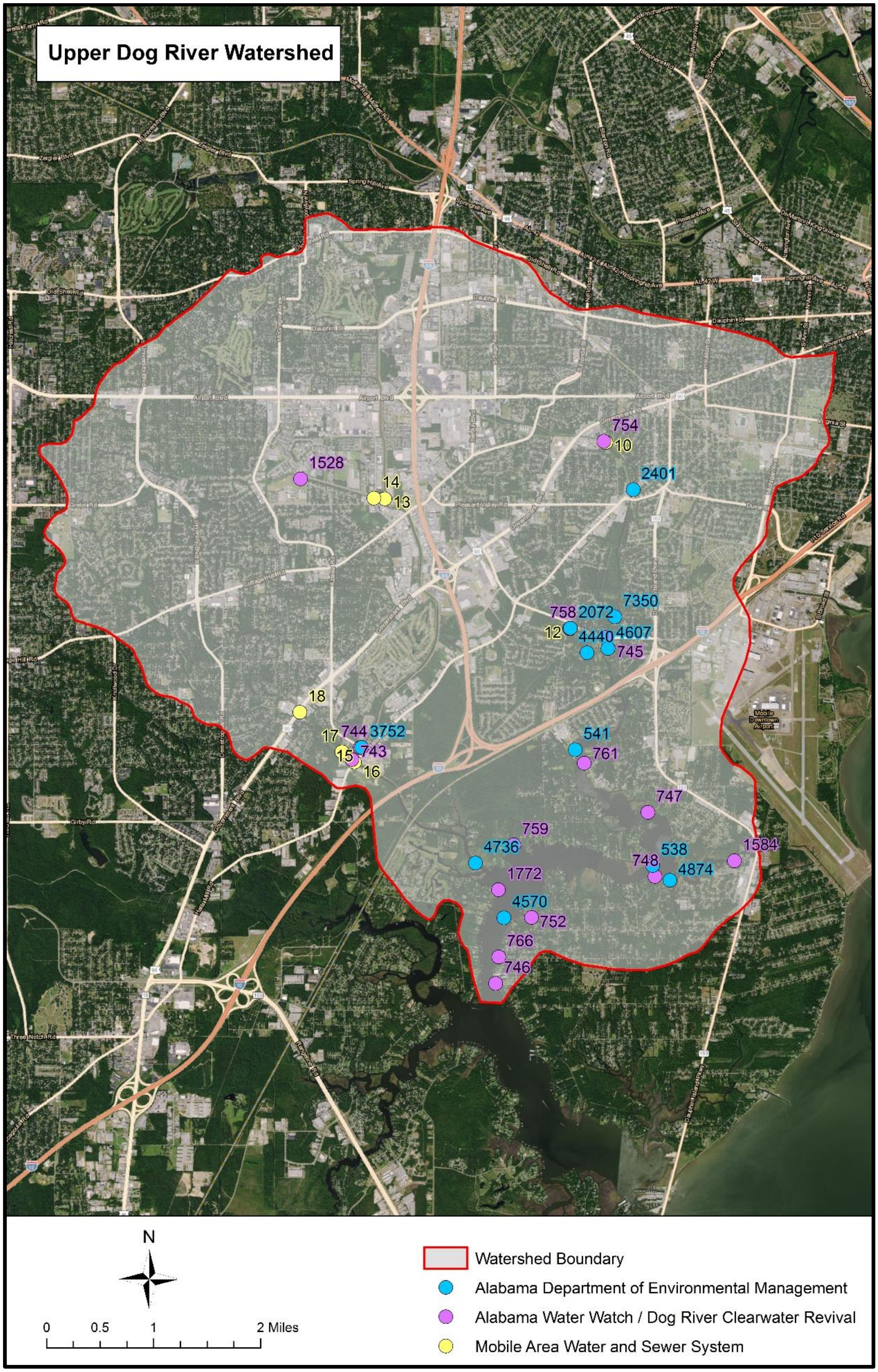

Figure 5.1.9: Water quality sampling stations in the Upper Dog River Watershed

Dissolved Oxygen

Figure 5.1.10 gives a time series plot of DO data from multiple water quality stations in the Upper Dog River Watershed compared to ADEM's coastal and freshwater criteria thresholds for Fish and Wildlife and Swimming and Other Whole Body Water-Contact Sports. Figure 5.1.10 shows DO concentrations frequently violating the regulatory criteria for both uses, and shows violations have become much more frequent since 2005.

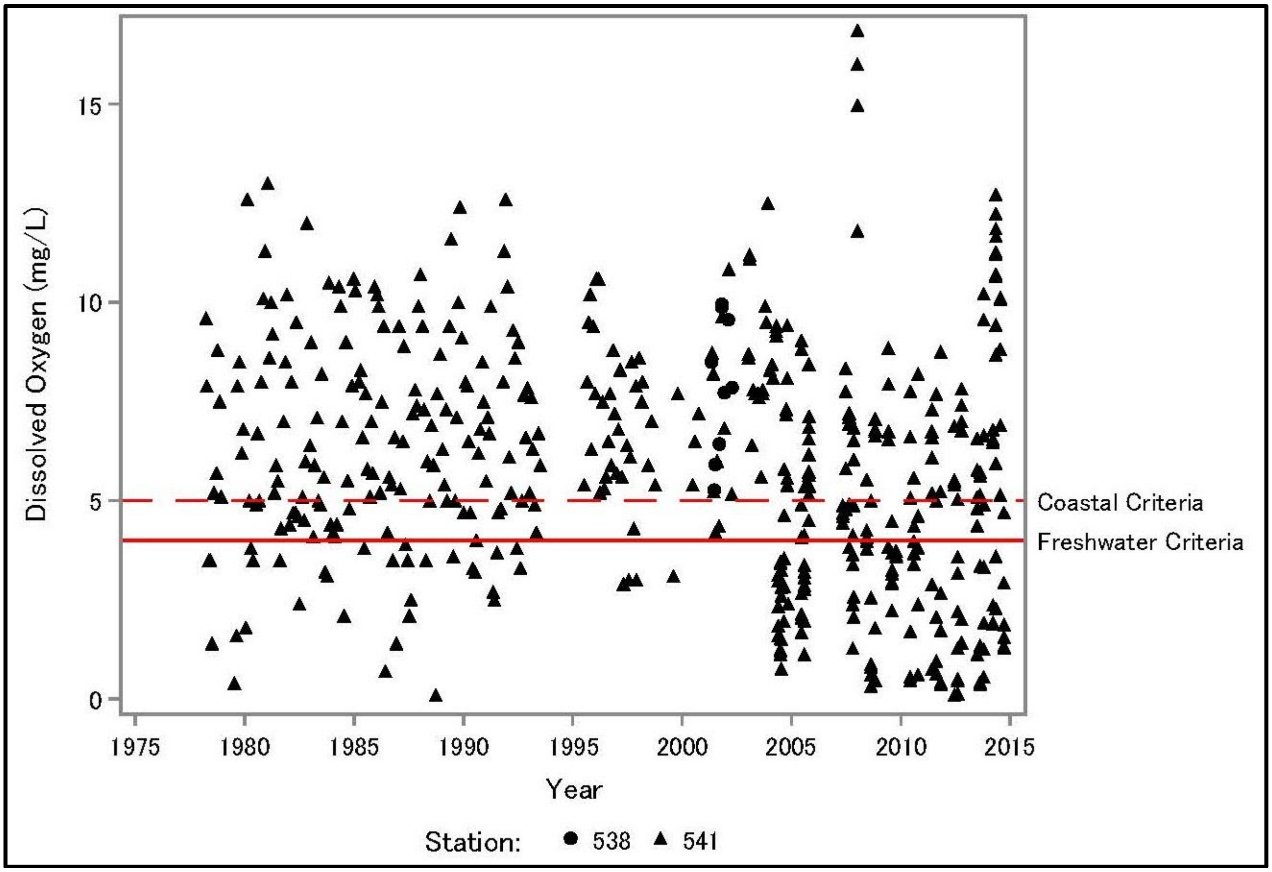

Figure 5.1.10: Composite time series of DO concentrations from multiple stations in the upper portion of Dog River

A data series of vertical DO profiles taken at ADEM station 541 are shown in Figure 5.1.11. These profiles show DO concentrations decrease with depth and frequently approach zero near the bottom. These patterns indicate excessive organic enrichment and associated microbial respiration below the salinity stratification depth, resulting in frequent occurrences of DO concentrations falling below the regulatory standard.

Multiple tributaries discharge into upper Dog River each with unique watershed characteristics (e.g., land use, residence time, etc.). Upon comparing the overall trend in DO concentrations between tributaries, it appears DO concentrations in the Eastern tributaries (East Eslava Creek and East Bolton Branch) were more frequently depressed below the Coastal Criteria (5 mg/L) compared to the Western tributaries (Montlimar Canal and Moore Creek).

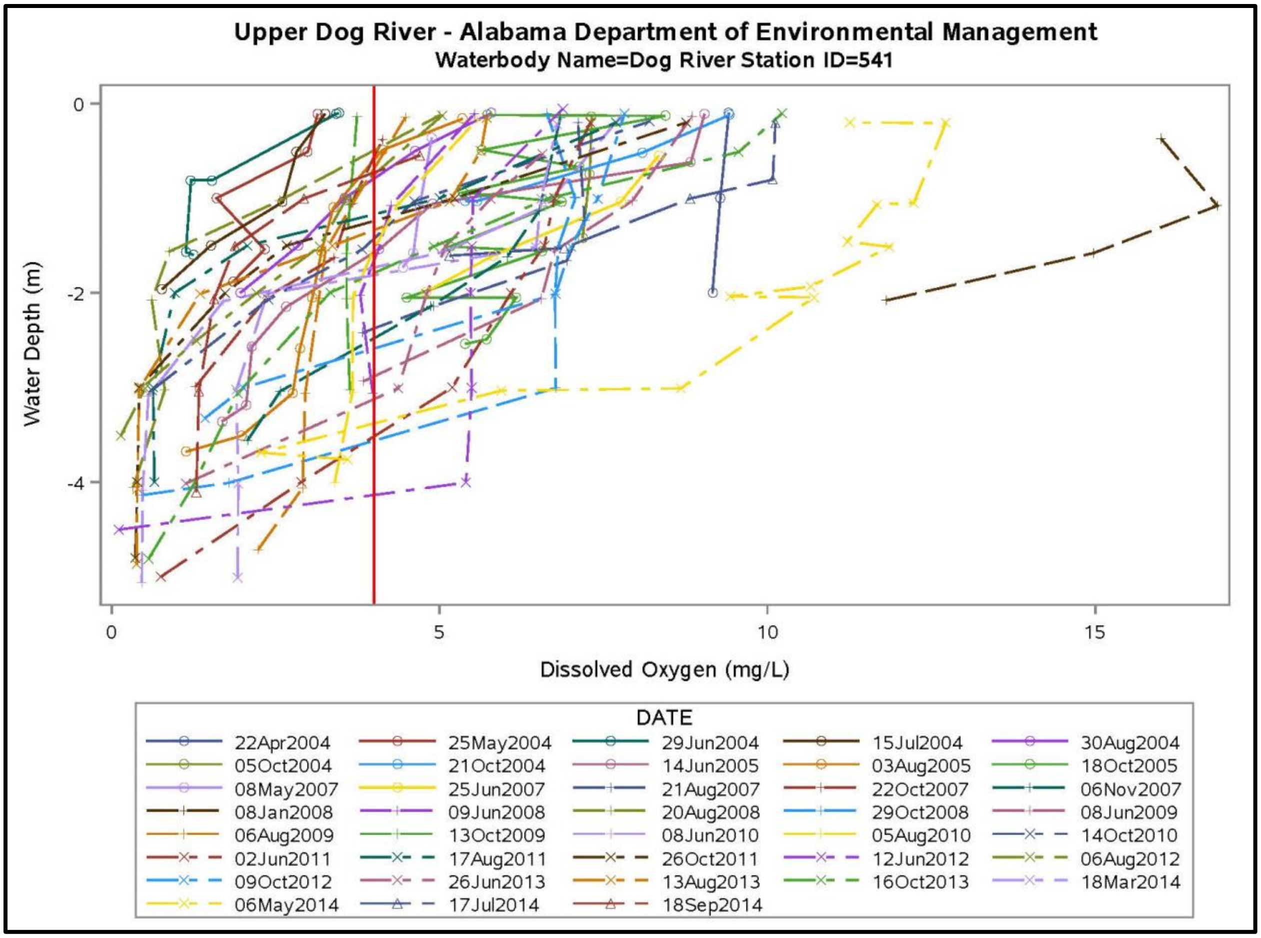

Figure 5.1.11: Data series of DO profiles at ADEM Station 541 in the upper portion of Dog River

Chlorophyll-a

Figure 5.1.12 shows a time series plot of chlorophyll-a data from multiple stations in tidally-influenced segments of the upper portion of Dog River with NCA criteria for good (‹ 5μg/L), fair (5-20 μg/L), and poor (› 20μg/L) conditions (MBNEP, 2008). Figure 5.1.12 shows chlorophyll-a concentrations in upper portions of Dog River are generally in the fair range with frequent samples found in the poor range.

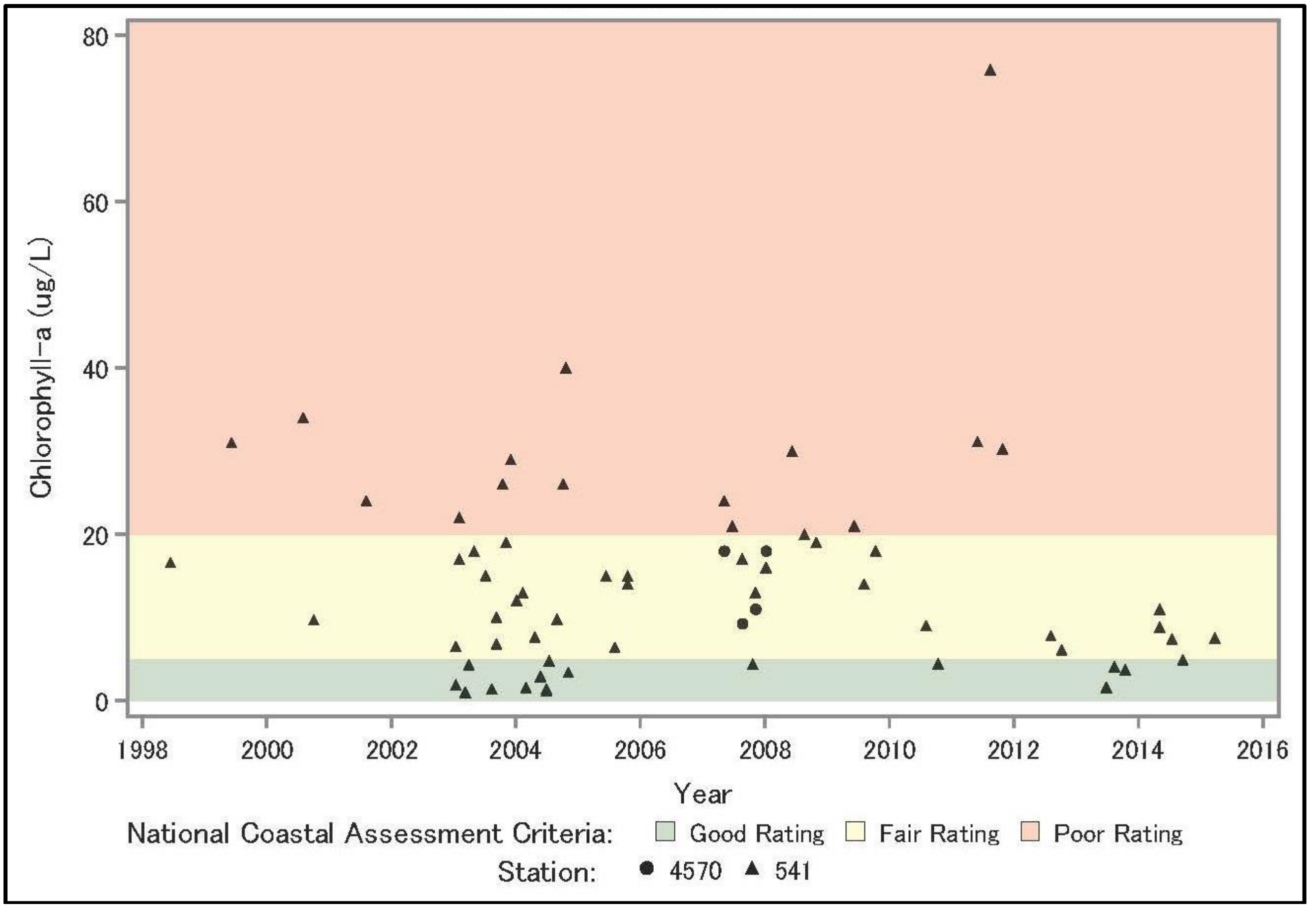

Figure 5.1.12: Composite time series chlorophyll-a concentrations at multiple stations in the tidally-influenced portion of upper Dog River

Nutrients

Figures 5.1.13 and 5.1.14 display time series plots of TN and TP data, respectively, from multiple stations in tidally-influenced segments of the Upper Dog River Watershed. The threshold criteria for TN include good (‹0.4 mg/L), fair (0.4 – 0.8 mg/L), and poor (›0.9 mg/L), while the threshold criteria for TP include good (‹0.02 mg/L), fair (0.02 – 0.04 mg/L), and poor (›0.04 mg/L). These plots show TN concentrations in upper portions of Dog River are almost always in the fair or poor range, while TP are virtually always in the poor range. These findings show that the upper portion of Dog River is nutrient enriched with particularly high phosphorus concentration.

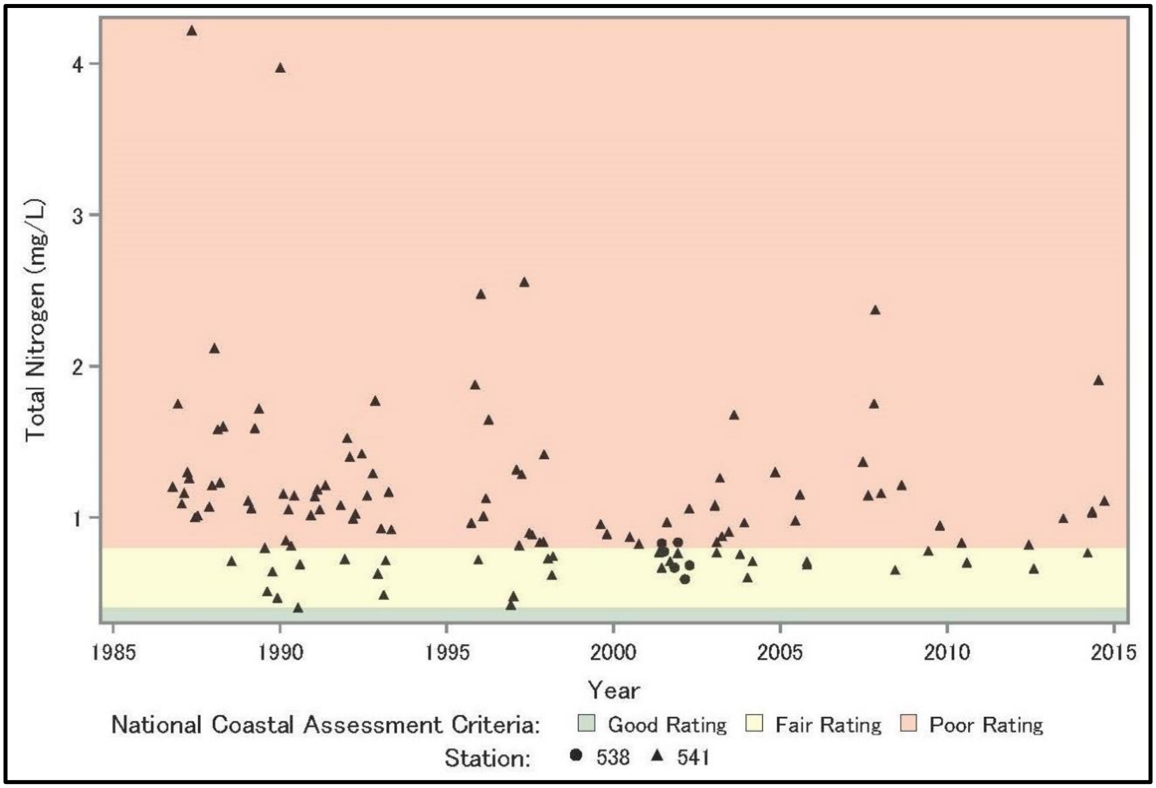

Figure 5.1.13: Composite time series of TN concentrations from multiple stations in the tidally-influenced portion of upper Dog River

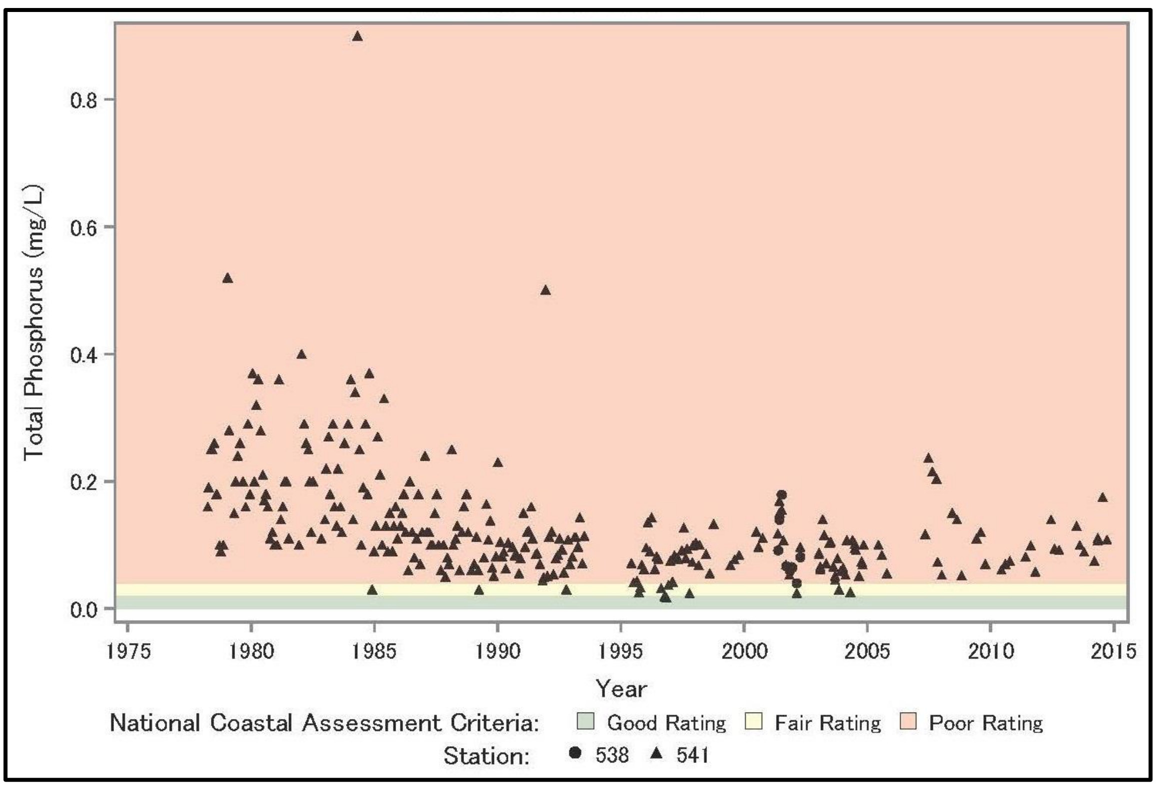

Figure 5.1.14: Composite time series of TP concentrations from multiple stations in the tidally-influenced portion of upper Dog River

Bacteria

Figure 5.1.15 shows a time series plot of bacteria concentrations measures as most probable number (MPN) of enterococcus cells at ADEM Station 541 with applicable regulatory criteria indicated. Figure 5.1.15 shows sampled bacteria concentrations at this location are almost always less than the regulatory standards, indicating generally safe swimming conditions.

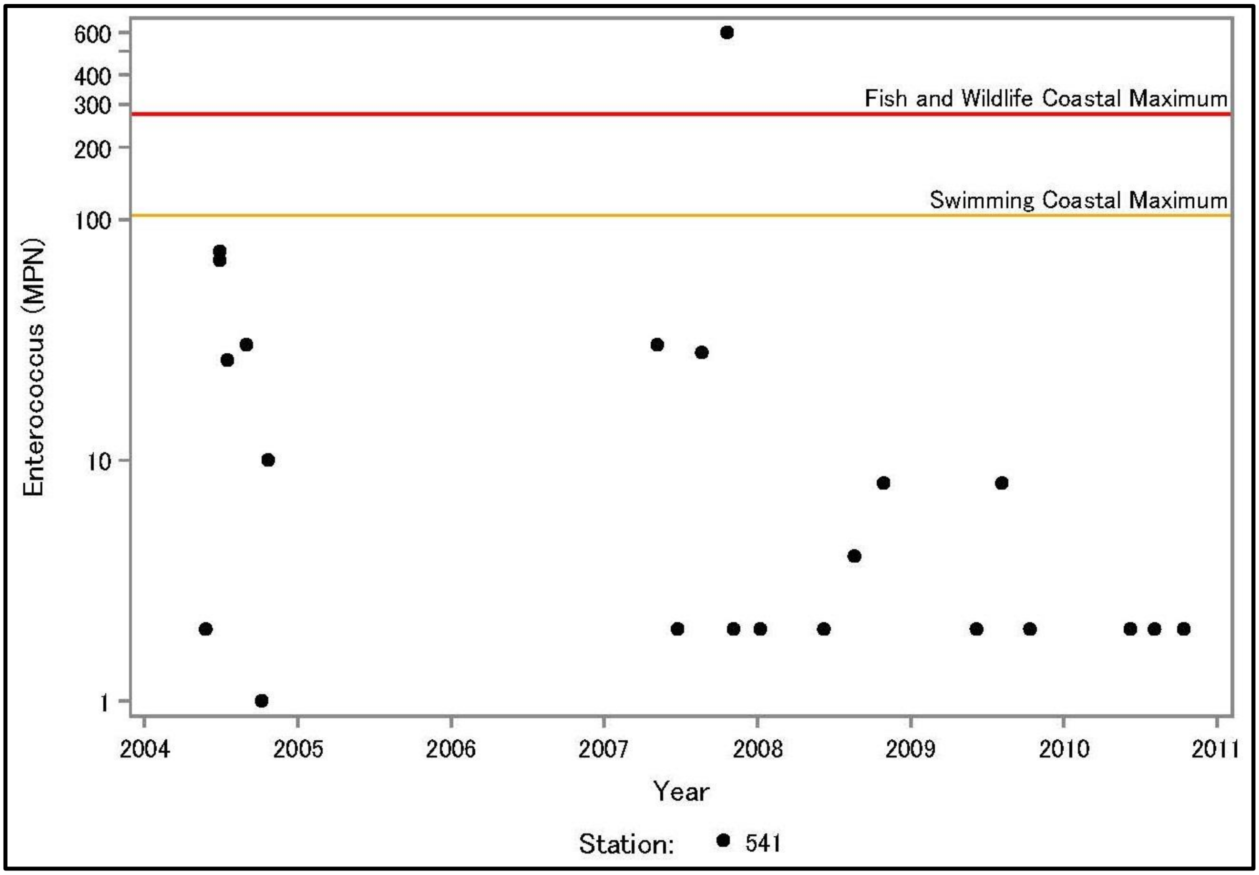

Figure 5.1.15: Composite time series of bacteria concentrations for ADEM Station 541 in the upper portion of Dog River

Note: Y-axis is plotted using a Log-10 scale.

A time series plot of bacteria concentrations at ADEM stations 4607 and 7350, located on East Eslava Creek, the primary tributary to upper Dog River, are displayed in Figure 5.1.16. This plot shows bacterial concentrations in the upper reaches of East Eslava Creek frequently exceed regulatory standards. This finding is further supported by data from MAWSS. High bacterial concentrations are also typical in the other tributaries in the Upper Dog River Watershed. Intensely urbanized, these tributaries have experienced documented SSOs and numerous illicit discharges.

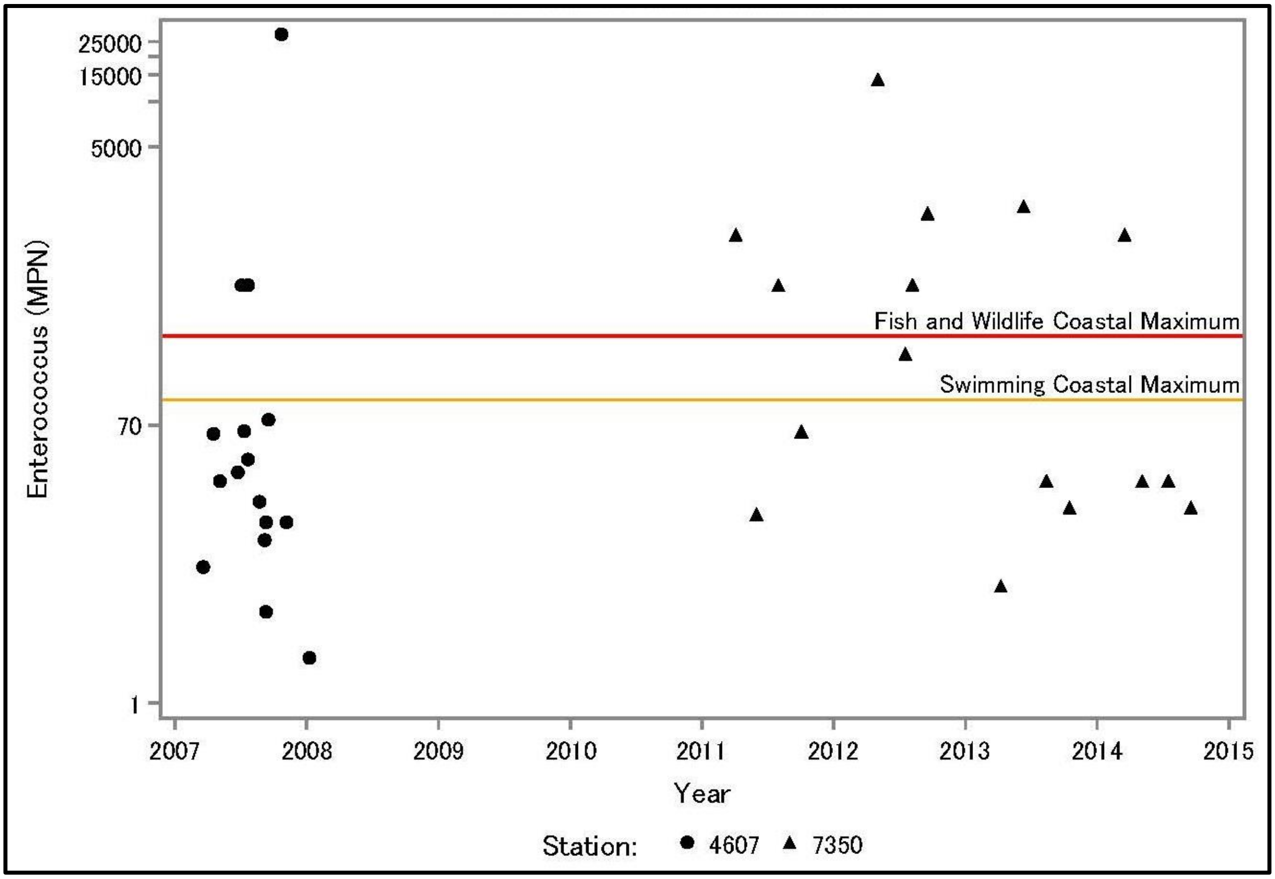

Figure 5.1.16: Composite time series of bacteria concentrations for ADEM Stations 4607 and 7350 located on East Eslava Creek in the upper portion of Dog River

Note: Y-axis is plotted using a Log-10 scale.

5.1.4.4 Lower Dog River Watershed

The Lower Dog River Watershed encompasses approximately 26.58 square miles with approximately 271,599 feet (over 51 miles) of surface water drainages (USGS, 2017). The relief within the Watershed is approximately 70 feet. The majority of that relief occurs in the western half of the area within the Southern Pine Hills physiographic district. Tributary drainages are well defined within the Southern Pine Hills district because of its greater topographic relief while the gentle topography of the Coastal Lowlands district is favorable to the creation of floodplains and wetland areas along drainages. The total relief of the floodplain of the Lower Dog River Watershed east of U.S. Highway 90 is approximately 30 feet.

The Lower Dog River Watershed includes lower portions of Dog River as well as Rabbit Creek and Alligator Bayou. Sampling stations in this Watershed are shown in Figure 5.1.17. In terms of sampling intensity, long-term ADEM stations 537 (Dog River confluence with Mobile Bay), 1019 (Dog River estuary near Alligator Bayou), and 7331 (Rabbit Creek upstream of Rangeline Road) have the largest number of samples.

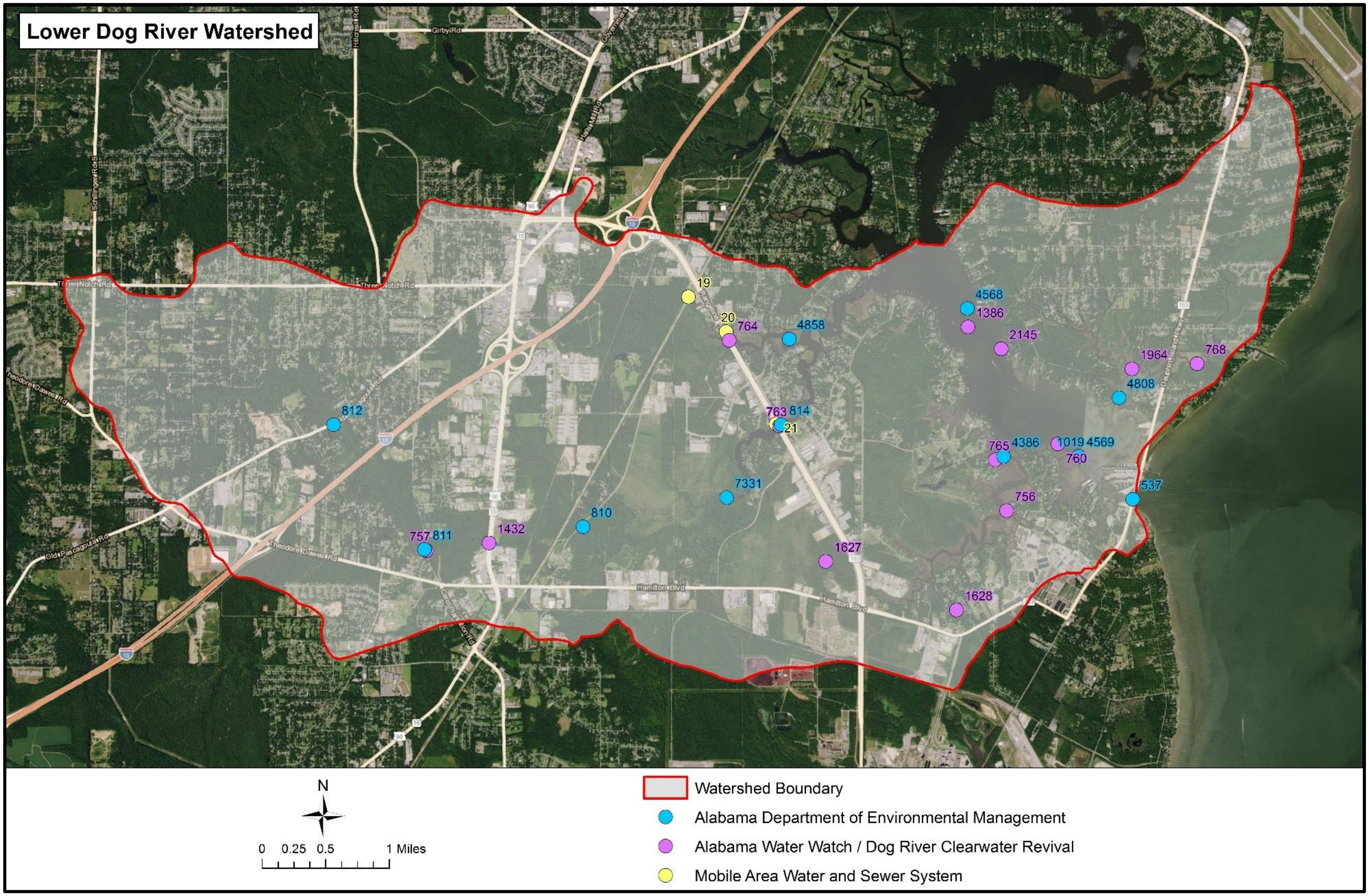

Figure 5.1.17: Water quality sampling stations in the Lower Dog River Watershed

Dissolved Oxygen

A plot of DO data from ADEM stations 1019 and 537 with both the coastal and freshwater criteria is shown on Figure 5.1.18. This plot reveals DO concentrations are almost always exceeding the regulatory minimum. The measured maximum DO concentrations have decreased since 2007.

Similar trends in healthy oxygenated waters were observed in several of the tributaries to Lower Dog River Watershed including Rabbit Creek and Rattlesnake Bayou. In contrast, recent DO data collected by AWW/DRCR in Perch Creek were consistently below the coastal criteria (5 mg/L). This preliminary dataset is limited making it difficult to draw definitive conclusions on the DO status of Perch Creek. However, it demonstrates the importance of continual water quality monitoring in order to capture changes in water quality status which may be directly or indirectly impacted by alterations within the Watershed.

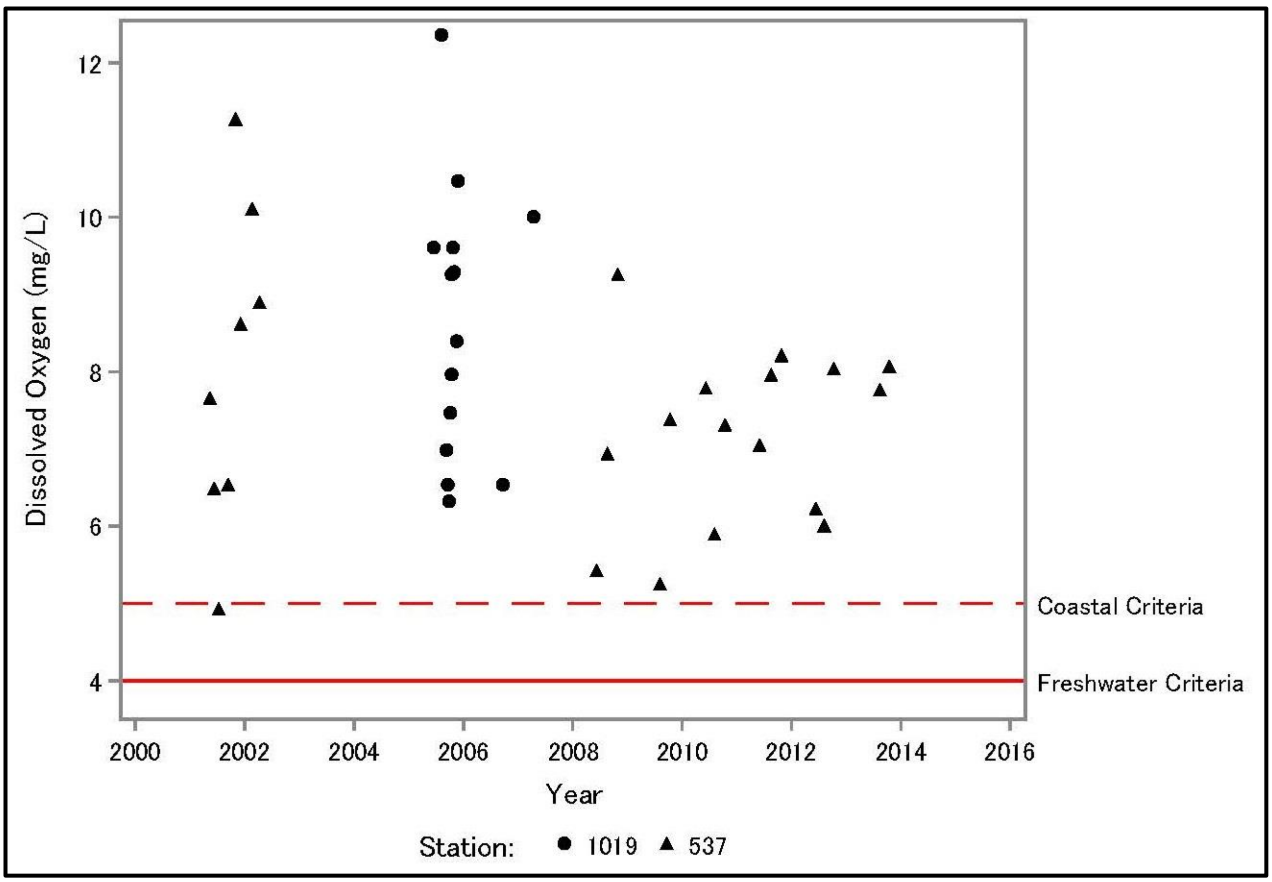

Figure 5.1.18: Composite time series of DO concentrations at ADEM Stations 1019 and 537 in lower Dog River

The data series of vertical DO profiles taken at ADEM station 1019 (Figure 5.1.19) profiles DO concentrations that are generally evenly-mixed throughout the water column and do not decrease substantially below the salinity stratification depth. These patterns indicate a healthy oxygen environment for fish and shellfish, with normal levels of organic enrichment and associated bacterial respiration.

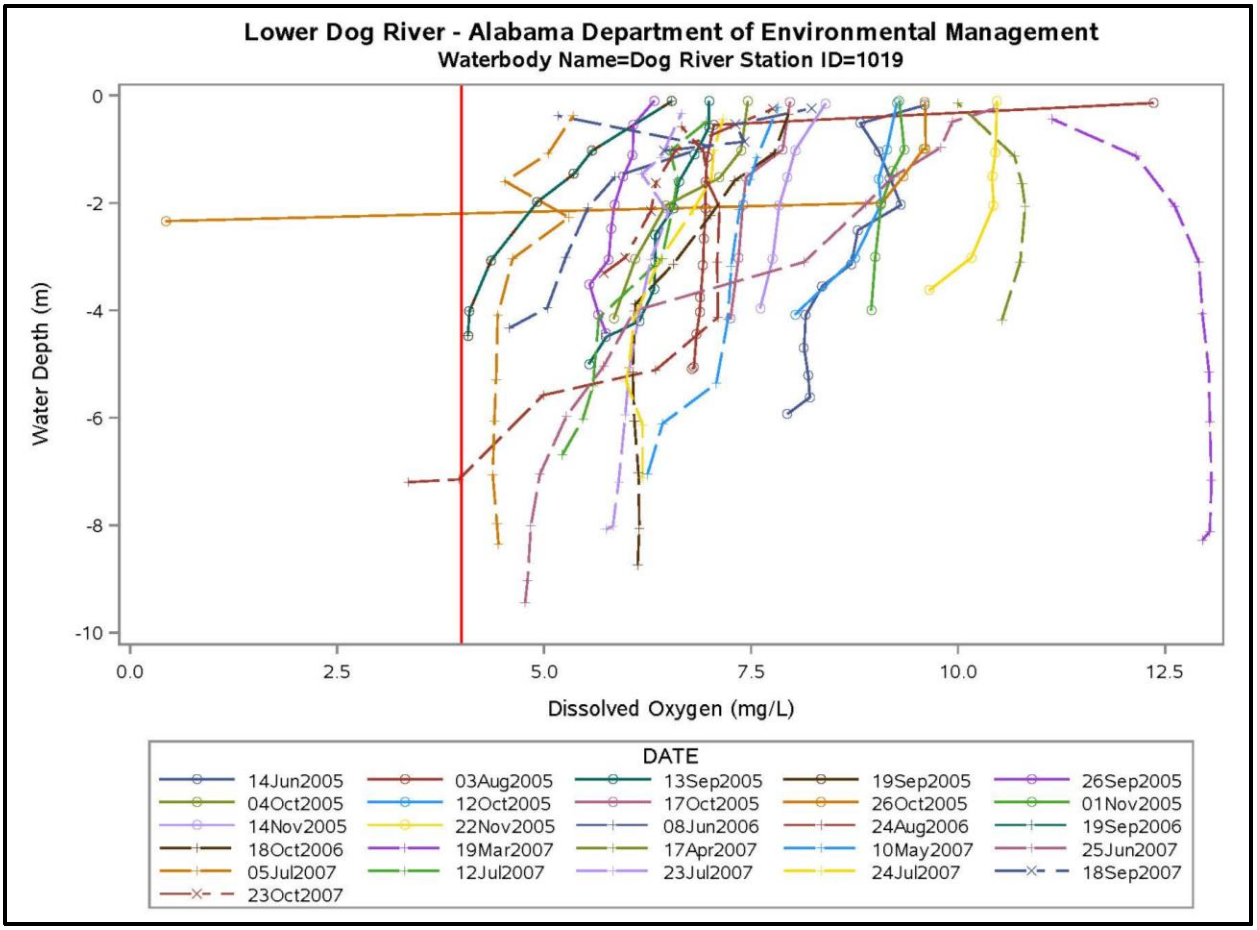

Figure 5.1.19: Date series of DO profiles at ADEM Station 1019 in lower portions of Dog River

Chlorophyll-a

Chlorophyll-a time series data from multiple ADEM stations in tidally-influenced segments of lower portions of Dog River are shown in Figure 5.1.20 with NCA criteria for good (‹ 5µg/L), fair (5-20 µg/L), and poor (› 20µg/L) conditions (MBNEP, 2008). This plot shows that chlorophyll-a concentrations in these segments are almost always in the fair to good range with a significantly decreasing trend over the past decade. These findings indicate that lower portions of Dog River are well-flushed and rarely exhibit problematic algae blooms.

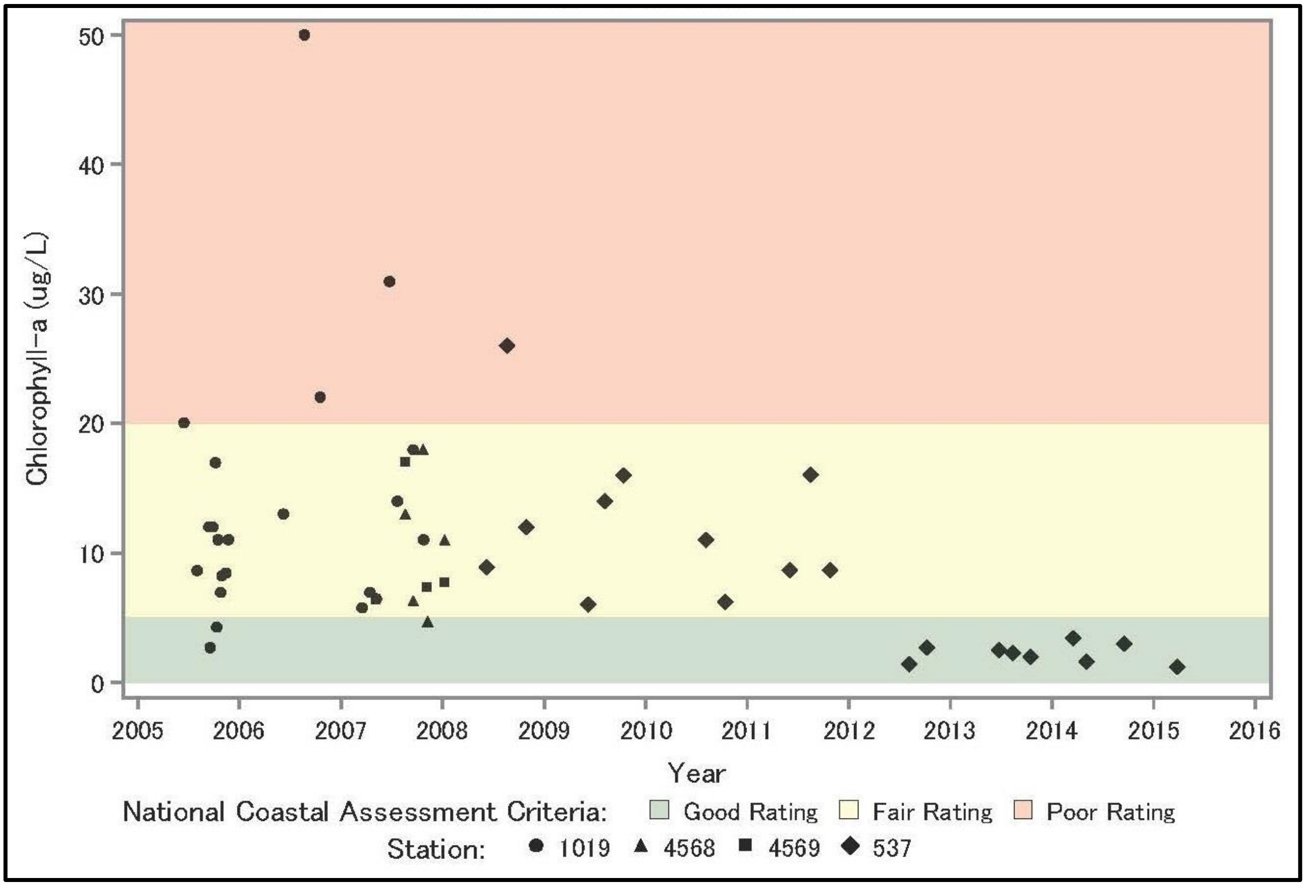

Figure 5.1.20: Composite time series of chlorophyll-a concentrations at multiple stations in the tidally-influenced portion of lower Dog River

Nutrients

Figures 5.1.21 and 5.1.22 display time series plots of TN and TP data, respectively, from multiple stations in tidally-influenced segments of the Lower Dog River Watershed. The threshold criteria for TN include good (<0.4 mg/L), fair (0.4 – 0.8 mg/L), and poor (>0.9 mg/L), while the threshold criteria for TP include good (<0.02 mg/L), fair (0.02 – 0.04 mg/L), and poor (>0.04 mg/L).

These plots show that TN concentrations in these segments are almost always in the fair to poor range, while TP is mostly in the poor range. There are no significant trends in either TN or TP. Nutrient concentrations at these levels could potentially give rise to problematic algae blooms; however, the efficient tidal flushing in these segments is likely responsible for the relatively low observed chlorophyll-a concentrations.

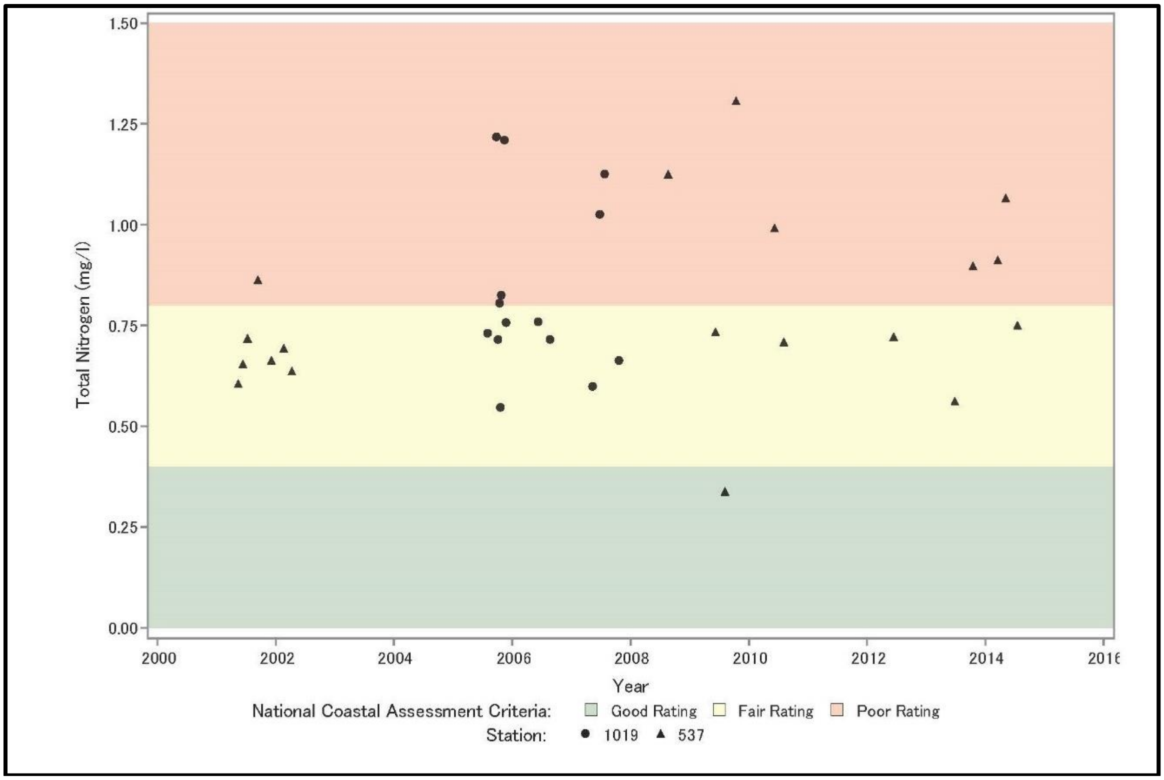

Figure 5.1.21: Composite time series of TN concentrations from multiple stations in the tidally-influenced portions of lower Dog River

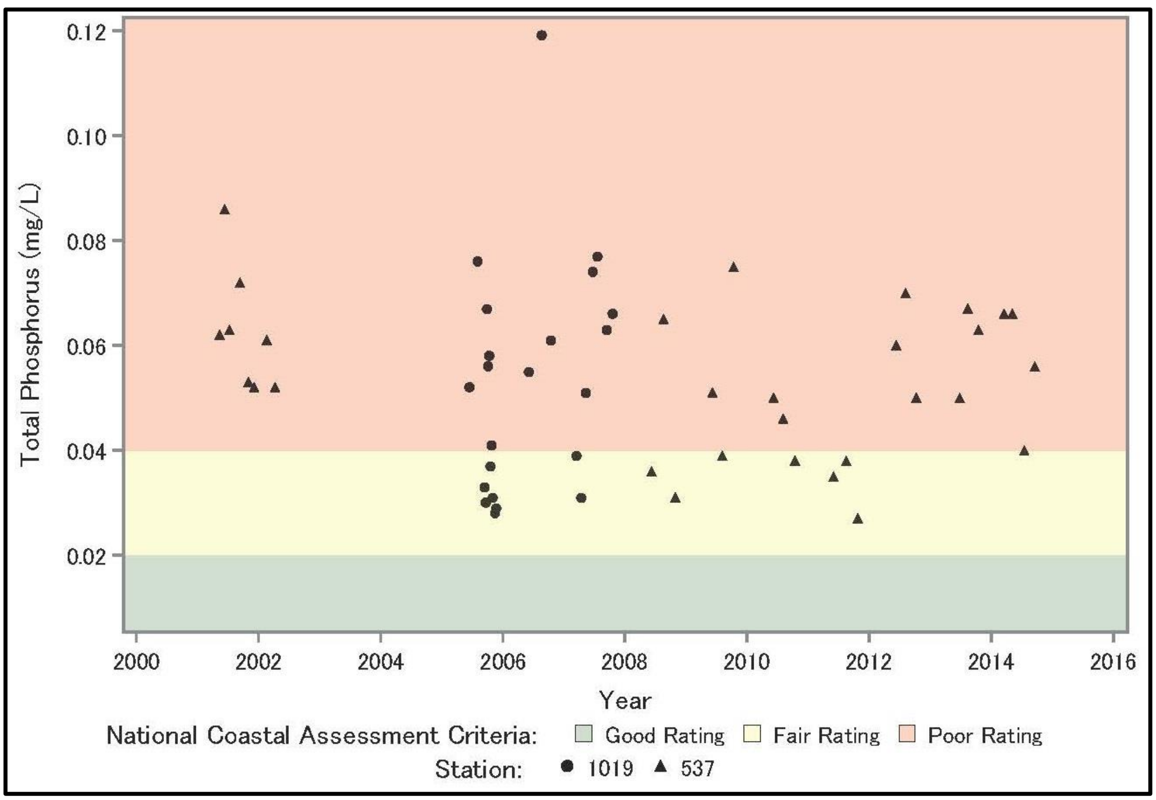

Figure 5.1.22: Composite time series of TP concentrations from multiple stations in the tidally-influenced portions of lower Dog River

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Bacteria

Concentrations of bacteria measured as most probable number (MPN) of enterococcus cells are shown in Figure 5.1.23 for ADEM Stations 1019 and 537 along with the applicable regulatory criteria. This time series plot reveals that bacteria concentrations are almost always below the swimming coastal maximum, and are frequently at very low concentrations. As with chlorophyll-a, the efficient tidal flushing and associated dilution with waters of Mobile Bay probably contributes to the low observed bacteria concentrations in lower portions of Dog River.

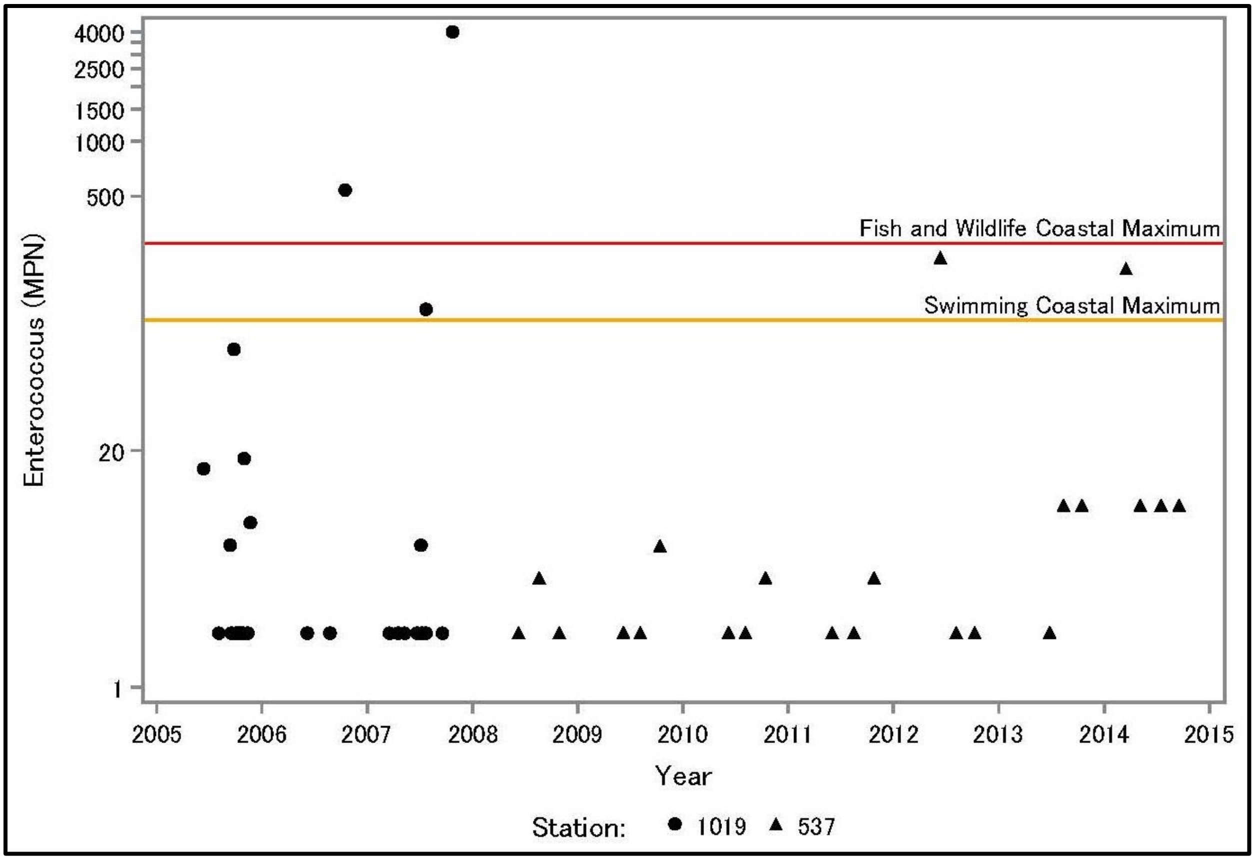

Figure 5.1.23: Composite time series of bacteria concentrations for ADEM Stations 1019 and 537 in lower portions of Dog River

Note: Y-axis is plotted using a Log-10 scale.

5.1.4.5 Metals and Organics

ADEM has analyzed surface water samples from the greater Dog River Watershed for several common heavy metals including: arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. However, the data for these parameters are very sparse. The data that are available generally indicate that metals concentrations in Dog River surface waters are frequently below detection levels and generally well below established EPA chronic and acute threshold levels.

There are insufficient data in the available ambient surface water datasets to assess organic contaminants in the greater Dog River Watershed.

5.1.4.6 Sediment

In 2012, GSA (Cook and Moss, 2012) conducted a study for the MBNEP to assess sediment loading rates in the greater Dog River Watershed. The Cook and Moss (2012) study is provided in Appendix A. In this study, GSA conducted field sampling and site assessments and calculated total sediment loads in ten (10) tributaries in the greater Dog River Watershed. Total sediment loads include both suspended and bed sediments. GSA sediment sampling sites are shown in Figure 5.1.24.

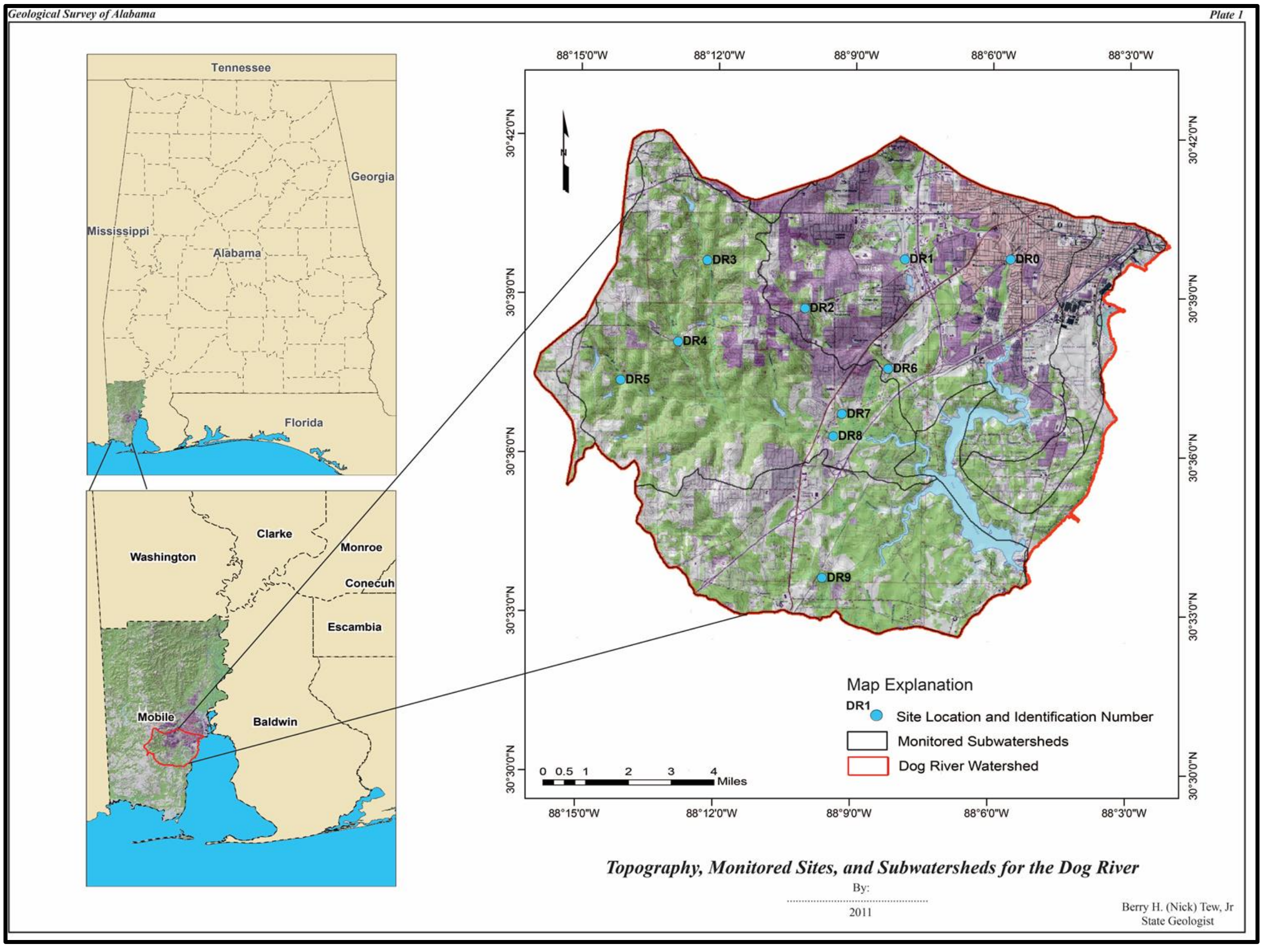

Figure 5.1.24: GSA monitoring site locations in the greater Dog River Watershed (from Cook and Moss, 2012)

Suspended sediment is defined as that portion of a water sample that can be separated from the water by filtering. This solid material may be composed of organic and inorganic particles such as algae; industrial and municipal wastes; urban and agricultural nonpoint source pollutants carried by runoff; and sand, silt, and eroded material from geologic formations. These materials are transported to stream channels by overland flow related to stormwater runoff and cause varying levels of turbidity. Bed load sediment is composed of streambed particles too large or too dense to be carried in suspension by flow. Transport of streambed material is controlled by a number of factors including: stream discharge and flow velocity; erosion and sediment supply; stream base level; and physical properties of the streambed material. Most streambeds are in a state of constant flux in order to maintain a stable base level elevation. Local factors affecting base level include fluctuations in the water table elevation, changes in the supply of sediment to the stream caused by changing precipitation rates, and land use practices that promote excessive erosion in the floodplain or upland areas of a watershed.

GSA completed a study of discharge and sediment loading rates in tributaries of Dog River (Cook and Moss, 2012). The study found stream flow characteristics of tributaries varied widely due to a wide range of landforms, channel types, and flow regimes influenced by urbanization, channel modifications, and floodplain structures. The greatest stream velocities measured were found to be more related to extensive channelization than stream gradient (Cook and Moss, 2012).

Most of the erosion in developed watersheds is caused by human activities. Without human impacts, the natural erosion rate, called the *geologic erosion rate*, would be about 3,546 tons of sediment per year in the ten (10) tributaries sampled in the greater Dog River Watershed. With extensive development and human activity, the ten (10) tributaries carry a calculated 25,577 tons of sediment per annum, greater than seven times the geologic erosion rate.

Figure 5.1.25 shows the estimated total sediment loads for nine (9) monitored tributaries in the greater Dog River Watershed. The largest total annual sediment load (10,803 tons/year) was estimated for East Eslava Creek (Site 10). When the data were normalized, allowing comparison of sediment loads with respect to unit drainage areas, Spencer Branch (Site 2) had the largest sediment loading (4,332 tons/square mile/year). Only Halls Mill Creek tributaries were dominated by bed sediment loads, whereas other tributaries were dominated by suspended sediments.

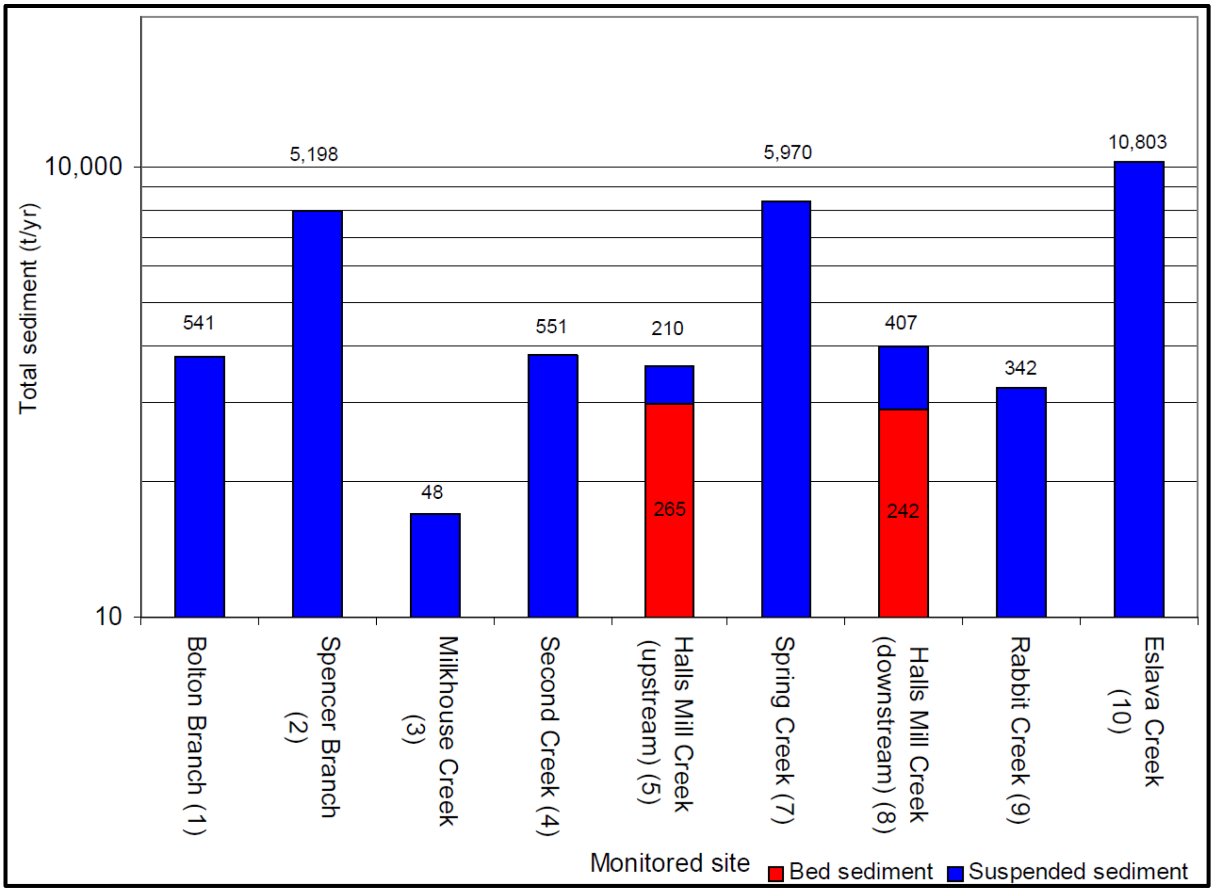

Figure 5.1.25: Estimated total sediment loads for monitored tributaries in the greater Dog River Watershed (from Cook and Moss, 2012)

Comparisons of sediment loads from other watersheds are helpful in determining the severity of erosion problems in a watershed of interest. GSA compared estimates of sediment loads of Dog River and its tributaries to those from Magnolia River at U.S. Highway 98, D'Olive Creek at U.S. Highway 90, and Tiawasee Creek upstream of Lake Forest in Baldwin County. From this comparison, it was determined that sediment loads estimated for Spencer Branch, Spring Creek, and Eslava Creek in the greater Dog River Watershed are among the highest of about 55 streams assessed by GSA statewide. These findings reflect the impacts of intense urbanization on stream dynamics, erosion, and sediment loads.

Relative water quality conditions, estimated by accounting for intensity of urban land use and land cover and impervious surface coverages (Chapter 4), are given in Table 5.1.4 for the three watersheds that comprise the greater Dog River Watershed. Generally speaking, conditions improve moving from the upper to the lower portions of the greater Dog River Watershed. This spatial trend is likely due to two factors: 1) the upper Watershed is more intensely developed and 2) the lower Watershed is better flushed and diluted by tidal water exchange with Mobile Bay.

The Upper Dog River Watershed is more impacted with organic and nutrient enrichment, bacteria, and associated hypoxic episodes and algae blooms. This is due to the very intense urban development and extensive hydrologic modifications, including channelization, in this portion of the Watershed. With respect to sediment loads, upper Dog River and its various tributaries are the most problematic. This is due primarily to the topographic relief in the Upper Dog River Watershed, where the hydrologic and erosional effects of urbanization are most amplified and where streamflow velocities are the highest.

Furthermore, the loss of wetland habitat is of significant concern as it contributes to declining water quality and increased sedimentation. Wetlands naturally filter sediment, nutrients, bacteria, and other impurities. The preservation and restoration of existing wetlands in each of the watersheds is essential to the health of the greater Dog River Watershed.

Table 5.1.4: Relative water quality summary assessment for watersheds located in the greater Dog River Watershed (ESA, 2016b)

Parameter Class	Watershed		
	Upper Dog River	Halls Mill Creek	Lower Dog River
Dissolved Oxygen	Poor	Good	Good
Chlorophyll-a	Fair	Good	Good
Nutrients	Poor	Fair	Fair
Bacteria	Poor	Poor	Fair
Metals*	Poor	Good	Good
Sediment	Poor	Fair	Good

* Assessment based on land use and land cover and impervious surfaces rather than sample data

5.1.4.7 National Pollutant Discharge Elimination System (NPDES) Permits

The EPA regulations established Phase I of the National Pollutant Discharge Elimination System (NPDES) stormwater program in 1990. The Phase I program for municipal separate storm sewer systems (MS4s) requires operators serving populations of 100,000 or more to implement a stormwater management program. The goal is to control polluted discharges to the maximum extent practicable. Jurisdiction over permitting and enforcement of the stormwater program in Alabama was assigned to ADEM (City of Mobile, 2016c).

The City of Mobile was issued NPDES Permit Number ALS000007 and, to fulfill the NPDES requirement, developed a Stormwater Management Program. Ten (10) program elements are included in the Plan:

1. Stormwater Collection System Operations;
2. Public Education and Public Involvement on Stormwater Impacts;
3. Illicit Discharges Detection and Elimination (IDDE);
4. Construction Site Stormwater Runoff Control;
5. Post-Construction Stormwater Management in New Development and Re-development;
6. Spill Prevention and Response;

7. Pollution Prevention / Good Housekeeping for Municipal Operations;
8. Application of Pesticide, Herbicide, and Fertilizer (PHFs);
9. Oil, Toxics, and Household Hazardous Waste Control; and
10. Industrial Stormwater Runoff (City of Mobile, 2016c).

The City's Stormwater Management Plan is an MS4-specific comprehensive program to accomplish the following goals (City of Mobile, 2016c):

1. Reduce discharge of pollutants from MS4 to the maximum extent practicable;
2. Monitor stormwater collection system operations;
3. Identify and eliminate illicit discharges and improper disposal into the storm sewer;
4. Develop, implement, and enforce controls to minimize pollutants from construction activities;
5. Develop and implement pollution prevention/good housekeeping practices for municipal operations;
6. Develop and implement stormwater management practices for new developments and re-developments;
7. Reduce discharges of pollutants from the application of pesticides, herbicides, and fertilizers;
8. Prevent, contain, and respond to spills that may discharge into the MS4;
9. Monitor and control pollutants in stormwater discharges from industrial facilities (such as municipal landfills, hazardous waste treatment, sewage treatment, storage, disposal and recovery facilities subject to Emergency Planning and Community Right to Know Act [EPCRA] Title III, Section 313); and
10. Implement public education activities regarding the stormwater management program, recycling programs, household hazardous waste and proper disposal, etc.

5.2 HABITAT CONDITIONS

5.2.1 Invasive Species

The greater Dog River Watershed is host to several invasive species. Site reconnaissance conducted by the Watershed Management Team (WMT) identified several invasive species of concern in the greater Dog River Watershed including:

- Cogongrass (*Imperata cylinrica*)
- Chinese Privet (*Ligustrum sinense*)
- Chinese Tallow or Popcorn Tree (*Triadica sebifera*)
- Japanese Climbing Fern (*Lygodium japonicum*)
- Eurasian Watermilfoil (*Myriophyllum spicatum*)
- Hydrilla (*Hydrilla verticillata*)
- Dotted Duckweed (*Landoltia punctata*)
- Alligatorweed (*Alternanthera philoxeroides*)
- Common Reed *(Phragmites australis)*

The following information was obtained from the Alabama Cooperative Extension System (ACES), ACES (2017), and Outdoor Alabama, (http://www.outdooralabama.

com/sites/default/files/images/File/Weeks_Bay/AIANSPlan200812.pdf).

Cogongrass (*Imperata cylinrica*)

Cogongrass, shown in Figure 5.2.1, has exhibited extensive growth within the greater Dog River Watershed over the last decade. This aggressive grass is difficult to eradicate even under strict management practices. Burning and site mowing can remove the standing plants; however, these alone can actually increase expansion. Seed transport occurs when infested areas are mowed or when dirt, hay, etc., are transported from land containing Cogongrass.

Figure 5.2.1: Example of Cogongrass at Halls Mill Creek off Cody Road

Chinese Privet (*Ligustrum sinense*)

A shade tolerant, evergreen shrub, Chinese Privet, shown in Figure 5.2.2, is known for its ability to propagate in almost all habitat types including urban areas, upland forests, bottomland hardwood wetlands, etc. The distribution is almost the entire southeastern U.S. and throughout the greater Dog River Watershed. This fast-growing species outcompetes native vegetation, and therefore inhibits native forest regeneration. Chinese Privet is dense along stream channels due to seed transport to downstream areas and throughout the Watershed.

Figure 5.2.2: Example of Chinese Privet located near Coley Drive and Ogburn Avenue

Chinese Tallow or Popcorn Tree (*Triadica sebifera*)

Native to Asia, the distribution of Chinese Tallow trees is widespread throughout Alabama. Easily recognizable by its diamond-shaped leaves, it exhibits vibrant fall foliage. This fast-growing species, combined with astonishingly high seed yields, allows for rapid expansion. In addition, it easily adapts to various soil types and conditions. Chinese Tallow trees were observed throughout the Watershed predominately in clear-cut or areas of disturbance such as power-line easements and along stream channels as shown in Figure 5.2.3.

Figure 5.2.3: Example of Chinese Tallow or Popcorn Tree on Eslava Creek

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Japanese Climbing Fern (*Lygodium japonicum*)

Native to Asia and Australia, Japanese Climbing Fern is a viney perennial fern found throughout the southeastern United States. The Japanese Climbing Fern, shown in Figure 5.2.4, is spread through wind-blown spores and contaminated pine straw. Fronds die back after hard freezes, but dead vines provide a trellis for vigorous new growth in the Spring.

Figure 5.2.4: Example of Japanese Climbing Fern (Photo credit: Nancy Loewenstein, Auburn University)

Eurasian Watermilfoil (*Myriophyllum spicatum*)

Eurasian Watermilfoil is native to Europe, Asia, and northern Africa, and was thought to be accidentally introduced from Eurasia in the 1940s. Eurasian Watermilfoil forms large mats on the water surface as shown in Figure 5.2.5.

Figure 5.2.5: Example of Eurasian Watermilfoil in the greater Dog River Watershed

Hydrilla (*Hydrilla verticillata*)

Native to India, Hydrilla was originally introduced as an ornamental aquarium plant trade in Florida. It has been transported throughout the waterways of Alabama via boats, boat trailers, and outboard motors, as Hydrilla can reproduce by fragmentation as well as from tubers produced at the ends of rhizomes. Hydrilla, shown in Figure 5.2.6, is common in Mobile County and is found throughout the greater Dog River Watershed.

Figure 5.2.6: Example of Hydrilla (Photo credit: C. Smoot Major, University of South Alabama)

Dotted Duckweed (*Landoltia punctata*)

Dotted Duckweed, shown in Figure 5.2.7, is a small, free-floating aquatic plant comprised of one to four fronds that produce fine roots and are covered by a waxy cuticle. Dotted Duckweed is native to Australia and southeast Asia. Dotted Duckweed is considered a pioneer species that is easily distributed and colonizes quickly.

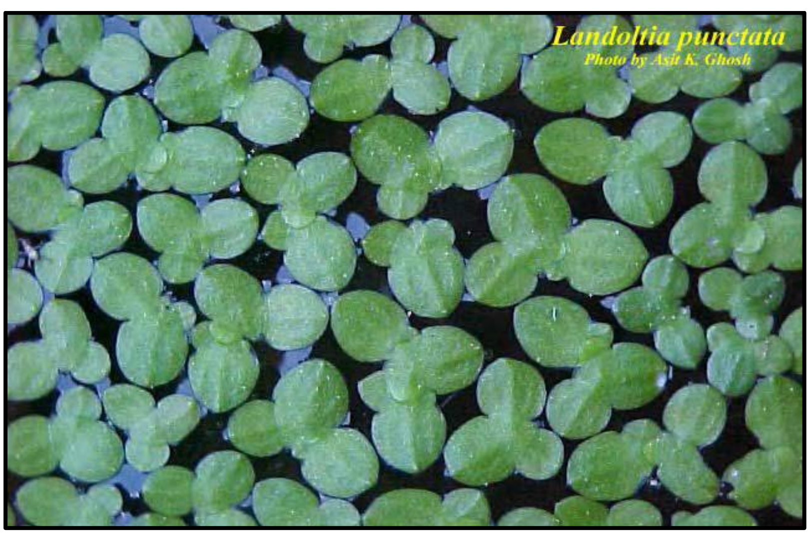

Figure: 5.2.7: Example of Dotted Duckweed (Photo credit: Asit Ghosh)

Alligatorweed (*Alternanthera philoxeroides*)

Alligatorweed is a summer perennial herb that grows over water or on land. Alligatorweed, shown in Figure 5.2.8, is native to South America but occurs throughout Alabama. It was first documented in Mobile in 1897. By forming dense, tangled mats on the surface of waterbodies, Alligatorweed outcompetes native aquatic vegetation for sunlight.

Figure 5.2.8: Example of Alligatorweed (Photo credit: C. Smoot Major, University of South Alabama)

Common Reed *(Phragmites australis)*

Common Reed, shown in Figure 5.2.9, although found naturally throughout coastal Alabama, in many instances, is considered an invasive species. It grows in dense populations that easily outcompete native vegetation. Located within the tidal portion of Dog River, it also dominates the landscape of shorelines along Mobile Bay. Native marsh plants such as Bulrush (*Schoenoplectus sp.*), Cord Grass (*Spartina alterniflora*), and Black Needle Rush (*Juncus roemerianus*) within the greater Dog River Watershed are replaced with *Phragmites.*

Figure 5.2.9: Example of Common Reed in the greater Dog River Watershed

5.2.2 Wetlands

Wetlands in the greater Dog River Watershed have suffered noticeable degradation over the past 64 years. Figures 5.2.10, 5.2.11, and 5.2.12 provide qualitative visual illustrations of the degradation that has occurred to wetlands in the Watershed by comparing historical aerial imagery from the University of Alabama (UA, 2016) for 1952 and 1974 with current (2016) Google Earth imagery (Google Earth, 2016). Collectively, the aerial imageries shown in Figures 5.2.10, 5.2.11, and 5.2.12 show drastic diminution of wetlands, narrowing or reduction of spits (point bars), and urban expansion in the greater Dog River Watershed. These changes are supported by anecdotal community accounts.

Figure 5.2.10: Aerial imagery representing the loss or diminution of wetlands located on Dog River west of Brookley Field for 1952 (left), 1974 (middle), and 2016 (right) (UA, 2016; Google Earth, 2016)

Figure 5.2.11: Aerial imagery representing the narrowing or reduction of spits (point bars) located on Dog River near the Neshota subdivision for 1952 (left), 1974 (middle), and 2016 (right) (UA, 2016; Google Earth, 2016)

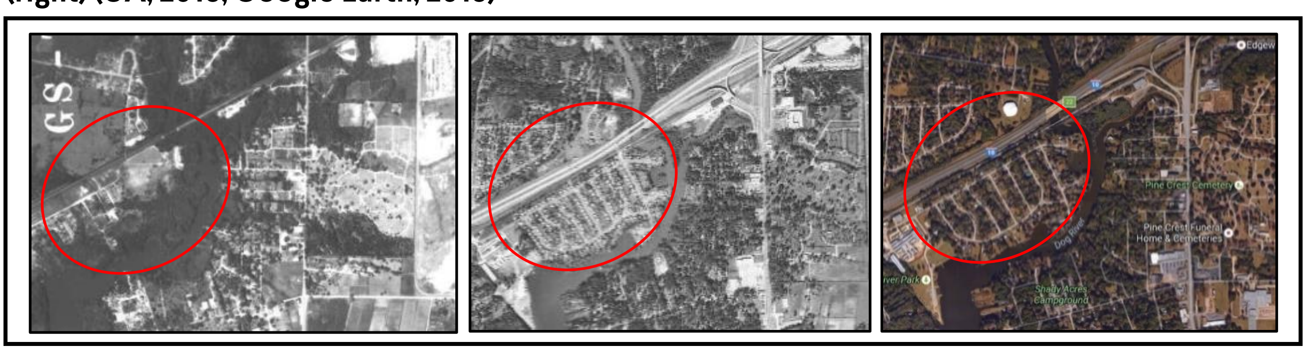

Figure 5.2.12: Aerial imagery representing urban expansion surrounding Dog River located south of I-10 and west of Dauphin Island Parkway for 1952 (left), 1974 (middle), and 2016 (right) (UA, 2016; Google Earth, 2016)

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5.2.2.1 Wetland Rapid Assessment Procedure (WRAP)

The Wetland Rapid Assessment Procedure (WRAP) methodology was used by the WMP project team to assess the current conditions of wetlands throughout the greater Dog River Watershed. WRAP is a rating index that establishes a numerical ranking for both ecological and anthropogenic factors that can then be used to evaluate the current wetland condition (Miller and Gunsalus, 1999). This methodology is used throughout the southeastern United States and by the Mobile District of the U.S. Army Corps of Engineers (USACE). Field observations are collected on the following WRAP variables: Wildlife Utilization; Wetland Overstory/Shrub Canopy; Wetland Vegetative Ground Cover; Adjacent Upland Support/Wetland Buffer; Field Indicators of Wetland Hydrology; and Water Quality Input and Treatment Systems. The highest possible overall score is one (1). Representative wetland areas, which were easily accessible, were selected from each of the three watersheds that comprise the greater Dog River Watershed to perform WRAP evaluations. The WRAP sheets for these wetland areas are located in Appendix E.

5.2.2.2 Halls Mill Creek Watershed Wetlands

Halls Mill Creek Watershed is the largest and most western watershed comprising the greater Dog River Watershed. The Watershed comprises mostly residential uses with some commercial use (Chapter 4). Wetlands in the Halls Mill Creek Watershed encompass nearly 1,926 acres and are non-tidally influenced and in relatively pristine condition (USFWS, 2010). The two largest tracts of natural wetland in the greater Dog River Watershed are Milkhouse Creek Wetlands and Hillcrest Road Wetlands, which are described in more detail, as well as the Hippie Beach wetland representative area.

Milkhouse Creek Wetlands

The Milkhouse Creek wetland representative area (WRAP score = 0.66) is located to the south of Cottage Hill Road and to the east of Sollie Road (Figure 5.2.13 and Figure 5.2.14). A sewer easement runs through the wetlands in this area. Large Chinese Tallow (*Triadica sebifera*) and Chinese Privet (*Ligustrum sinense*) were observed along the easement and within its 25-50 foot buffer.

Bottomland hardwoods that include Red Maple (*Acer rubrum*), Tulip Poplar (*Liriodendron tulipifera*), and Sweet Bay (*Magnolia virginiana*) dominate the forest canopy, however the ground cover exhibited an abundance of Chinese Privet regeneration. This wetland area is connected with other wetland systems and provides habitat and corridors for wildlife.

Figure 5.2.13: Aerial imagery of the Milkhouse Creek wetlands (USDA, 2015; USFWS, 2010)

Figure 5.2.14: General view of the Milkhouse Creek wetlands

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Hillcrest Road Wetlands

The Hillcrest Road representative wetland area (WRAP score = 0.77) is located to the west of Hillcrest Road and south of the Windsor Subdivision (Figure 5.2.15 and Figure 5.2.16). The forest in this wetland system is dominated by Sweet Bay (*Magnolia virginiana*), Red Maple (*Acer rubrum*), and Black Willow (*Salix nigra*). Minimal invasive species were observed. This system contains adequate upland food sources and protective cover for wildlife. Natural, undeveloped and residential areas comprise a majority of the surrounding land use.

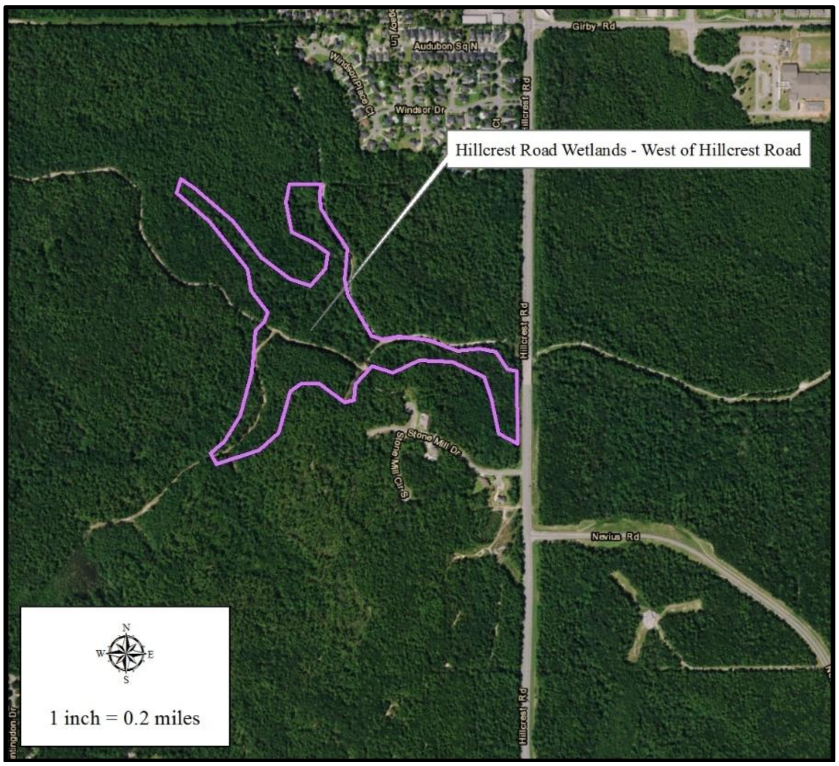

Figure 5.2.15*: Aerial imagery of the Hillcrest Road wetlands (USDA, 2015; USFWS, 2010)*

Figure 5.2.16: General view of the Hillcrest Road wetlands

Hippie Beach Wetlands

The Hippie Beach representative wetland area (WRAP score = 0.86) is located adjacent to Halls Mill Creek, to the east of Interstate 10, to the west of Shipyard Road and to the north of Cypress Business Park (Figure 5.2.17 and Figure 5.2.18). This wetland system hosts a healthy tree canopy including Sweet Bay (*Magnolia virginiana*) and Red Maple (*Acer rubrum*). Native wetland species cover the ground with species such as Royal Fern (*Osmunda regalis*). Natural regeneration of the native vegetation was observed. These wetlands also exhibit a natural hydrology and provide abundant resources for aquatic species and wildlife.

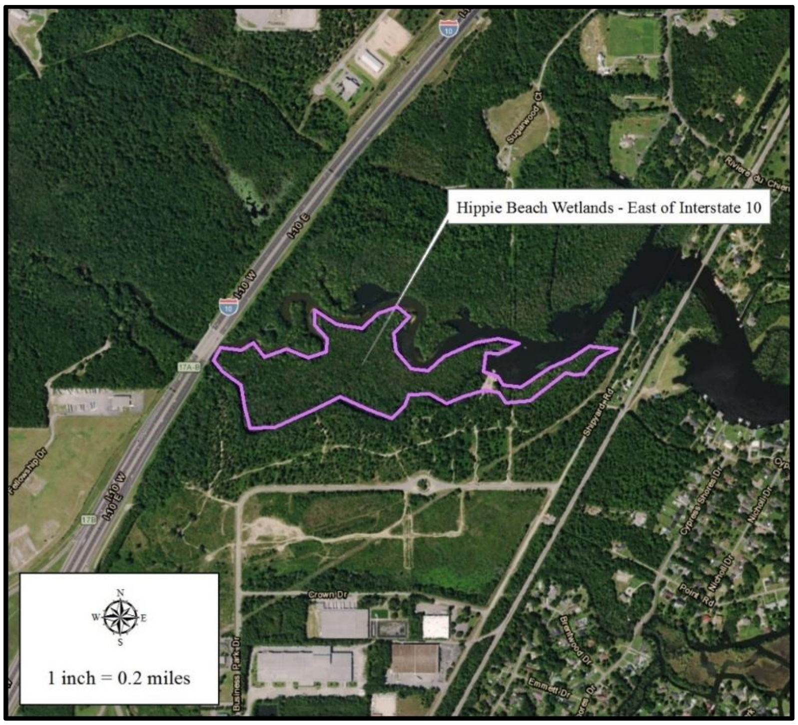

Figure 5.2.17: Aerial imagery of the Hippie Beach wetlands (USDA, 2015; USFWS, 2010)

Figure 5.2.18: General view of the Hippie Beach wetlands

5.2.2.3 Upper Dog River Watershed Wetlands

The Upper Dog River Watershed is situated west of downtown Mobile. The Watershed, although mainly comprising residential and commercial uses, contains approximately 846 acres of wetlands (USFWS, 2010). The wetlands are concentrated in the southern portion of the Watershed south of the U.S. Highway 90 corridor. The majority of the wetlands north of U.S. Highway 90 have been heavily altered. Wetlands south of U.S. Highway 90 include pocket wetlands ranging from a few square feet to several acres.

Wetlands in the Upper Dog River Watershed serve as natural buffers for stormwater flowing south to Dog River and its tributaries. The largest tract of remaining wetland habitat in this Watershed is situated around the interchange of Interstate 65 and Interstate 10, referred herein as the interstate interchange wetlands.

Interstate Interchange Wetlands

The interstate interchange representative wetland area (WRAP score = 0.61) is located to the northwest of the Interstate 65 and Interstate 10 interchange, south of Halls Mills Road, and to the east of Lee Lane (Figure 5.2.19 and Figure 5.2.20). The wetland canopy consists of a mixture of bottomland hardwoods, Pine Trees, and the invasive Chinese Tallow (*Triadica sebifera*). Overgrowth of Green Briar (*Smilax sp.*) and Muscadine (*Vitis rotundifolia*) were noted in the overstory. An abundance of Netted-Chain Fern (*Woodwardia areolata*) was observed throughout the ground cover. The land use surrounding the wetland is comprised of natural area, industrial, commercial, and high-volume highways. However, substantial commercial and residential developments surrounding this area have negatively impacted these wetland habitats.

Figure 5.2.19: Aerial imagery of the interstate interchange wetlands (USDA, 2015; USFWS, 2010)

Figure 5.2.20: General view of the interstate interchange wetlands

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5.2.2.4 Lower Dog River Watershed Wetlands

The Lower Dog River Watershed is situated south and east of Dog River and comprises both residential and commercial land uses. Approximately 2,450 acres of wetlands, both tidally and non-tidally influenced, exist in this Watershed (USFWS, 2010). Although the majority of residential areas are situated on Dog River and its tributaries, the wetlands in this Watershed appear to be in fair condition.

Perch Creek, east of Dog River, and its tributaries are also included within the Lower Dog River Watershed. The wetlands surrounding Perch Creek are mostly undisturbed. Several large tracts of land containing wetlands occur to the west of Rangeline Road. The Lower Dog River Watershed contains many undisturbed wetlands including tidally-influenced wetlands.

More detailed descriptions of wetland habitats in the Lower Dog River Watershed are provided below for the following representative areas: 1) Old Pascagoula Road Wetlands; 2) Rangeline Road Wetlands; and 3) Rabbit Creek Drive Wetlands.

Old Pascagoula Road Wetlands

The Old Pascagoula Road representative wetland area (WRAP score = 0.62) is located to the north of Old Pascagoula Road and to the south of Three Notch Road (Figure 5.2.21 and Figure 5.2.22). The canopy consists of native bottomland hardwoods, however the shrub layer contains many invasive species. Chinese Privet (*Ligustrum sinense*), Japanese Climbing Fern (*Lygodium japonicum*), and Mimosa (*Albizia julibrissin*) were noted throughout the assessment area. The area contains adequate resources for wildlife and connectivity to wildlife corridors.

Figure 5.2.21: Aerial imagery of the Old Pascagoula Road wetlands location (USDA, 2015; USFWS, 2010)

Figure 5.2.22: General view of the Old Pascagoula Road wetlands

Rangeline Road Wetlands

The Rangeline Road representative wetland area (WRAP score = 0.64) is located to the north of Island Road and to the west of Rangeline Road (Figure 5.2.23 and Figure 5.2.24). This area was ponded and contained many native bottomland hardwoods, including Oak (*Quercus sp.*) and Maple (*Acer sp.*), which appeared to have been naturally regenerating. Adequate upland area was noted for wildlife; to the northeast, although, the wetland is adjacent to high volume highways and industrial and commercial developments.

The Rangeline Road wetland is surrounded by industrial and commercial development but appears to be in healthy condition. There is strong evidence of natural recruitment in the forest and less than 25% invasive species ground cover. Trees such as Sweet Bay Magnolias (*Magnolia virginiana*) and Oaks are common along with ground cover plants such as Netted-Chain Fern (*Woodwardia areolata*). The upland buffer provides cover, food, and habitat, and is a connection to wildlife corridors. Although signs of wildlife and natural plant species were noted, the hydrology was slightly altered due to man-made influences.

Figure 5.2.23: Aerial imagery of the Rangeline Road wetlands location (USDA, 2015; USFWS, 2010)

Figure 5.2.24: General view of the Rangeline Road wetlands

Rabbit Creek Drive Wetlands

The Rabbit Creek Drive representative wetland area (WRAP score = 0.67) is located to the north of Hamilton Boulevard and to the west of Rabbit Creek Drive (Figure 5.2.25 and Figure 5.2.26). This wetland area is associated with a braided stream channel system that was not flowing at the time of the WRAP assessment. The canopy contained hardwoods, including Sweet Bay (*Magnolia virginiana*), Southern Magnolia (*Magnolia grandiflora*), and several Oaks. An abundance of Chinese Privet (*Ligustrum sinense*) was noted, along with areas of Netted-Chain Fern (*Woodwardia areolata*). Although surrounded to the west and east by mostly industrial development, natural land uses comprise the areas north and south of the wetland. This wetland supports adequate resources and connectivity for wildlife.

Figure 5.2.25: Aerial imagery of the Rabbit Creek Drive wetlands location (USDA, 2015; USFWS, 2010)

Figure 5.2.26: General view of the Rabbit Creek Drive wetlands

5.2.3 Streams

The greater Dog River Watershed encompasses approximately 174 linear miles of surface water network systems, and is shown in Figure 5.2.27 (USGS, 2017). The current conditions of stream segments in the greater Dog River Watershed range from those that appear to be stressed, heavily impacted, altered, and unnatural stream systems to those that appear to be thriving, pristine, unaltered, and natural stream systems. The varying degree of stream conditions observed for the greater Dog River Watershed is reflective of the cumulative influence urbanization has had on the Watershed.

A general overview of streams and their current conditions are further described in subsequent sections (Sections 5.2.3.1 through 5.2.3.3). Additional assessment of stream conditions and altered hydrology are also provided in Sections 5.2.4.2 through 5.2.4.4.

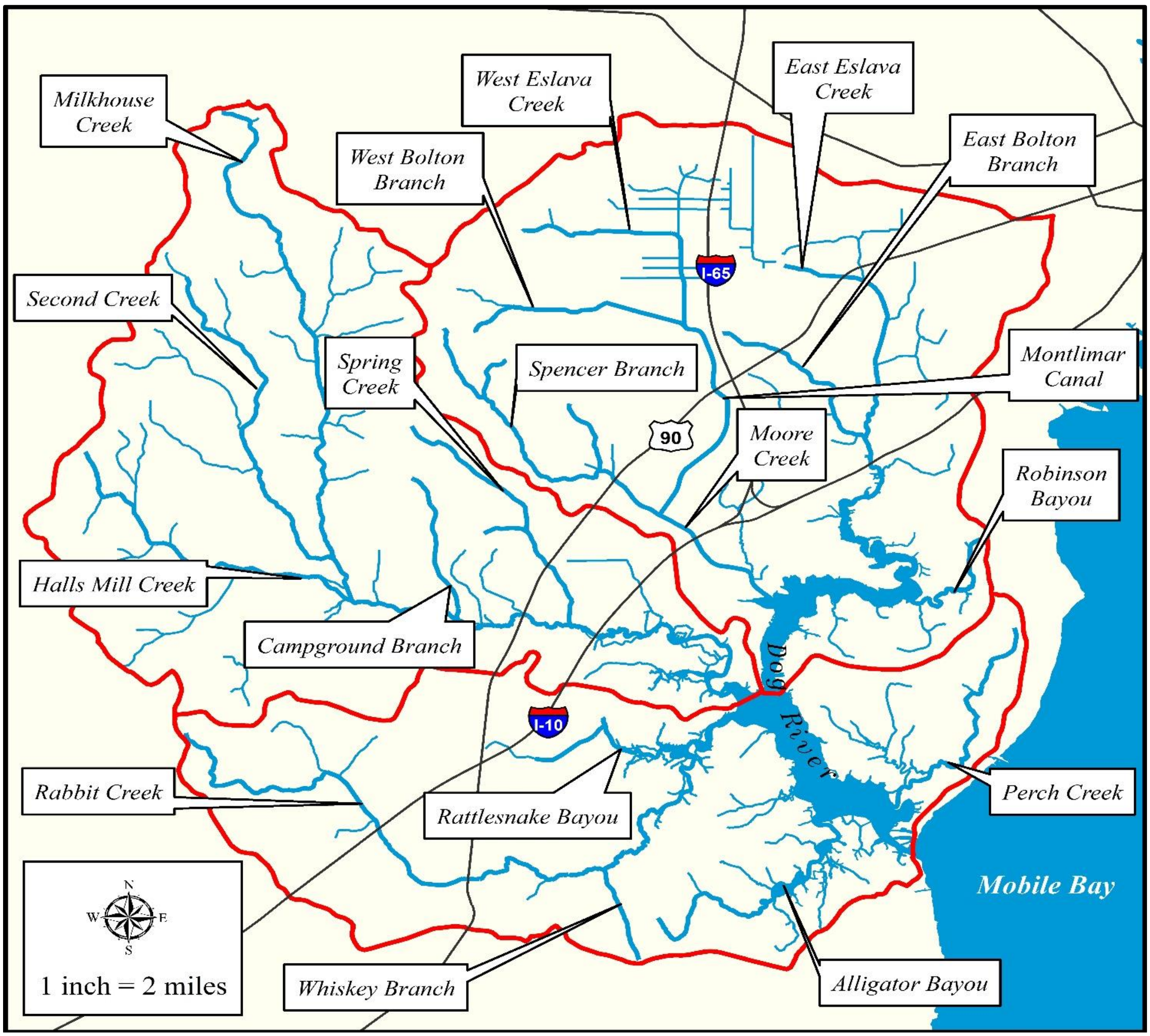

Figure 5.2.27: Stream network system in the greater Dog River Watershed (USGS, 2017)

5.2.3.1 Halls Mill Creek Watershed Streams

The Halls Mill Creek Watershed receives its name from its largest surface water drainage system, Halls Mill Creek. Halls Mill Creek is approximately 59,711 linear feet and drains several smaller tributaries including: Campground Branch, Milkhouse Creek, Second Creek, Spring Creek, and numerous unnamed tributaries (USGS, 2017). As shown in Figures 5.2.28, 5.2.29, 5.2.30, 5.2.31, and 5.2.32, the Halls Mill Creek Watershed features areas of intact natural stream segments and areas where segments of the stream are more heavily altered.

Figure 5.2.28: General view of Halls Mill Creek near Riviere Du Chien Court

Figure 5.2.29: General views of Campground Branch upstream from Girby Road (left) and downstream from Girby Road (right)

Figure 5.2.30: General views of Milkhouse Creek near its headwaters (left) and near Cody Road (right)

Figure 5.2.31: General views of Second Creek near its headwaters (left) and near Cody Road (right)

Figure 5.2.32: General views of Spring Creek downstream from Rochelle Street (left) and near Halls Mill Road (right)

5.2.3.2 Upper Dog River Watershed Streams

The Upper Dog River Watershed receives its name from its largest surface water drainage system, Dog River. Dog River is approximately 51,362 linear feet and drains several smaller tributaries including: Bolton Branch, Eslava Creek, Moore Creek, Robinson Bayou, Spencer Branch, and numerous unnamed tributaries (USGS, 2017). Many stream sections in the Upper Dog River Watershed are heavily armored and channelized with man-made materials such as concrete, gabion baskets, and riprap. However, there are also examples in the Upper Dog River Watershed where less altered stream segments can be found. As shown in Figures 5.2.33, 5.2.34, 5.2.35, 5.2.36, 5.2.37, and 5.2.38, the Upper Dog River Watershed features areas of intact natural stream segments and areas where segments of the stream are more heavily altered.

Figure 5.2.33: General view of upper Dog River near Scenic Drive

Figure 5.2.34: General view of East Bolton Branch downstream from McVay Drive (left) and West Bolton Branch upstream from Azalea Road (right)

Figure 5.2.35: General views of East Eslava Creek near U.S. Highway 90 (left) and upstream from McVay Drive litter trap (right)

Figure 5.2.36: General views of Moore Creek upstream from U.S. Highway 90 (left) and downstream from U.S Highway 90 (right)

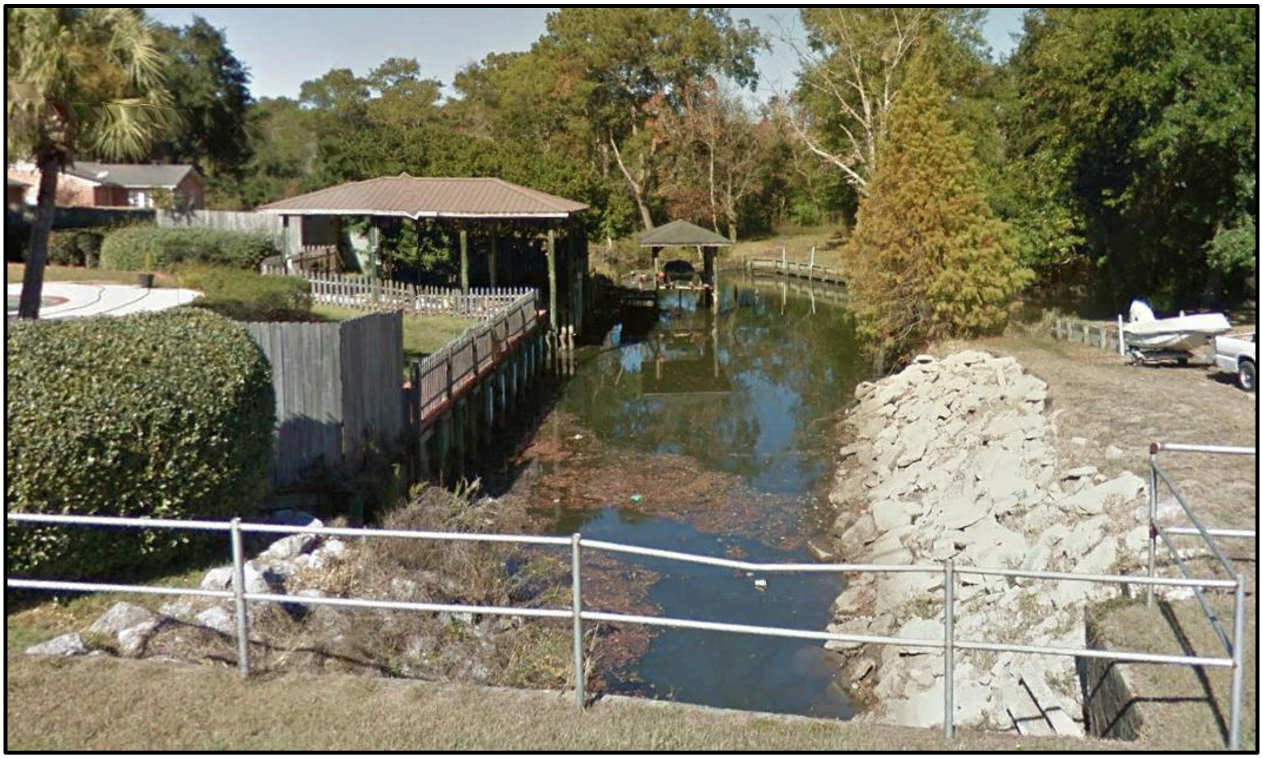

Figure 5.2.37: General view of Robinson Bayou near Gulfdale Drive (Photo credit: Google Earth, 2017)

Figure 5.2.38: General views of Spencer Branch upstream from Cottage Hill Road (left) and downstream from Demetropolis Road (right)

5.2.3.3 Lower Dog River Watershed Streams

The Lower Dog River Watershed receives its name from its largest surface water drainage system, Dog River. Dog River is approximately 51,362 linear feet and drains several smaller tributaries including: Alligator Bayou, Perch Creek, Rabbit Creek, Rattlesnake Bayou, Whiskey Branch, and numerous unnamed tributaries (USGS, 2017).

The streams and tributaries located in the lower Dog River Watershed are generally in good condition, although many segments feature waterfront residential development. As shown in Figures 5.2.39, 5.2.40, 5.2.41, 5.2.42, 5.2.43, and 5.2.44, the Lower Dog River Watershed features areas of intact natural stream segments and areas where segments of the stream are more heavily altered.

Figure 5.2.39: General view of lower Dog River near Dauphin Island Parkway

Figure 5.2.40: General view of Alligator Bayou

Figure 5.2.41: General view of Perch Creek upstream from Hannon Road (left) and downstream from Terrell Road (right)

Figure 5.2.42: General view of Rabbit Creek near Old Pascagoula Road (left) and west of U.S. Highway 90 (right)

Figure 5.2.43: General view of Rattlesnake Bayou

Figure 5.2.44: General view of Whiskey Branch downstream from Hamilton Boulevard (Photo credit: Google Earth, 2017)

5

5.2.4 Altered Hydrology

Changes in watershed uses and characteristics, including natural buffer removal and land use conversion to development, have the ability to impact a channel's natural geomorphology – specifically its dimensions, pattern, and profile. Development has the potential to alter specific stormwater runoff and flow regime patterns inherent in a natural, unaltered system. Increases in runoff due to increased impervious surfaces and the associated intensifications in hydrologic peaks and decreases in lag time during storm events potentially translate to increased flow and energy in channels that have evolved over time to convey lower flows in unaltered systems. The increased runoff has the potential to create new or exacerbate existing stream bank erosion, destabilizing streams and leading to headcutting and bank sloughing, augmenting sediment loads in the stream system.

Stream channels may have been physically altered, realigned, or channelized to allow for development or to address perceived concerns, such as flooding and erosion. Physical alterations may include, but are not limited to, concrete lining to create culverts or armoring with rip rap and gabions. In areas where vegetated stream banks may have been replaced by concrete-lined channels, conveyance for stormwater increases while flooding is reduced. However, infiltration is hindered, stormwater runoff volumes and pollutant loads are increased, and the natural habitats from the bed and embankments of the stream are destroyed, thereby hampering the natural ecological services provided by the stream. In some cases, areas with riparian buffer vegetation has been replaced by lawns to the stream bank edge, eliminating these productive ecotones along streams.

Gabions, pictured in Figure 5.2.45, are meant to channel and enhance stormwater conveyance, but can confine stormwater flow and stimulate deepening. Additionally, areas armored with gabions may accumulate sediment during frequent reduced flows in an enlarged channel due to solids dropping out of the water column to the stream bed. Fortunately, gabions are infrequently used measures across the greater Dog River Watershed.

Figure 5.2.45: Example of gabion structures being used along a streambank in the greater Dog River Watershed

Trees within riparian buffers provide shade to reduce higher water temperatures. Increased water temperatures can lead to lower solubility of oxygen which stimulates hypoxic conditions. Tree roots also provide natural bank stabilization and increase habitat complexity which enhances species diversity. Loss of riparian buffers has the potential to decrease biological diversity given the changes in chemical and physical properties of the water and loss of habitat and food sources for wildlife and aquatic organisms.

Stream bank erosion actively occurs within stream reaches as well. During storm events, increased runoff results in high in-stream flows, which encourages bank and bed erosion in susceptible streams. As the channel bed scours, the streams become more entrenched, further reducing a stream's ability to relieve high flows. Increased instream flows then compound the risk of bank erosion and sloughing. Eventually, sediments are delivered to lower-gradient reaches downstream (aggradation) where the sediment can no longer be transported.

Additionally, exposed sanitary sewer lines, as shown in Figure 5.2.46, can be found within some stream channels in the greater Dog River Watershed. Leaks and failures of these lines could potentially have significant impacts on water quality by introducing nutrients and oxygen-demanding waste material.

Figure 5.2.46: Example of an exposed sanitary sewer line in Spring Creek

5.2.4.1 Altered Creek Geomorphology

Field investigations were performed on several stream segments in the greater Dog River Watershed to better characterize their existing conditions and identify potential geomorphological alterations associated with impacts to the Watershed. Aerial photography was also analyzed to provide general details on existing stream conditions and conditions of the greater Dog River Watershed. Figure 5.2.47 provides an overview of the stream segments and specific stream locations that were assessed. Detailed descriptions are provided herein on the potential sources of sediment, other pollutants, or issues that were investigated through field reconnaissance at the locations and stream segments identified in Figure 5.2.47.

Figure 5.2.47: Stream investigations in Greater Dog River Watershed (USGS, 2017)

5.2.4.2 Halls Mill Creek Watershed Altered Hydrology

Multiple stream segments in the Halls Mill Creek Watershed were assessed to better understand their current geomorphic condition. Detailed descriptions are provided herein on the potential sources of sediment, other pollutants, or issues which were investigated through field reconnaissance at their respective locations.

Spring Creek Investigations

Spring Creek flows from near its crossing at Cottage Hill Road to its confluence with Halls Mill Creek. Spring Creek was investigated at seven locations from Cottage Hill Road to Halls Mill Road; locations are shown in Figure 5.2.48. Land use along Spring Creek is predominately residential with some commercial areas, and features significant development in close proximity to the creek in many areas. Abundant buffer of Spring Creek exists only in isolated reaches of the stream.

Figure 5.2.48: Locations of Spring Creek investigations (USDA, 2015; USGS, 2017)

Spring Creek appears to have segments of stream that have experienced historical erosion, resulting in a channel that is moderately to highly entrenched. Most sections of the channel have since been stabilized, either through armoring, including gabions, riprap, or other hardened structures, or through natural methods including vegetation within the stream buffer and on the streambanks.

Spring Creek – Cottage Hill Road to Woodland Road

Upstream from Cottage Hill Road, a concrete-lined stormwater culvert flows into a pond before the stream resumes and crosses Cottage Hill Road. Below this crossing, the channel runs along a sanitary sewer line with sections of the sewer line and manholes exposed in the channel, shown in Figures 5.2.49 and 5.2.50. The area downstream of Cottage Hill Road is heavily-lined with sections of broken concrete, shown in Figures 5.2.49 and 5.2.50. Further downstream from this section of broken concrete, the stream transitions to an unarmored, highly eroded, vertical bank susceptible to future erosion, shown in Figures 5.2.51 and 5.2.52. This section of Spring Creek is entrenched with clay and sand substrates.

Figure 5.2.49: Concrete lined channel with exposed manhole (Spring Creek – Cottage Hill Road to Woodland Road)

Figure 5.2.50: Concrete riprap and eroding bank interface with visible sewer line (Spring Creek – Cottage Hill Road to Woodland Road)

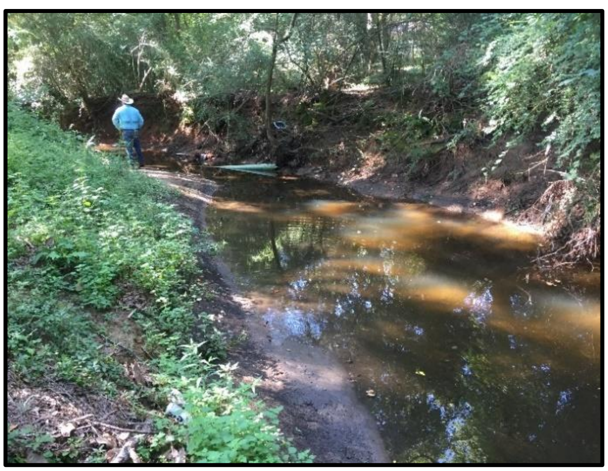

Figure 5.2.51: Example of eroding banks (Spring Creek – Cottage Hill Road to Woodland Road)

5.2.52: Eroding banks, instream deposition, and susceptible manhole (Spring Creek – Cottage Hill Road to Woodland Road)

Instream deposition at this section of Spring Creek is unlikely from upstream sources, because upstream sediment should collect in the pond located north (upstream) of Cottage Hill Road. Instead, sediment deposition and loading in Spring Creek, shown in Figures 5.2.51 through 5.2.54, is likely the result of bank erosion.

Figure 5.2.53: Example of instream deposition (Spring Creek– Cottage Hill Road to Woodland Road)

Figure 5.2.54: Example of eroding banks (Spring Creek – Cottage Hill Road to Woodland Road)

Spring Creek – Upstream of Knollwood Drive to Granada Avenue

This stream section is relatively stable and not a significant source of sediment loads to the Spring Creek system. This reach has abundant vegetative buffer and vegetation on the streambanks, which contribute to the stability of the creek in this section. Large amounts of deposition, however, are present in the channel, indicating an upstream sediment source, likely from the reach of Spring Creek downstream of Cottage Hill Road to Woodland Road.

Spring Creek – Timberlane Drive to Longleaf Drive

The Timberlane Drive to Longleaf Drive section of Spring Creek, Figures 5.2.55 through 5.2.57, is highly entrenched with high, vertical banks and an inaccessible floodplain. The channel has been heavily impacted with hardened structures including riprap and concrete. Vegetation along the channel is limited to herbaceous species and some opportunistic shrubs. Trees are further offset from the stream in the buffer. Despite the armoring of the channel, the banks are not well protected in numerous areas of this section due to the steep sloping banks. Sediment deposition is also evident in the stormwater drains to the channel along Timberlane Drive, shown in Figure 5.2.58. In several locations along this reach, the banks are vertical and eroding. The FEMA flood map, Figure 5.2.59, shows that unlike other sections of Spring Creek in the area, the stream and associated flood potential are completely confined in the channel due to the high banks.

Figure 5.2.55: Upstream of Longleaf Drive (Spring Creek – Timberland Drive to Longleaf Drive)

Figure 5.2.57: Sloughing banks and resulting sedimentation in channel (Spring Creek – Timberland Drive to Longleaf Drive)

Figure 5.2.56: Example of eroding Banks (Spring Creek – Timberland Drive to Longleaf Drive)

Figure 5.2.58: Sediment deposition on curb on Timberlane Drive drain (Spring Creek –Timberland Drive to Longleaf Drive)

Figure 5.2.59: Confinement of flood waters in Spring Creek (FEMA, 2015; USDA, 2015)

Spring Creek – Maudelayne Drive North

Spring Creek at Maudelayne Drive North section is stable and does not appear to contribute to sediment loads in the system. Upstream of the Maudelayne Drive North road crossing, Figure 5.2.60, the channel features stable banks with dense vegetation. A sign on Maudelayne Drive North, Figure 5.2.61, indicates current flooding concerns at the crossing – a result of either the culvert being too small when installed or an indication of increased discharges upstream since installation of the culvert. Downstream from the Maudelayne Drive North road crossing, the channel is stabilized with riprap, shown in Figure 5.2.62. Buffer in this area, like many in this stream corridor, is minimal due to residential development along the creek.

Figure 5.2.60: Spring Creek upstream from the Maudelayne Drive North road crossing

Figure 5.2.61: Flood hazard sign located at the Maudelayne Drive North road crossing

Figure 5.2.62: Riprap armoring on Spring Creek downstream from Maudelayne Drive North

Unnamed Tributary to Spring Creek – Shortleaf Drive Crossing

An unnamed tributary to Spring Creek at Shortleaf Drive, Figures 5.2.63 and 5.2.64, was assessed upstream from the road crossing. This section of stream channel exhibits very stable stream characteristics with bankfull at or near top of bank, a dense vegetation buffer, and a dense, deep root cover. The floodplain showed good deposition of sediment and looks to be a pollutant sink, due to frequent flooding. One section has an active headcut where the channel bed has eroded, but it is currently stabilized with a root mass that extends across the channel.

Figure 5.2.63: Stable stream examples for unnamed tributary to Spring Creek (Spring Creek – Shortleaf Drive Crossing)

Figure 5.2.64: Examples of headcut (left) and root depth and mass (right) from unnamed tributary to Spring Creek (Spring Creek – Shortleaf Drive Crossing)

5

Spring Creek – Maudelayne Drive South to Girby Road

Between Girby Road and Maudelayne Drive South, Spring Creek is natural and moderately entrenched with vegetative buffer and forest, shown in Figures 5.2.65 through 5.2.70. Despite being moderately entrenched, the channel appears stable but with possible historical bank erosion resulting in the entrenchment and widening of the current stream. Vegetation is growing well on the banks. Root depth and density and the angle of the banks (range from 45- to 80- degrees) are aiding stream stability in this reach. A commercial area borders the eastern stream buffer with a large parking area. Riprap and broken concrete are present in some sections of the channel, notably at points of stormwater discharge.

Figure 5.2.65: Entrenched channel (Spring Creek upstream from Girby Road)

Figure 5.2.66: Spring Creek near point of discharge from parking lot runoff (Spring Creek upstream from Girby Road)

Figure 5.2.67: Vegetation density on creek bank (Spring Creek upstream from Girby Road)

Figure 5.2.68: Root depth and vegetation density on creek bank (Spring Creek upstream from Girby Road)

Figure 5.2.69: Root depth and vegetation density on creek bank (Spring Creek upstream from Girby Road)

Figure 5.2.70: Stable bank angle on creek bank but vegetated with privet (Spring Creek upstream from Girby Road)

In this reach, Spring Creek has large amounts of deposition found in the mid-channel and as point bars. This type of deposition suggests sediment is from an upstream source given the banks themselves do not appear to be contributing an excessive amount of sediment. Despite the prevalence of deposition bars in the channel, the channel does not appear to be aggrading. The deposition appears to be mobile and replenished by the upstream source.

Downstream of Girby Road, Spring Creek is stable, but its natural geomorphology has been severely altered. The channel is armored with gabions, has no forest coverage, and the channel is confined by roads and commercial development, shown in Figures 5.2.71 and 5.2.72. Herbaceous vegetation has grown well on and in the channel, adding to stability and providing some habitat.

Figure 5.2.71: Example of commercial Development (Spring Creek – downstream Girby Road)

Figure 5.2.72: Example of herbaceous vegetation (Spring Creek – downstream Girby Road to Government Boulevard)

Three main stormwater drains are located at this segment of Spring Creek: 1) roadside drain along Girby Road that drains the southern end of the commercial area; 2) a drain for the large parking lot; and (3) a drain for the north end of the commercial area and possibly Demetropolis Road, Figures 5.2.73 and 5.2.74.

Figure 5.2.73: Examples of roadside drains (Spring Creek – near Girby Road)

Figure 5.2.74: Example of parking area drain (left) and roadside drain (right) from commercial development (Spring Creek – Girby Road)

Spring Creek – at Halls Mill Road

Downstream of U.S. Highway 90 near Halls Mill Road, Spring Creek is heavily armored with gabions. In this reach, Spring Creek features large amounts of deposition in the mid-channel and as point bars, shown in Figures 5.2.75 and 5.2.76. Deposition observed at the Halls Mill Road crossing suggest sediment is from an upstream source given the gabion armored banks themselves do not appear to be contributing an excessive amount of sediment to the system.

Sediment deposited in this reach of Spring Creek is periodically dredged by the City of Mobile. While the artificial removal of sediment from downstream locations has the potential to disrupt a channel's natural stability upstream, rigid structures such as box culvert roadway crossings, Figure 5.2.77, are providing grade control for upstream segments of Spring Creek. Therefore, the periodic removal of sediment near Halls Mill Road does not appear to exacerbate upstream erosion.

Figure 5.2.75: General view of sediment deposition (Spring Creek - at Halls Mill Road Crossing)

Figure 5.2.76: Example of sediment deposition and gabion armoring (Spring Creek – at Halls Mill Road)

Figure 5.2.77: General view of box culvert (Spring Creek - at Halls Mill Road)

Halls Mill Creek Investigations

Halls Mill Creek runs from approximately the intersection of Cottage Hill Road and Dawes Road to its confluence with Dog River, Figure 5.2.78. Development in this Watershed is predominately residential with some commercial development in the upper portions of the basin and light industrial development in its lower basin. The upper portion of the creek has been ponded to form Dawes Lake. The vast majority of the channel appears to have extensive buffer with the majority of impacts being associated with the previously described lake and street crossing. High turbidity and siltation is evident in upper portions of Halls Mill Creek, likely stemming from stormwater runoff. The mid-section contains large woodland expanses with unspoiled wetland tracts. The lower portion of Halls Mill Creek includes many reaches of shorelines altered by the inclusion of manmade shoreline protection structures, including bulkheads.

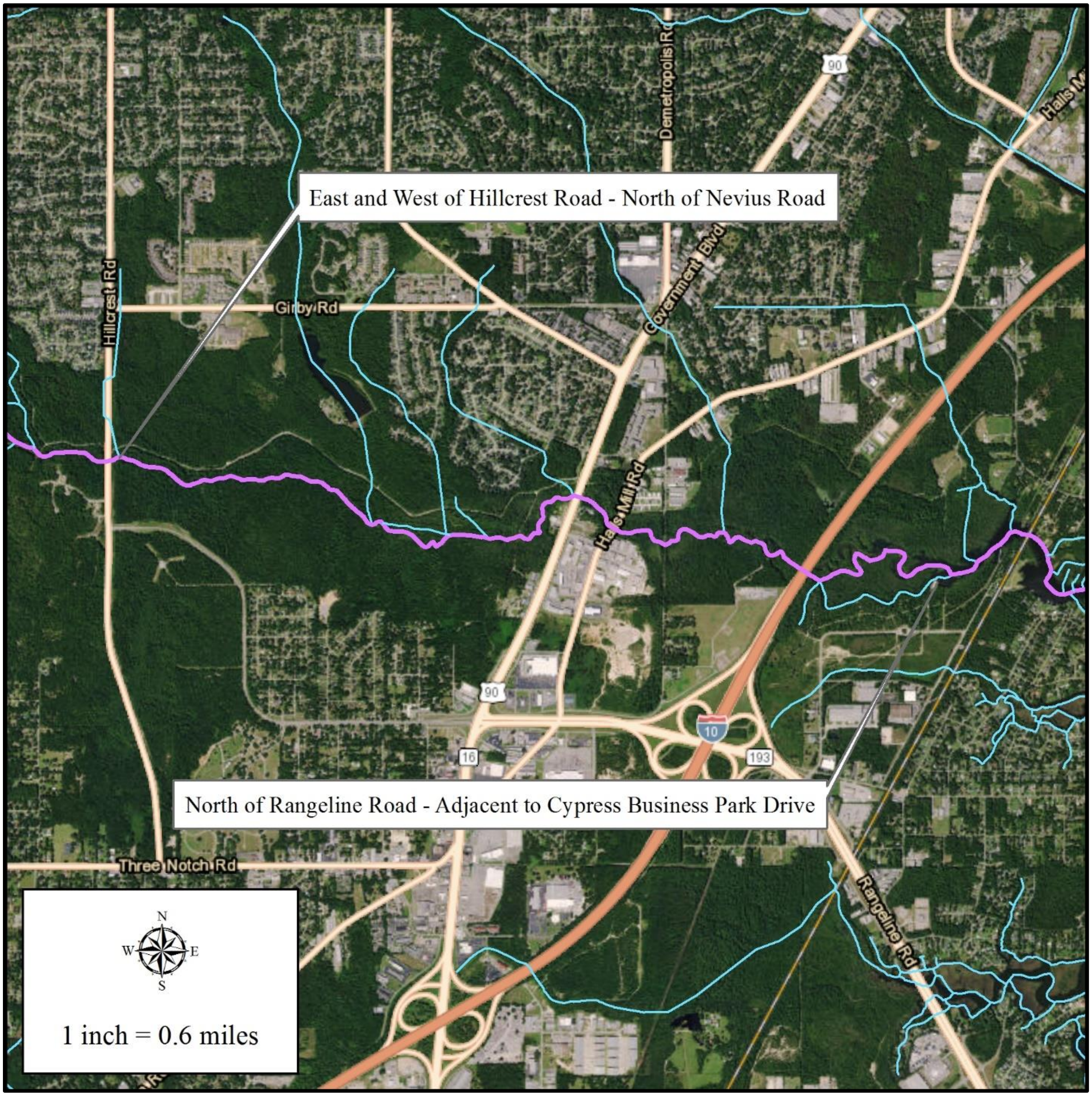

Figure 5.2.78: Locations of Halls Mill Creek investigations (USDA, 2015; USGS, 2017)

Halls Mill Creek – East and West of Hillcrest Road - North of Nevius Road

A large tract of undeveloped land exists east and west of Hillcrest Road just north of Nevius Road, shown in Figure 5.2.78. West of Hillcrest Road are several large tracts of land along Halls Mill Creek and its tributaries.

The creek flows west-to-east as a braided system and transitions into a single-thread channel before flowing under Hillcrest Road. The creek geomorphology in this area appears to have minimal impacts, due to a lack of watershed alteration in the immediate vicinity.

Halls Mill Creek – North of Rangeline Road - Adjacent to Cypress Business Park Drive

This location includes approximately 190 acres of upland and wetland habitat, including waterfront access. The land is currently undeveloped but is intended to be a business park. A small section of the waterfront is used by the local community and is known as Hippie Beach. There is evidence, Figures 5.2.79 and 5.2.80, in this area of All Terrain Vehicle (ATV) usage, trespassing, and littering. A number of access trails traverse the site from the paved road to the waterfront. Due to the foot and ATV traffic on these trails, the unimproved paths are not vegetated and have become destabilized. Stormwater runoff has caused erosion, rilling, and headcutting along the trails in the uplands and sedimentation in the lowlands. Figure 5.2.81 shows sediment from the paved road being transported through the curb-and-gutter stormwater drain into the lowland area and Halls Mill Creek.

Figure 5.2.79: Examples of trespassing, ATV trails, and onsite erosion at Hippie Beach (Halls Mill Creek – N of Rangeline Road - adjacent to Cypress Business Park Drive)

Figure 5.2.80: Examples of sedimentation, trash, and ATV usage at Hippie Beach (Halls Mill Creek – N of Rangeline Road - adjacent to Cypress Business Park Drive)

Figure 5.2.81: Examples of sediment migrating to the lowland areas (left) and sedimentation on street near stormwater drain (right) at Hippie Beach (Halls Mill Creek – N of Rangeline Road - adjacent to Cypress Business Park Drive)

Halls Mill Creek at Hippie Beach is wide and thickly vegetated along the buffer, Figure 5.2.82. Sediment is being delivered to the channel due to anthropogenic activities up-gradient of the stream.

Figure 5.2.82: General views of Halls Mill Creek from Hippie Beach

Milkhouse Creek Investigation

Milkhouse Creek is a tributary to Halls Mill Creek as is shown in Figure 5.2.83. It flows from southeast of the intersection of Zeigler Boulevard and Schillinger Road North to its confluence with Halls Mill Creek. The adjacent land use is heavily developed, primarily with residences and some commercial areas. Much of the buffer width around Milkhouse Creek has been lost to development, and in several areas, the development has nearly eliminated the buffer completely. Upstream of Cody Road crossing Milkhouse Creek has been dammed forming Optimist Lake.

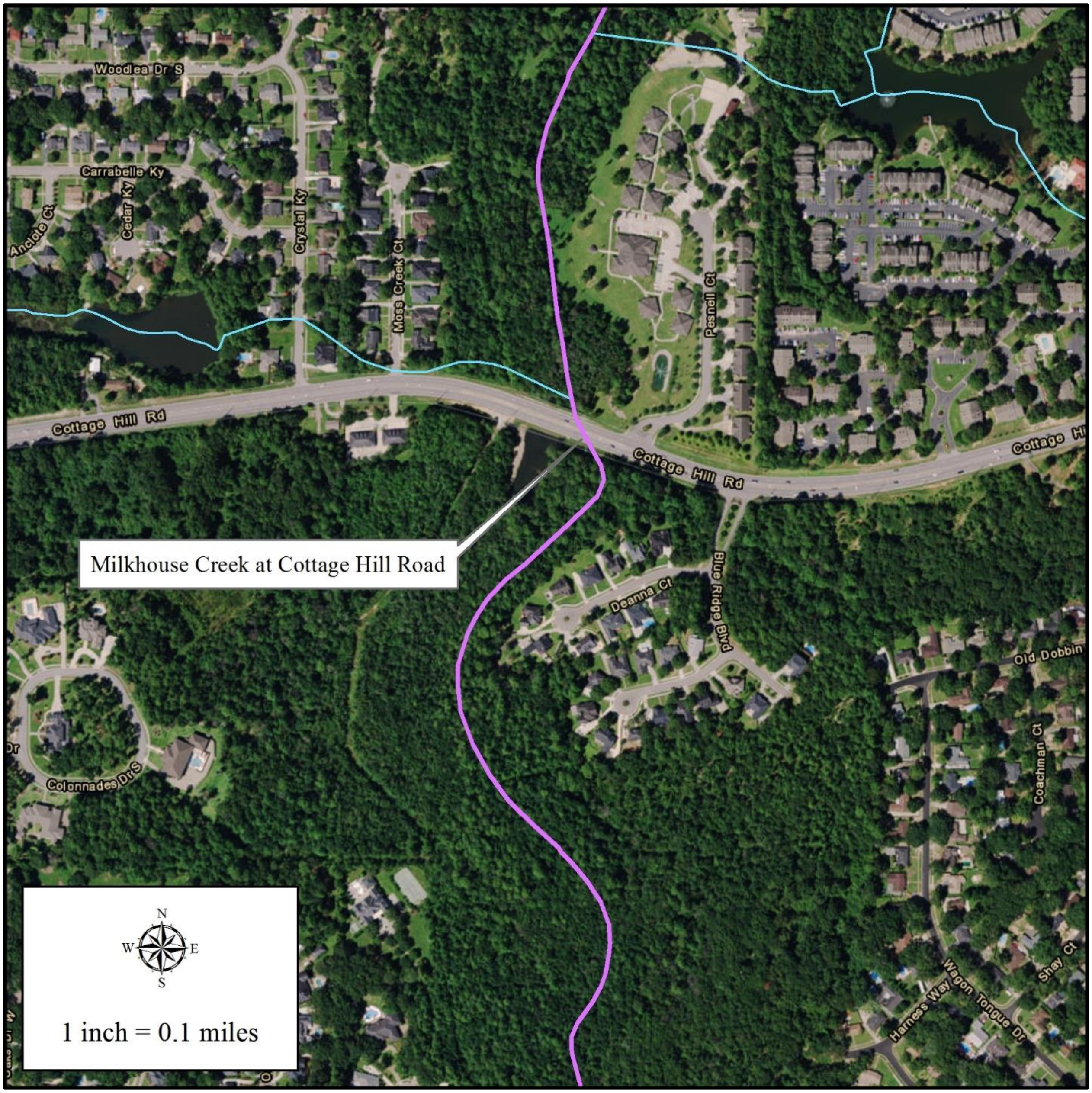

Figure 5.2.83: Locations for Milkhouse Creek investigations (USDA, 2015; USGS, 2017)

Milkhouse Creek at Cottage Hill Road

Milkhouse Creek was investigated at Cottage Hill Road, shown in Figure 5.2.83. A large ponded area located south of Cottage Hill Road reflects evidence of beaver activity, shown in Figure 5.2.84. The stream system is naturally braided, shown in Figure 5.2.85, and appears stable, likely due to the wide, undisturbed buffer maintained along the channel, in spite of residential development in the Watershed. The multiple-threaded system has low banks demonstrating connectivity to the floodplain. However, a large sediment plume was found emanating from one of the culverts under Cottage Hill Road.

Figure 5.2.84: Examples of water ponding on Milkhouse Creek (Milkhouse Creek at Cottage Hill Road)

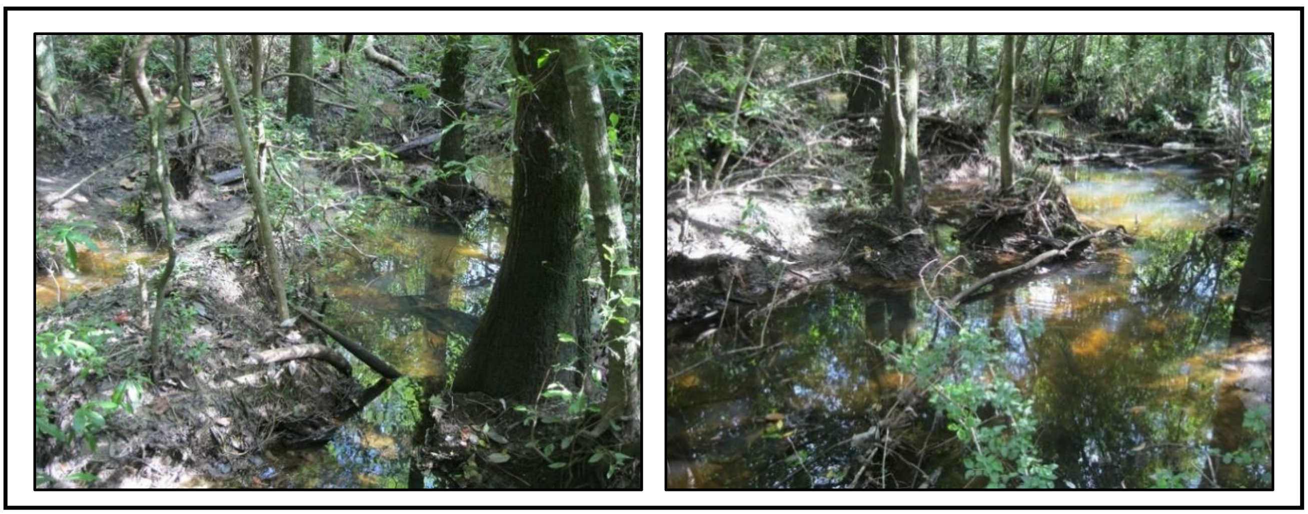

Figure 5.2.85: Examples of a naturally braided stream system (Milkhouse Creek at Cottage Hill Road)

Second Creek Investigation

Second Creek, a tributary to Halls Mill Creek, flows from Old Government Street in the north to its confluence with Milkhouse Creek, Figure 5.2.86. The headwaters of Second Creek have been heavily impacted due to dense commercial development along Schillinger Road. Additionally, dense residential development in close proximity to the channel has impacted the stream's natural buffer.

Figure 5.2.86: Second Creek investigation (USDA, 2015; USGS, 2017)

Second Creek at Cottage Hill Road – West of Milkhouse Creek

Second Creek was observed at the bridge crossing of Cottage Hill Road, Figure 5.2.86. Downstream from the crossing reveals a moderately stable to potentially unstable stream system with little impairment from invasive species. Access downstream is limited due to private properties. From the limited investigation, it was noted that the stream has isolated areas of erosion, but these appear to be due to loss of vegetative buffer along private property, Figure 5.2.87. Additionally, the pattern of the channel appears somewhat impacted for the small portion of channel investigated downstream of the culvert. It is possible that the effects of the water energy coming through the culvert or altered land use (i.e., loss of historic buffer on the banks) have caused the transformation in these localized areas. Due to the residential coverage of this area and other privately-owned properties along the channel, it was not possible to thoroughly investigate this stream reach.

Figure 5.2.87: Examples of vegetation density and high bank on Second Creek (Second Creek at Cottage Hill Road – West of Milkhouse Creek)

5.2.4.3 Upper Dog River Watershed Altered Hydrology

Multiple stream segments in the Upper Dog River Watershed were assessed to better understand their current geomorphic condition. Detailed descriptions are provided herein on the potential sources of sediment, other pollutants, or issues which were investigated through field reconnaissance at their respective locations.

Moore Creek Investigations

The upper portion of Moore Creek is dominated by urbanized development and drains a large portion of the Upper Dog River Watershed, shown in Figure 5.2.88. Moore Creek is characterized by stream armoring, channelization, bank stabilization, and grade control structures which were elected to manage stormwater and decrease the risk of flooding in the urbanized areas. Heavy sediment loads from runoff and erosion is evident in segments of this portion of the stream, as well as near the Montlimar Canal. However, the lower portion of Moore Creek is more natural with many wetlands near its junction with Dog River.

Figure 5.2.88: Locations of Moore Creek investigations (USDA, 2015; USGS, 2017)

Moore Creek – Downstream of Government Boulevard

The downstream section of Moore Creek, south of the Government Boulevard road crossing, Figure 5.2.89, appears heavily modified with concrete-lined, over-widened sections and sheet pile weirs in the channel. In these over-widened sections, the banks are high, indicating a moderately to highly-entrenched system. However, they are sloped back at an angle of repose providing bank stability for the majority of the bank length. Due to the excessive over-widening of the channel, large areas of deposition were evident in the channel, creating midchannel and point bars, indicating its potential as a sink of suspended sediments. The banks are only vegetated with herbaceous plants that have led to isolated areas of bank erosion where root depth and density are not sufficient to resist erosive forces during high flow.

Figure 5.2.89: General view of Moore Creek (Moore Creek – Downstream of Government Boulevard)

Riviere Du Chien – Former Cypress Creek Golf Course

The Cypress Creek Country Club in Riviere Du Chien has a golf course that is not currently being utilized. This golf course has a number of waterways discharging into Moore Creek. The waterways have negligible buffer with turf up to the banks, shown in Figure 5.2.90. Historical photography, Figure 5.2.91, indicates these waterways have been severely altered and created as canals as amenities to the property.

Figure 5.2.90: General view of Riviere Du Chien (Riviere Du Chien – Former Cypress Creek Golf Course)

Figure 5.2.91: Historical aerial photo of Riviere Du Chien in 1938 (UA, 2016)

Bolton Branch (East and West) and Montlimar Canal Investigations

Approximately 70 years ago (1943-1953) Interstate 65 was constructed in Mobile, resulting in the separation of both Eslava Creek and Bolton Branch into their respective East and West designations (i.e. East Eslava Creek, West Eslava Creek, East Bolton Branch, West Bolton Branch). Additionally, during this ten-year time period wetlands located west of Interstate 65 were channelized to form Montlimar Canal.

West Bolton Branch, East Bolton Branch, and Montlimar Canal stream segments are heavily impacted and influenced by urbanization and development and feature extensive channelization, shown in Figure 5.2.92. Many sections of these streams feature banks armored with riprap, metal, or concrete revetments. Extensive channelization has altered the streams' natural geomorphology and reduced the ecological services historically provided by these systems.

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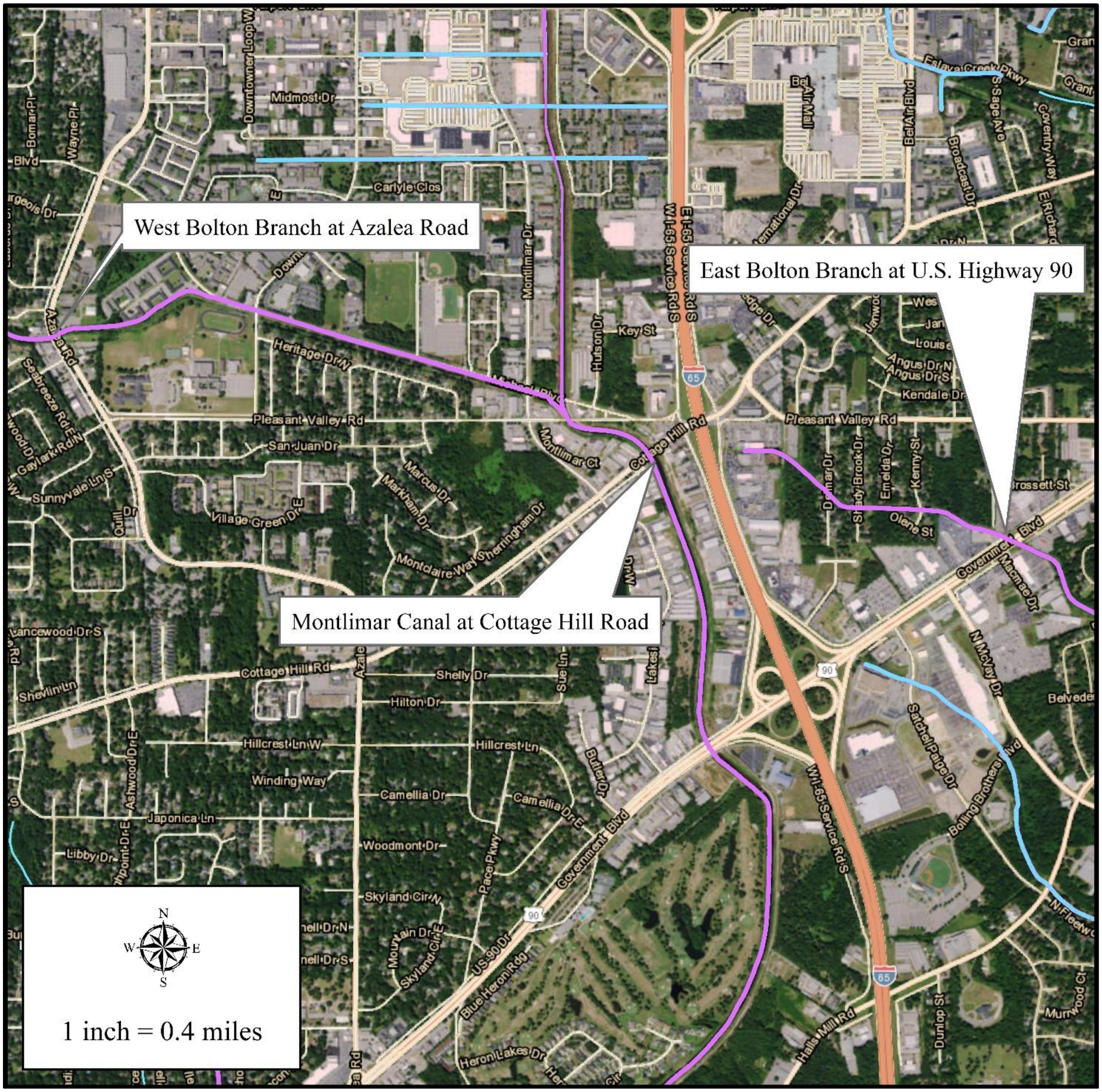

Figure 5.2.92: Locations of Bolton Branch (East and West) and Montlimar Canal investigations (USDA, 2015; USGS, 2017)

West Bolton Branch –Azalea Road

West Bolton Branch was investigated at its crossing with Azalea Road. This segment of West Bolton Branch features negligible vegetation in the buffer and on the streambanks, leaving the stream prone to erosion. The use of concrete and metal retainment structures are used along the bank for stabilization. Figure 5.2.93 illustrates typical characteristics of West Bolton Branch.

Figure 5.2.93: General view of West Bolton Branch upstream of Azalea Road

East Bolton Branch – U.S. Highway 90

East Bolton Branch was investigated south of U.S. Highway 90. Instead of a natural, vegetative riparian buffer, residences and commercial sites have been built immediately adjacent to the channel, throughout which several rigid stabilization techniques, including riprap and concrete, have been implemented. Figure 5.2.94 illustrates typical characteristics of East Bolton Branch.

Figure 5.2.94: General view of East Bolton Branch at U.S. Highway 90 crossing

Montlimar Canal – Cottage Hill Rd

Montlimar Canal was investigated at the Cottage Hill Road crossing. Montlimar Canal receives its flow from West Eslava Creek and West Bolton Branch. The draining of wetlands has eliminated the natural physical, chemical, and biological functions of the former wetlands, eliminating habitat and creating an artificial channel that further suffers from lack of vegetative buffer and cover. Figure 5.2.95 illustrates typical characteristics of Montlimar Canal.

Figure 5.2.95: General view of Montlimar Canal downstream of Cottage Hill Road crossing

Spencer Branch Investigation

Spencer Branch flows from a Grelot Road crossing to its confluence with Moore Creek, Figure 5.2.96. The entire reach appears to be converted from a natural to a concrete-lined channel. Spencer Branch is densely developed with residences directly adjacent to the channel. Much of the buffer has been eliminated.

Figure 5.2.96: Locations of Spencer Branch investigations (USDA, 2015; USGS, 2017)

Spencer Branch – South of Grelot Road

Spencer Branch was investigated south of Grelot Road. Figure 5.2.97 illustrates typical characteristics of Spencer Branch.

Figure 5.2.97: General view of Spencer Branch upstream from Cottage Hill Road

5.2.4.4 Lower Dog River Watershed Altered Hydrology

Multiple stream segments in the Lower Dog River Watershed were assessed to better understand their current geomorphic condition. Detailed descriptions are provided herein on the potential sources of sediment, other pollutants, or issues which were investigated through field reconnaissance at their respective locations.

Rabbit Creek Investigations

Rabbit Creek flows from southwest of the intersection of Three Notch Road and Schillinger Road to its confluence with lower Dog River. Figure 5.2.98 shows locations where Rabbit Creek was investigated. The channel appears highly impacted in its upper reaches as it is conveyed through residential and commercial areas via curb-and-gutter and stormwater drains. The stream becomes more natural downstream of the crossing of Gunn Road. From Gunn Road to Rangeline Road, the channel has wide buffer for the majority of the reach. From Rangeline Road downstream, the channel is in more backwater conditions, and residences with docks line the channel.

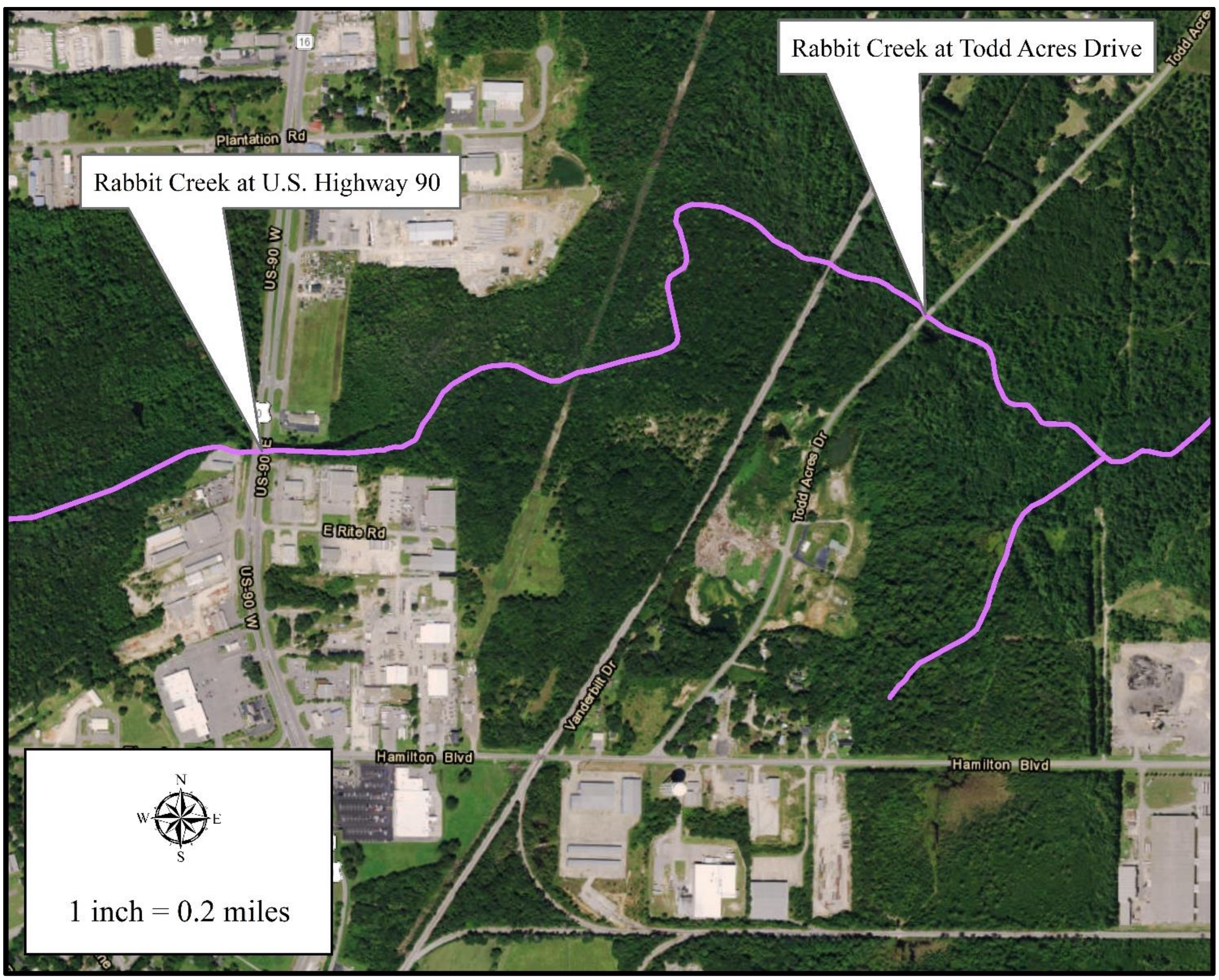

Figure 5.2.98: Locations of Rabbit Creek investigations (USDA, 2015; USGS, 2017)

Rabbit Creek at U.S. Highway 90

Though not necessarily in pristine condition, Rabbit Creek, exhibits good bank stability with heavy vegetation on the banks and lack of noticeable erosion in the channel both downstream and upstream of the culverts at U.S. Highway 90, Figures 5.2.99 and 5.2.100 respectively.

The channel geomorphology is likely impacted by the highway corridor and commercial development in the immediate vicinity, but lasting impacts appear negligible. The northern bank downstream of the culvert is vegetated with turf and lacks natural buffer; however, bank erosion is not evident. The water in Rabbit Creek is slow moving and deep, indicating possible beaver activity, which further reduces the potential for erosion and promotes deposition.

Figure 5.2.99: Rabbit Creek upstream from U.S. Highway 90

Figure 5.2.100: Rabbit Creek downstream from U.S. Highway 90

Rabbit Creek at Todd Acres Drive

Rabbit Creek was investigated at the Todd Acres Drive roadway crossing. Figure 5.2.101 provides a general view of Rabbit Creek downstream of the roadway crossing. Rabbit Creek at this location appears to be in pristine condition featuring a wide heavily vegetated buffer and stable banks with dense vegetation. Invasive species such as Chinese Tallow or Popcorn Tree (*Triadica sebifera*) were observed at this location.

Figure 5.2.101: General view of Rabbit Creek downstream from Todd Acres Drive

Rattlesnake Bayou Investigations

From the Interstate 10 Service Road in the west to Business Parkway in the east, Figure 5.2.102, the geomorphology of the unnamed tributary to Rattlesnake Bayou is heavily impacted from development. The channel has been re-routed and channelized to accommodate the interstate and commercial development. In the process, the stream buffer in the area has been eliminated, leaving the channel susceptible to erosion.

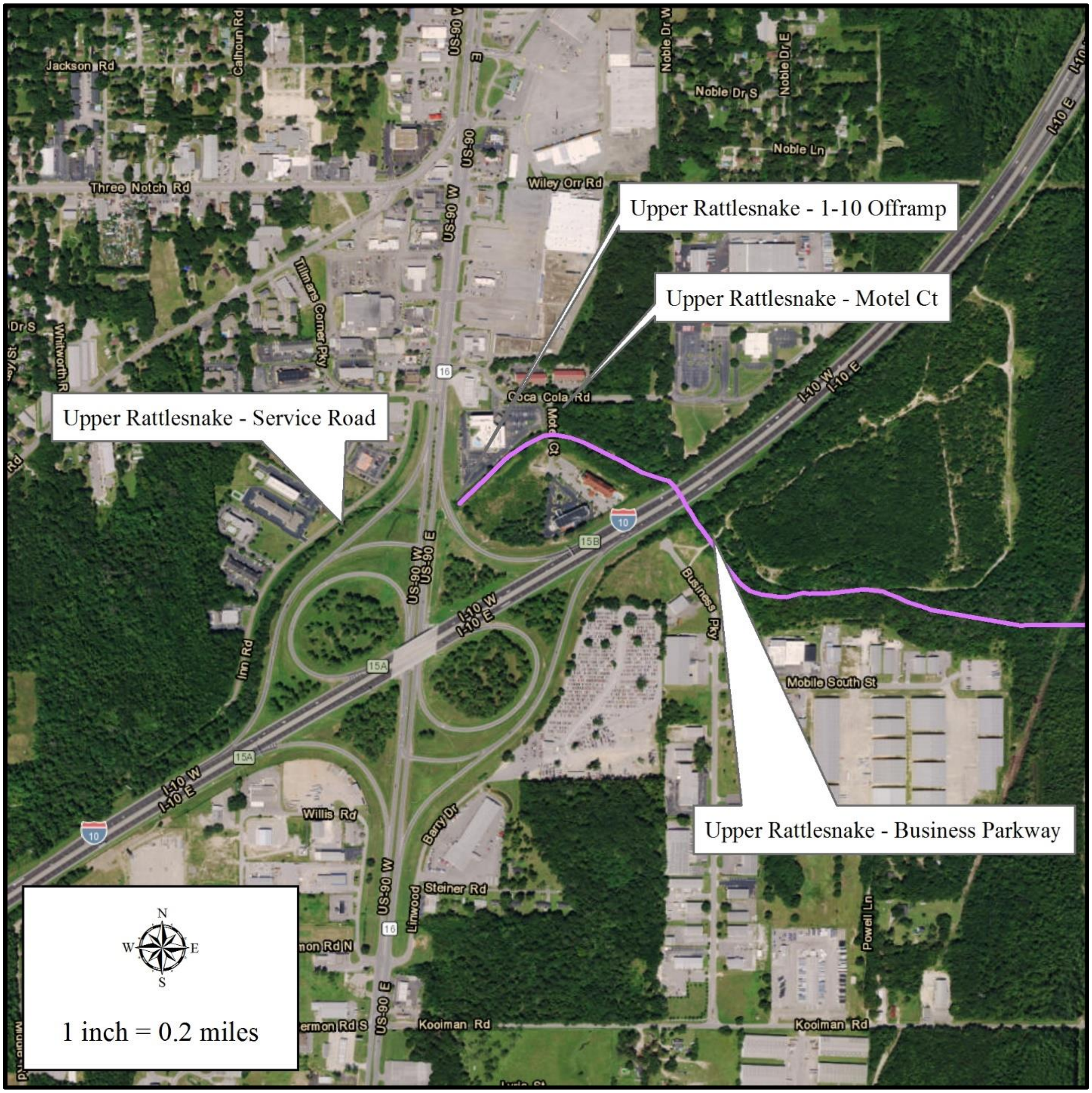

Figure 5.2.102: Locations of Rattlesnake Bayou investigations (USDA, 2015; USGS, 2017)

Upper Rattlesnake Bayou - Service Road

The upper portion of Rattlesnake Bayou, along the service road, is a collection of earthen and concrete-lined drains flowing toward Interstate 10 where they converge to form an unnamed tributary to Rattlesnake Bayou. The streams do not have a vegetative buffer other than turf and sparse trees. Flow appears to be restrained, perhaps due to damming at the interstate crossing, which has minimized erosion in this section. The streams exhibit moderate to high entrenchment, which could potentially encourage erosion during high flows. Figures 5.2.103 and 5.2.104 provide general views of the existing conditions.

Figure 5.2.103: General view of grass clippings, garbage, and tree debris discarded in the unnamed tributary of Rattlesnake Bayou (Upper Rattlesnake Bayou - Service Road)

Figure 5.2.104: Concrete drain (left) and mowed bank (right) show ponded water in the unnamed tributary of Rattlesnake Bayou (Upper Rattlesnake Bayou - Service Road)

Upper Rattlesnake Bayou – Interstate 10 Offramp

Downstream of the Government Boulevard crossing, the channel becomes highly entrenched. The banks are very high and narrow, Figures 5.2.105, and allow a great amount of energy to pass through the system to downstream reaches during high flows, potentially creating erosion issues at this and lower reaches. Sections of the streambanks show active erosion. The buffer is relatively young with a predominate herbaceous and shrub layer including invasive species.

Figure 5.2.105: General view of entrenched channel and herbaceous shrub layer (Upper Rattlesnake Bayou – Interstate 10 Offramp)

Upper Rattlesnake Bayou - Motel Court

In the vicinity of the Motel Court crossing, the channel is still entrenched but shows a gradual transition to a slightly more stable system. The banks appear to be more stable, but active erosion could still be occurring in this area, Figure 5.2.106. The buffers, like upstream, are relatively young with predominately herbaceous and shrub vegetation including invasive species.

Figure 5.2.106: General view of a somewhat stable bank (left) and a stable bank with deposition bench (right) downstream from Motel Court (Upper Rattlesnake Bayou - Motel Court)

Rattlesnake Bayou - Business Parkway

Rattlesnake Bayou, downstream of the Interstate 10 crossing, is an entrenched system with high banks. Several areas of riprap are on the banks or in the channel. Although the banks appear relatively stable, the entrenched system allows high water flows and high sediment loads from upstream sources to be conveyed downstream.

A low-water crossing, Figure 5.2.107, spans the channel bottom northeast of Business Parkway, providing access to a sewer easement parallel to the stream. Directly downstream of the low-water crossing, Figure 5.2.108, the banks are high with minimal root protection and density, vertical, and are showing signs of active erosion. The steep banks lack a floodplain and indicate recent erosion activity.

Figure 5.2.107: General view of the low-water crossing (Rattlesnake Bayou - Business Parkway)

Figure 5.2.108: General view of eroding banks (Rattlesnake Bayou - Business Parkway)

Further downstream, northeast of Business Parkway and north of Mobile Street South, the banks begin to have improved vegetative protection but in the form of invasive privet and vines, Figure 5.2.109. Evidence of erosion diminishes downstream but is still evident by exposed suspended roots on the banks, Figure 5.2.110. Bank heights continue to drop until high flows appear to have access to the floodplain with the channel transitioning from a moderately entrenched system to a minimally entrenched system, and sediment is apparent on the floodplain, Figures 5.2.111 and 5.2.112. At this point, the stream becomes stable with low erosion potential.

Figure 5.2.109: general view of high banks, good vegetation density, and evidence of erosion (Rattlesnake Bayou - Business Parkway)

Figure 5.2.110: Lower banks, fair vegetation density, and evidence of erosion (Rattlesnake Bayou - Business Parkway)

Figure 5.2.111: General view of very low banks with equilibrium (Rattlesnake Bayou - Business Parkway)

Figure 5.2.112: General view of system aggradation and reduced channel capacity (Rattlesnake Bayou - Business Parkway)

Continuing along this reach north of Mobile Street South, as the stream becomes unconfined with access to the floodplain, the channel transitions from a single-threaded channel to a braided channel. In this area, with the wide, accessible floodplain and large sediment supply, the system is acting as an alluvial fan with the channel aggrading due to the sediment load. In-stream energy decreases during high flows as a result of decreased stream gradient and accessible floodplain, and the stream can no longer transport sediment downstream at the rate it receives sediment from upstream.

5.3 RESILIENCY

The greater Dog River Watershed is routinely affected by high volumes of rainfall associated with either frequent precipitation events in the form of isolated thunderstorms or less frequently occurring precipitation events such as hurricanes. When high volumes of rainfall occur over short durations it can cause localized or widespread flooding, particularly in areas where the natural hydrologic system, illustrated in Figure 5.3.1, has been altered. Therefore, it is important to understand a watershed's hydrologic resilience, monitor any resiliency changes, and properly plan for these changes. The term resilience means "the ability of a community to bounce back after hazardous events such as hurricanes, coastal storms, and flooding – rather than simply reacting to impacts" (NOAA, 2015b).

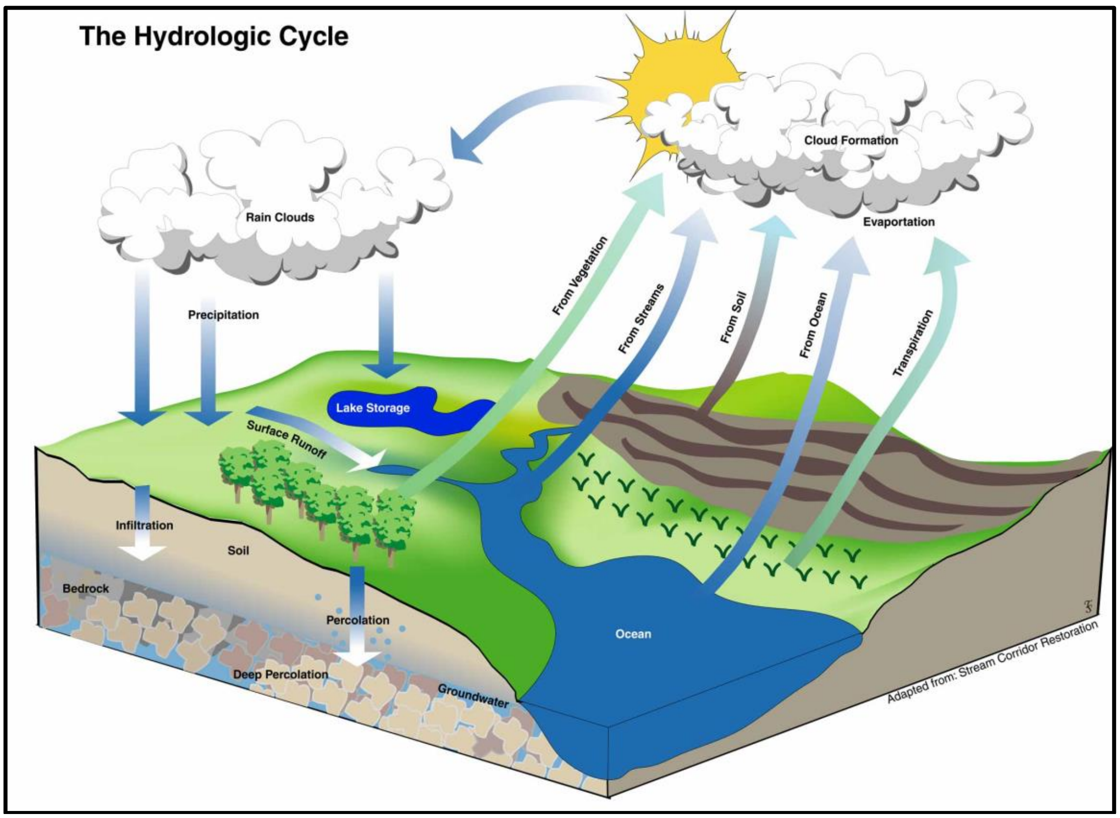

Figure 5.3.1: General overview of the hydrologic cycle (from Shultz, 2017)

Many naturally occurring features or processes directly influence the hydrologic resilience of the greater Dog River Watershed including its geographic location along the Gulf Coast, existing physiography (predominately Coastal Lowlands), topography, annual rainfall (greater than 69 inches per year since 2012), and sea level rise. In addition, the hydrologic resilience of the Watershed is affected by the built-environment (i.e. percentage of impervious cover, percentage of urbanization, construction within with 100-year floodplain, etc.), which are discussed throughout this WMP.

Over the coming decades, the populations of the Gulf of Mexico's major cities and their surrounding communities (including our greater Dog River Watershed community) are expected to increase. Coupled with the potential impacts of climate change and sea level rise on storm intensity and frequency, communities will be required to plan for events where more citizens and their homes and businesses are in the path of increasingly dangerous and costly storm conditions. The planning and regulatory decisions communities are making today about how and where they develop dictate their ability to recover after coastal storm events. Understanding where and how our communities are vulnerable to loss from coastal hazards, and adapting planning and development practices to compensate for these vulnerabilities, will ultimately result in lives, dollars, and habitats saved and stronger communities and economies in the future.

5.3.1 Flooding

The greater Dog River Watershed experiences a variety of flood events related to coastal flooding, riverine flooding, and flash flooding. Between April 28th and 29th, 2014 a significant flash flooding event occurred in Mobile County, producing upwards of 10-15 inches of rainfall. Additionally, the timing of this historic rainfall event was preceded by two weeks of excessive rainfall where rainfall totals were 200-600% of normal totals (Mobile County EMA, 2015). Damages from this particular flooding event included localized flooding, street flooding, and sinkholes (Mobile County EMA, 2015). Unfortunately, riverine and flash flood related events are common during the spring when midlatitude cyclones associated with normally occurring weather patterns oversaturate the drainage system. Additionally, high tides and storm surges can also inhibit proper drainage in the greater Dog River Watershed.

The 2015 Mobile County Multi-Hazard Mitigation Plan (Mobile County EMA, 2015) reports data from the National Climatic Data Center (NCDC) provided in Table 5.3.1. Table 5.3.1 reveals that there have been 100 flood events reported for Mobile County from 1995 to 2014. Total damages from these flood related events were estimated to cost nearly $8.5 million. Table 5.3.1 indicates that Mobile County averages 5 floods per year incurring an average of $422,750 in total damages annually (Mobile County EMA, 2015).

Table 5.3.1: Mobile County flood events, 1995-2014 (from Mobile County EMA, 2015)

Year	Floods	Deaths	Injuries	Total Damages
1995	-	-	-	-
1996	1	0	0	$300,000
1997	3	0	0	$11,000
1998	7	0	0	$1,115,000
1999	6	0	0	$45,000
2000	2	0	0	$25,000
2001	6	0	0	$19,000
2002	5	0	0	$0
2003	5	0	0	$0
2004	2	0	0	$10,000
2005	7	0	0	$80,000
2006	3	0	0	$50,000
2007	4	0	0	$0
2008	9	0	0	$290,000
2009	10	0	0	$0
2010	10	0	0	$0
2011	6	0	0	$0
2012	4	0	0	$5,000
2013	5	0	0	$0
2014	5	0	0	$6,505,000
TOTAL	**100**	**0**	**0**	**$8,455,000**
Annual Average	**5**	**0**	**0**	**$422,750**

The causes for the flooding events reported in Table 5.3.1 vary according to amount of rainfall, flow of stormwater, and capacity of the receiving channel to discharge (Mobile County EMA, 2015). As previously discussed throughout this WMP, the greater Dog River Watershed's low topographic footprint, high annual rainfall, and amount of impervious surfaces (development) collectively contribute to the threat of routine flooding events in many low-lying and near coastal areas of the Watershed. Additionally, poor land development planning in the past facilitated the degradation and removal of natural wetlands, stream buffers, and floodplains, further reducing the ability of the Watershed to naturally buffer, retain, absorb, transport, and filter water.

5.3.2 Sea Level Rise

Sea level rise (SLR) has been a persistent trend observed globally for over a century. SLR is expected to continue with rates anticipated to accelerate through the end of this century and beyond (IPCC, 2013). However, developing future SLR projections is notoriously difficult due to the numerous variables involved, and as a result, there is a wide range of projections in the scientific literature. SLR is caused by two primary factors: 1) thermal expansion of ocean waters, and 2) the melting of polar continental ice sheets. The factors are affected by rising global temperatures controlled by wide range of variables including changes in greenhouse gas emissions and numerous other feedback loops. Due to this complexity, SLR projections are expressed in terms of potential scenarios and probabilistic ranges.

Four potential SLR scenarios were developed by the National Oceanic and Atmospheric Administration (NOAA) (NOAA, 2012a), and reflect different degrees of ocean warming and ice sheet loss. These four scenarios are shown in Table 5.3.2.

Table 5.3.2: Global SLR Scenarios for 2100 (from NOAA, 2012a)

Scenario	SLR by 2100 (meters)	SLR by 2100 (feet)
Highest	**2.0**	**6.6**
Intermediate High	**1.2**	**3.9**
Intermediate Low	**0.5**	**1.6**
Lowest	**0.2**	**0.7**

The International Panel on Climate Change (IPCC, 2013) has developed SLR projections based on four complex multivariate scenarios (Representative Concentration Pathways – RCPs) including both environmental and sociopolitical factors (e.g., policy variables that address energy and greenhouse gas emissions). Figure 5.3.2 depicts the various SLR ranges predicted by IPCC (2013).

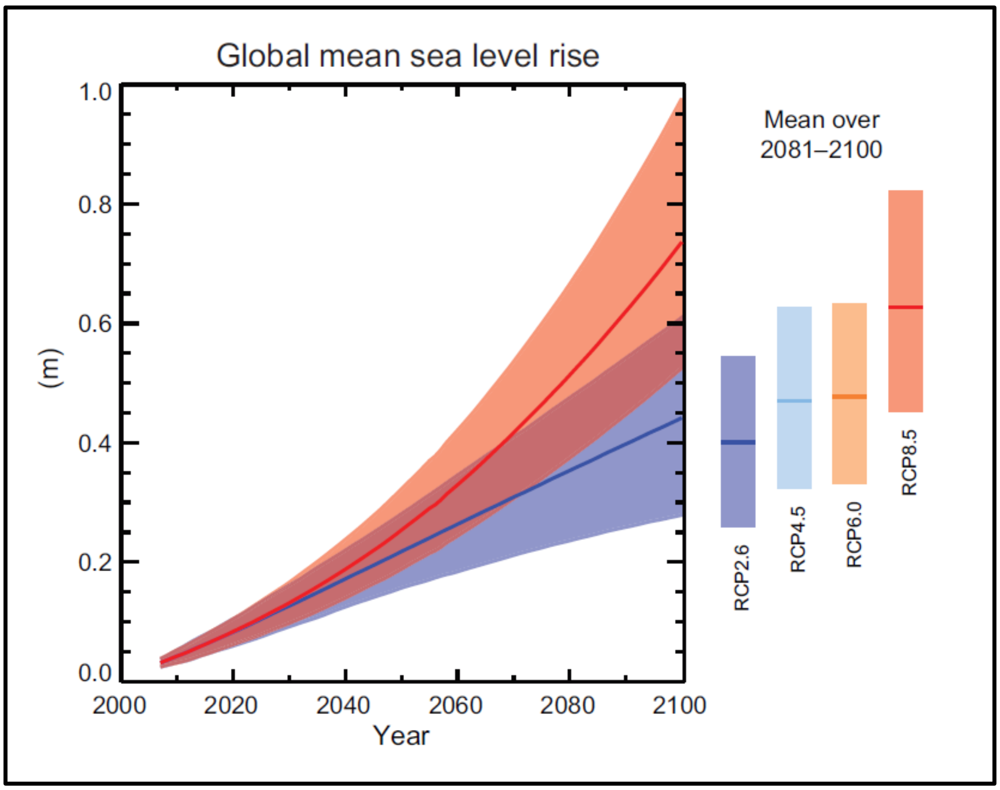

Figure 5.3.2: Global SLR scenarios for 2100 (IPCC, 2013)

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5.3.2.1 Sea Level Affecting Marshes Model

Salt marshes are amongst the most susceptible ecosystems to the effects of accelerated SLR, and many coastal resource management agencies have become concerned about the long-term loss of tidal marshes and the ecosystem services they provide. The Sea Level Affecting Marshes Model (SLAMM) was developed in the 1990s by the EPA to assist coastal resource management agencies in quantifying potential tidal marsh losses from SLR and to support planning efforts to offset those losses.

SLAMM simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term SLR. A complex decision tree incorporating geometric and qualitative relationships is used to represent transfers among coastal habitat classes. Each site is divided into cells of equal area. Each cell has an elevation, slope, and aspect. Figure 5.3.3 conceptually illustrates the SLAMM grid structure.

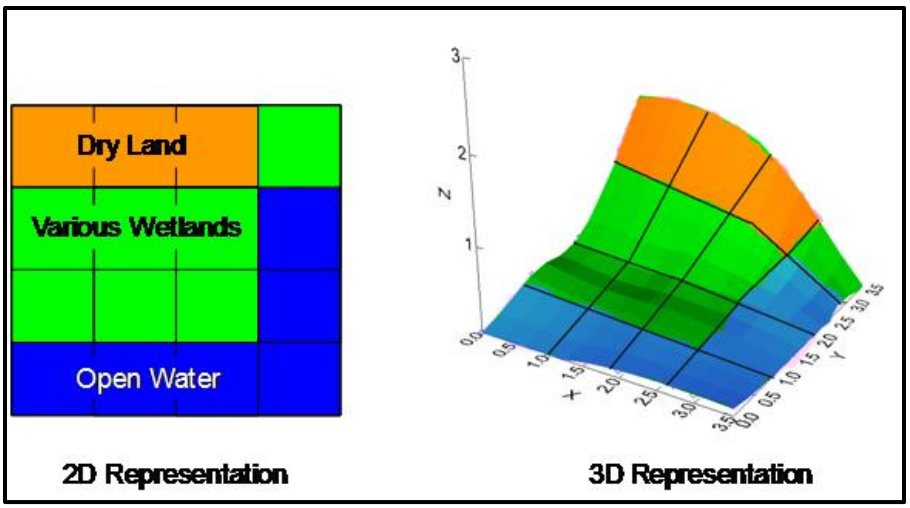


Figure 5.3.3: Conceptual grid structure of the SLAMM (from Clough, 2014)

Relative sea level change is computed for each site for each time step. It is the sum of the historic, eustatic trend, the site-specific rate of change of elevation due to subsidence and isostatic adjustments, and the accelerated rise depending on the scenario chosen (Titus et al., 1991). Once the relative sea level change is computed, SLAMM simulates five primary processes that affect tidal marshes under various sea-level rise scenarios. These processes are described below.

Inundation

The rise of water levels and the salt boundary are tracked by reducing elevations of each cell as sea levels rise, thus keeping mean tide level (MTL) constant at zero. Spatially variable effects of land subsidence or isostatic rebound are included in these elevation calculations. The effects on each cell are calculated based on the minimum elevation and slope of that cell.

Erosion

Erosion is triggered based on a threshold of maximum fetch and the proximity of the marsh to open estuarine waters. When these conditions are met, horizontal erosion occurs at a rate based on site-specific data.

Overwash

Barrier islands of under 500 meters width are assumed to undergo overwash at a user-specified interval. Beach migration and transport of sediments are calculated.

Saturation

Tidal and freshwater wetlands can migrate onto adjacent uplands as a response to increased saturation of the water table in response to rising sea level.

Accretion

Sea-level rise is offset by sedimentation and vertical accretion using average or site-specific values for each wetland habitat category. Accretion rates may be spatially variable within a given model domain.

Successive versions of the model have been used to estimate the impacts of SLR on various regions of the United States. SLAMM Version 6.0, the latest version of the model, was developed in 2009 and is the first open-source version of SLAMM. A modified version of SLAMM 6 with additional refinements was used to simulate tidal habitat changes in the greater Dog River Watershed (ESA, 2016a). The full report on the model setup, verification, results, discussion and conclusions are provided in Appendix B.

The greater Dog River Watershed SLAMM integrates three factors into the various model scenarios. These factors and the range of their values include:

- SLR (low = 21 inches; high = 29 inches);
- Accretion rates (low = 0.12 inches/year; high = 0.52 inches/year); and
- Protect development (no or yes).

In the model, SLR is added to each datum over time. To test the sensitivity of the model to SLR, the model was run with predicted intermediate low and intermediate high rates of SLR up to the year 2100 as reported by IPCC (2013).

The term “accretion” refers to the net land elevation changes resulting from the processes of sedimentation and erosion. Accretion rates are highly locally-specific; therefore, literature values derived from the Dog River area were used in the development of accretion rates for the model (ESA, 2016a). Smith et al. (2013) took sediment cores of marsh sediments in Mobile Bay to estimate sedimentation rates. Near Fowl River, less than ten miles south of Dog River, Smith et al. (2013) found sedimentation rates of 0.45 – 0.58 in/yr (11.5 – 14.8 mm/yr) for fringing marshes and 0.11 – 0.13 in/yr (2.9 – 3.3 mm/yr) for interior marshes. These values are assumed to be representative of Dog River’s sedimentation rates. To test sensitivity to sedimentation rates, the model was run with marsh accretion rates of 0.12 in/yr (3.1 mm/yr, based off of interior marsh data) and 0.52 in/yr (13.2 mm/yr, based off fringing marsh data) (ESA, 2016a).

Table 5.3.3 presents the four scenarios that were run in SLAMM to test the model sensitivity and to simulate habitat conversions in the greater Dog River Watershed.

Table 5.3.3: Dog River SLAMM Scenarios (ESA, 2016a)

Run	Sea-Level Rise	Accretion Rates	Protect Development
Run 1	Low (21 in)	Low (0.12 in/yr)	No
Run 2	High (29 in)	Low (0.12 in/yr)	No
Run 3	High (29 in)	High (0.52 in/yr)	No
Run 4	High (29 in)	Low (0.12 in/yr)	Yes

The SLAMM generates tabular and graphical output quantifying changes in habitat types resulting from the various interacting factors. Habitat change maps and acreage plots were generated for each model run, and are provided in the full SLAMM report (ESA, 2016a; Appendix B). Examples of the model's output are shown in Figures 5.3.4 and 5.3.5.

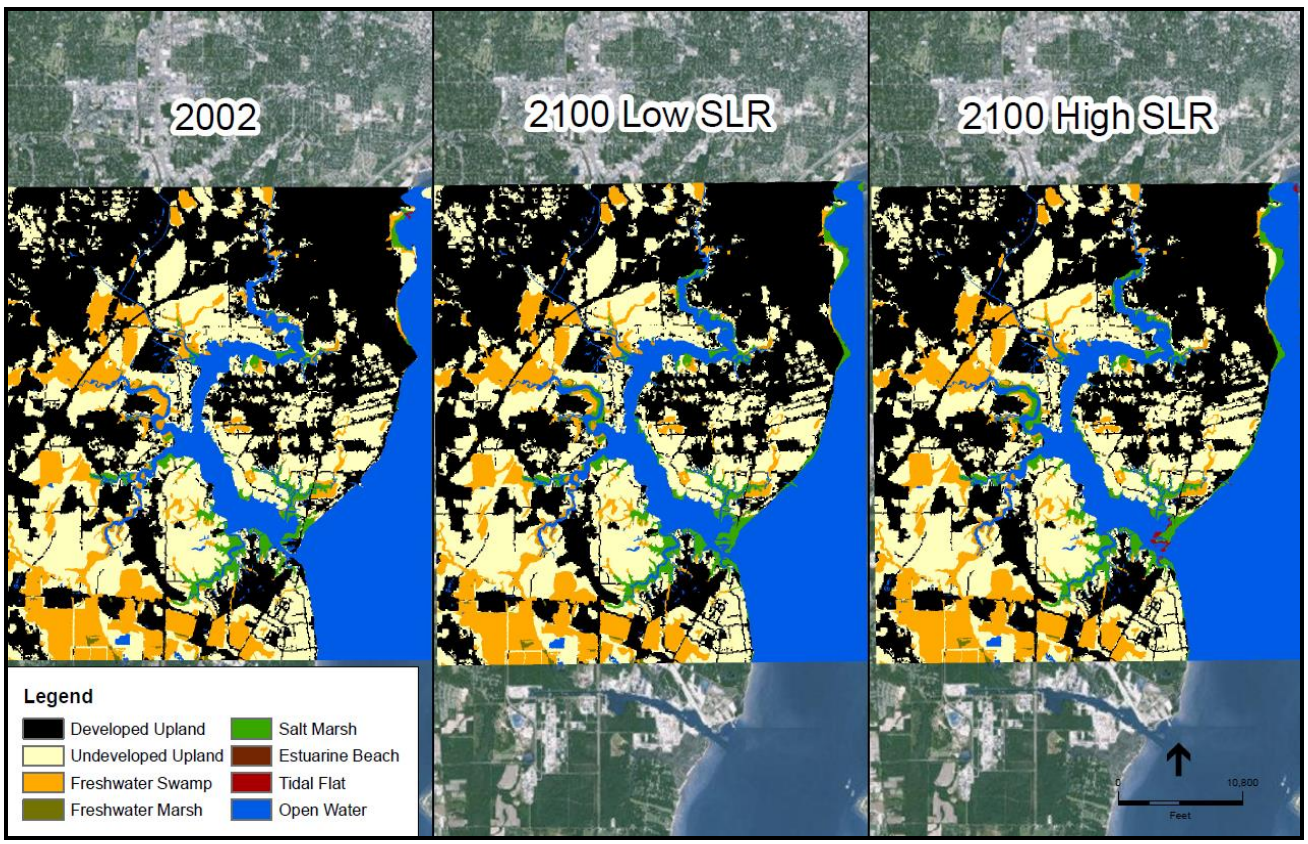


Figure 5.3.4: The greater Dog River Watershed habitat change map with low (middle) and high (right) SLR (ESA, 2016a)

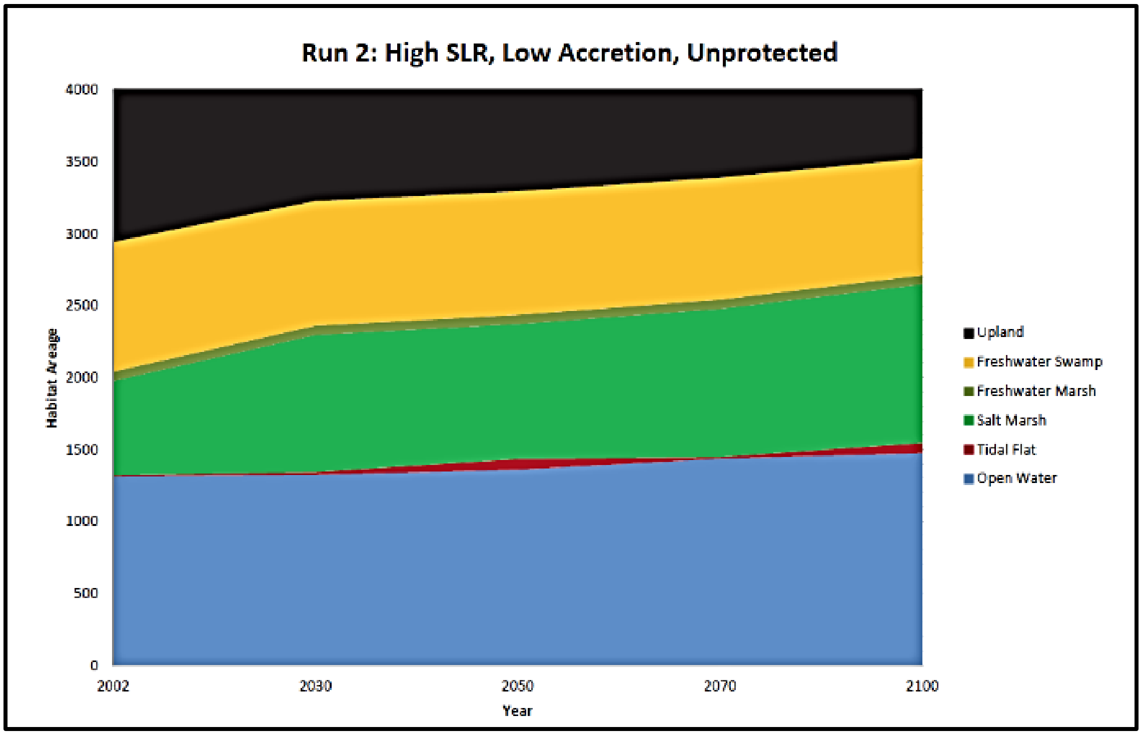


Figure 5.3.5: The greater Dog River Watershed habitat change over time (ESA, 2016a)

Of the three factors integrated in the Dog River SLAMM, these results suggest that the model is most sensitive to SLR rates. Table 5.3.4 shows the modeled habitat changes for the low and high SLR scenarios for the period of 2002 to 2100.

Table 5.3.4: Habitat acreages for two SLR scenarios in the greater Dog River Watershed

Habitat	Modeled Acreage in 2002	Acreage in 2100		Acreage difference 2100-2002	
		Low	High	Low	High
Developed Upland	49,986	49,818	49,772	-168	-214
Undeveloped Upland	26,372	26,052	26,003	-320	-369
Freshwater Swamp	4,872	4,849	4,813	-23	-88
Freshwater Marsh	65	65	64	0	-1
Salt Marsh	663	1,071	1,101	407	446
Tidal Flat	28	9	72	-19	64
Open Water	11,314	11,436	11,475	122	160

In both SLR scenarios, uplands, freshwater swamp, and marsh habitats are converted to salt marsh and open water habitats. Under the low SLR scenario, salt marsh acreage increases as upland and freshwater swamp habitats become more tidally inundated, and this effect is even more pronounced under the high SLR scenario (ESA, 2016a). The most significant habitat changes related to SLR are predicted to occur about four miles upstream of the Dog River confluence with Mobile Bay. In particular, the extensive contiguous freshwater swamp near the mouth of Halls Mill Creek is predicted to convert partially to salt marsh with low SLR and almost entirely to salt marsh with high SLR (ESA, 2016a).

Over 60% of the modeled area in the Greater Dog River Watershed is developed uplands (ESA, 2016a), and with SLR, low-lying uplands will be at risk for more severe coastal flooding and more frequent tidal inundation. The SLAMM results predict that up to 214 acres of new salt marsh, tidal flat, and open water could be created if these habitats are allowed to migrate into adjacent upland areas (ESA, 2016a). In the unprotected scenario, the model predicts that low-lying developed areas at the mouth of Dog River would convert to salt marsh and tidal flats by 2100 if these areas were properly prepared to transition to coastal wetland habitats (ESA, 2016a).

5.3.3 Storm Surge

NOAA and the National Weather Service (NWS) developed the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model to estimate near worst case inundation scenarios generated by a storm. The model employs historical, hypothetical, or predicted hurricanes data as well as the characteristics of the coastline, and track intensity, size, and forward speeds of the hurricane to estimate storm surge heights. It is a numerical model available for basins covering the United States coastal regions in the Atlantic and Pacific Oceans including the Gulf of Mexico, Hawaii, Puerto Rico, the Virgin Islands, and the Bahamas (NOAA, 2012b).

In 2016, a dynamic model methodology was developed for the northern Gulf of Mexico along Alabama, Mississippi, and the Florida Panhandle to model the effects of climate change and SLR on tidal and hurricane storm surge flooding; particularly in the coastal areas under SLR scenarios by 2100. The approach adapts the large-domain, high resolution, tide, wind-wave, and hurricane storm surge model by including shoreline and barrier island morphology, marsh migration, and land use and land cover change (Bilskie et al., 2016).

Following an exhaustive analysis of hurricane records for the Gulf of Mexico, ten hurricane events were identified to contain the greatest amount of observed peak surges for input in the 2016 dynamic model methodology: Isaac (2012), Katrina (2005), Dennis (2005), Ivan (2004), Georges (1998), Earl (1998), Opal (1995), Kate (1985), Elena (1985), and Agnes (1972). MOMs were developed for each SLR scenario using the ten historic hurricanes for a total of five MOMs surfaces; current sea level and sea level at the year 2100 at low (0.2 meters), intermediate-low (0.5 meters), intermediate -high (1.2 meters), and high (2.0 meters) SLR (Bilskie et al., 2016).

In Figures 5.3.6 and 5.3.7, simulated MOMs storm surges are depicted for the current sea level and sea level at the year 2100 at high (2.0 meters) SLR. The simulation at the present conditions produced a storm surge from approximately three to four meters in the Mobile Bay system. The simulated MOMs at higher degrees (0.2, 0.5, 1.2, and 2.0 meters) of sea level rise produce increased surges in the northern portion of Mobile Bay. These levels of inundation have the potential of causing millions of dollars in damage due to hurricane- and SLR-induced saltwater intrusion. However, the presence of dense vegetation found in some marshes, wetlands, and forests can decrease the transference of momentum from the wind to the surface of the water. The vegetative landscape can affect surge levels and inundation extents in minimizing their effects (Bilskie et al., 2016).

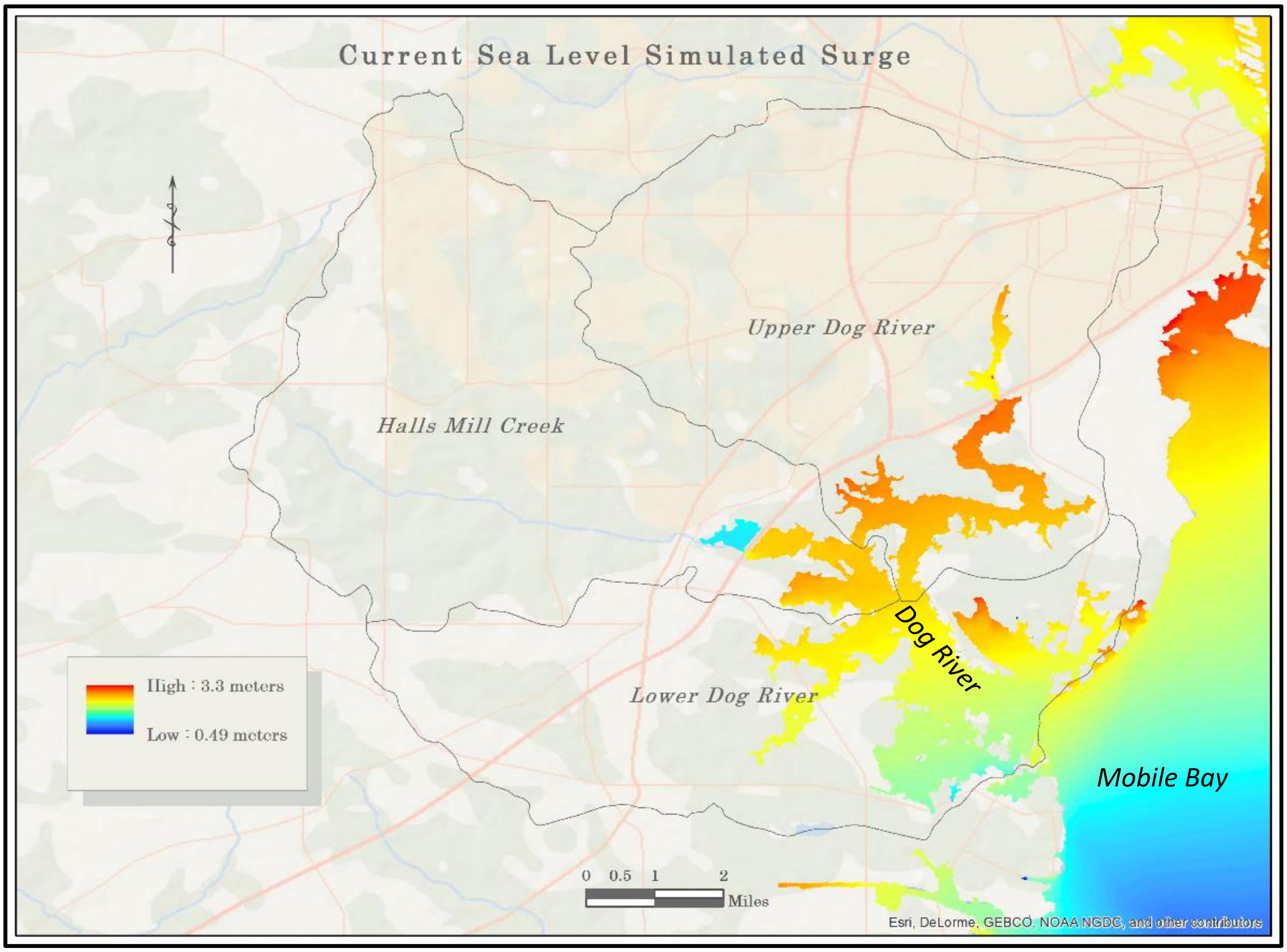


Figure 5.3.6: Simulated MOMs storm surge at current sea level (Bilskie et al., 2016)

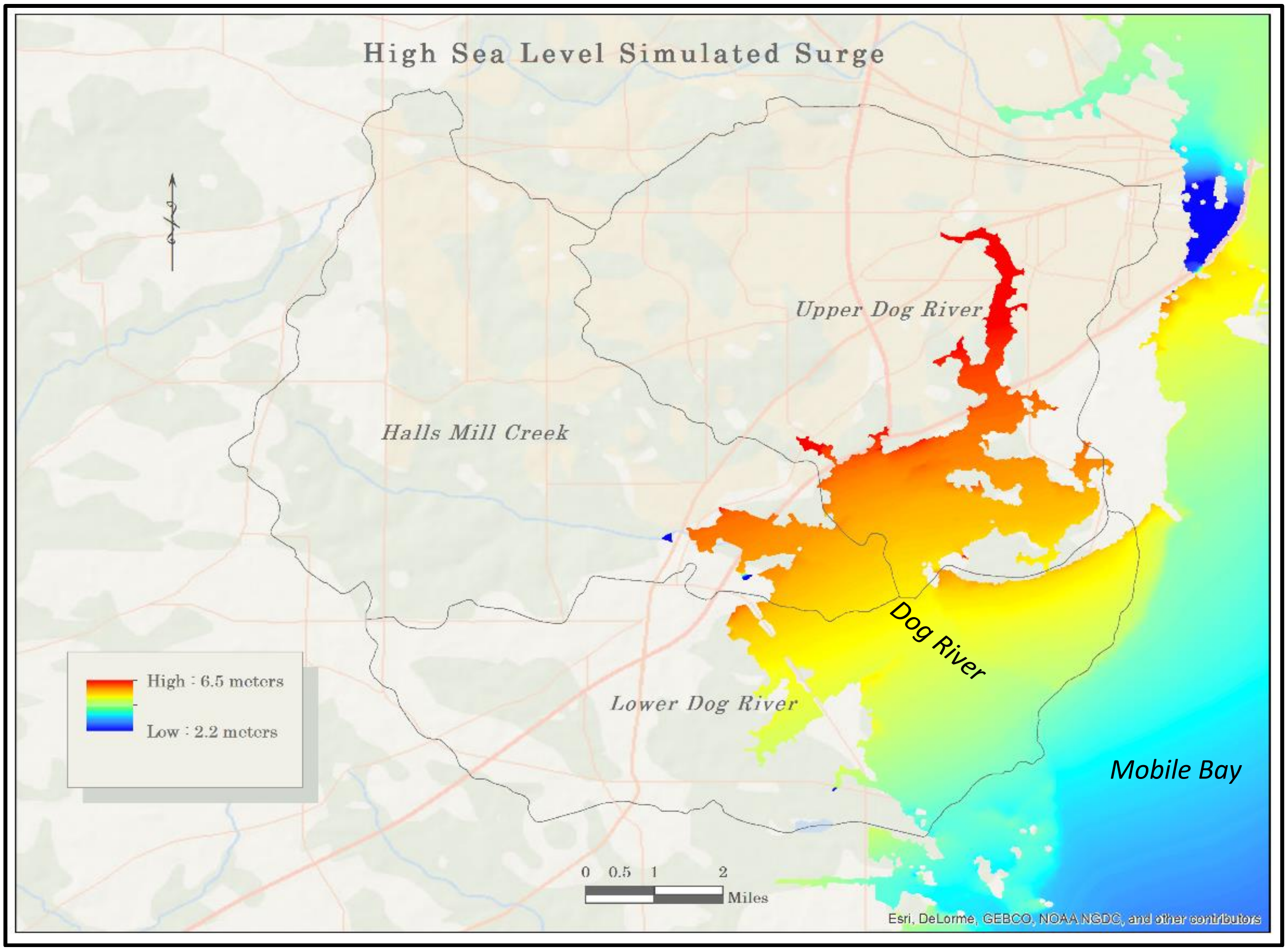


Figure 5.3.7: Simulated MOMs storm surge at high sea level rise (Source: Bilskie et al., 2016)

Storm surge can have a negative impact on the affected communities and their surrounding natural environment, damaging structures and infrastructure and altering the delicate ecological balance. Hurricane- and SLR-induced saltwater intrusion introduces the possibility of widespread damage, as well as the loss of intertidal salt marshes. In biological and ecological terms, the consequences may include the loss of habitat and the increased vulnerability of wildlife in the coastal zones. In addition, a shift in the sediment and salinity patterns resulting from increased inundation can have a direct impact on oyster, shrimp, and fish populations (Bilskie et al., 2016).

5.4 SHORELINES

Existing shoreline data for the greater Dog River Watershed was made available by the GSA (Jones and Tidwell, 2011). In 2010, the GSA (Jones and Tidwell, 2011) conducted a study of the "Dog River System" as part of its effort to classify general shoreline type, shoreline protection methods, and to quantify shoreline change in Mobile and Baldwin counties. The "Dog River System" as investigated by Jones and Tidwell (2011) comprises portions of Dog River and several of its tributaries including: Alligator Bayou, Halls Mill Creek, Moore Creek, Robinsons Bayou, Perch Creek, Rabbit Creek, and Rattlesnake Bayou. However, Jones and Tidwell (2011) did not investigate all segments of all surface water network systems in the greater Dog River Watershed.

5.4.1 Shoreline Type Classification

Jones and Tidwell (2011) classified shoreline types in the greater Dog River Watershed by conducting visual field interpretation of approximately 668,979 linear feet (126.7 miles) of shoreline between March 16, 2010 and October 29, 2010. However, when identification of shoreline type was prohibited by shoreline stabilization methods, the type of shoreline was evaluated based on the landward area (Jones and Tidwell, 2011). The shoreline classification scheme used by Jones and Tidwell (2011) for identifying shoreline type is provided in Table 5.4.1. Definitions pertaining to the various classifications presented in Table 5.4.1 are provided in Jones et al. (2009).

Table 5.4.1: Classification of shoreline type (from Jones and Tidwell, 2011)

Shoreline Type Classification
(Natural Shoreline Characteristics)
1. Artificial
2. Vegetated bank shoreline
a. Bluff
b. High bank
c. Low bank
3. Sediment bank shoreline
a. Bluff
b. High bank
c. Low bank
4. Organic shorelines
a. Open shoreline vegetated fringe
b. Swamp forest
c. Marsh
5. Sediment bank shoreline
a. Bluff
b. High bank
c. Low bank
6. Inlet
a. Ebb-tide delta
b. Flood-tide delta
7. Pocket beach

Jones and Tidwell (2011) identified 11 shoreline classification types in the greater Dog River Watershed, provided in Table 5.4.2. Table 5.4.2 reveals that the two most frequent shoreline types identified in the greater Dog River Watershed include organic shorelines (48.59%) and vegetated bank shorelines (47.45%) (Jones and Tidwell, 2011). Specifically, the three most predominate shoreline classification types identified by Jones and Tidwell (2011) include: vegetated bank (low, 0-5 ft); organic marsh; and organic swamp forest. Additionally, locations of the shoreline classification types described in Table 5.4.2 are illustrated in Figure 5.4.1.

Table 5.4.2: Greater Dog River Watershed shoreline classification types (from Jones and Tidwell, 2011)

Dog River System		
Shoreline type classification	**Length (ft)**	**Percent (%)**
Artificial	10,572	1.58
Inlet	2,921	0.44
Organic (marsh)	156,885	23.45
Organic (open, vegetated fringe)	66,636	9.96
Organic (swamp forest)	101,545	15.18
Pocket Beach	213	0.03
Sediment bank (high, 5 - 20 ft)	1,166	0.17
Sediment bank (low, 0 - 5 ft)	11,634	1.74
Vegetated bank (bluff, > 20 ft)	1,407	0.21
Vegetated bank (high, 5 - 20 ft)	31,561	4.72
Vegetated bank (low, 0 - 5 ft)	284,440	42.52
Total	668,979	100.00

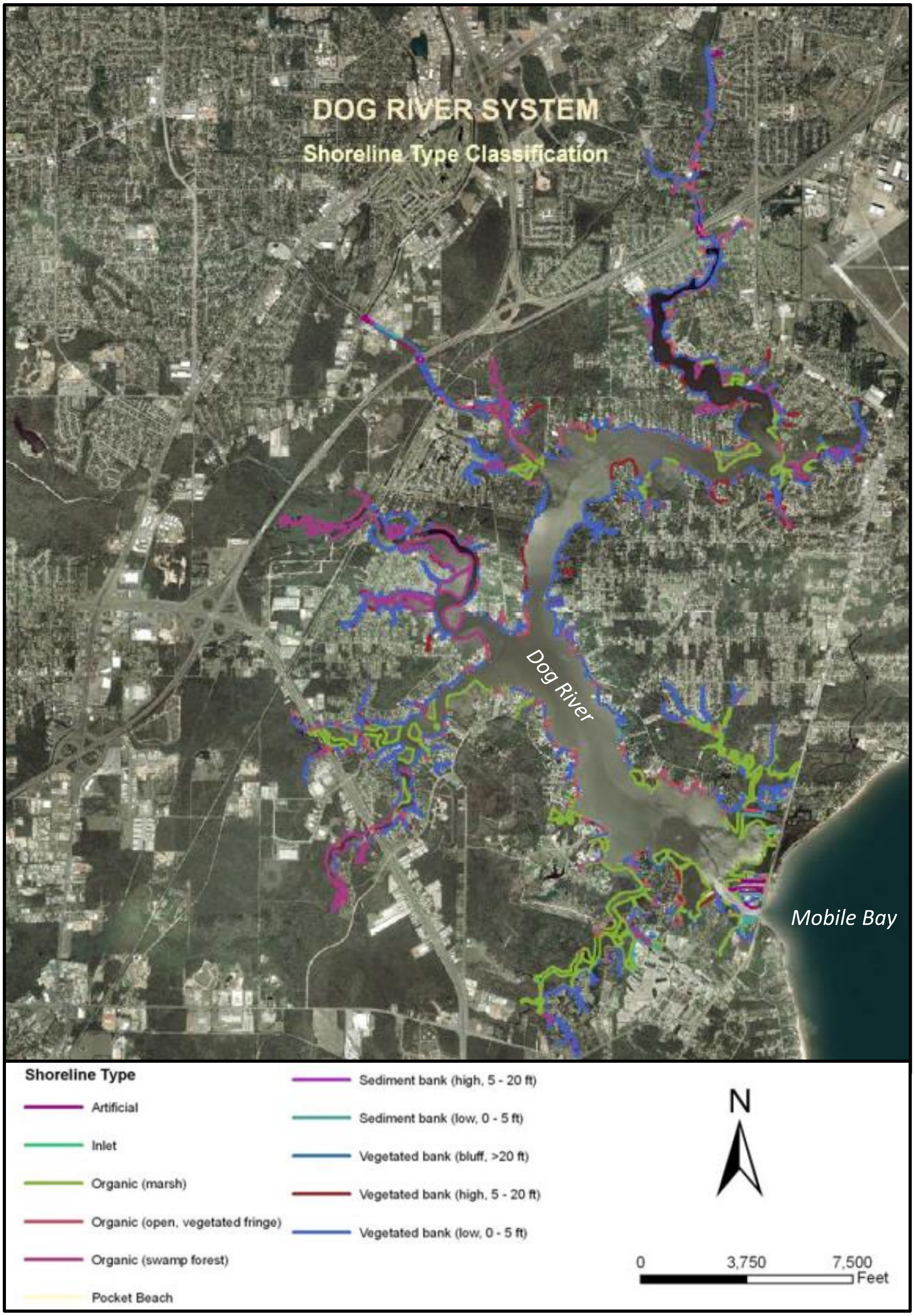


Figure 5.4.1: The greater Dog River Watershed shoreline classification types (from Jones and Tidwell, 2011)

5

5.4.2 Shoreline Protection Methods

Jones and Tidwell (2011) identified shoreline protection methods in the greater Dog River Watershed by conducting visual field interpretation of approximately 669,399 linear feet (126.8 miles) of shoreline between March 16, 2010 and October 29, 2010. Table 5.4.3 and Figure 5.4.2, respectively, report and illustrate the results of their investigation.

Table 5.4.3: Shoreline protection methods identified in the greater Dog River Watershed (from Jones and Tidwell, 2011)

Dog River System		
Shore protection classification	**Length (ft)**	**Percent (%)**
Abutment	1,874	0.28
Artificial	7,553	1.13
Boat Ramp	3,315	0.50
Breakwater (offshore)	288	0.04
Bulkhead (concrete, rock w/riprap)	825	0.12
Bulkhead (concrete, rock)	13,756	2.05
Bulkhead (steel, wood)	125,804	18.79
Bulkhead (w/retaining walls)	660	0.10
Bulkhead (w/riprap)	3,851	0.58
Cement	1,678	0.25
Groin	75	0.01
Jetty (steel pile, rock, concrete)	46	0.01
Natural, unretained	457,451	68.34
Revetment	668	0.10
Rubble/riprap	44,682	6.67
Sill (rock, shell)	771	0.12
Sill (wood w/riprap)	319	0.05
Sill (wood)	5,540	0.83
Silt fence	114	0.02
Weir	129	0.02
Total	669,399	100.00

Table 5.4.3 and Figure 5.4.2 suggest natural, unretained shorelines were the most frequently observed (68.34%) shoreline protection method for shoreline segments in the greater Dog River Watershed (Jones and Tidwell, 2011). Natural, unretained shoreline classification is defined as natural shoreline settings with vegetation or sediment exposed and no apparent shoreline modification to protect the land behind it (Jones et al., 2009). When structural shoreline protection methods and modifications were found in the greater Dog River Watershed, the most frequently observed method included bulkheads (21.64%), which are vertical stabilization structures oriented parallel the shoreline primarily to retain upland soil (Jones and Tidwell, 2011).

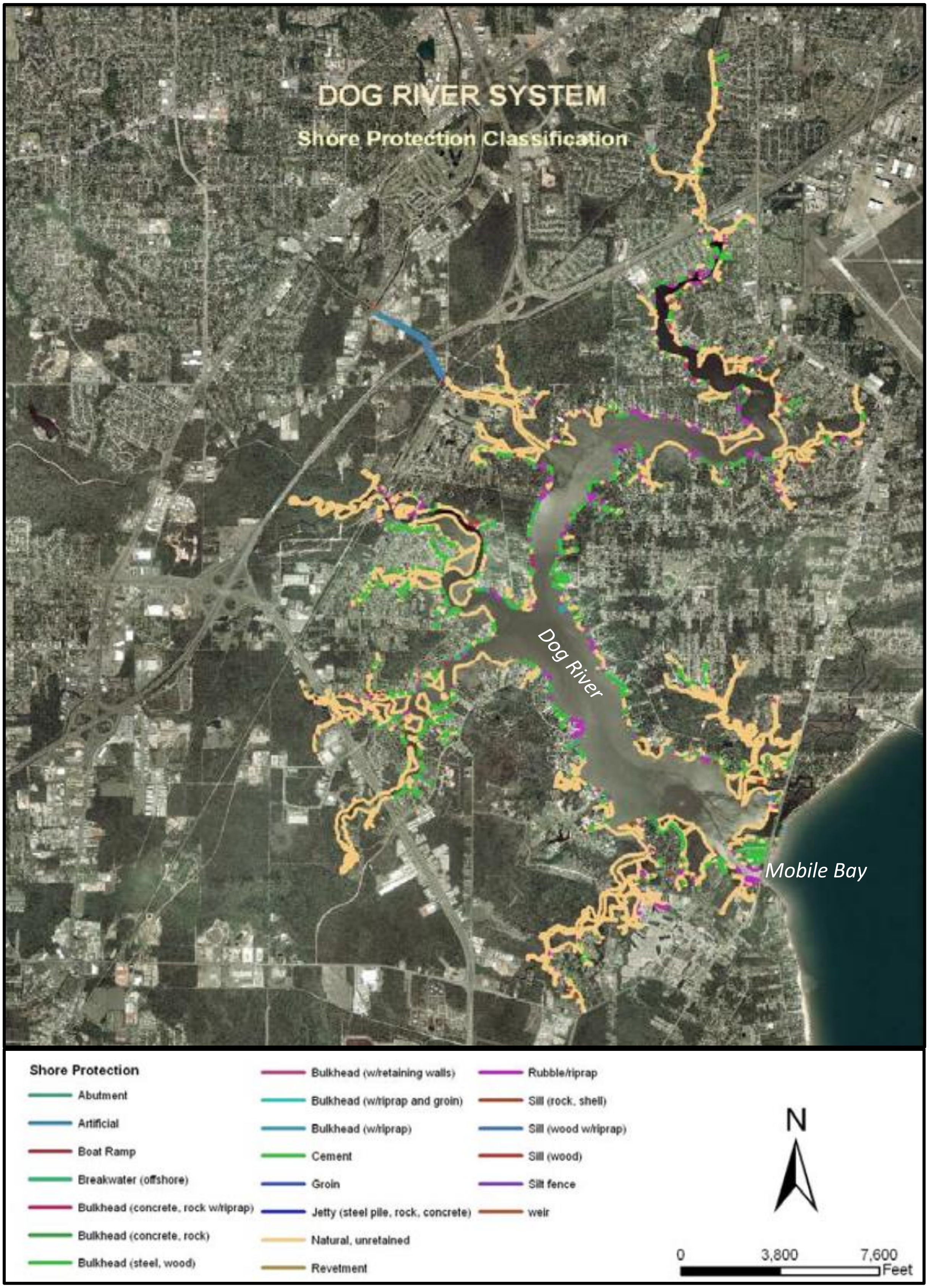


Figure 5.4.2: Shoreline protection method identified in the greater Dog River Watershed (from Jones and Tidwell, 2011)

5.5 ACCESS

Large stretches of the shoreline along Halls Mill Creek, Dog River, and their tributaries are privately owned either by individuals or organizations, or have been developed as commercial properties. Table 5.5.1 details the percentages of privately and publicly owned properties.

5.5.1 Property Ownership

Property ownership information was extracted from parcel data acquired from the Mobile County Revenue Commission (MCRC), (MCRC, 2016). The majority of the greater Dog River Watershed is composed of privately owned properties with a small percentage of publicly owned land. Table 5.5.1 suggests that between 93% and 96% of the land within the greater Dog River Watershed is privately owned, and between 3% and 6% of the land within the greater Dog River Watershed is publicly owned (MCRC, 2016).

Publicly owned land is split between the various city, county, state, and federal governments and includes features such as parks, cemeteries, and roadways. Property ownership for government buildings in the greater Dog River Watershed is negligible.

Table 5.5.1: Privately and publicly owned property in the greater Dog River Watershed (MCRC, 2016)

Watershed	Ownership	Square Feet	Percentage
Upper Dog River Watershed	Public	44,044,253.36	5.7
	Private	724,168,539.5	94.3
Lower Dog River Watershed	Public	23,961,858.99	3.8
	Private	599,016,792.92	96.2
Halls Mill Creek Watershed	Public	51,943,406.05	6.4
	Private	753,772,925.99	93.6

5.5.2 Recreational Opportunities

Recreational opportunities within the greater Dog River Watershed are diverse and include walking trails, sports complexes, nature trails, boating, fishing, and swimming. Parks and recreational opportunities and amenities are listed by watershed in Table 5.5.2 and are displayed in Figures 5.5.1 and 5.5.2. Existing data on access to marinas, boat ramps, fishing areas, parks, and trails are provided in Figures 5.5.1 and 5.5.2. The Dog River Clearwater Revival (DGCR) website, http://dogriver.wpengine.com/what-we-do/water-land-trails/dog-river-scenic-blueway/, also provides a Blueway Trail map, shown in Figure 5.5.3.

Table 5.5.2: Parks and Recreational Opportunities (City of Mobile, 2016b)

Watershed	Park	Amenities*
Halls Mill Creek Watershed	Halls Mill Creek, Mary Knoll, Timberlane, Vista Ridge	7
	Medal of Honor	1, 2, 6
	Mims Lambert, West Mobile County, Westside	1, 2
Upper Dog River Watershed	Joe A. Bailey, Crestview, Doyle, Fry, Hackmeyer, Stotts (Demetropolis), Walsh	1, 2
	Baumhauer-Randle, Crawford-Murphy	1, 2, 4
	Bayview, Glenwood, Highcrest, Memorial, Primrose, San Souci, Skyland, Sky Ranch	7
	Denton	2
	Dog River, Laun, Rickarby	1, 2, 5
	Harmon, PFC Johnson Howard	1, 2, 6
	Herndon	1
	Martha B. Maitre	1, 2
	Malibar Heights	1
	Mathews	1
	Public Safety Memorial	6
	Rich	2
	Trimmer	1,2,5
Lower Dog River Watershed	Bayshore, Hollingers Island	7
	Boykin	1
	McNally, Trimmer	1, 2, 5
	Stewart Road	1, 2

*Amenities: (1) sports, (2) playground, (3) fishing, (4) swimming, (5) boating, (6) nature/walking trail, (7) greenspace/picnic tables only

Currently there are eight parks in the Halls Mill Creek Watershed: Mary Knoll, Medal of Honor, Mims Lambert, Timberlane, West Side, West Mobile County, Vista Ridge, and Schwarz Parks (City of Mobile, 2016b). There are 30 parks in the Upper Dog River Watershed (City of Mobile, 2016b). The majority of these facilities have ballfields, some have walking paths, and three have hiking/nature trails. A lengthy walking trail connects Glenwood Park and Memorial Park. A scenic nature/hiking trail is located at Medal of Honor Park partially within the Upper Dog River and Halls Mill Creek Watersheds. Dog River Park, in the Upper Dog River Watershed, is home to the City's only municipal boat ramp providing direct access to Dog River. In the northern portions of the Upper Dog River Watershed there are two additional walking trails that connect the Three Mile Creek Watershed with downtown Mobile.

There are six parks in the Lower Dog River Watershed: Boykin Park, Hollingers Island Park, McNally Park, Trimmer Park, Stewart Park, and Bayshore Park (City of Mobile, 2016b). Trimmer Park and McNally Park have walking trails; the trail at McNally Park connects the Lower Dog River Watershed to the adjoining Garrow's Bend Watershed. Additionally, a portion of the Crepe Myrtle Trail lies in the Lower Dog Watershed and travels north passing through the Garrow's Bend Watershed, and is proposed to continue north as a connection to downtown Mobile as a bicycle route.

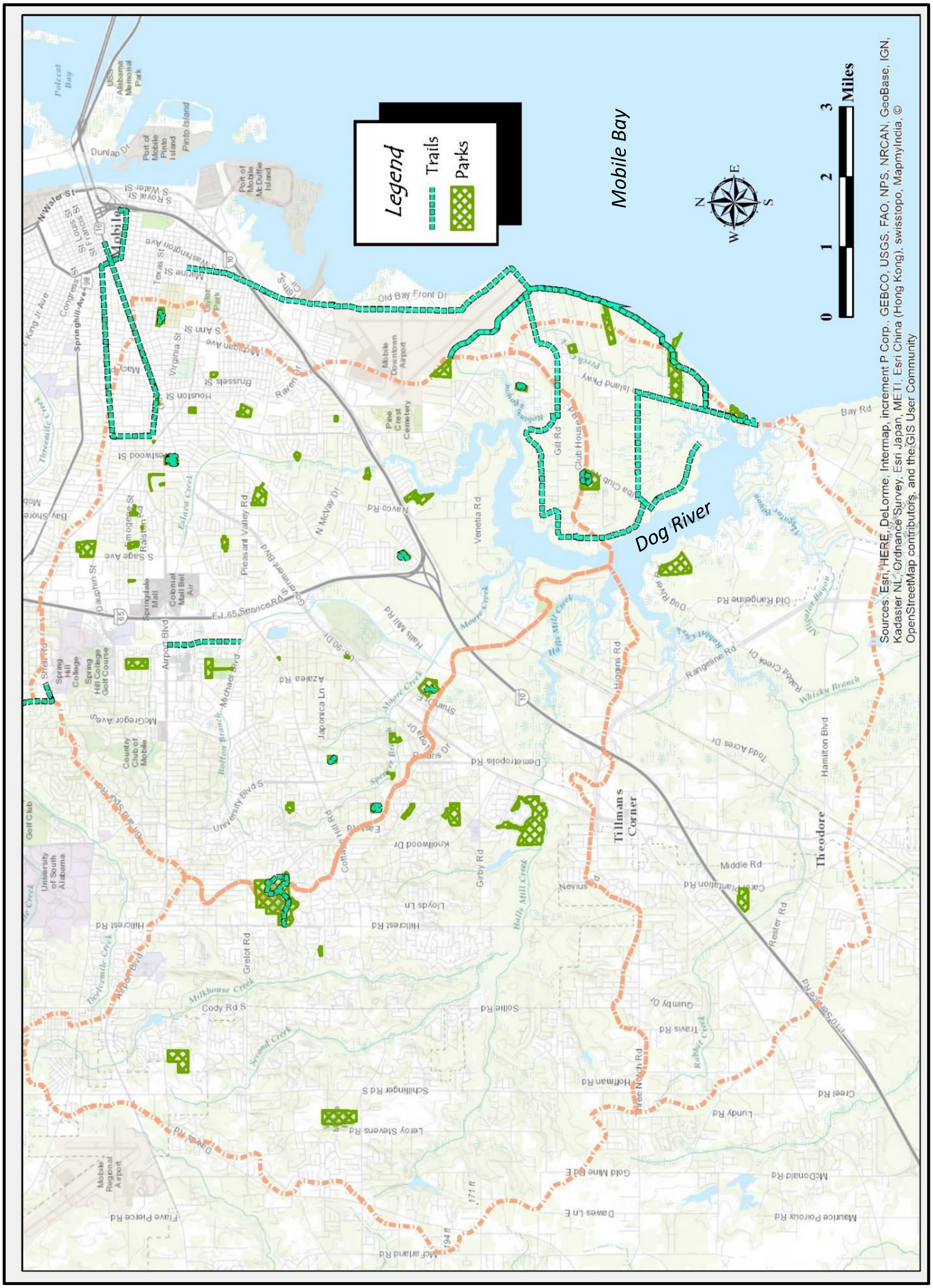


Figure 5.5.1: Locations of parks and trails in the greater Dog River Watershed (City of Mobile, 2016b)

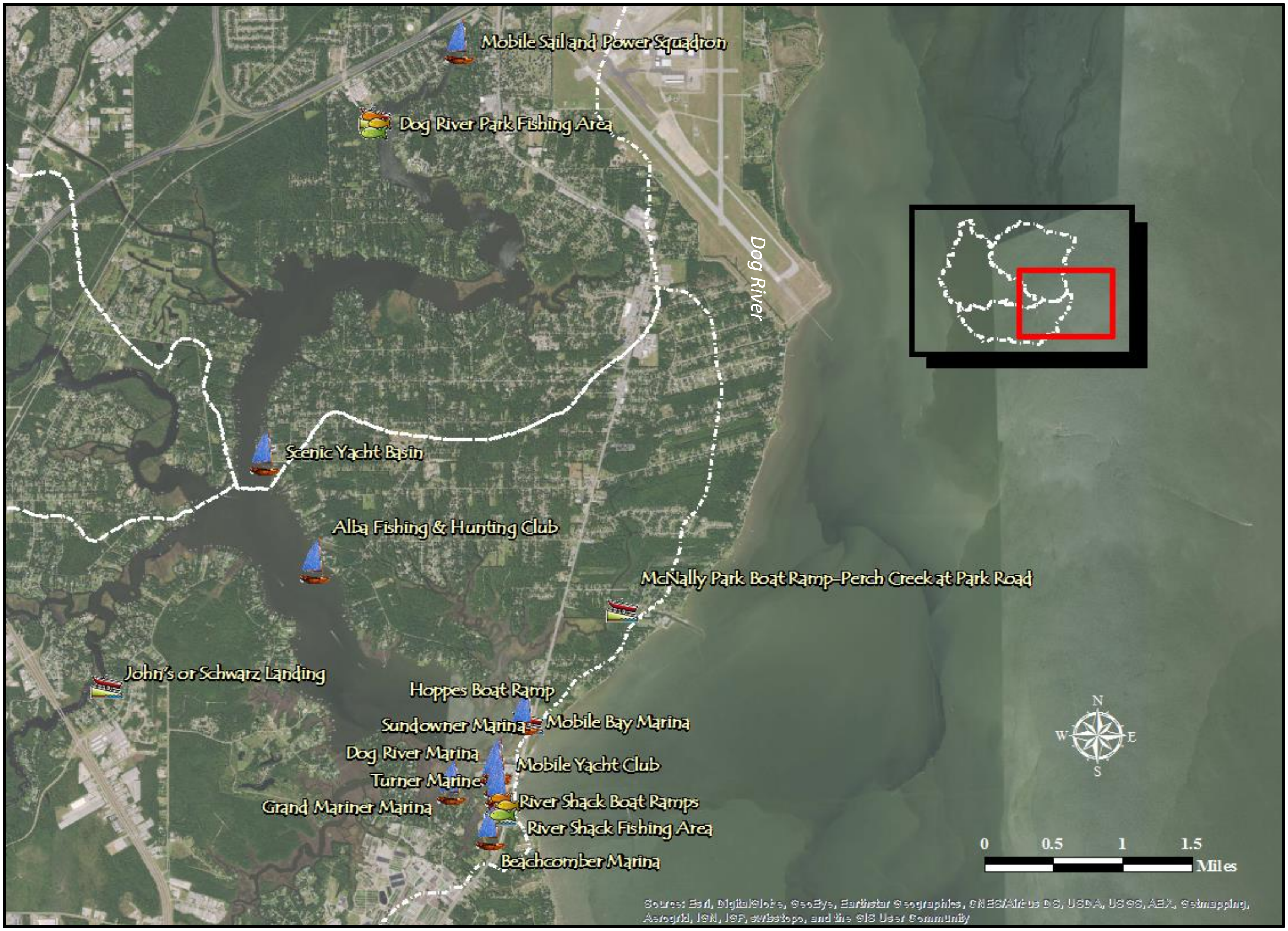


Figure 5.5.2: Marinas, boat launches, and fishing areas (City of Mobile, 2016b)

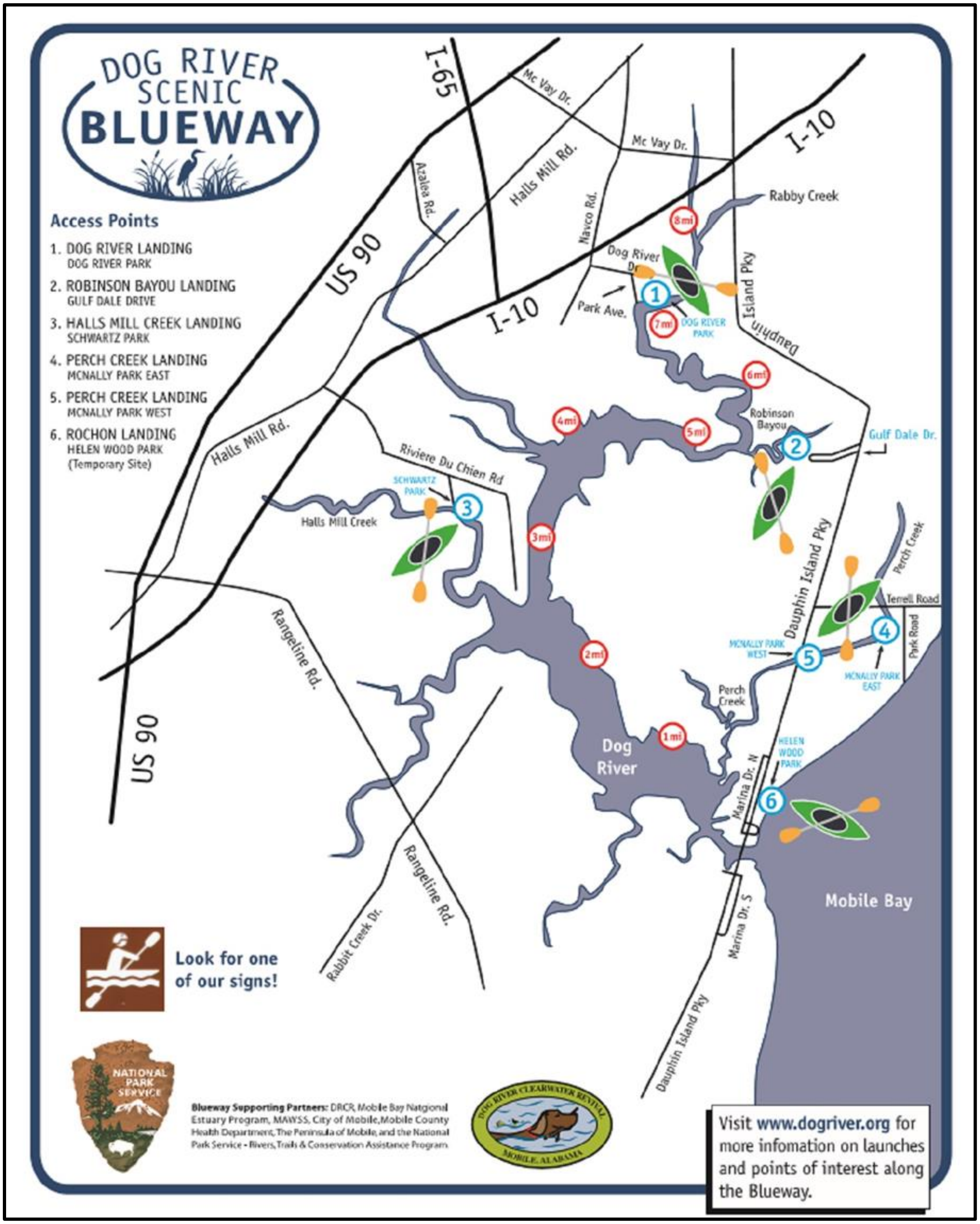


Figure 5.5.3: Blueway map for Dog River (from DRCR)

5.6 DATA GAPS

The compilation of information during the development of the greater Dog River WMP has led to the identification of significant gaps in the data acquired, which should guide future research and data collection relevant to the goals of the WMP. The following were identified either as limited in content or lacking the content necessary to provide adequate answers:

1. Establishment of long-term monitoring stations with consistent parametric coverage to support long-term tracking of status and trends and regulatory compliance.
2. Assessment of loadings of nutrients and other pollutants based on routine simultaneous measurements of flow and concentrations at primary tributary inflows.
3. Microbial source tracking to identify animal sources (e.g., human, dogs, cattle, etc.) of observed bacterial violations.
4. Discharge and sediment loading data compilation in Moore Creek near Halls Mill Road at Latitude 30.6275 North and Longitude -88.13737 West. During the GSA's data collection period for the *Analysis of Discharge and Sediment Loading Rates in Tributaries of Dog River in the Mobile Metropolitan Area* study researchers were unable to capture data along this area of interest due to site conditions.
5. Establishment of continuous discharge data sites.
6. Assessment of sediment loadings specific to the Watershed.
7. Assessment of the flora, fauna, and protected and invasive species specific to the Watershed.
8. Complete and accurate channel lining data collection.
9. Detailed investigation of the historical and cultural assets of the Watershed.
10. Initiate a comprehensive hydrologic modeling program specific to the Watershed.
11. Field verification of impervious surface data.
12. Evaluation of the impacts of SLR on local infrastructure.

5

5.6.1 Water Quality Data Gap Identification

As previously noted, the temporal, spatial, and parametric coverage of ambient surface water quality data from Dog River (stream) have varied substantially, as very few stations have been monitored consistently. Although sufficient historic and recent data exist to adequately determine the general status and trends in surface water quality, water quality monitoring measures are in need of improvement. Recommendations are presented in Chapter 7 of this document to address identified informational gaps including:

- Establishment of long-term stations with consistent parametric coverage to support long-term tracking of status and trends and regulatory compliance;
- Assessment of loadings of nutrients and other pollutants based on routine simultaneous measurements of flow and concentrations at primary tributary inflows; and
- Microbial source tracking to identify animal sources (e.g., humans, dogs, cattle, etc.) of observed bacterial violations.

6.0 IDENTIFICATION OF CRITICAL AREAS AND ISSUES

Critical areas and issues affecting the health of the greater Dog River Watershed were identified in a multifaceted fashion through input from the greater Dog River Watershed Management Plan (WMP) Steering Committee, public workshops, field reconnaissance by the Watershed Management Team (WMT), scientific modeling, analysis of historical aerial photography and maps, and analysis of other data. Critical areas and issues identified for the greater Dog River Watershed are predominately correlated to effects from urbanization and development and include:

- Water quality degradation and pollution impairment of surface waters;
- Physical degradation and impairment of surface waters and critical habitats;
- Improving the Watershed's hydrologic resilience; and
- Improving public access to the water network system.

6.1 WATER QUALITY DEGRADATION AND POLLUTION IMPAIRMENT OF SURFACE WATERS

Water quality degradation and the pollution impairment of surface waters located within the greater Dog River Watershed were identified as priority issues based on studies by the Geological Survey of Alabama (GSA), data provided by the Alabama Department of Environmental Management (ADEM) and the Alabama Water Watch (AWW) organization, public perception, and input from the Steering Committee and WMT. As outlined in Chapter 5, surface waters in the greater Dog River Watershed experience water quality degradation and impairment from several pollutants including pathogens, nutrients, litter, and sediment.

Intense rainfall and stormwater runoff events facilitate the substantial loading of pollutants in the greater Dog River Watershed, particularly from areas heavily urbanized by impervious surfaces. As stormwater runoff moves through the surface water network system, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and groundwater reservoirs. Stormwater runoff rates are greatly affected by the amount of rainfall and the type of ground surface present. Stormwater runoff is greatest in urbanized areas with large amounts of impervious surfaces. For over 20 years ADEM has noted that elevated pollutant concentrations follow heavy precipitation events and storm activity in the Watershed indicating that non-point sources (stormwater runoff) significantly influence water quality in the greater Dog River Watershed (ADEM, 1994).

6.1.1 Pathogens and Nutrients

Pathogen and nutrient loadings originate from either point or nonpoint sources. Point source contributions are typically attributed to municipal wastewater facilities, municipal separate storm sewer systems (MS4s), illicit discharges, and leaking or overflowing sewers (ADEM, 2005). Nonpoint source contributions are typically attributed to urban runoff, onsite wastewater systems (septic tanks), wildlife and waterfowl, manure applications, and livestock grazing (ADEM, 2005). Within the greater Dog River Watershed, sanitary sewer overflows (SSOs) and illicit discharges associated with outfalls for MS4s are two significant sources for pathogen and nutrient pollutant loadings.

6.1.1.1 Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are events where untreated sewage is discharged from the sewage collection and conveyance system to the environment. SSOs can be the result of pipeline blockages from sand and grease, but, most often, they are the result of aging pipelines and pump lift stations that are incapable of handling large volumes of rainfall. Small cracks in conveyance pipelines, caused by tree roots and deterioration, allow rainwater to infiltrate into the pipelines. In addition, during heavy rainfall events, surface and groundwater may seep into the sewage conveyance system. These additional sources of water may exceed the carrying capacity of the conveyance system and cause overflows. SSOs endanger human health, as well as fish and wildlife, by releasing bacteria, viruses, and other pathogens, as well as nutrients and oxygen demanding materials to nearby surface waters.

The advanced age of the sewage collection and conveyance facilities in the greater Dog River Watershed and the high amount of precipitation that falls in coastal Alabama have created a high frequency of SSOs in the Watershed. Table 6.1.1 reveals that millions of gallons of untreated sewage are released each year in the greater Dog River Watershed (Mobile Baykeeper, 2017). The Mobile Baykeeper organization has tracked SSOs in the greater Mobile Bay area for over a decade. Figures 6.1.1 and 6.1.2 show the location and relative magnitude in terms of volumes released from SSOs in and around the greater Dog River Watershed in 2016 and in 2017, respectively (Mobile Baykeeper, 2017). Figures 6.1.1 and 6.1.2 reveal that many of these documented SSOs occurred in the Upper Dog River Watershed near Eslava Creek.

Table 6.1.1: Reported sewage spills reaching waterbodies in the greater Dog River Watershed (from Mobile Baykeeper, 2017)

Named Waterbody	2016		2017 (January to May 8th, 2017)	
	Number of Reported Spills	Sewage Spilled per Waterbody (Gallons)	Number of Reported Spills	Sewage Spilled per Waterbody (Gallons)
East Bolton Branch	2	9,975	-	-
West Bolton Branch	1	1,260	-	-
Dog River	7	14,755	15	477,035
East Eslava Creek	98	961,735	109	1,692,000
Halls Mill Creek	2	181,200	3	271,425
Milkhouse Creek	-	-	1	1,400
Montlimar Creek	-	-	2	1,219
Rabbit Creek	2	600	2	7,950
Robinson Bayou	4	10,900	-	-
Second Creek	1	1,400	1	252,000
Spring Creek	2	19,435	-	-
Total	119	1,201,260	133	2,703,029

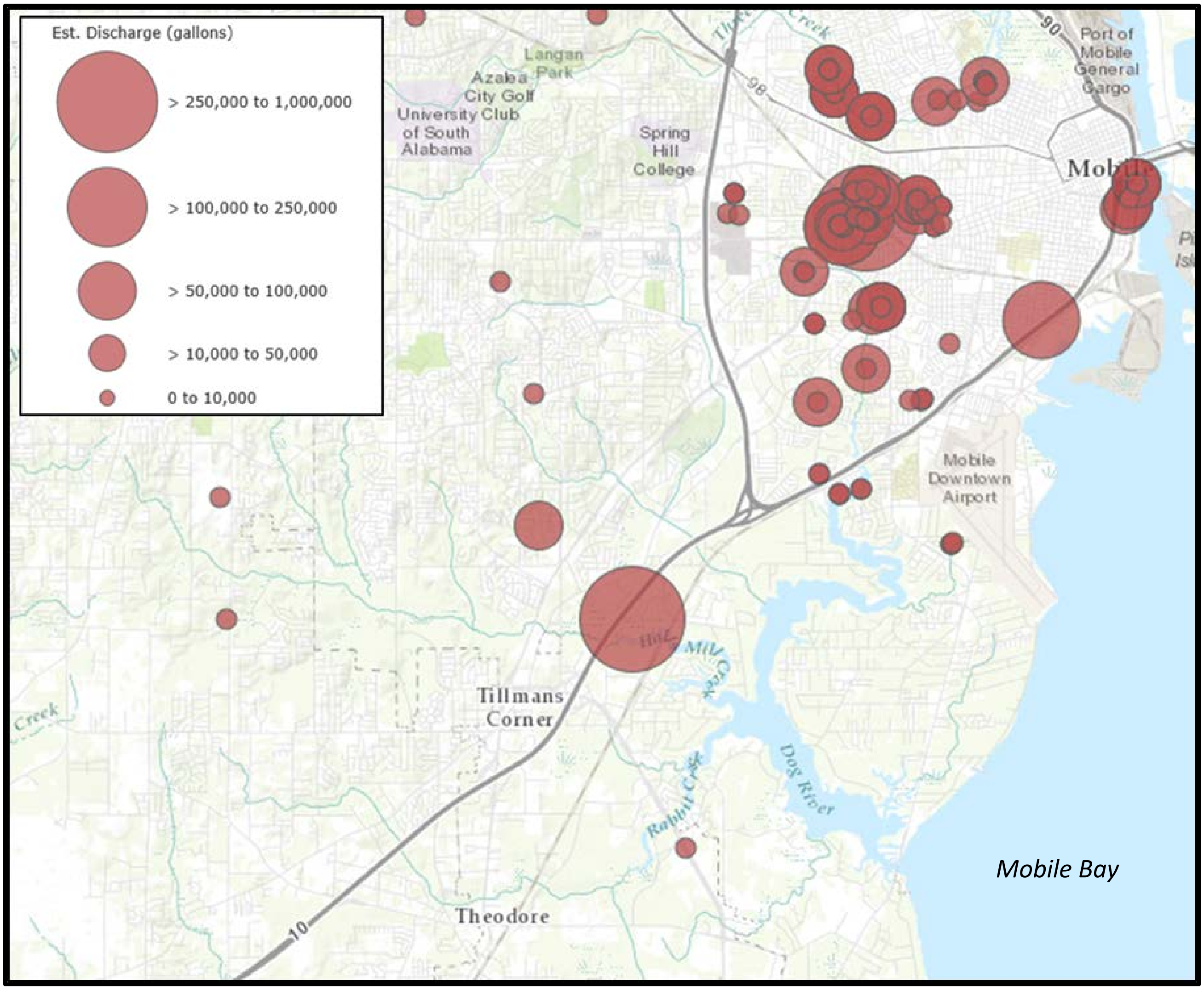


Figure 6.1.1: Location and relative magnitude of SSOs occurring in 2016 (Mobile Baykeeper, 2017)

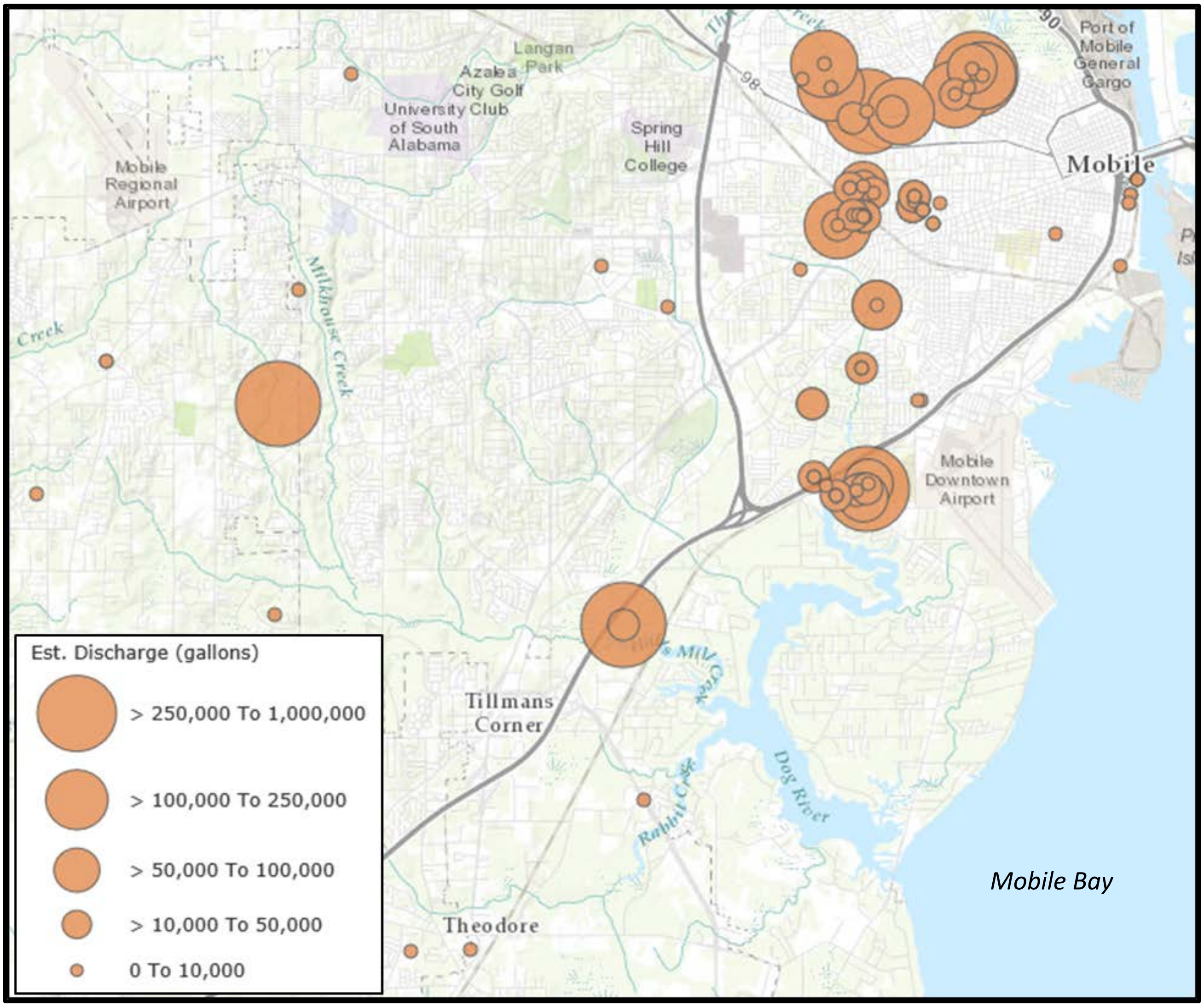


Figure 6.1.2: Location and relative magnitude of SSOs occurring January through May 8, 2017 (Mobile Baykeeper, 2017)

6.1.1.2 Illicit Discharges

An outfall is a specific location where MS4s discharge from a pipe, ditch, or other point of concentrated flow into either a stream or waterbody. Proper identification and mapping of outfalls provides a specific location (point source) that can be monitored prior to it discharging into local waterways. An illicit discharge is any kind of waste or wastewater from non-stormwater sources discharged to MS4s. MS4s consist of storm drains, ditches, man-made channels, and municipal streets. Examples of illicit discharges include: 1) Lawn cuttings; 2) Trash and litter; 3) Effluent from a failing septic system; 4) Eroded sediment from construction sites; and 5) Chemical spills from industrial sites (e.g., automotive oil and solvents).

The City of Mobile owns and operates the MS4s that overlap most of the greater Dog River Watershed. As part of their responsibilities as the permit holder, the City of Mobile has mapped all stormwater outfalls to surface waters. In addition, the City is required to track and document illicit discharges to its MS4s as part of its Illicit Discharge Detection and Elimination (IDDE) Plan. Figure 6.1.3 shows the locations of outfalls and illicit discharges in the greater Dog River Watershed (City of Mobile, 2016a). Efforts to eliminate water quality issues that arise through illicit discharges are vital.

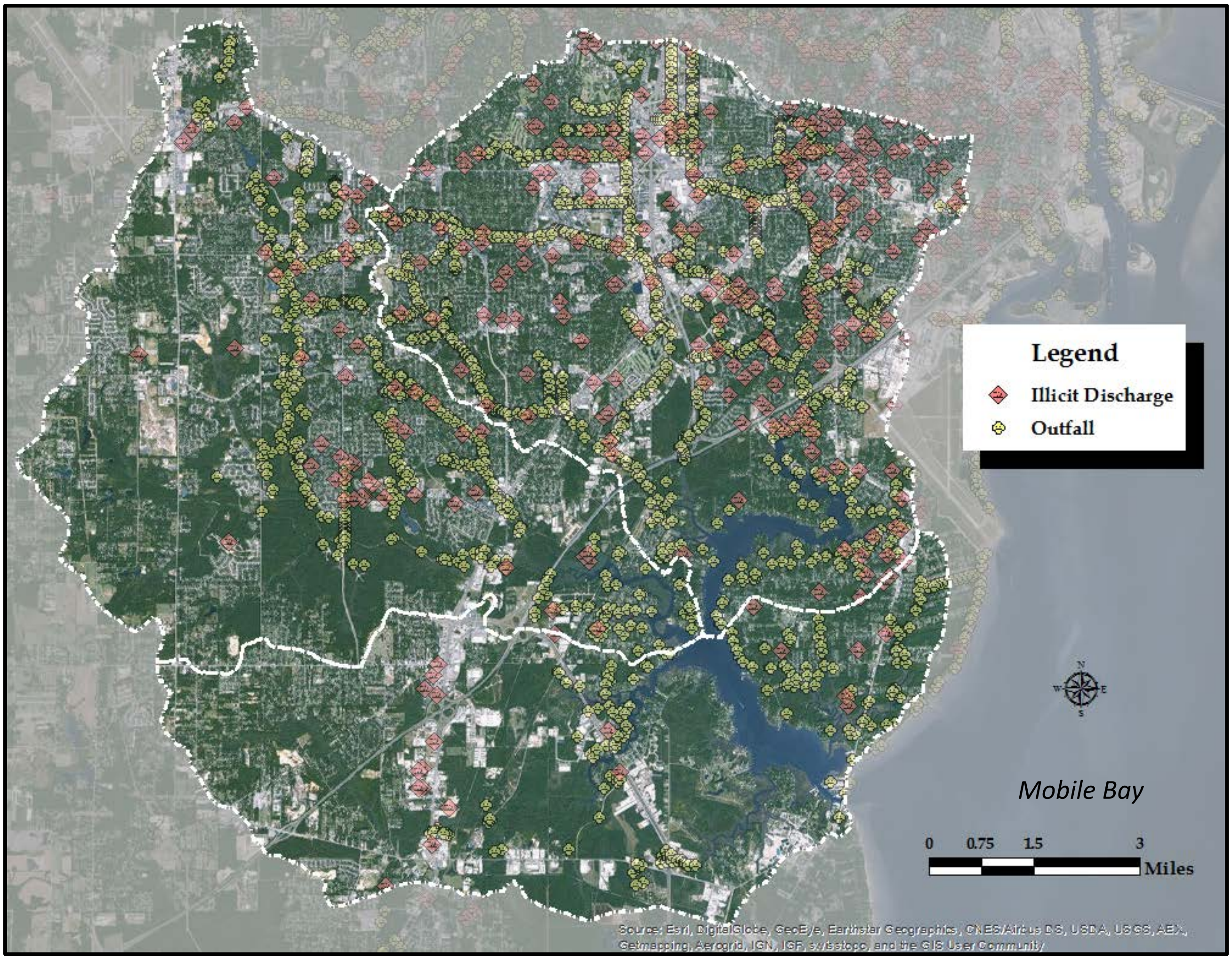


Figure 6.1.3: Outfalls and illicit discharge locations in the greater Dog River Watershed (City of Mobile, 2016a)

6.1.2 Litter

In addition to pathogens and nutrients, stormwater runoff also transports litter from urbanized areas (parking lots and roadside ditches) into stream channels and ultimately into Dog River and Mobile Bay. Combating litter requires a multifaceted approach that not only targets the cleanup of existing litter but focuses on educating the community to stop it at its source. Increased development and population directly correlate to increased litter sources. Controlling litter has been a longtime focus and remains a significant issue of concern.

Litter contributes to pollutant loads that impact the quality of the water, the health of its habitats, and the overall quality of life in the greater Dog River Watershed. Figure 6.1.4 is a general view of Milkhouse Creek that illustrates the issue of litter degrading the water quality and habitats in the Watershed. Litter has historically been a significant and reoccurring issue for the Watershed. A permeant litter trap, shown in Figure 6.1.5, was installed to reduce litter loads on Eslava Creek. The Eslava Creek litter trap has been a proven and effective tool in reducing the quantity of litter that enters Dog River and Mobile Bay. Continued effort and strategies are necessary to effectively control litter on all tributaries of Dog River.

Figure 6.1.4: Example of litter occurring on Milkhouse Creek in the Halls Mill Creek Watershed

Figure 6.1.5: A general view of the litter trap located on Eslava Creek at McVay Drive

6.1.3 Sediment

Suspended sediment is defined as the portion of a water sample that can be separated from the water by filtering. Sediment may be composed of organic and inorganic particles that include algae, industrial and municipal wastes, urban and agricultural runoff, eroded material from geologic formations, or streambed particles that are too large or too dense to be carried in suspension by stream flow. These materials are transported to stream channels by overland flow related to stormwater runoff and cause varying levels of turbidity. Suspended sediment loading within the greater Dog River Watershed was identified as a priority issue based on studies by the GSA, data provided by the ADEM and the AWW organization, public perception, and input from the Steering Committee.

The investigation completed by Cook and Moss (2012) (Appendix A) indicates that estimated erosion and sediment transport rates within the greater Dog River Watershed are the highest in Eslava Creek, Spencer Branch, and Spring Creek. Eslava Creek and Spencer Branch are located within the Upper Dog River Watershed, and Spring Creek is located within the Halls Mill Creek Watershed. Sediment loads estimated for Spencer Branch, Spring Creek, and Eslava Creek in the greater Dog River Watershed were seven times the natural background geologic erosion rates, and as shown in Figure 6.1.6 were among the highest of about 55 streams assessed by GSA statewide (Cook and Moss, 2012). Cook and Moss (2012) report that these stream segments (Spencer Branch, Spring Creek, and Eslava Creek) feature consistently higher sediment loads resulting from stormwater runoff related to more mature urban areas of the Watershed. These findings reflect the impacts intense urbanization has on stream dynamics, erosion, and sediment loads.

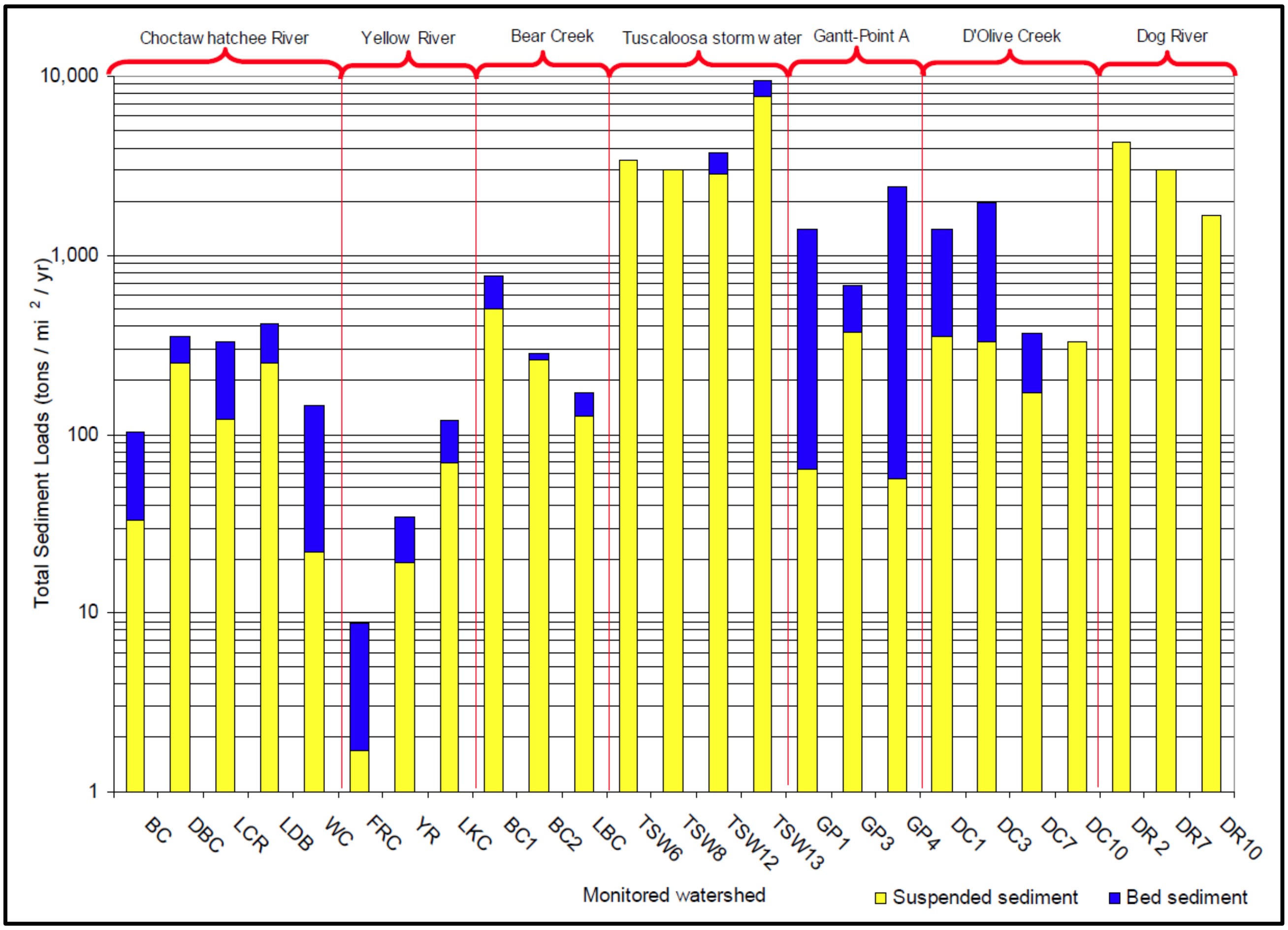


Figure 6.1.6: Comparison of estimated normalized total sediment loads from select streams through Alabama and Eslava Creek, Spencer Branch, and Spring Creek (from Cook and Moss, 2012)

6.1.4 Estimation of Nonpoint Source Stormwater Pollutant Loads

Urban pollution (pathogens, nutrients, sediment, trash, etc.) from stormwater is a significant concern contributing to degraded water quality within the greater Dog River Watershed. Because of the critical role stormwater runoff from urbanized areas has for pollutant loads in the Watershed, an estimate of annual nonpoint source stormwater pollutant loads from urban areas was developed for the greater Dog River Watershed (ESA, 2016b). A geospatially based calculation model utilized readily available land use and soil type data combined with curve number (CN), runoff coefficient (C), and event mean concentration (EMC) lookup tables for the following key pollutants: 1) Total nitrogen (TN); 2) Total phosphorous (TP); 3) Total suspended solids (TSS); 4) Biological oxygen demand (BOD); 5) Copper; 6) Lead; and 7) Zinc. Based on the methods described by ESA (2016b), annual pollutant loads were developed for each Watershed that comprise the greater Dog River Watershed for the following pollutants: TN, TP, BOD, TSS, copper, lead, and zinc. Table 6.1.2 shows the estimated annual pollutant loads by Watershed (pounds per year). Table 6.1.3 shows the estimated annual pollutant load per unit volume of runoff (pounds per acre, feet per year) by Watershed.

Table 6.1.2: Estimated annual pollutant load (ESA, 2016b)

Watershed	Area (Acres)	Runoff Volume (Ac-Ft)	Estimated Annual Load (Pounds/Year)						
			TN	TP	BOD	TSS	Copper	Lead	Zinc
Halls Mill Creek	20,863	28,486	76,622	11,352	242,496	1,272,934	406	114	1,729
Lower Dog River	16,996	35,842	58,759	8,771	188,409	1,007,041	310	91	1,366
Upper Dog River	21,798	39,480	138,492	20,394	472,764	2,517,176	751	224	3,399
Total (greater Dog River)	**59,656**	**103,808**	**273,873**	**40,517**	**903,670**	**4,797,151**	**1,466**	**429**	**6,494**

Table 6.1.3: Estimated annual pollutant load per unit volume of runoff (ESA, 2016b)

Watershed	Area (Acres)	Runoff Volume (Ac-Ft)	Estimated Annual Load Per Runoff Volume (Pounds/Ac-Ft/Year)						
			TN	TP	BOD	TSS	Copper	Lead	Zinc
Halls Mill Creek	20,863	28,486	2.7	0.1	21.4	5.2	<0.1	0.3	15.2
Lower Dog River	16,996	35,842	1.6	0.1	21.5	5.3	<0.1	0.3	15.0
Upper Dog River	21,978	39,480	3.5	0.1	23.2	5.3	<0.1	0.3	15.2
Total (greater Dog River)	**59,656**	**103,808**	**7.8**	**0.3**	**66.1**	**15.8**	**<0.3**	**0.9**	**45.4**

Approximately 103,808 acre feet of water per year, or approximately 100 million gallons per day, on average, of stormwater runoff are delivered to Mobile Bay by the surface water drainages of Dog River. With this quantity of stormwater runoff comes a substantial annual load of pollutants, approximately 153 tons of TN, 23 tons of TP, 51 tons of material that increase BOD, and 27,000 tons of TSS. In terms of total annual load, the Upper Dog River Watershed has the highest pollution loads of the three watersheds that comprise the greater Dog River Watershed. This is primarily due to the intensity of the land development and associated impervious surface (urbanization), which results in the greater runoff volumes.

Based on pollutant load per unit volume of runoff given in Table 6.1.3, the Upper Dog River Watershed is the most polluting, followed by the Halls Mill Creek and Lower Dog River watersheds. Again, this is primarily due to the intensity of the land development and associated impervious surface, urbanization, as well as the particular mix and location of land use types in these watersheds. Figure 6.1.7 shows the geospatial concentrations (annual areal loadings) of TN, TP, BOD, TSS, and zinc in the greater Dog River Watershed. In the greater Dog River Watershed, the areal loadings of zinc are similar to those for copper and lead, which are strongly associated with urban land uses.

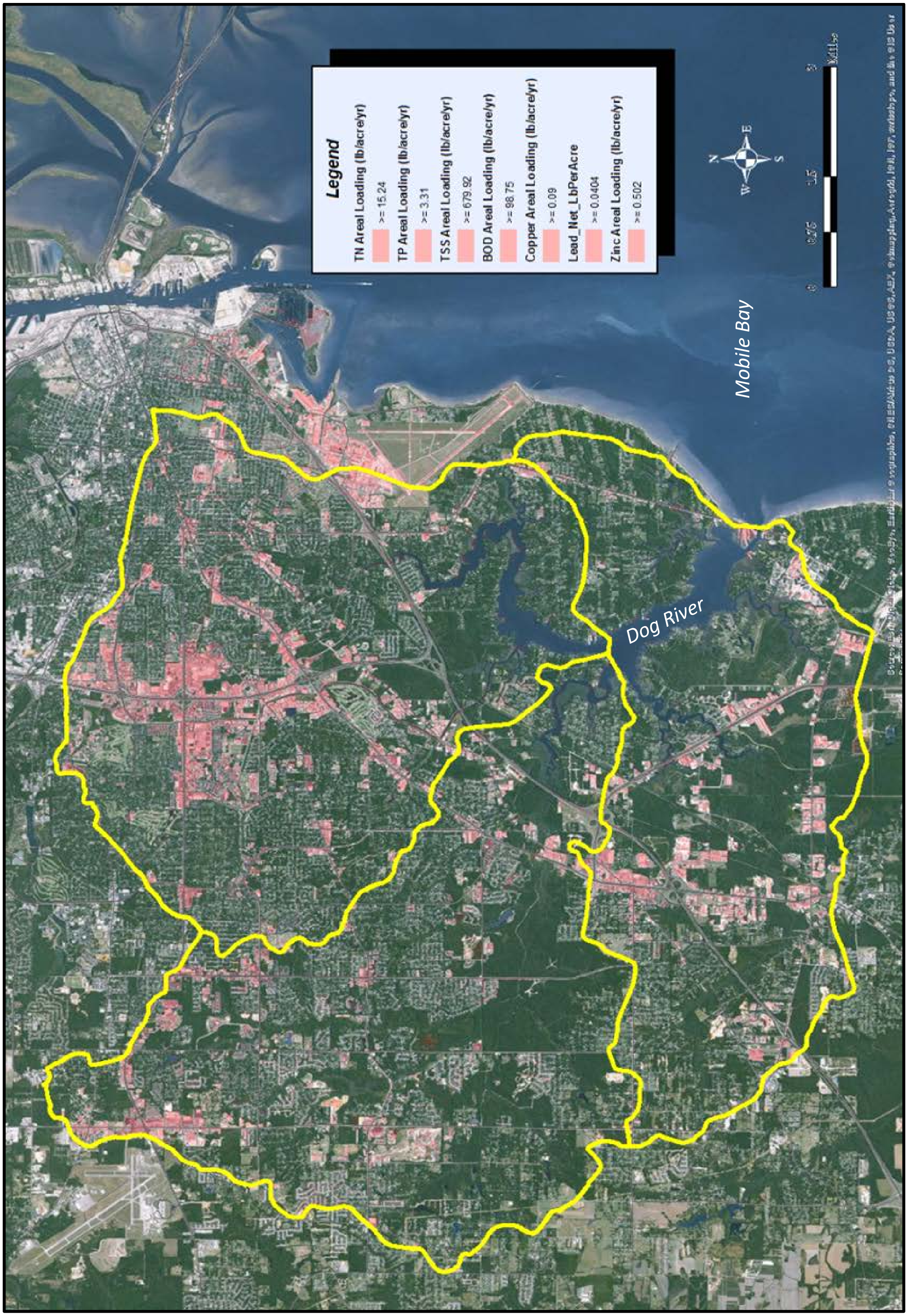


Figure 6.1.7: Annual areal pollutant loads in the greater Dog River Watershed (ESA, 2016b)

6.2 PHYSICAL DEGRADATION AND IMPAIRMENT OF SURFACE WATERS AND CRITICAL HABITATS

Habitat loss and degradation are critical issues affecting the health and resiliency of the greater Dog River Watershed. Development and urbanization are the most intense stressors facilitating the physical degradation and impairment of water quality and habitats in the greater Dog River Watershed. Development increases the amount of impervious surface coverage while additionally facilitating the encroachment and removal of natural habitats. Researchers suggest that stream degradation can occur when the percentage of impervious cover reaches as little as 10% of the total watershed surface area (Scheuler, 2003). As noted in Chapter 4 of this WMP, impervious surfaces cover approximately 16.08% of the total surface area in the greater Dog River Watershed (Xian et al., 2011), indicating streams in the Watershed are likely degraded or stressed due to increases in impervious coverage overtime.

Furthermore, surface water network systems located within the greater Dog River Watershed have become extensively altered (armored, channelized, realigned, etc.) to allow for development and urbanization. The physical alteration of channel geomorphology (dimensions, pattern, and profile), buffers, and floodplains results in altered flow regimes (timing and quantity) with the potential to create new or exacerbate existing stream bank erosion. Flow regimes of watersheds change in response to losses in native buffers, floodplains, and wetland habitats, which have historically provided ecosystem services of infiltration, retention, and absorption. The loss of infiltration, retention, and absorption services coupled with the channelization and armoring of the surface water network system results in a “flashy” hydrologic system (intensified hydrologic peaks with decreased lag times). During storm events, this can translate to increased flow and energy, which the native channels and hydrologic system have not evolved the capacity to handle. This can lead to headcutting and bank sloughing, augmenting the sediment load of the stream system, particularly during heavy rainfall events.

Additionally, habitats in the greater Dog River Watershed are host to several invasive species commonly observed in Mobile County and throughout the southeast. As previously discussed throughout this WMP (Chapters 3 and 5), the spread of invasive species is recognized as one of the major factors contributing to ecosystem change and instability. Invasive species have the ability to displace or eradicate native species, alter fire regimes, damage infrastructure, and threaten human livelihoods. These fast-growing species outcompete native vegetation and threaten the ecological diversity of uplands, wetlands, riparian buffers, and surface waters. Without treatment, these areas can become homogenous stands, eradicating natural and native species.

As described throughout this WMP, impervious surfaces, man-made alterations, and invasive species, etc., collectively contribute to the cumulative loss and degradation of natural, native habitats (forests, wetlands, streams, intertidal zones, coasts, etc.) in the greater Dog River Watershed. In particular, a great concern for the future health and resiliency of the Watershed are locations where native habitats have been extensively impacted or altered to the degree that they are unstable or have reduced ecosystem health or functions. Critical habitats of concern identified by this WMP for the greater Dog River Watershed include streams, wetlands, and shorelines.

6.2.1 Streams

Streambed particles roll, tumble, or are periodically suspended as they move downstream. Transport of sediment is controlled by a number of factors including stream discharge and flow velocity, erosion and sediment supply, stream base level, and physical properties material. Most streams are in a constant state of flux as the channel is continually modified by sediment deposition and transport. Local factors affecting stream channel stability include fluctuations in the water table elevation, changes in the supply of sediment to the stream caused by changing precipitation rates, and/or land use practices (urbanization) that promote excessive erosion in the floodplain or upland areas of the greater Dog River Watershed.

The GSA completed a study of discharge and sediment loading rates in tributaries of the Dog River Watershed (Cook and Moss, 2012). Cook and Moss (2012) concluded that stream flow characteristics of tributaries, provided in Table 6.2.1, varied widely due to a wide range of landforms, channel types, and flow regimes influenced by urbanization, channel modifications, and floodplain structures. Measured stream velocities were greatest where extensive channelization was present, and were not related to stream gradient (Cook and Moss, 2012).

Table 6.2.1: Stream flow characteristics for monitored sites in the greater Dog River Watershed (from Cook and Moss, 2012)

Monitored Site	Average Discharge (cfs)	Maximum Discharge (cfs)	Minimum Discharge (cfs)	Average Flow Velocity (ft/s)	Maximum Flow Velocity (ft/s)	Minimum Flow Velocity (ft/s)	Stream Gradient (ft/ mi)
West Bolton Branch	58.9	268.0	2.7	3.3	9.00	0.72	55
Spencer Branch	26.8	83.4	0.0	2.70	7.50	0.00	62
Milkhouse Creek	12.0	23.2	3.0	-	-	-	44
Second Creek	46.1	150.0	7.4	-	-	-	44
Halls Mill Creek (upstream)	30.6	120.0	4.5	0.60	1.00	0.07	64
Spring Creek	20.5	65.4	1.2	2.40	5.45	0.61	58
Halls Mill Creek (downstream)	72.8	107.0	44.5	1.20	1.50	1.08	26
Rabbit Creek	53.0	200.0	12.1	-	-	-	31
East Eslava Creek	99.7	318.0	4.4	2.1	3.00	1.10	6

Changes in watershed uses and characteristics, including natural buffer removal and land use conversion to development, have the ability to impact a stream channel's natural geomorphology — specifically, its dimensions, pattern, and profile. The increased runoff has the potential to create new or exacerbate existing stream bank erosion, destabilizing streams and leading to headcutting and bank sloughing augmenting sediment loads in the stream system. Throughout the greater Dog River Watershed, stream channels have been physically altered, realigned and channelized. Physical alterations may include, but are not limited to, concrete lining to create culverts or armoring with rip rap and gabion. In areas where vegetated stream banks may have been replaced by concrete-lined channels, conveyance for stormwater increases while flooding is reduced. However, infiltration is hindered, stormwater runoff volumes and pollutant loads are increased, and the natural habitats from the bed and embankments of the stream are destroyed, thereby hampering the natural ecological services provided by the stream. Additionally, the loss of riparian buffer vegetation eliminates shade over the streams leading to higher water temperatures, which can potentially affect water quality.

Generally, stream conditions improve moving from upper to lower portions of the greater Dog River Watershed. This spatial trend is likely due to more intense development in the upper Watershed, and the lower Watershed being better flushed and diluted by tidal water exchange with Mobile Bay.

6.2.2 Wetlands

Wetland areas (both forested wetlands and tidal marsh) naturally act as buffers to filter contaminates and store flood flows through increased attenuation. However, many of these areas have been lost or hydrologically altered over time. The greatest loss of historic wetland habitats in the Watershed has occurred as a result of draining and/or filling of wetlands for development and the conversion of wetlands and/or floodplain to impervious surfaces. As shown in Figure 6.2.1, the greatest loss of wetland habitats in the greater Dog River Watershed appears to have occurred prior to the passage of the Clean Water Act in 1972, which regulates the discharge of dredge and fill material into waters of the United States, including wetlands.

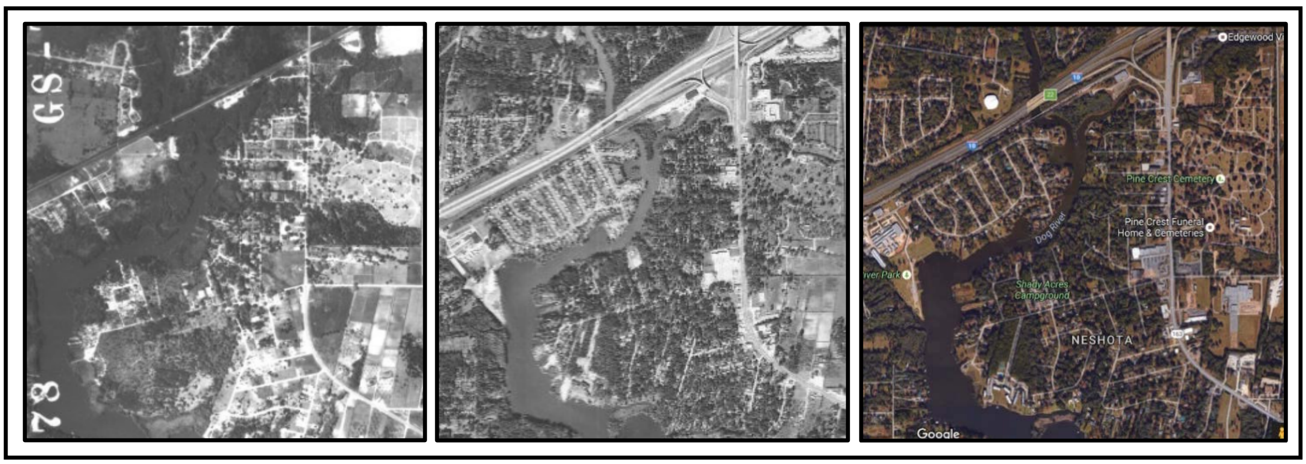


Figure 6.2.1: Aerial imagery of wetland loss along Dog River in 1950 (left), 1974 (middle), and 2016 (right) (UA, 2016; Google, 2016)

Native wetlands in the greater Dog River Watershed historically provided valuable habitats for wildlife, flood control, groundwater recharge, filtering of pollutants, etc. The drastic depletion and fragmentation of wetlands has reduced the level of ecosystem services provided by these critical habitats, therefore lessoning the health and hydrologic resiliency of the entire Watershed. As described throughout the WMP, there are only a handful of large wetland tracts that remain within the Watershed and therefore, there is an increased emphasis placed on their long-term protection. The loss of historic wetland habitats in the greater Dog River Watershed coupled with manmade hydrologic alterations collectively contribute to increased stress and pressure on remaining riparian and tidal wetlands located within the Watershed. Additionally, coastal wetland spits and fringe wetlands are decreasing in size due to additional vulnerabilities to sea level rise, wave action, storm surge, and the effects of urban growth (increased flows from stormwater, etc.).

6.2.3 Shorelines

Shorelines, where land and water intersect, are unique and dynamic environments with variable features and compositions. The forces and stresses transforming shorelines can be natural in occurrence (waves, tides, storms, etc.), or the result of anthropogenic influences and modifications (development, urbanization, armoring, etc.). Relatedly, the forces and stresses influencing shorelines can result in their rapid or subtle alteration overtime. Shorelines located in the greater Dog River Watershed are vulnerable to these forces and stresses, which has resulted in their continued degradation (erosion and recession) over time. Here, erosion refers to the vertical loss of shoreline habitat, and recession refers to the horizontal loss of shoreline habitat. Although erosion and recession are natural responses of shorelines to natural processes and environmental stressors, in the greater Dog River Watershed, shoreline responses to erosion and recession have been accelerated or intensified as a result of anthropogenic impacts.

Anthropogenic impacts increasing the severity and frequency of erosion and recession of shorelines in the greater Dog River Watershed include:

- Increased development and impervious surface coverage in the Watershed (increased frequency, intensity, and duration of high flow stormwater events);
- Lost, degraded, and fragmented natural habitats (forests, wetlands, etc.) and ecosystem services (lost ability of the Watershed to naturally intercept, retain, filter, absorb, and buffer water);
- Increased wave action (increased vessel activity – increased boat wake frequency, intensity and duration);
- Increased coastal and shoreline development (reduced shoreline migration ability); and
- Increased armoring (reduced habitat values and ecosystem services; increased reflection and transfer of energy accelerating the loss of adjacent unprotected shorelines).

The most prevalent cause of natural shoreline habitat loss and degradation along densely populated coasts is the armoring of shorelines (Scyphers et al., 2014). Shoreline armoring disrupts the exchange between land and water, destroying important intertidal and subtidal environments, further reducing the biodiversity, resiliency, and ecosystem services and functions once provided by large intact tracts of natural shoreline habitats. Jones and Tidwell (2011) investigated shoreline armoring in the greater Dog River Watershed and found that the majority (approximately 68.34%) of shoreline habitats they investigated in the Watershed were natural and lacked shoreline protection armoring methods (bulkheads, breakwaters, sills, revetments, etc.). When armoring was elected the mostly frequently observed method was bulkheads (Jones and Tidwell, 2011). However, their study was a snap shot in time, reflective of present conditions observed in 2010 and did not thoroughly investigate all shoreline habitats and reaches in the Watershed, particularly those located in upper headwaters where intense urbanization and developments have altered the natural geomorphology of the surface water network system. Therefore, the total estimated quantity of shoreline armoring for the entire greater Dog River Watershed is likely higher than the total lengths reflected by Jones and Tidwell (2011).

Unfortunately, bulkheads, the most frequently observed armoring method in the Watershed, are also known to facilitate accelerated erosion and recession of adjacent unarmored shorelines. Scyphers et al. (2014) reports that intensified erosional and recessional effects from adjacently located bulkheads frequently forces property owners of neighboring unprotected natural shorelines, to seek shoreline armoring solutions. Furthermore, Scyphers et al. (2014) reports that when property owners decide to armor their natural shorelines they are most likely to select the same armoring solution as their neighbors. This relationship, identified by Scyphers et al. (2014), suggests that existing unarmored shorelines located adjacently to armored shorelines in the greater Dog River Watershed will likely become armored in the future, using the same armoring technique as their neighbor, predominately converting to bulkheads.

Because of the historical shoreline trends observed in the Watershed and increased likelihood that bulkhead armoring will continue to occur in the greater Dog River Watershed, the protection and restoration of remaining natural shoreline habitats is a critical issue identified by this WMP.

6.3 HYDROLOGIC RESILIENCY

Urbanization (coastal and upland development) has collectively impacted and altered the natural hydrology and hydrologic functions of the greater Dog River Watershed resulting in a Watershed with reduced resiliency. Consequently, the Watershed is susceptible to reoccurring flood events and is trending towards increased vulnerability to effects from storm surge and sea level rise. Therefore, resiliency, particularly hydrologic resiliency, of the greater Dog River Watershed through flooding, sea level rise, and storm surge is a critical issue identified by this WMP.

6.3.1 Flooding

Flooding throughout the greater Dog River Watershed is a critical issue and area of concern. Factors affecting the Watershed's vulnerability to flooding (timing, quantity, location) include:

- Amount of annual rainfall (dealing with large quantities in short durations);
- Low-lying topography/ physiography;
- Altered stream network/ conveyance system (straighten and channelized for quick conveyance);
- Extensive development (increased impervious surfaces, development in areas that were critical to hydrologic system function);
- Loss of stream floodplains, buffers, and wetlands (decreased retention, infiltration, and overall hydrologic system stability);
- Effects from sea level rise; and

- Surge effects from storms.

Historically, man-made alterations, such as stream channel channelization and concrete-lining, were implemented in efforts to offset and mitigate flooding concerns (actual or perceived); however, these alterations don't always alleviate flooding concerns. In some instances, improperly sized or improperly functioning stormwater conveyance systems have contributed to localized flooding problems or transferred flooding issues further downstream or upstream. Additionally, the greater Dog River Watershed has lost many of its natural buffers, floodplains, retention areas, and absorption capabilities that were historically provided as ecosystem services from large, intact tracts of natural shoreline, marsh, forest, and wetland habitats. Collectively, the location and intensity of land use land cover transformations over time have resulted in a watershed that is increasingly threatened and susceptible to flood events (coastal, riverine, and flash).

Management strategies to alleviate flooding throughout the greater Dog River Watershed are discussed in Chapter 7 (Management Measures).

6.3.2 Sea Level Rise

Sea level rise (SLR) has been a persistent trend observed globally over a century. SLR is expected to continue with rates expected to accelerate through the end of this century and beyond (IPCC, 2013). The Sea Level Affecting Marshes Model (SLAMM) predicts that up to 214 acres of new salt marsh, tidal flat, and open water could be created in the greater Dog River Watershed if coastal habitats are allowed to migrate into upland areas (ESA, 2016a). Over 60% of the modeled area in the greater Dog River Watershed is developed uplands, and with SLR low-lying uplands will be at risk for more severe coastal flooding and more frequent tidal inundation. In the unprotected scenario, the model predicts that low-lying developed areas at the mouth of Dog River would convert to salt marsh and tidal flats by 2100 if these areas were properly prepared to transition to coastal wetland habitats (ESA, 2016a). A strategy of managed retreat from low-lying upland areas would allow nearby salt marshes to migrate as sea levels rise.

Sea level rise is an issue not only the greater Dog River Watershed but throughout all coastal watersheds. Management strategies identified and implemented today must account for the effects of sea level rise and subsequent habitat migration that have both ecological and economic impacts.

6.3.3 Storm Surge

A Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model was used to identify areas prone to storm surges in the greater Dog River Watershed. Under current sea level conditions, the surge from storms may reach up to 10.8 feet (3.3 meters) (Bilskie et al., 2016). Under the worst-case scenario with a sea level rise of 2.0 meters by the year 2100, the surge may reach approximately 21 feet (6.5 meters) (Bilskie et al., 2016). With sea levels rising, the flooding caused by the storm surge would extend beyond current flood zones affecting many more thousands of individuals, homes, and businesses. Natural wetlands in the lower portion of the Watershed provide the greatest protection for storm surge caused by tropical storm systems. The preservation and protection of these areas are vital as the effects of storm surge are magnified by additional habitat losses.

Communities must stay focused on efforts to enhance resiliency to increase protection and mitigate impacts caused storm surge and sea level rise. The planning and regulatory decisions communities are making today about how and where they develop dictate their ability to recover after coastal storm events.

6.4 ACCESS

In coastal Alabama and throughout the greater Dog River Watershed, there is a direct correlation between our coastal waters and the general public's association with their overall quality of life. As outlined in the Mobile Bay National Estuary Program's (MBNEP's) Comprehensive Conservation and Management Plan for Alabama's Estuaries and Coast 2013-2018, access to water or open spaces for recreation and vistas was one of the six common values that residents identified as most important to protecting our coastal quality of life. As discussed in previous sections of this WMP, natural streams and wetlands have been replaced with concrete ditches and increased development. These alterations have negatively impacted and potentially severed the public's connection to these vital resources. This issue can be combated by restoring impacted areas or protecting natural areas that create additional recreational opportunities to access our natural resources. Recreational opportunities include walking trails, nature trails, parks, boat ramps (both motorized and canoe/kayak), fishing areas, swimming areas, etc. Reestablishing an individual's connection with their watershed will increase their awareness to protect it for future generations.

7.0 MANAGEMENT MEASURES

The ecology, hydrology, and water quality of the greater Dog River Watershed have been degraded by cumulative impacts for over fifty years by employing hard surfaces and channelization to enhance runoff of rainfall and to minimize flooding. The Watershed conditions are outlined in Chapter 5 and the critical issues are identified in Chapter 6 of this Watershed Management Plan (WMP). Management measures are potential opportunities and/or actions that can be implemented to target these critical issues and mitigate their impact to the overall health of the Watershed. Management measures outlined in this Chapter will help achieve the goals of this WMP which include:

- Improving water quality;
- Protecting and restoring critical habitats;
- Improving resiliency; and
- Improving access.

7.1 DEVELOP A GREATER DOG RIVER WATERSHED HYDROLOGIC MODEL AND PROGRAM

The quantity and quality of natural streams, floodplains, and wetlands in a watershed collectively influence the health of the system. These naturally functioning drainages are known to help mitigate the effects of heavy rainfall events by providing temporary storage of water during high flow events. They contribute to the vitality of an ecosystem by storing, filtering, cleaning, and transmitting surface water and groundwater. Through these processes, pollution is removed, nutrients are recycled, and groundwater is recharged. Additionally, natural drainage systems enhance biodiversity by providing habitats for a wide variety of fish, wildlife, and plants.

However, in the greater Dog River Watershed, ecosystem health and services have declined as urbanization and development have increased. It is recommended that a comprehensive hydrologic model of the greater Dog River Watershed be completed to gain a better understanding of the hydrologic processes (stormwater flows) occurring throughout the Watershed. A hydrologic model will help determine where recommended preservation, restoration, and conservation activities will have the greatest impacts for improving the health and resiliency of the Watershed. Following completion of the model, a thorough program can be established to train municipal personnel to use the model in their efforts to manage stormwater on a local level. A watershed hydrologic modeling program will be used to address issues including but not limited to:

- Modeling the dynamics and importance of restoration and preservation of wetlands, streams, and stormwater projects;

- Evaluating impacts of future growth (i.e., increased runoff, increased sediment loadings, etc.). This capability could be used for ensuring additional development pressures in the Watershed do not negatively impact restoration projects further downstream;
- Facilitating quantitative estimates of loadings that simulate both upland urban runoff and in-stream processes, providing a better understanding of water movement and shear stress along shorelines;
- Help managers evaluate proposed new developments with respect to compliance with any new stormwater related codes or standards that are established for such new developments;
- Help train decision makers to make accurate assessments affecting stormwater runoff and improvements; and
- Evaluating the potential use of retrofit measures in already developed areas.

Additional support for the development of a greater Dog River Watershed hydrologic modeling program is discussed in subsequent sections throughout this Chapter.

7.2 IMPLEMENT BEST MANAGEMENT PRACTICES

Any activity that could potentially cause pollutants to enter waterways in the greater Dog River Watershed should utilize Best Management Practices (BMPs) to minimize pollutant discharges to the maximum extent practical. BMPs include structural and non-structural practices that are designed to minimize the potential for pollutants to come in to contact with precipitation and stormwater and/or controlling and treating stormwater runoff that has come in contact with a pollutant. BMPs are designed and implemented based on specific activities and the potential pollutant sources associated with those activities. These activities include such diverse things as construction of roads and buildings, farming, nurseries, and ranching. Implementing stormwater BMPs reduces stormwater runoff and increases infiltration of stormwater into the ground, restoring adequate water quality.

BMPs that will help target this WMP's goals of improving water quality include, but are not limited to, the following:

- Litter control measures (Section 7.2.1);
- Wastewater improvements (Section 7.2.2);
- Stormwater improvements (Section 7.2.3); and
- Invasive species management (Section 7.2.4).

Again, the hydrologic modeling program recommended in Section 7.1 will help determine the prioritization and implementation of recommended BMPs in the greater Dog River Watershed.

7.2.1 Litter Control Measures

Litter has been a consistent issue facing the greater Dog River Watershed for many years. Combating litter will take a multifaceted approach that includes the expansion of existing programs, increased regulatory control and enforcement, and a relentless education component in order to treat the problem at its source. In addition to public outreach, active trash collection and removal efforts should be supported and enhanced as much as possible.

Litter control measures that will help target this WMP's preliminary goals to reduce trash pollution and recovery tonnages by 50% over 10-years include, but are not limited, to the following:

- Installing 2-6 additional litter traps on heavily urbanized surface water drainage network systems (Section 7.2.1.1);
- Implementing additional litter control measures like stormwater pipe screens (Section 7.2.1.2);
- Supporting the City of Mobile's current litter control measures (Section 7.2.1.3); and
- Supporting litter reduction outreach and educational programs (Section 7.2.1.4).

7.2.1.1 Install Additional Litter Traps

As mentioned in earlier chapters of this WMP, the City of Mobile operates a litter trap on East Eslava Creek located at McVay Drive. As shown in Figure 7.2.1., this litter trap has proven to be an effective measure to collect floatable litter and debris. Furthermore, capturing floatable litter and debris in the East Eslava Creek litter trap helps reduce the quantity of litter that is transported downstream to Dog River.

Figure 7.2.1: General view of the East Eslava Creek litter trap

Litter trap technology is a recommended and proven solution for waterways, such as those in the greater Dog River Watershed, as they chronically combat pollution effects from floatable litter and combined sewer overflows (Storm Water Systems, 2015). Therefore, a management measure recommendation of this WMP is to install two to six additional litter traps at strategic locations within the greater Dog River Watershed. Figure 7.2.2 displays locations where additional litter trap installations could potentially be utilized. These locations were selected to maximize litter collection across the entire Watershed and are based upon stakeholder and Steering Committee input and field investigations conducted by the Watershed Management Team (WMT). Two potential priority locations for litter trap installation include West Bolton Branch near Montlimar Canal and Moore Creek. Additional recommended litter trap locations include Spring Creek, Milkhouse Creek, Rabbit Creek, and Rattlesnake Bayou. Again, the hydrologic modeling program (Section 7.1) will help determine the quantity and locations where the greatest efficiencies from installing additional litter traps in the Watershed will be obtained.

With the implementation of additional litter traps, the labor and maintenance of these areas will need to be addressed. In order to effectively collect litter throughout the Watershed, these measures must be expanded and efforts increased. Funding would be required to pay for not only the necessary infrastructure, but also the long-term costs associated with on-going maintenance and operation. Potential solutions to fund litter control management measures could include stormwater fees or increased public-private partnership participation as referenced in Chapter 8.

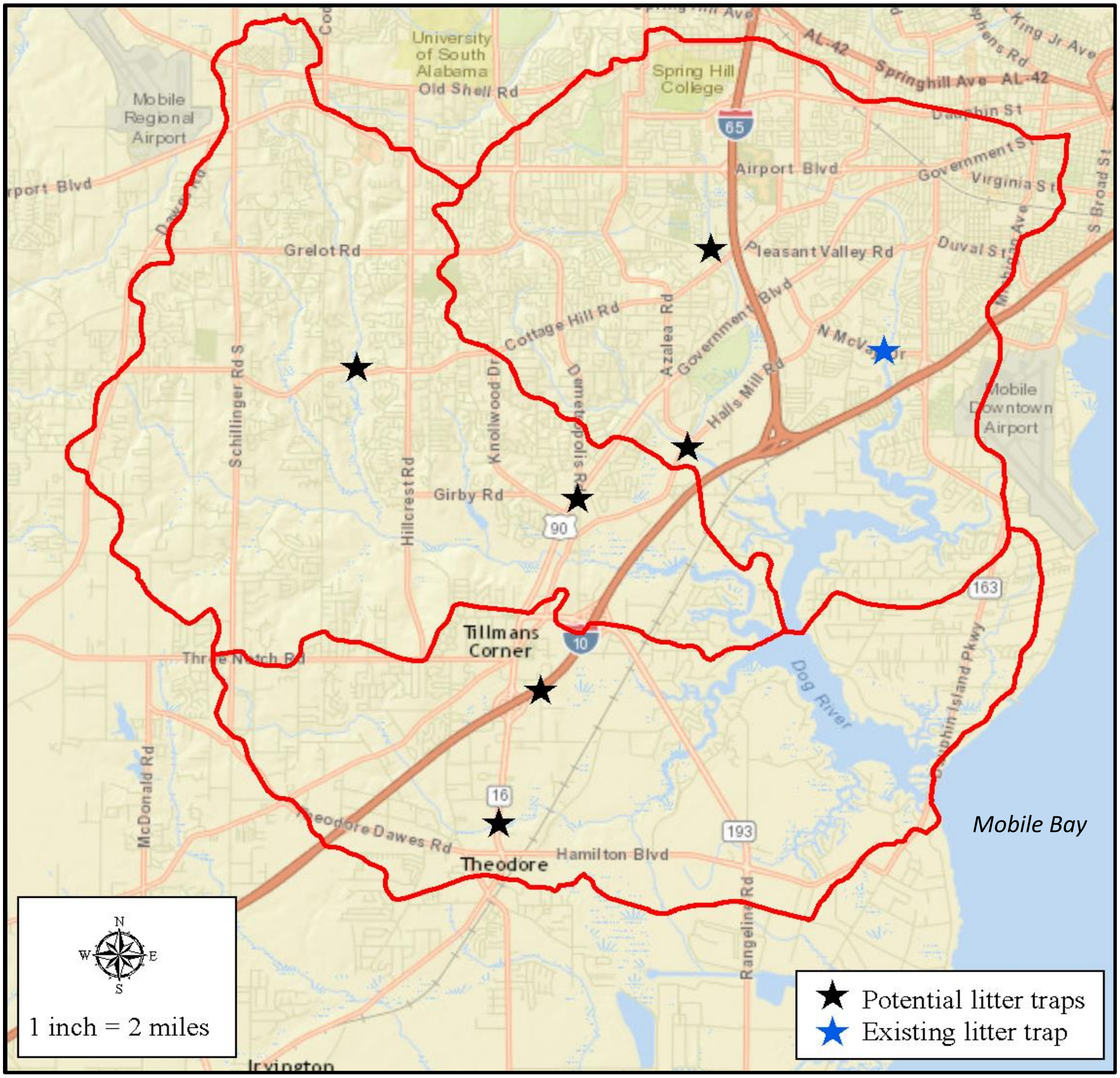


Figure 7.2.2: Potential locations for additional litter traps

7.2.1.2 Implement Additional Litter Collection Measures

Additional litter collection measures could also be implemented, such as the stormwater pipe screens shown in Figure 7.2.3 (Storm Water Systems, 2015). This technology is another proven, effective strategy used to reduce litter from urban hot spots. Stormwater pipe screens, unlike litter traps, can be implemented in intermittent, heavily urbanized drainages to collect the first flush of debris and litter carried by stormwater runoff. Stormwater pipe screens have the potential to fully capture gross pollutants (contaminants that would be retained by a 5mm mesh screen), which could reduce the levels of phosphorous and nitrogen in the surface waters of the Watershed (Storm Water Systems, 2015).

Figure 7.2.3: Example of stormwater pipe screens (Photo Credit: Storm Water Systems, 2015)

7.2.1.3 Support Additional Litter Control Measures in Use

Additional litter control measures adopted and operated by the City of Mobile include:

- Increasing the use of litter boats, shown in Figure 7.2.4, which target existing litter within the waterways;
- Increasing the use of cleaning vacuum trucks, shown in Figure 7.2.5, which clear trash from catch basins around the City; and
- Increasing the use of catch basin screens, shown in Figure 7.2.6, which prevent trash from entering the stormwater system and ultimately the streams.

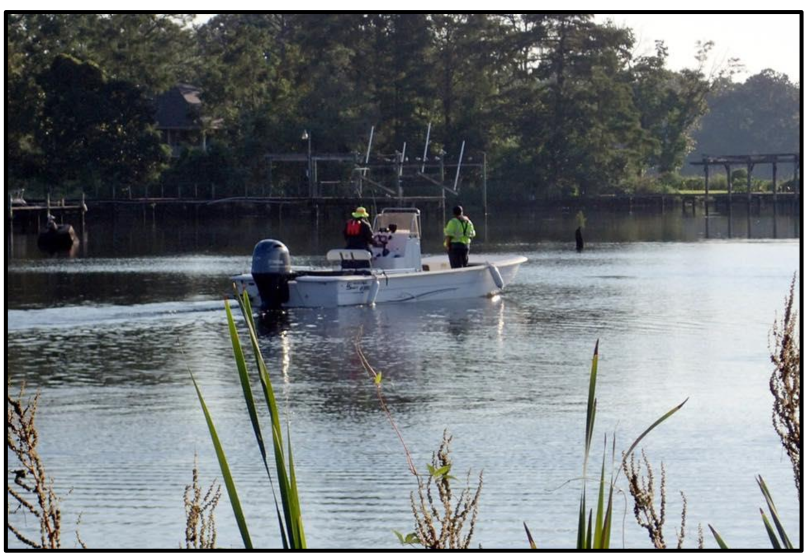


Figure 7.2.4: City of Mobile litter boat (DRCR, 2016)

Figure 7.2.5: City of Mobile cleaning vacuum truck (City of Mobile, 2016c)

Figure 7.2.6: General example of catch basin screens (City of Mobile, 2016c)

7.2.1.4 Support Litter Reduction Outreach and Educational Programs

Litter reduction methods mentioned previously are only part of the long-term solution. Citizen education and increased awareness is the best management measure to treat the litter problem at its direct source. A Litter Reduction Program is already established and in operation by the City of Mobile. Dog River Clearwater Revival (DRCR) organization along with an appointed watershed coordinator, discussed in Section 7.8, should support the efforts of the City and establish a public outreach and education program targeted at litter reduction. Informational signage at boat landings and public access points should encourage the public to help preserve and protect Dog River through wise stewardship. Trash containers and dumpsters should be located and maintained at public access points and other strategic locations with appropriate signage as a reminder to keep the greater Dog River Watershed clean and free of trash.

Community events, such as the Coastal Cleanup and Shoreline Cleanup events sponsored by DRCR, should be supported and encouraged.

The annual Alabama Coastal Cleanup event sponsored by DRCR in 2016 had the following goals and objectives:

- Provide immediate relief from onslaught of urban litter, debris, and trash streaming into the river;
- Sub-contract a cleanup crew to clean areas of the river that have had years of litter build up and are not accessible to city crews or volunteers;
- Continue to sponsor and enlarge the several Dog River Zones of the Alabama Coastal Cleanup in the fall;
- Engage and lead the Fall Coastal Cleanup;
- Coordinate Wheels Outta Water/ target sector removal; and
- Fund and organize private Contract Cleanup Crews to pick up trash from swaths of trashy spots on the river.

The Mobile Bay National Estuary Program (MBNEP) through their "Clean Water Future" campaign, "Keep Mobile Beautiful", and many others including DRCR have worked tirelessly to educate the public about the environmental harm created by litter. As part of "Keep Mobile Beautiful", recycling drop-off centers were implemented to promote a cleaner environment. The City, MBNEP, and DRCR also provide general education on the impacts of litter on the waterbodies as well as classroom presentations to grades K-4 through high school. These organizations inform the public so people are aware that littering upstream negatively affects downstream systems. Supporting those efforts and encouraging the formation of similar campaigns will be an effective measure to combat litter throughout the greater Dog River Watershed.

7.2.2 Implement Wastewater Improvements

The advanced age of the sewage collection and conveyance infrastructure and the high amount of precipitation in coastal Alabama have resulted in a high frequency of sanitary sewer overflows (SSOs) in the greater Dog River Watershed. SSOs endanger human health, as well as fish and wildlife, by releasing bacteria, viruses, and other pathogens, as well as nutrients and oxygen-demanding materials, to nearby surface waters. SSOs can also result from pipeline blockages from sand and grease, but most often they are the result of aging pipelines and pump lift stations incapable of handling large volumes of rainfall. Small cracks in sanitary sewer pipelines caused by tree roots and deterioration allow rainwater to infiltrate into the pipelines, causing release of millions of gallons of untreated sewage each year.

In the greater Dog River Watershed, the Mobile Area Water and Sewer System (MAWSS) owns and operates the majority of the Watershed's wastewater infrastructure. MAWSS serves approximately 205 square miles in Mobile County, operates two conventional wastewater treatment plants (WWTPs), and manages approximately 140 miles of force mains, 196 lift stations, and 1,260 miles of gravity sewers (MAWSS, 2017). Recommended management measures MAWSS can implement to help reduce the occurrence of SSOs in the greater Dog River Watershed are discussed in more detail in Section 7.2.2.1 and include but are not limited to:

- WWTP improvements;
- Severe weather attenuation tanks (SWATs);
- Severe weather attenuation basins (SWABs);
- Force main improvements;
- Lift station improvements; and
- Sewer line repairs and replacements.

7.2.2.1 SSO Management

MAWSS has planned wastewater improvements for SSO management. MAWSS's planned measures include:

1. Halls Mill Creek Lift Station SWAB Project:
   MAWSS plans to construct a SWAB at the Halls Mill Creek Lift Station. SWABs are open basins designed to store large volumes of urban runoff immediately following rainfall events, thereby lowering flows in the storm water collection system and preventing or reducing SSO events. This planned project was entered into the bidding process in January 2017, and is projected for completion by 2018. Figure 7.2.7 provides an overview of the location and preliminary layout for the SWAB design.

2. Eslava Trunk Sewer rehabilitation and SWAT Project:
   a. A SWAT, an enclosed structure designed to store large volumes of urban runoff immediately following rainfall events, thereby lowering flows in the storm water collection system and preventing or reducing SSO events, and a SWAB are planned for implementation. This project has a tentative completion date of June 31, 2019.
   b. An increase in the trunk sewer capacity is also planned with a tentative completion date of June 31, 2019.

3. Increasing capacity of branch lines.

4. Beginning in 2016, master planning efforts will evaluate the infiltration and inflow program, identify short- and long-term capital needs, and pursue fiscal policy changes to address priority capital needs for the entire sewer system.

5. Upgrades to the CC Williams Waste Water Treatment Plant (WWTP); to be completed by February of 2018

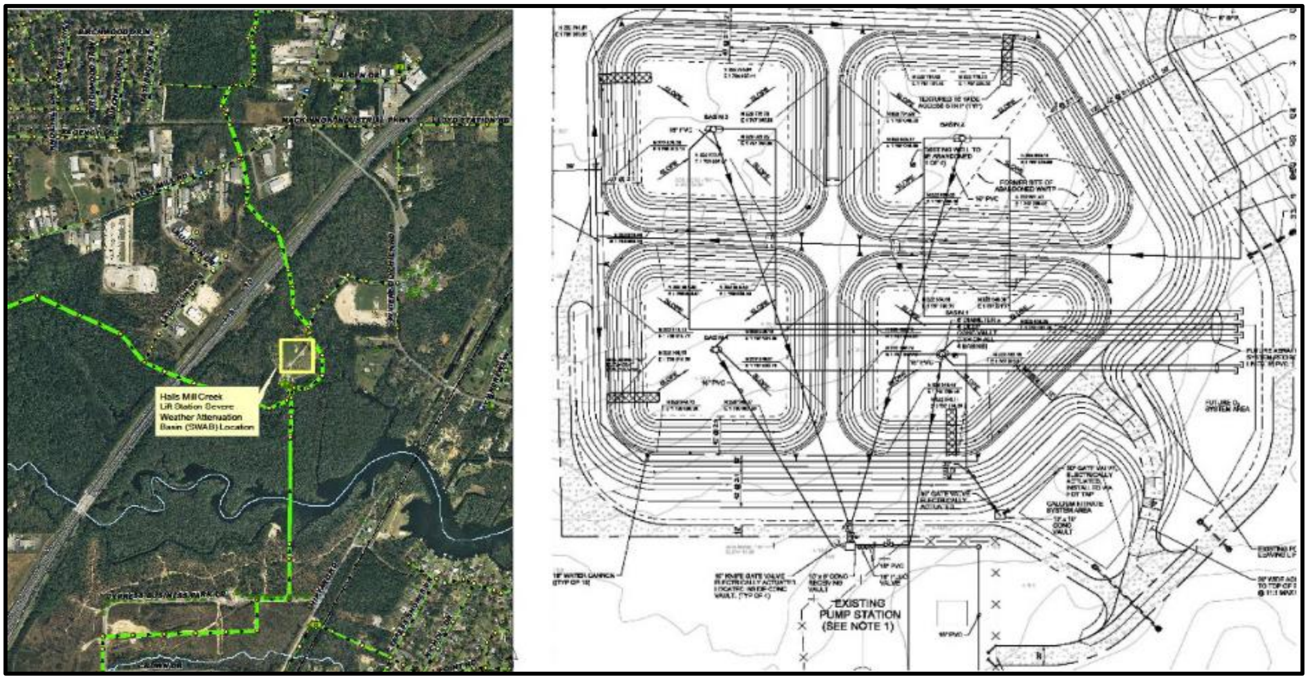


Figure 7.2.7: Halls Mill Creek preliminary SWAB design (MAWSS, 2016)

7.2.3 Implement Stormwater Drainage Improvements

As discussed throughout Chapter 6, stormwater (stormwater runoff) is a concern in the greater Dog River Watershed. Projects that enhance and improve stormwater drainage should be identified and supported. Presently, an area of Woodcock Branch (East Eslava Creek) is identified as a site that requires stormwater drainage improvement. It is recommended that DRCR along with an appointed watershed coordinator support this proposed project as well as identify additional projects and BMPs that will result in stormwater drainage improvement throughout the greater Dog River Watershed.

7.2.4 Invasive Species Management Program

As discussed in Chapter 5, the WMT identified several invasive species of concern in the greater Dog River Watershed including but not limited to:

- Cogongrass (*Imperata cylinrica*);
- Chinese Privet (*Ligustrum sinense*);
- Chinese Tallow or Popcorn Tree (*Triadica sebifera*);
- Japanese Climbing Fern (*Lygodium japonicum*);
- Eurasian Watermilfoil (*Myriophyllum spicatum*);
- Hydrilla (*Hydrilla verticillata*);
- Dotted Duckweed (*Landoltia punctata*);
- Alligatorweed (*Alternanthera philoxeroides*); and
- Common Reed *(Phragmites australis).*

It is recommended that DRCR along with an appointed watershed coordinator, discussed in Section 7.8, establish an Invasive Species Management Program based upon the following strategies:

- Cooperation and collaboration between state, county, and local governments;
- Inventory and monitoring of invasive species;
- Prevention through early detection;
- Constant monitoring and rapid response;
- Treatment and control using physical means; and
- Restoration of native species.

7.3 IMPLEMENT LOW IMPACT DEVELOPMENTS

In an effort to reduce stormwater impacts, preserve and restore natural landscapes, and protect water quality, systems and practices that mimic natural processes should be employed. These systems are referred to as low impact developments (LIDs). LID approaches create functional and appealing stormwater management systems by using such techniques as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, permeable pavement, and rainwater harvest techniques. Additionally, LID approaches also use nature as a model to manage rainfall at the source through sequenced runoff prevention strategies, runoff mitigation strategies, and treatment controls to remove pollutants. Furthermore, LIDs emphasize improved aesthetics, creation of wildlife habitats, and community involvement and engagement and, as noted by the U.S. Environmental Protection Agency (EPA), typically require lower initial investment with the ability to be maintained similarly to other landscaped areas.

Suggested LID techniques for new residential developments with potential pollutant load reductions are presented in Table 7.3.1, and recommended retrofits for existing developed areas are presented in Table 7.3.2.

Table 7.3.1: Recommended LID practices (ADEM, 2014)

Practice	Pollutant Removal			Cost
	Sediment	Nitrogen	Phosphorous	
Bioretention Cells	80 – 85%	40 - 50%	45 - 60%	medium/high
Constructed Stormwater Wetlands	80 – 85%	30 – 40%	40%	medium/high
Permeable Pavement	99%	65 – 80%	42 – 80%	high
Swales	35 – 80%	20 – 50%	20 – 50%	low
Level Spreaders and Grassed Filter Strips	40 – 50%	20 – 30%	20 – 35%	low
Rainwater Harvesting	Reduces flooding and erosion			medium
Green Roofs	Decrease runoff and peak flows			high
Riparian Buffers	60 – 85%	30%	35 – 40%	medium

Table 7.3.2: Recommended retrofit LID practices (ADEM, 2014)

Practice	Pollutant Removal			Cost
	Sediment	Nitrogen	Phosphorous	
Rain Gardens	Phosphorus and nitrogen removal			low
Curb Cuts	Directs runoff to primary stormwater control measure			medium
Disconnected Downspouts	Directs runoff to primary stormwater control measure			low
Retention Cells (where land is available)	80 – 85%	40 – 50%	45 – 60%	medium/high

Recommended LID management measures illustrated for use in the greater Dog River Watershed include, but are not limited to, the following:

- Bioretention swales and cells (Section 7.3.1); and
- Constructed stormwater wetlands (Section 7.3.2).

Again, the hydrologic modeling program recommended in Section 7.1 will inform the prioritization and implementation of recommended LIDs in the greater Dog River Watershed.

7.3.1 Implement Bioretention Swales and Cells

Bioretention swales are gently sloping drainage ditches filled with vegetation that are designed to remove silt and other pollution from stormwater and surface water runoff (Gibney, 2015). Large under-utilized parking areas may be suitable for partial pavement removal and replacement with natural vegetation, as well as installation of a bioretention swale as shown in Figure 7.3.1. Figure 7.3.2 displays four different types of swale designs.

Figures 7.3.1: Vegetated bioretention swale application example

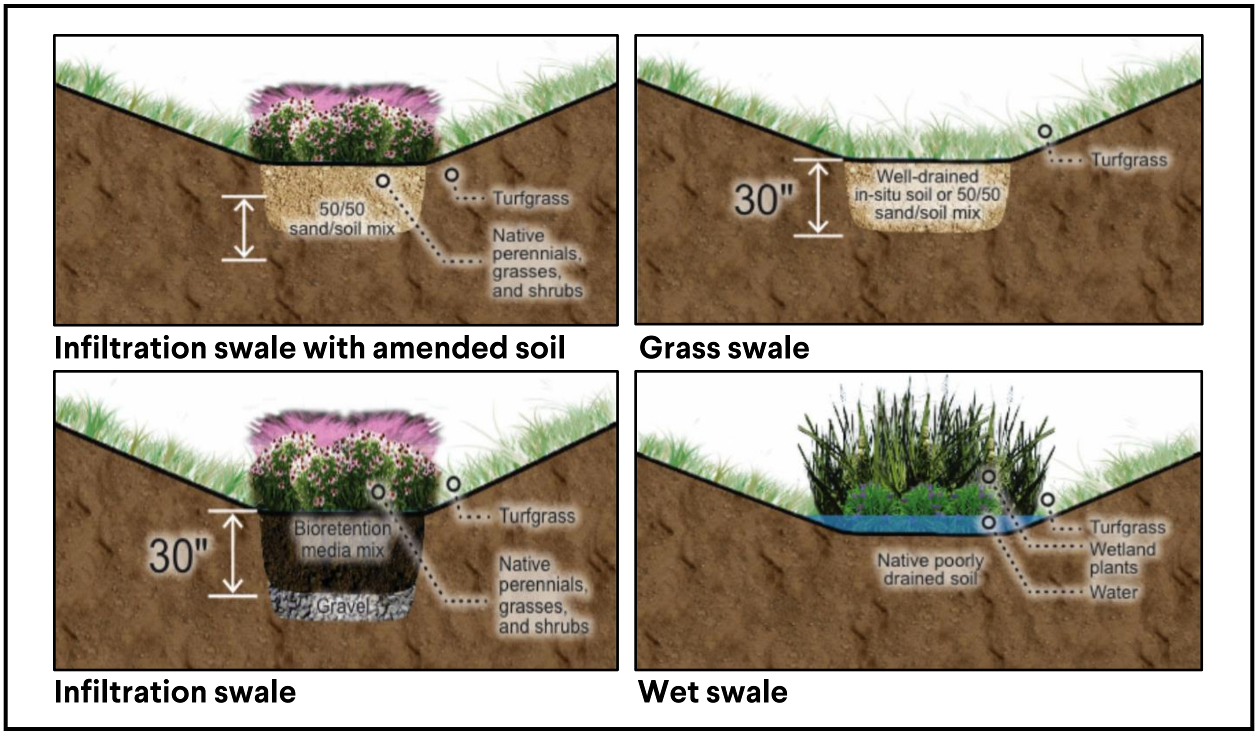


Figure 7.3.2: Examples of bioretention swales (ADEM, 2014)

Bioretention cells (BRCs) remove pollutants by the processes of absorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. BRCs are depressions on the surface that capture and store stormwater runoff for a short period of time. BRCs also support flood- and drought-tolerant native vegetation habitats (ACES, 2016b).

Figure 7.3.3 provides a profile of a typical BRC, while example applications of BRC's are presented in Figures 7.3.4 and 7.3.5. Here, large parking areas that were completely impervious were retrofitted with BRC's. As an alternative to eliminating the entire paved area, the removal of a small number of parking spaces allowed for a very effective BRC's. Note that in Figures 7.3.4 and 7.3.5 curb design allows entry points for parking area runoff.

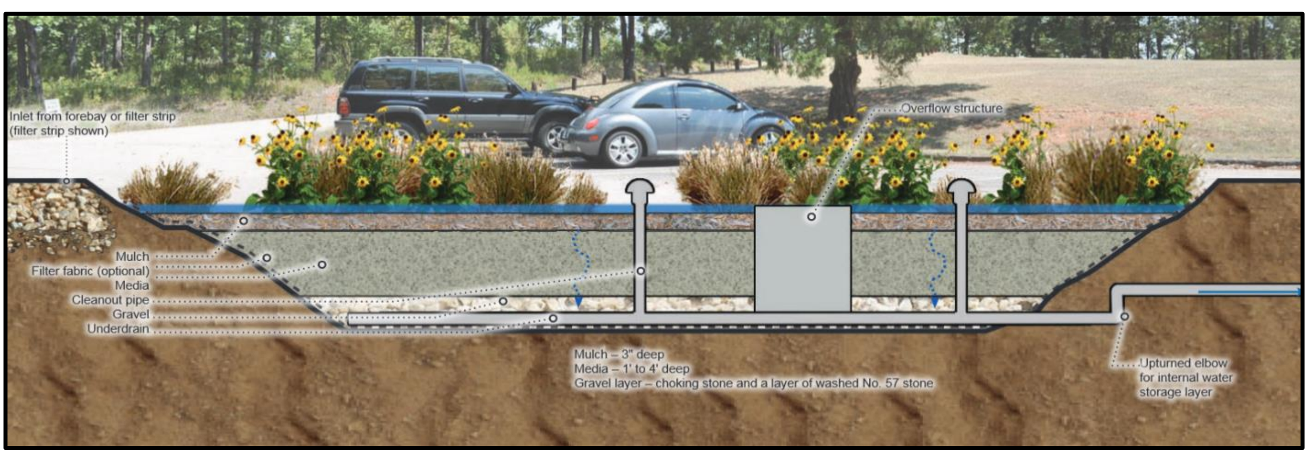


Figure 7.3.3: Example of a typical BRC profile (ACES, 2016b)

Figure 7.3.4: Example of an implemented BRC (Gibney, 2015)

Figure 7.3.5: Example of an implemented BRC on Dauphin Island Parkway before (left) and after (right) (DRCR, 2017)

A goal of this WMP is to create 5 acres of bioretention through the implementation of bioretention swales and cells. Numerous locations for potential bioretention areas and retrofits are found throughout the Watershed, and two potential locations are shown below. A potential bioretention swale application example along Moore Creek at Government Boulevard is shown in Figure 7.3.6. This location could potentially support a 0.23-acre retention swale. A potential BRC example location could be implemented along Spring Creek at Demetropolis Road and Girby Road is displayed in Figure 7.3.7. This location could potentially support a 1.39-acre BRC.

Figures 7.3.6: Potential location for a bioretention swale along Moore Creek

Figure 7.3.7: Potential location for a commercial lot BRC near Spring Creek

7.3.2 Implement Constructed Stormwater Wetlands

Constructed stormwater wetlands (CSWs) are another LID management option. CSWs function like natural wetlands to treat stormwater. CSWs treat stormwater runoff by using biological, chemical, and physical processes to promote infiltration, cycle nutrients, and filter and decompose pollutants (ACES, 2016b). Figure 7.3.8 provides a profile of a CSW, while an example application of a CSW is presented in Figure 7.3.9.

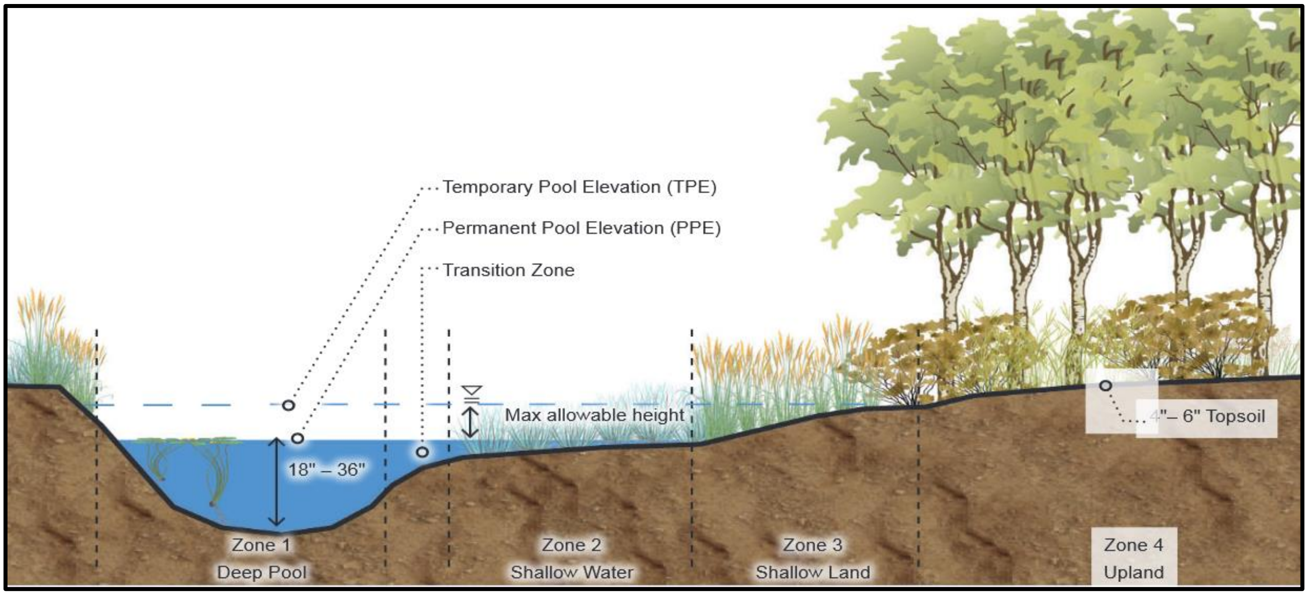


Figure 7.3.8: Example of a CSW profile (ACES, 2016b)

Figure 7.3.9: Example of an implemented CSW (JEC, 2015)

A goal of this WMP is to create 20 acres of CSW. Two example locations were selected for possible implementation. A potential CSW application example along East Eslava Creek at 2570 Government Boulevard is displayed in Figure 7.3.10. This location could potentially support a 1.72-acre CSW. Another potential example location for a CSW could be implemented along Perch Creek. This location, shown in Figure 7.3.11, could potentially support a 0.25-acre CSW.

Figures 7.3.10: Potential location for a CSW located along East Eslava Creek

Figure 7.3.11: Potential location for a CSW located along Perch Creek

7.4 PRESERVE ECOLOGICALLY SIGNIFICANT HABITATS

Over many decades, historical forests, wetlands, streams, floodplains, and other ecologically significant habitats have been lost to increases in urban development. Additional loss of critical habitats has occurred as a result of erosion caused by high flow events, boat wakes, and sea level rise. Although the loss and conversion of habitat is challenging and expensive to reverse, it is critical to protect and preserve remaining areas of ecological significance such as forests, wetlands, and stream floodplains, which provide a natural filter for pollutants, pathogens, sediment, etc. Failure to protect these wetlands, shorelines, marshes, and forests will exacerbate negative impacts described throughout this WMP.

Therefore, this WMP is recommending that a minimum of 1,000 acres of existing natural wetlands and ecologically significant land in the greater Dog River Watershed be acquired for preservation. Examples of potential preservation areas in the greater Dog River Watershed are displayed in Figure 7.4.1. Priority critical habitat preservation areas were identified using aerial and satellite imagery, wetland (USFWS, 2010) and floodplain data (FEMA, 2015), parcel data from the Mobile County Revenue Commission (MCRC) (MCRC, 2016), and stakeholder input.

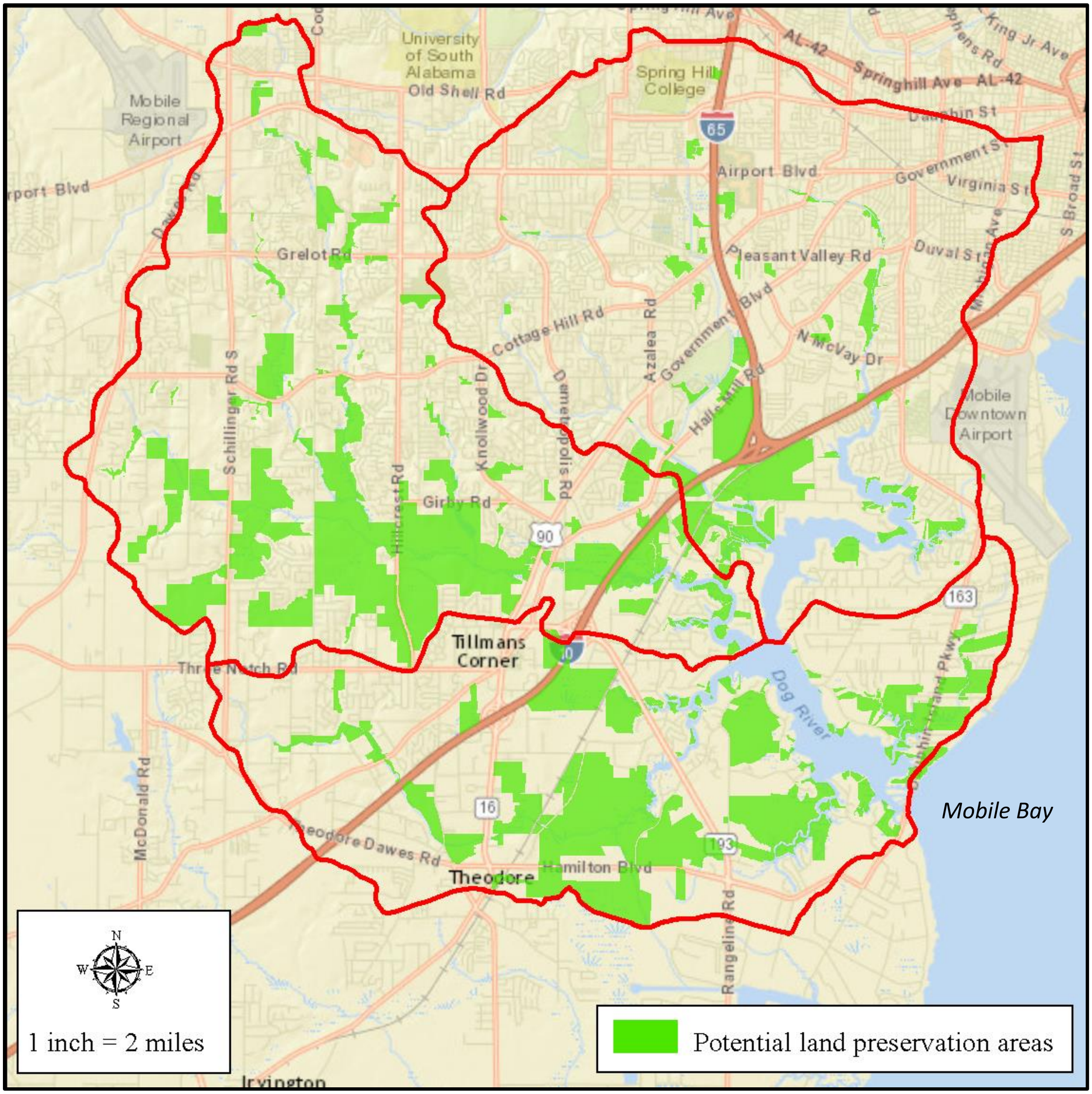


Figure 7.4.1: Potential areas for habitat preservation (FEMA, 2015; MCRC,2016; USFWS, 2010)

Wetland habitats for preservation are further discussed in Section 7.4.1. Additionally, the recommended hydrologic modeling program (Section 7.1) will help determine which preservation locations displayed in Figure 7.4.1 will have the greatest impact on the long-term health and resiliency of the greater Dog River Watershed.

7.4.1 Preserve Wetland Habitats

Potential wetland preservation areas in the greater Dog River Watershed are shown in Figure 7.4.2 and further described in Table 7.4.1. These areas were identified as priority sites primarily due to their size, as they are some of the largest remaining natural wetland tracts located within the

Watershed. Two of the identified sites are located in the Halls Mill Creek Watershed; these tracts are important to pursue for preservation given that the Halls Mill Creek Watershed is projected (see Table 3.8.2) to experience the largest population growth in the greater Dog River Watershed by 2030.

It should be noted that Table 7.4.1 is not an exhaustive list for priority wetland preservation sites, and other wetland tracts that become available in the future for long-term preservation and protection should be pursued aggressively. The protection of these natural wetland areas will help to ensure that water quality and habitat conditions do not continue to degrade and the benefits currently provided by these areas are not lost. Furthermore, the recommendation to complete an intensive hydrologic model of the Watershed (Section 7.1) will provide vital information that will enable stakeholders to prioritize and quantifiably identify key wetland areas for preservation.

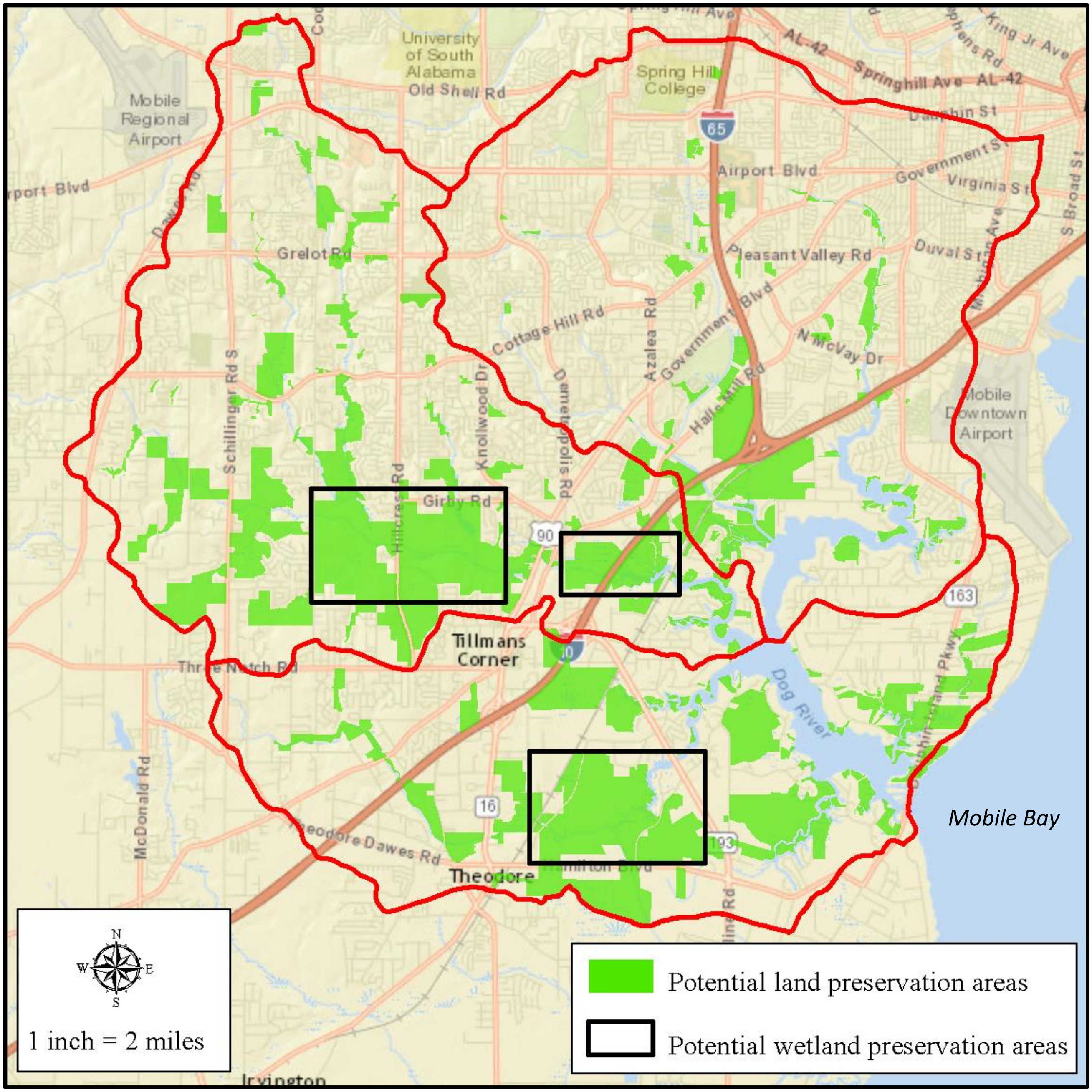
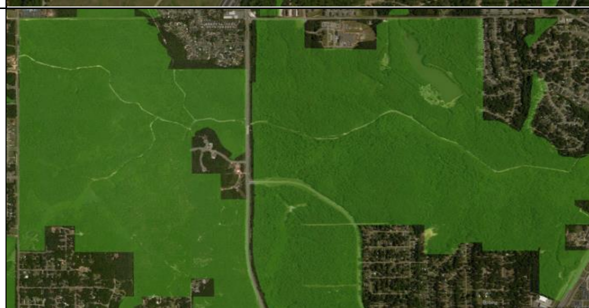
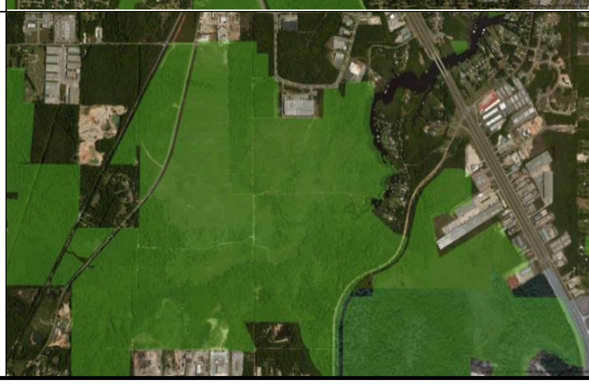


Figure 7.4.2: Potential areas for wetland preservation

Table 7.4.1: Potential areas for wetland preservation

Name	Location Diagram	Description
Halls Mill Creek Properties – Interstate 10 Area		This site is one of the largest contiguous bottomland hardwood wetland systems remaining in the greater Dog River Watershed. Preservation will help support the long-term health and vitality of the Watershed. Ecosystem services and functions include storing and filtering surface water and groundwater. A portion of this representative wetland area was evaluated by the WMT and was given a WRAP score of 0.86.
Halls Mill Creek Properties – Hillcrest Road Area		This site is one of the largest contiguous bottomland hardwood wetland systems remaining in the greater Dog River Watershed. Preservation will help support the long-term health and vitality of the Watershed. A portion of this representative wetland area was evaluated by the WMT. The evaluated area featured minimal invasive species and was given a WRAP score of 0.77.
Rabbit Creek Properties		This site is one of the largest contiguous bottomland hardwood wetland systems remaining in the greater Dog River Watershed. Preservation will help support the long-term health and vitality of the Watershed. Ecosystem services and functions include storing and filtering surface water and groundwater. A portion of this representative wetland area was evaluated by the WMT. The evaluated area featured a braided stream channel and was given a WRAP score of 0.67.

7.4.2 Support Other Habitat Acquisition and Preservation Efforts

Similar efforts are ongoing to identify and protect wetland habitats throughout the City of Mobile. The Mobile Bay Shore Habitat Conservation and Acquisition Initiative through the National Fish and Wildlife Foundation (NFWF) will utilize the Gulf Environmental Benefit Fund (GEBF) to identify high priority sites for acquisition and management of large, intact tidal marsh habitats within the City of Mobile including areas in the greater Dog River, Garrows Bend, and Three Mile Creek watersheds. The three areas identified by this initiative are shown in Figure 7.4.3.

The City of Mobile is the project recipient with additional project partners consisting of the Mobile Bay National Estuary Program (MBNEP), The Nature Conservancy (TNC), Alabama Coastal Foundation (ACF), and the Pelican Coast Conservancy. This initiative includes the assessment of ecological values and determining the net environmental benefit of protecting critical wetland habitats. Throughout the greater Dog River Watershed, 300 acres of riparian, wetland, and upland habitats along Perch Creek have been identified for acquisition. Projects such as this provide synergy with goals and objectives outlined throughout this WMP and should be supported.

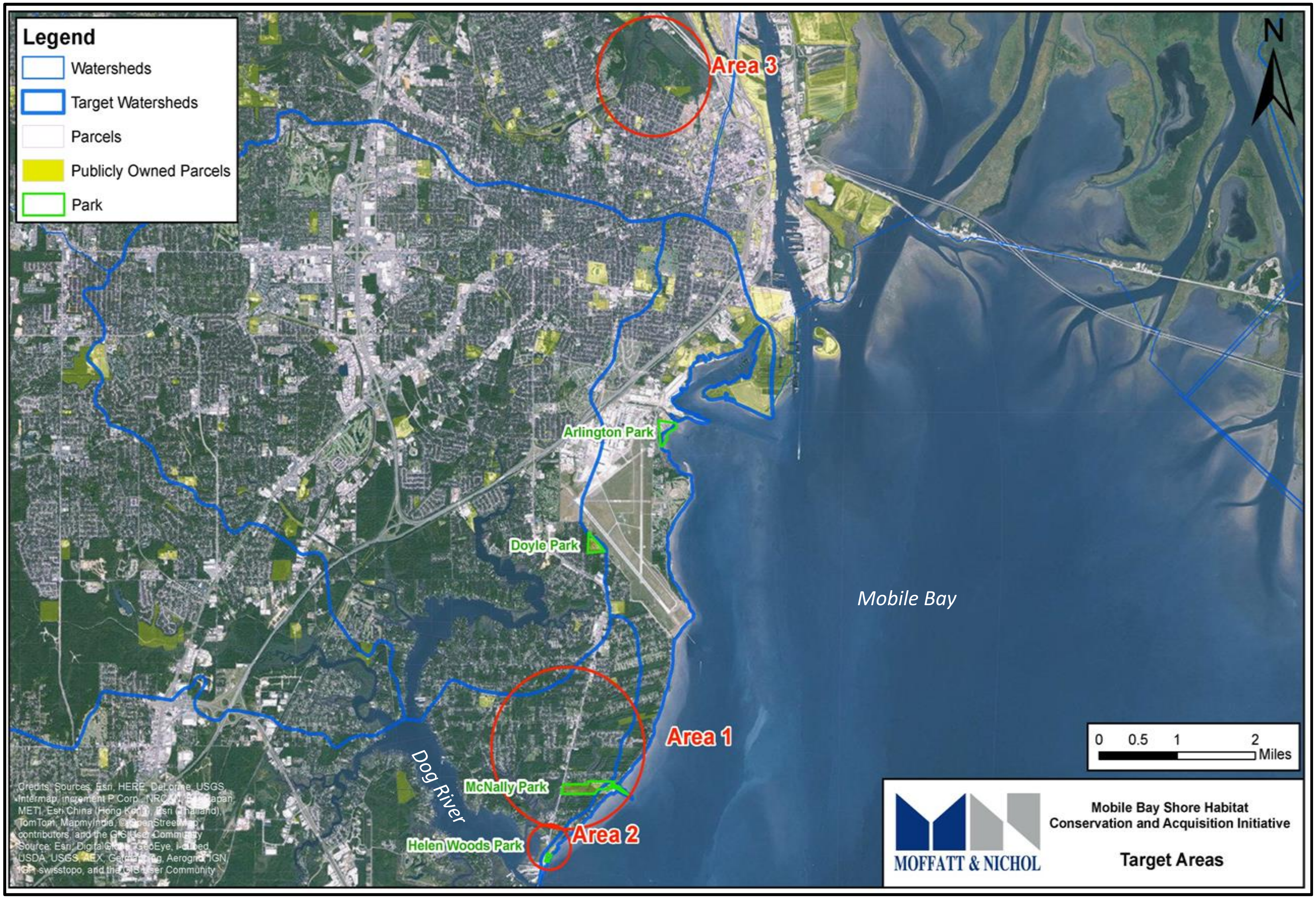


Figure 7.4.3: Target priority areas for preservation through the Mobile Bay Shore Habitat Conservation and Acquisition Initiative (Moffatt and Nichol, 2016)

7

7.5 RESTORE AND PROTECT CRITICAL HABITATS

Due to the amount of development that has occurred throughout the greater Dog River Watershed, an emphasis is placed on the protection and restoration of the remaining wetland and stream habitats. Failure to protect wetlands, shorelines, streams, and marshes will exacerbate the issues outlined throughout this WMP.

Management measures recommended to help protect and restore critical habitats in the greater Dog River Watershed include, but are not limited to, the following:

- Restoring 20,000 linear feet of riparian buffer (Section 7.5.1);
- Restoring 6,000 linear feet of stream network (Section 7.5.2); and
- Protecting and Restoring 3,000 linear feet of shoreline (Section 7.5.3).

Potential example locations for recommended management measures are provided herein for illustrative purposes. It is anticipated that the hydrologic modeling program recommended in Section 7.1 will help determine and prioritize potential sites for maximizing the efficiencies of their respective restoration and protection strategies.

7.5.1 Riparian Buffer Restoration

Riparian buffers are vitally important to the overall health of a stream. The natural vegetation increases nutrient uptake, infiltration, and absorption, therefore reducing nonpoint source pollution. Buffers are the transition zones that connect uplands (urban, natural, etc.) to floodplain wetlands and ultimately, creeks, streams, and rivers. As discussed in Chapter 6, there are areas in the greater Dog River Watershed exhibiting little to no riparian buffers.

The establishment of a riparian buffer zone will greatly enhance the environment of the channel and its surrounding areas. Riparian buffers decrease stream velocity, improve diffuse flow, and reduce nonpoint source pollution concentrations through nutrient cycling. They are also vital in the stabilization of streambanks, and provide habitats that attract and improve biodiversity. As identified in Figure 7.5.1, construction of a riparian buffer includes the following zones:

- **Zone 1:** Closest to the water body and 25-30 feet wide. A mix of wetland herbaceous and woody vegetation that has floodplain and/or wetland characteristics.
- **Zone 2:** The area between Zone 1 and the upland with a primary function of infiltration of runoff and filtration of pollutants. Zone 2 is 25-50 feet wide with woody vegetation.
- **Zone 3:** 25-foot strip of native grasses creating diffuse flow to Zone 2 *(optional).*

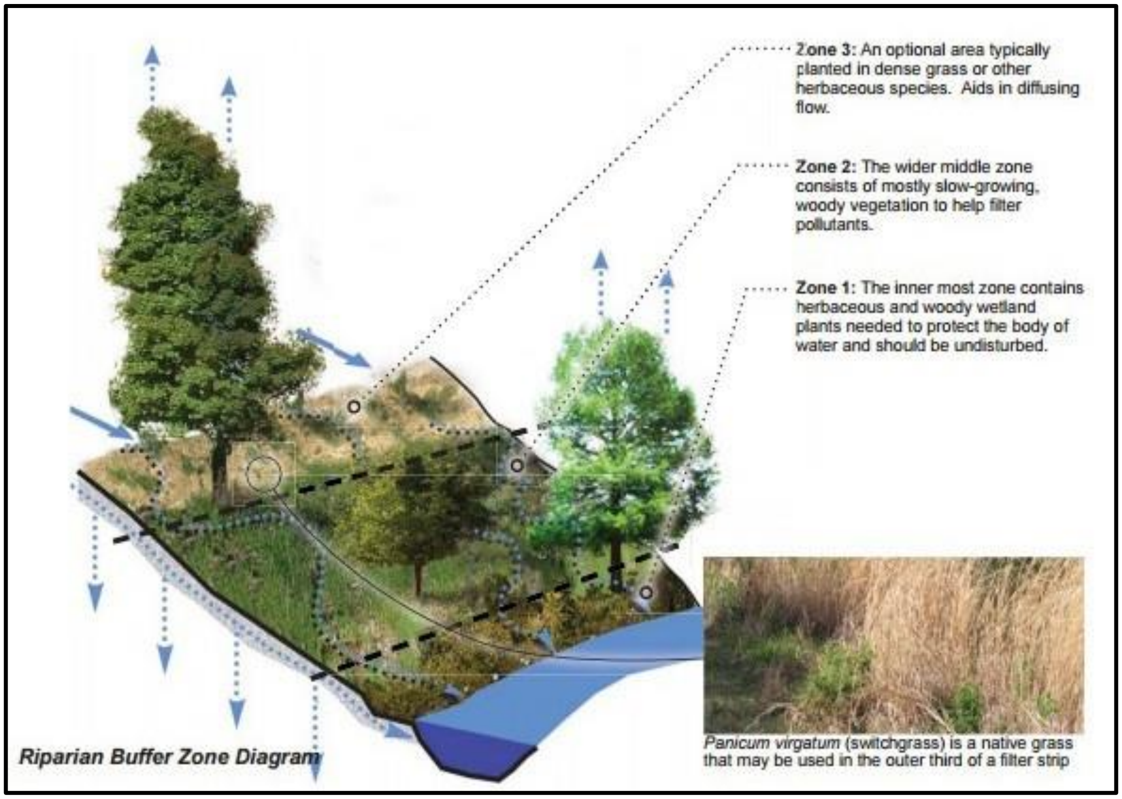


Figure 7.5.1: Riparian buffer zone diagram (ADEM, 2014)

Riparian buffers can range from 25-150 feet, depending on state-specific regulations, but are typically 100 feet or greater. A recommended management measure of this WMP is to restore approximately 20,000 linear feet of riparian buffer. Potential sites within the Greater Dog River Watershed identified for riparian buffer restoration are shown in Figure 7.5.2. Table 7.5.1 provides a summary of the potential riparian buffer restoration sites. However, it is anticipated that the hydrologic modeling program recommended in Section 7.1 will help determine and prioritize potential sites for riparian buffer restoration.

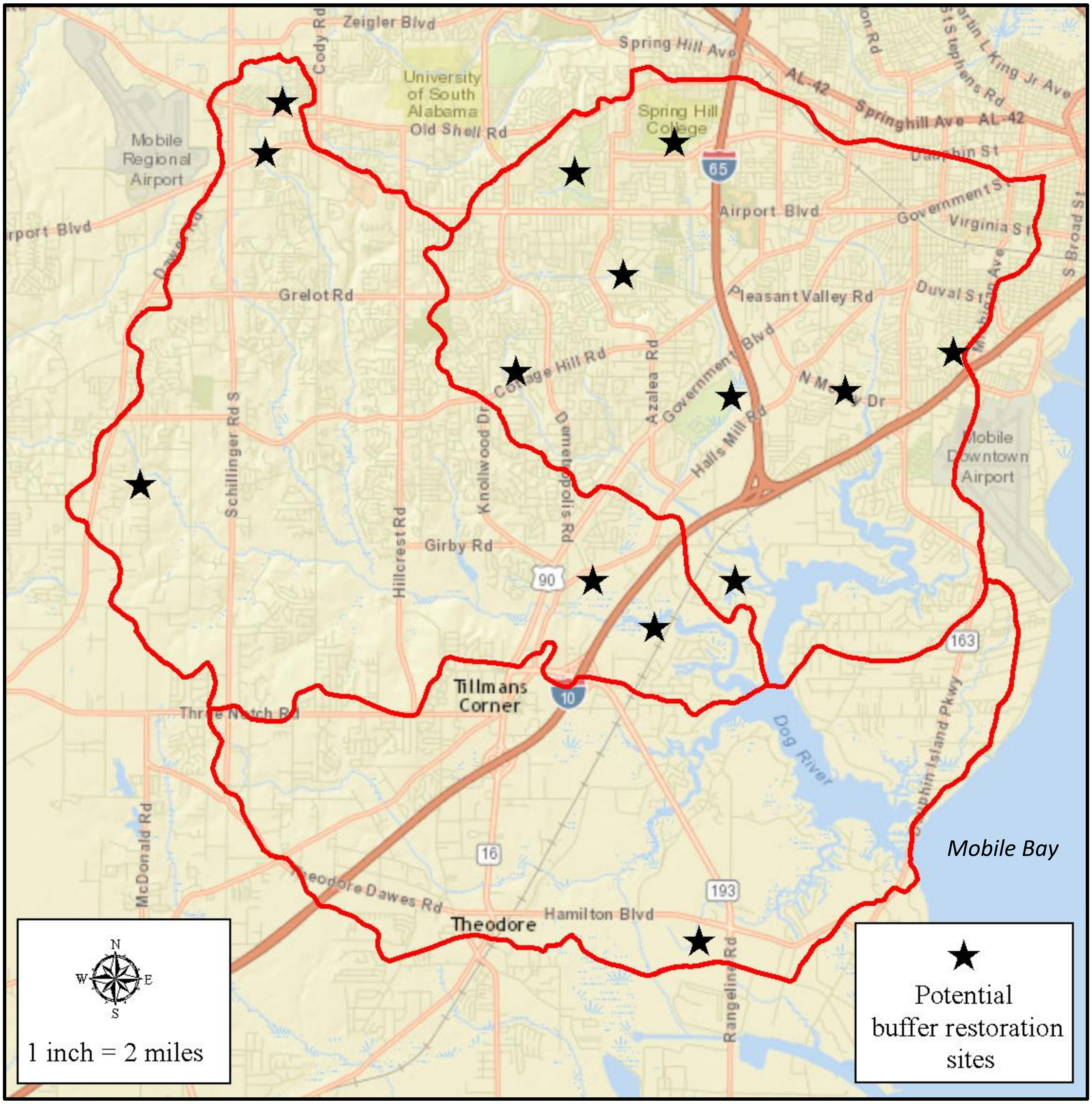
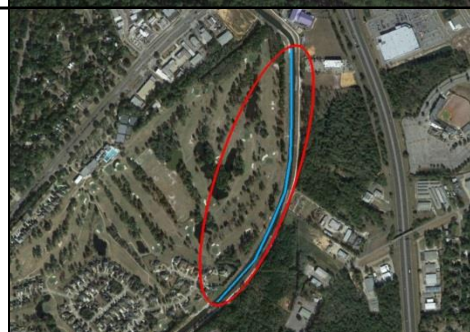


Figure 7.5.2: Potential areas for riparian buffer restoration

Table 7.5.1: Potential areas for riparian buffer restoration

Site Name	Location	Location Diagram	Linear Feet (ft)
RB-1	**Alligator Bayou** S of Hamilton Blvd, W of Rangeline Rd		1,111
RB-2	**Montlimar Canal** Heron Lakes Golf Course		3,496
RB-3	**West Bolton Branch** WP Davidson High School		2,591
RB-4	**West Eslava Creek** Country Club of Mobile Golf Course		2,096
RB-5	**East Eslava Creek** Near Eagle Dr		3,020

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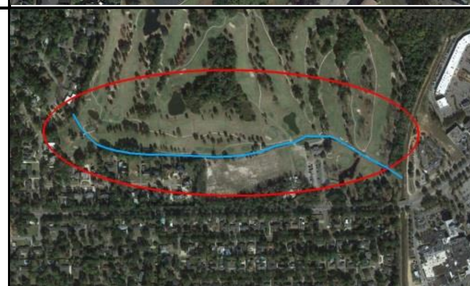
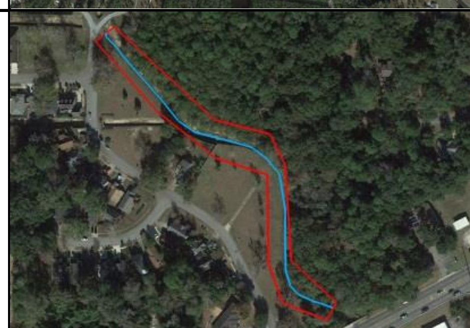
Site Name	Location	Location Diagram	Linear Feet (ft)
RB-6	**East Bolton Branch** SW McVay Drive, NW Navco Rd		574
RB-7	**WestEslava Creek** Spring Hill Golf Course		3,245
RB-8	**Halls Mill Creek** Hippie Beach		272
RB-9	**Halls Mill Creek** S of Dutchman Woods Dr, N of Silver Maple Drive		789
RB-10	**Milkhouse Creek** S of Airport Blvd		345

Site Name	Location	Location Diagram	Linear Feet (ft)
RB-11	**Milkhouse Creek** N of Old Shell Rd		364
RB-12	**Moore Creek** Riviere Du Chien Golf Course		4,832
RB-13	**Spencer Branch** N Cottage Hill Rd, E Panorama Dr		1,042
RB-14	**Spring Creek** S of Halls Mill Rd, E of Demetropolis Rd		794

**Potential areas for riparian buffer may also be considered as sites for other recommended management measures (BMPs, LIDs, stream restoration, living shorelines, etc.)

7.5.2 Stream Restoration

Restoring a stream's natural channel involves a multifaceted approach that includes careful research, design, and engineering. The effort may contain the extension of a floodplain, bank elevation, bank stabilization, reestablishing the stream's sinuosity, and installing energy dissipating structures to decrease water velocity and erosion. Restoring streams also provides ecological benefits and improves water quality.

7.5.2.1 Introduction to Natural Channel Design

The process of stream restoration through natural channel design involves a multiple-step approach including data collection, engineering and scientific assessment, design, construction, monitoring, and maintenance. The success of stream restoration is contingent upon sound design methodology and implementation. The restoration approach follows specific published guidelines and methods endorsed by numerous institutions and regulatory agencies including the EPA, U.S. Army Corps of Engineers (USACE), U.S. Fish and Wildlife Service (USFWS), and the North Carolina Stream Restoration Institute.

7.5.2.2 Identification of Impaired Streams

The identification and assessment of an impaired stream is the first step in the stream restoration and design process. A stream is classified through the Rosgen Classification of Natural Rivers based on collected data (Rosgen, 1994). The data obtained from the project stream also provide details regarding stream channel stability, potential for further degradation, and health of habitat. At this point, certain goals and a preliminary design approach may be identified as the stream design process continues.

7.5.2.3 Identification of Reference Streams

Following evaluation of an impacted stream reach, streams in close proximity to and within the same watershed as the impacted stream are identified and assessed with regard to their quality and value to the restoration project. From an engineering standpoint, these reference streams are judged based on apparent channel stability and certain morphological parameters. Similarities in surrounding topography and soil substrate are also compared between the reference streams and the impacted stream. Certain factors help identify reference stream suitability in the design approach. These factors include low-impact watershed use, bankfull at the top of the bank (Section 7.5.2.4), well-vegetated stream banks, and properly located bed features.

Data collected from the reference streams include but are not limited to:

- Feature spacing;
- Length and slope;
- Bankfull width and depth;
- Stream sinuosity; and
- Radius of curvature.

These data are then processed to develop target dimensions, patterns, and profiles for the design of the impacted stream. Collecting and processing data from streams of varying watershed sizes and drainage areas helps to determine "trends" in channel dimensions for the geophysical region. These reference streams can be scaled to match the drainage area of the stream channel being designed.

From a biological standpoint, reference streams are assessed based on habitat diversity, biota, and overall ecological quality. Ecologists assess the diversity of available habitat types including riffle/run sequences, woody debris, nutrient availability, and riparian buffer establishment. Baseline data is collected to identify the presence of biota in the reference stream and project reach. The data are used to gauge the long-term ecological success of the restoration project.

7.5.2.4 Design Development

Once data describing existing conditions from the impaired stream and reference data from reference streams have been collected, detailed restoration design of the impacted stream can commence. One crucial parameter of design is bankfull discharge. Bankfull discharge is calculated based on the anticipated one- to two-year rainfall event, drainage area for the project reach, land use within the drainage area, and substrate characteristics. The data are entered into a hydrologic model providing a bankfull flow rate target. Regional trend data collected from the reference streams should be used to corroborate the hydrology model. Utilizing the calculated flow rate, anticipated channel slope for the restored stream and projected channel "roughness," the size of the channel can be calculated to ensure overbank flow on an approximate annual frequency. Elevating the stream channel to meet its floodplain is important to make sure the channel is stable. Regional curves generated from recorded data are used to validate certain design criteria.

The layout of the stream design is then prepared using available topographical data and data obtained from the reference streams. Considering the characteristics of the land and potential constraints in the surrounding area, the layout design can follow four different approaches. The four priorities for restoration of impaired and incised streams were developed by Rosgen (1994) and include the following:

- **Priority 1:** Establish bankfull stage at the historical floodplain elevation.
- **Priority 2:** Create a new floodplain and stream pattern with the streambed remaining at the present elevation.
- **Priority 3:** Widen the floodplain at the existing bankfull elevation.
- **Priority 4:** Stabilize existing stream banks in place.

Priority 1 Restoration: Establish bankfull stage at the historical floodplain elevation.

For a Priority 1 restoration, the incised channel is re-established on the historical floodplain using the relic channel or by way of construction of a new morphologically-stable channel. The channel is "lifted" to a higher elevation to connect with the historical floodplain, as illustrated in Figure 7.5.3. The new channel has the dimension, pattern, and profile characteristic of a stable form, and its floodplain is on the existing ground surface. The existing incised channel is either completely filled or partially filled to create discontinuous oxbow lakes and offline wetlands level with new floodplain elevation.

The surrounding land use may prohibit this restoration approach. Priority 1 restorations typically result in higher flood elevations and require sufficient land for meandering, posing a problem where flooding and land-use issues exist. Constraints such as permanent culverts upstream and downstream of the restoration reach can also render this approach infeasible.

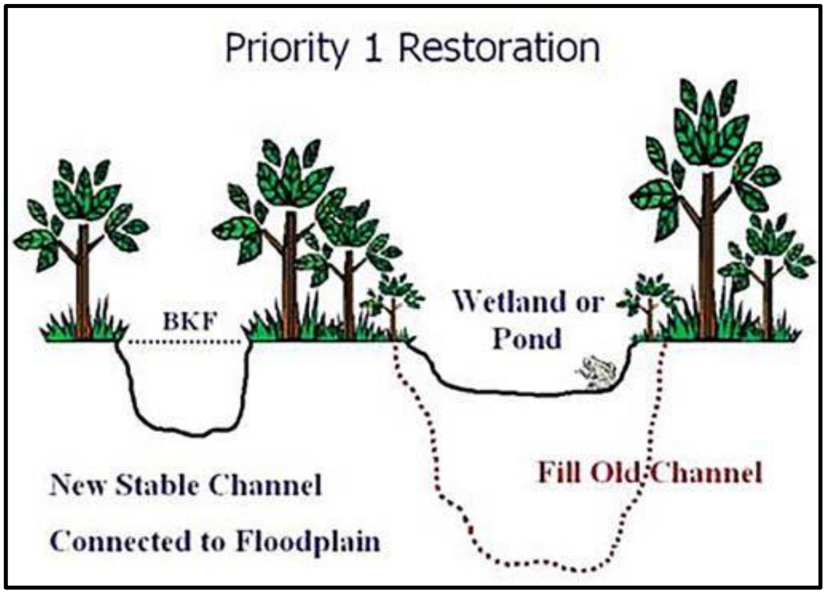


Figure 7.5.3: Conceptual cross section of Priority 1 restoration (Doll et al., 2003)

Priority 2 Restoration: Create a new floodplain and stream pattern with the stream bed remaining at the present elevation.

In a Priority 2 restoration, a new stable channel with the appropriate dimension, pattern, and profile is constructed at the elevation of the existing channel. A new floodplain is established, typically at a lower elevation than the historical floodplain, as depicted in Figure 7.5.4. The new channel is typically a meandering channel with bankfull at the elevation of the new floodplain. This type of project can be constructed in dry conditions while streamflow continues in its original channel or is diverted around the construction site.

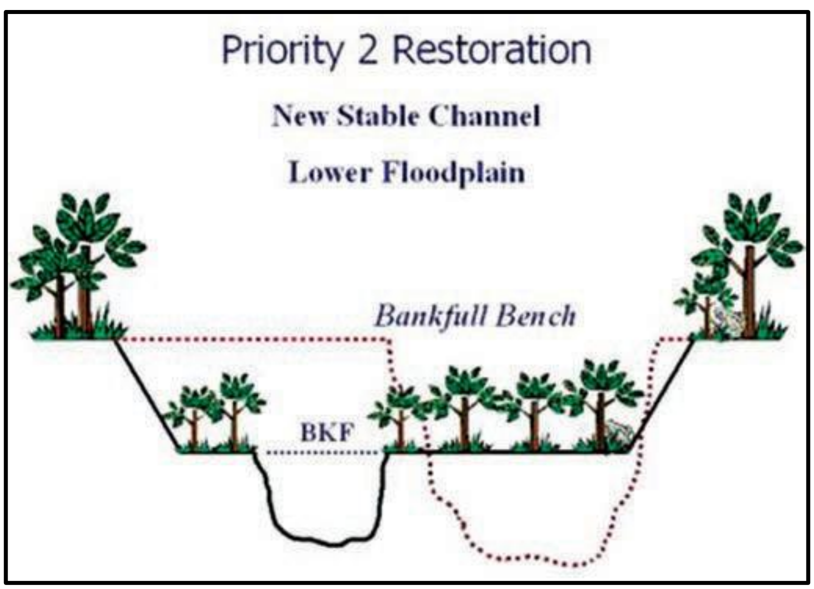


Figure 7.5.4: Conceptual cross section of Priority 2 restoration (Doll et al., 2003)

A major advantage of the Priority 2 approach is that flooding does not increase and may, in some cases, decrease as the floodplain is excavated at a lower elevation. Riparian wetlands in the stream corridor created by the excavation may be enhanced with this approach. Priority 2 projects typically produce more cut material than is needed to fill the old channel. This means that designers should consider the expense and logistics of managing extra soil material excavated from the floodplain. Surrounding land uses can limit the use of this approach if there are concerns about widening the stream corridor.

Priority 3 Restoration: Widen the floodplain at the existing bankfull elevation.

Priority 3 restorations entail converting the existing unstable stream to a more stable stream at the existing elevation and with the existing pattern of the channel but without an active floodplain, as illustrated in Figure 7.5.5. This approach involves establishing proper dimension and profile by excavating the existing channel to modify the Rosgen stream classification. This restoration concept is implemented where streams are confined (laterally contained) and physical constraints limit the use of Priorities 1 and 2 restorations. A Priority 3 restoration can produce a moderately stable stream system, but may require structural measures and maintenance. For these reasons, it may be more expensive and complex to construct, depending on valley conditions and structure requirements.

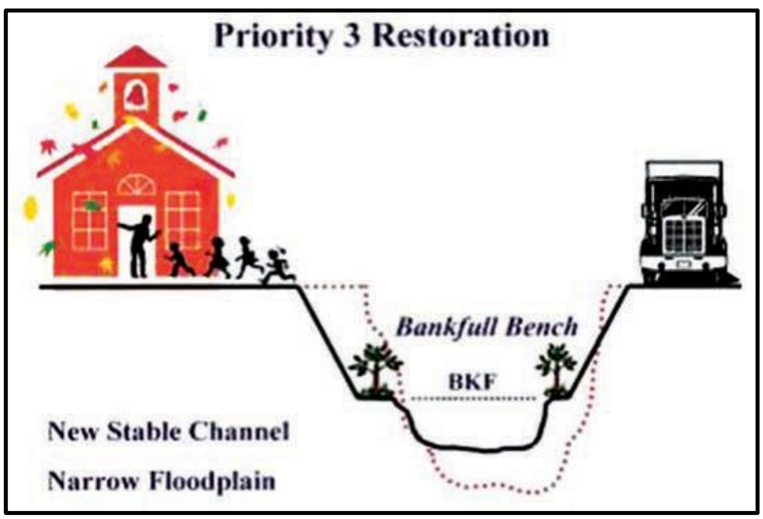


Figure 7.5.5: Conceptual cross section of Priority 3 restoration (Doll et al., 2003)

Priority 4 Restoration: Stabilize existing stream banks in place.

In a Priority 4 restoration approach, the existing channel is stabilized in place utilizing stabilization materials and methods that have been used to decrease streambed and stream bank erosion, including riprap, gabions, and bio-engineering methods. Because this method does not address existing excessive shear stress and velocity that may have caused the impaired channel, it is considered high risk. This approach also limits aquatic habitat and is the least desirable option from a biological and aesthetic standpoint. Table 7.5.2 summarizes the advantages and disadvantages of the four priorities for restoration of impaired and incised streams.

Table 7.5.2: Advantages and disadvantages of incised stream restoration options (Doll et al., 2003)

Priority	Advantages	Disadvantages
1	• Results in long-term stable stream • Restores optimal habitat values • Enhances wetlands by raising water table • Minimal excavation required	• Increases flooding potential • Requires wide stream corridor • Cost associated w/ excess soil disposal • May disturb existing vegetation
2	• Results in long-term stable stream Improves habitat values • Enhances wetlands in stream corridor • May decrease flooding potential	• Requires wide stream corridor to implement • Requires extensive excavation • May disturb existing vegetation
3	• Results in moderately stable stream • Improves habitat values • May decrease flooding potential • Maintains narrow stream corridor	• May disturb existing vegetation • Does not enhance riparian wetlands • Requires structural stabilization measures
4	• May stabilize stream banks • Maintains narrow stream corridor • May not disturb existing vegetation	• Does not reduce shear stress • May not improve habitat values • May require costly structural measures • May require maintenance

A recommended management measure of this WMP is to restore approximately 6,000 linear feet of stream channel. However, there are a large number of constraints that limit the amount of stream restoration opportunities throughout the Watershed. The primary limiting factor is the lack of available floodplain and amount of existing infrastructure within the floodplain. The infrastructure that has encroached into the stream's floodplain has forced man-made alterations (concrete lining and straight-lining) to the stream channels, therefore, the existing landscape does not allow for these alterations to be reversed. Several stream channel segments were identified as potential stream restoration areas within the greater Dog River Watershed. Table 7.5.3 describes potential sites and the type of possible restoration as well as their respective location. Figures 7.5.6-7.1.6 provide general views of the potential sites recommended for stream restoration. However, it is anticipated that the hydrologic modeling program recommend in Section 7.1 will help determine and prioritize potential sites for stream restoration.

Table 7.5.3: Potential areas for stream restoration

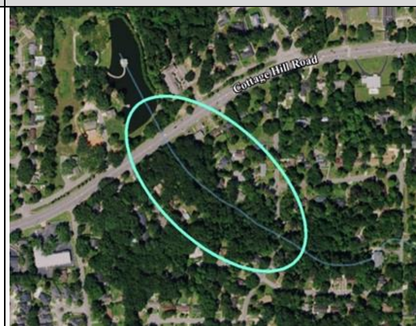
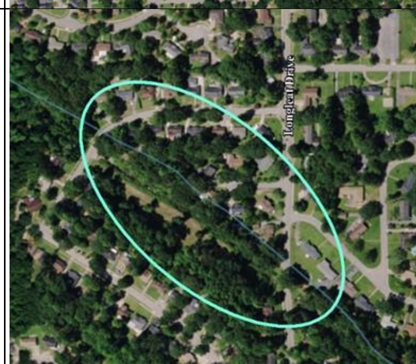
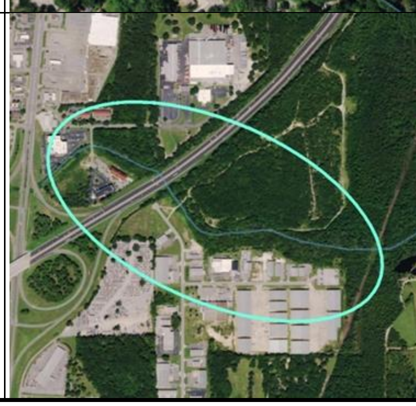
Location	Linear Feet (ft)	Priority Type	Location Diagram	Description
Spring Creek Cottage Hill to Woodland Road	750	Priority 3		Due to the proximity of residences and sewer line in the area, Priority 3 restoration would likely be the more feasible restoration option. This would entail restoring the eroding channel and protecting the sewer line adjacent to or within the channel.
Spring Creek Timberline Drive to Longleaf Drive	875	Priority 2 or 3		Due to the highly-entrenched nature of the system and proximity of residences, Priority 2 or 3 restoration would likely be the more feasible restoration options, depending on land constraints. It is recommended that the entrenched channel be restored and connected to an accessible floodplain and an improved riparian buffer be established.
Unnamed Tributary to Rattlesnake Bayou I-10 off-ramp to Motel Ct; Motel Ct to I-10 overpass; Downstream I-10	3,400	Priority 2 or 3		Due to the highly-entrenched nature of the system and proximity of commercial, municipal, and utility property and easements, Priority 2 or 3 restoration would likely be the more feasible restoration options, depending on land constraints. It is recommended that the entrenched channel be restored and connected to an accessible floodplain and an improved riparian buffer be established.

Figure 7.5.6: Cottage Hill Road to Woodland Road potential restoration area

Figure 7.5.7: Timberline Drive to Longleaf Drive potential restoration area

Figure 7.5.8: I-10 ramp to Motel Court potential restoration area

7.5.3 Shoreline Protection and Restoration

There is evidence that shorelines having intact natural habitat (e.g., wetlands, dunes, oyster reefs, beaches, etc.) experience less damage from severe storms and are more resilient than hardened shorelines (NOAA, 2015a). However, as discussed in Chapter 6, natural riverine and coastal shoreline habitats in the greater Dog River Watershed have experienced losses and degradation. Therefore, management measures should focus on protecting, conserving, preserving, or restoring shorelines and natural shoreline habitats in the greater Dog River Watershed.

A recommended management measure of this WMP is to restore 3,000 linear feet of shoreline habitat in the greater Dog River Watershed through the implementation of living shoreline techniques. However, it is anticipated that the hydrologic modeling program recommended in Section 7.1 will help determine and prioritize potential sites or segments of shoreline for implementation of living shoreline management measures.

7.5.3.1 Implement Living Shorelines

Stabilization solutions for shorelines range from green (soft) or natural and nature-based measures to gray (hard) or structural types, shown in Figure 7.5.9 (SAGE, 2015). The term "living shoreline" refers to the management of shorelines through natural means such as the placement of structural organic materials and plants native to the local environment, with limited or strategic use of structures. The implementation of a living shoreline method, as opposed to armoring techniques, seek to maintain the sustenance and improve biodiversity of the ecosystem.

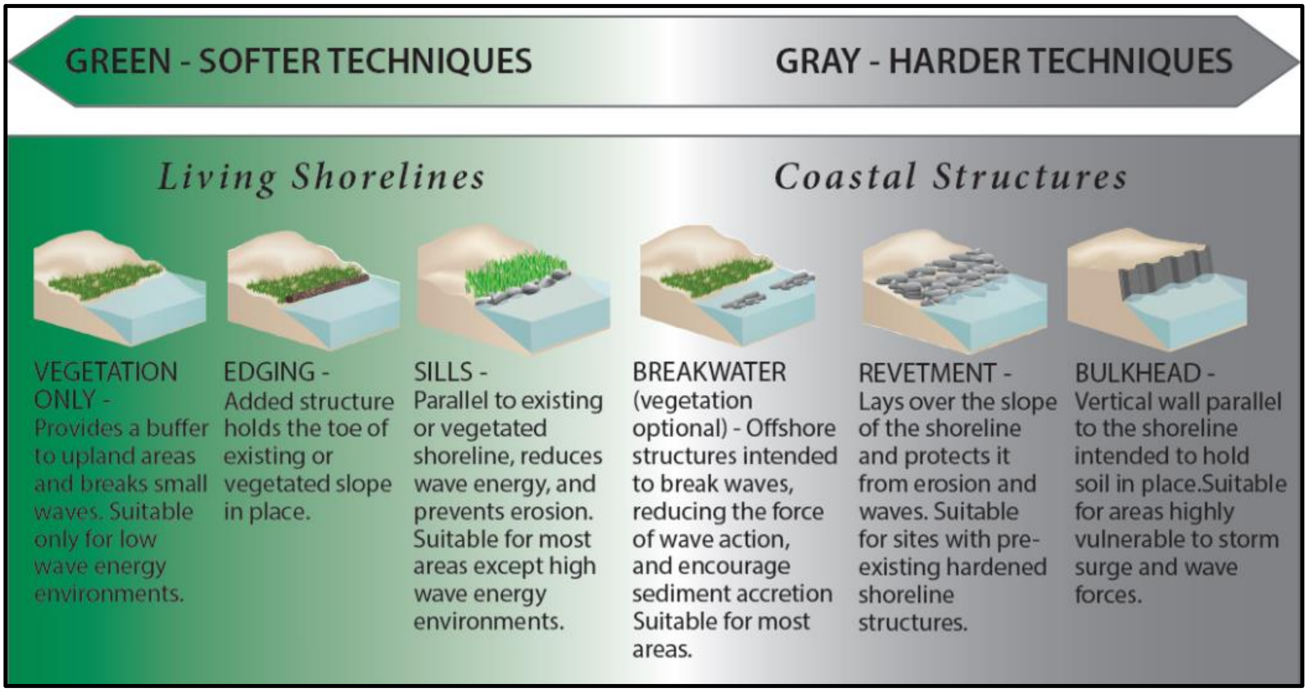


Figure 7.5.9: Green (soft) to gray (hard) shoreline stabilization techniques (NOAA, 2015a)

Vertical bulkheads degrade habitat at their toes and reflect boat wake energy to nearby unprotected shorelines, causing erosion. Much better alternatives involve the use of living shorelines technologies. Living shorelines combine engineered erosion control using living plant material, oyster shells, earthen material or a combination of natural structures with riprap, offshore or headland breakwaters to protect property from erosion (Boyd, 2007). Living shorelines are designed to absorb and dissipate energy, rather than reflect it, and also seek to provide habitat for aquatic life.

Much of the greater Dog River Watershed's shorelines may perform quite well with soft structures. Examples of areas suited for living shorelines are presented in Figures 7.5.10 through 7.5.12.

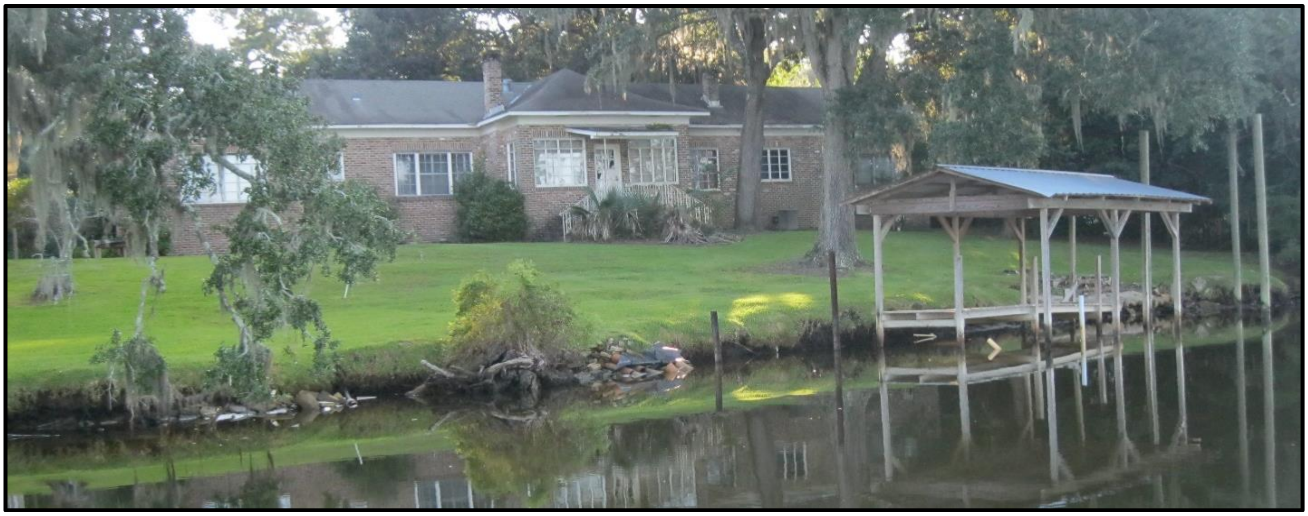


Figure 7.5.10: General example of an area suitable for living shoreline along Alligator Bayou

Figure 7.5.11: General example of an area suitable for a living shoreline along Moore Creek

Figure 7.5.12: General example of an area suitable for a living shoreline along Halls Mill Creek

7.6 IMPROVING WATERSHED RESILIENCE

The greater Dog River Watershed includes coastal and upland habitats that are being impacted by increasing development pressures and natural hazards. Natural hazards include both short-term events such as thunderstorms, tropical storms, and coastal flooding, as well as long-term changes associated with sea level rise and climate change. Development, changing sea levels, increases in frequency and intensity of storm events, and increases in frequency and intensity of flooding events will alter the long-term balance and distribution of native habitats and resiliency of the Watershed.

Building community (Watershed) resilience involves implementing a wide range of strategies to minimize impacts from development pressures and maximize recovery from weather and climate-related hazards (storms, floods, rising sea levels). Such strategies need to integrate both the built-environment and the natural environment, and include short-term (LIDs, BMPs, etc.) and long-term sustainability solutions (planning, adaptation, etc.).

Management strategies for improving the resiliency of the greater Dog River Watershed include, but are not limited to, the following:

- Best management practices (Section 7.2);
- Low impact development (Section 7.3);
- Habitat preservation (Section 7.4);
- Habitat restoration (Section 7.5);
- Adaptive planning (Section 7.6.1);
- Habitat migration (Section 7.6.2); and
- Managed retreat (Section 7.6.2).

7.6.1 Strategies for Adaptation

Development of an adaptation planning strategy provides local governments and vested stakeholders a guide to better determine vulnerable areas and develop strategies to mitigate the effects caused by SLR and flooding. The following summary was adapted from the Florida Department of Economic Opportunity accessed at (http://www.floridajobs.org/docs/default-source/2015-community-development/communityplanning/crdp/adaptationplanninginflorida.pdf?sfvrsn=2). The adaptation strategy was developed recognizing that

SLR will increase coastal vulnerability to a variety of problems, including:

- Increased flooding and drainage problems;
- Destruction of natural resource habitats;
- Higher storm surge, increased evacuation areas and evacuation time frames;
- Increased shoreline erosion;
- Saltwater intrusion; and
- Loss of infrastructure and existing development.

The adaptation strategy prescribes a series of steps that a community may take to become more resilient to the impacts of storm surge, flash floods, stormwater runoff and SLR. The three main strategies a community may use to protect infrastructure and developed areas are:

I. Protection

Protection strategies involve "hard" and "soft" structural defensive measures to mitigate the impacts of rising seas and increased flooding. These include shoreline armoring or beach nourishment. This decreases vulnerability yet allows structures and infrastructure in the area to remain unaltered. Protection strategies may be targeted for areas of a community that are location-dependent and cannot be significantly changed structurally (i.e. downtown centers, areas of historical significance, water-dependent uses, etc.).

II. Accommodation

"The accommodation strategy mitigates the risk of sea level rise through changes in human behavior or infrastructure while maintaining existing uses of coastal areas. For example, it might involve modifying existing infrastructure for adaptive land uses, raising the ground level or improving drainage facilities, encouraging salt resistant crops, restoring sand beaches, and improving flood warning systems" (Lee, 2014).

III. Retreat

Retreat involves the actual removal of existing development, possible relocation to other areas, and the prevention of future development in these high-risk areas. Retreat options usually involve the acquisition of vulnerable land for public ownership, but may also include other strategies such as: transfer of development rights, purchase of development rights, rolling easements, conservation easements, etc. Additional information related to habitat migration and managed retreat is found below in Section 7.6.2.

7.6.2 Facilitate Habitat Migration and Managed Retreat

Integral to building coastal resilience is the protection and enhancement of salt marsh wetlands. Coastal wetlands not only provide critical habitat for fish and shellfish species sustaining the commercial fisheries so important to the economies of Gulf communities, but they also function as physical buffers to absorb storm surge and protect developed areas from coastal flooding. Naturally intact coastal habitat expanses can provide significant reductions to damages from flooding and storm surge (NOAA, 2015a). "There is evidence that shorelines having intact natural coastal habitats (e.g., wetlands, dunes, mangroves, and coral reefs) experience less damage from severe storms and are more resilient than hardened shorelines (Arkema et al., 2013; Gittman et al., 2014)" (NOAA, 2015a). Although salt marshes are able to trap sediment and keep pace with historic sea level rise, hydrologic and physical modifications in watersheds and rapidly increasing sea levels threaten to reduce the ability of coastal wetlands to adapt. A key strategy in planning for sea level rise involves the identification of low-lying coastal uplands that can be preserved or conserved now to allow coastal wetlands to migrate inland and maintain their essential community functions in the future.

It is recommended that the Dog River Watershed Management Plan identify large undeveloped tracts in the Lower Dog River and Halls Mill Creek Watersheds for potential public acquisition, conservation easements, or to ensure that there is adequate land area to allow for the upland migration of tidal marsh habitats with future SLR. Managed retreat allows salt marshes, tidal flats, and other coastal habitats the ability to migrate and retreat upland as sea levels rise. Key preservation areas for managed retreat in the greater Dog River Watershed were identified using the Sea Level Affecting Marshes Model (SLAMM) (ESA, 2016a). Figures 7.6.1- 7.6.3 identify potential preservation target areas based upon the SLAMM simulation run under the worst-case scenario (high SLR with low accretion) (Appendix B) for each individual Watershed (Upper Dog River, Halls Mill Creek, and Lower Dog River), while Figure 7.6.4 depicts the same areas but on the scale for the entire greater Dog River Watershed.

Approximately ninety-five (95) acres of key preservation areas for managed retreat were identified within the greater Dog River Watershed. Figures 7.6.1-7.6.3 outline potential preservation target areas and are color-coded based on their respective acreages (1-2 acres, 2-5 acres and › 5 acres). It is recommended that at least 50% of these ninety-five (95) acres be preserved in perpetuity through long-term protection such as restrictive covenants or conservation easements. Permanent protection of these areas will provide an opportunity for the coastal habitats to migrate over time in such a way that will positively benefit the ecological conditions (increased habitat) while providing economic benefit (reduced flooding and repeated impacts to infrastructure).

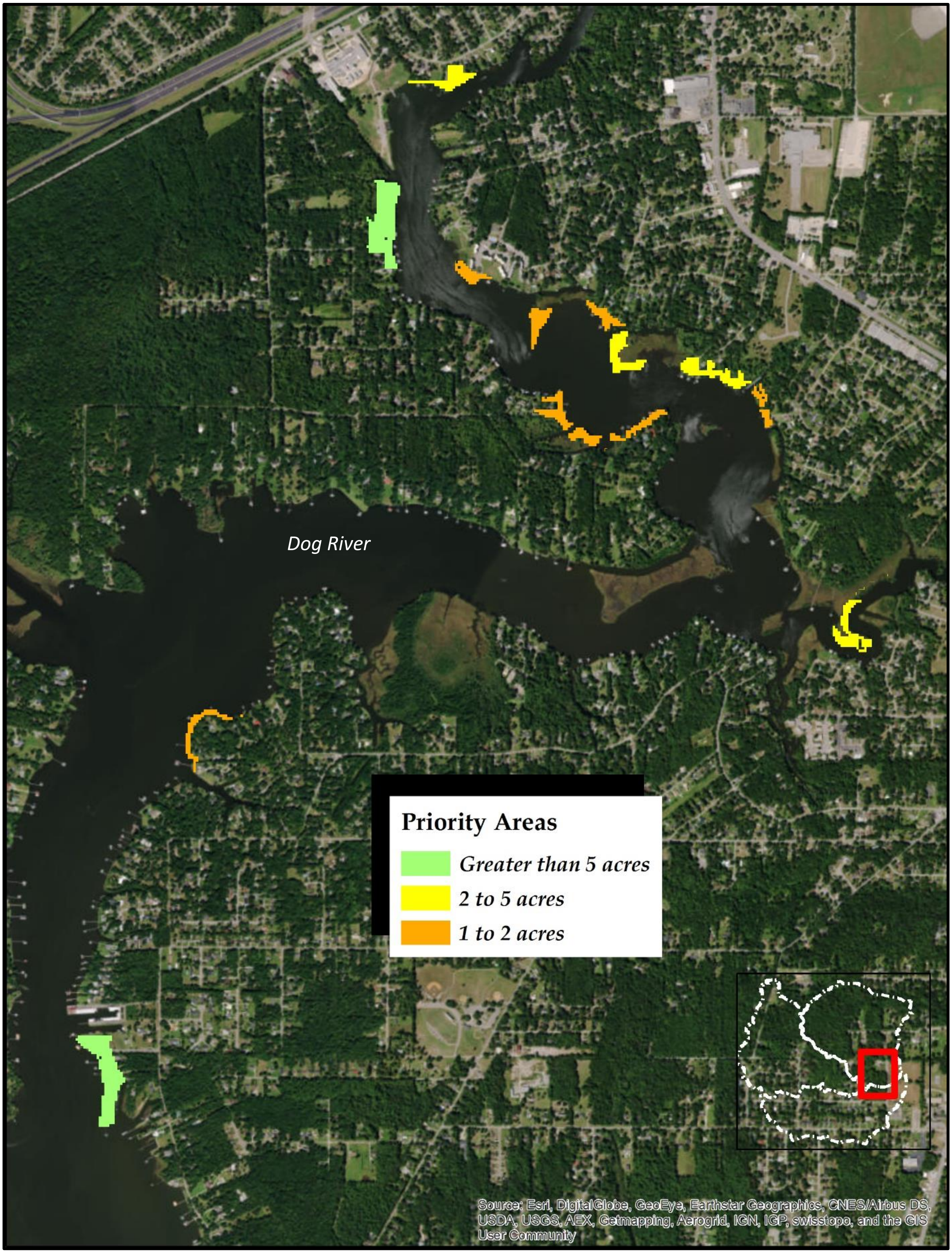


Figure 7.6.1: Upper Dog River Watershed priority habitat migration areas (ESA, 2016a)

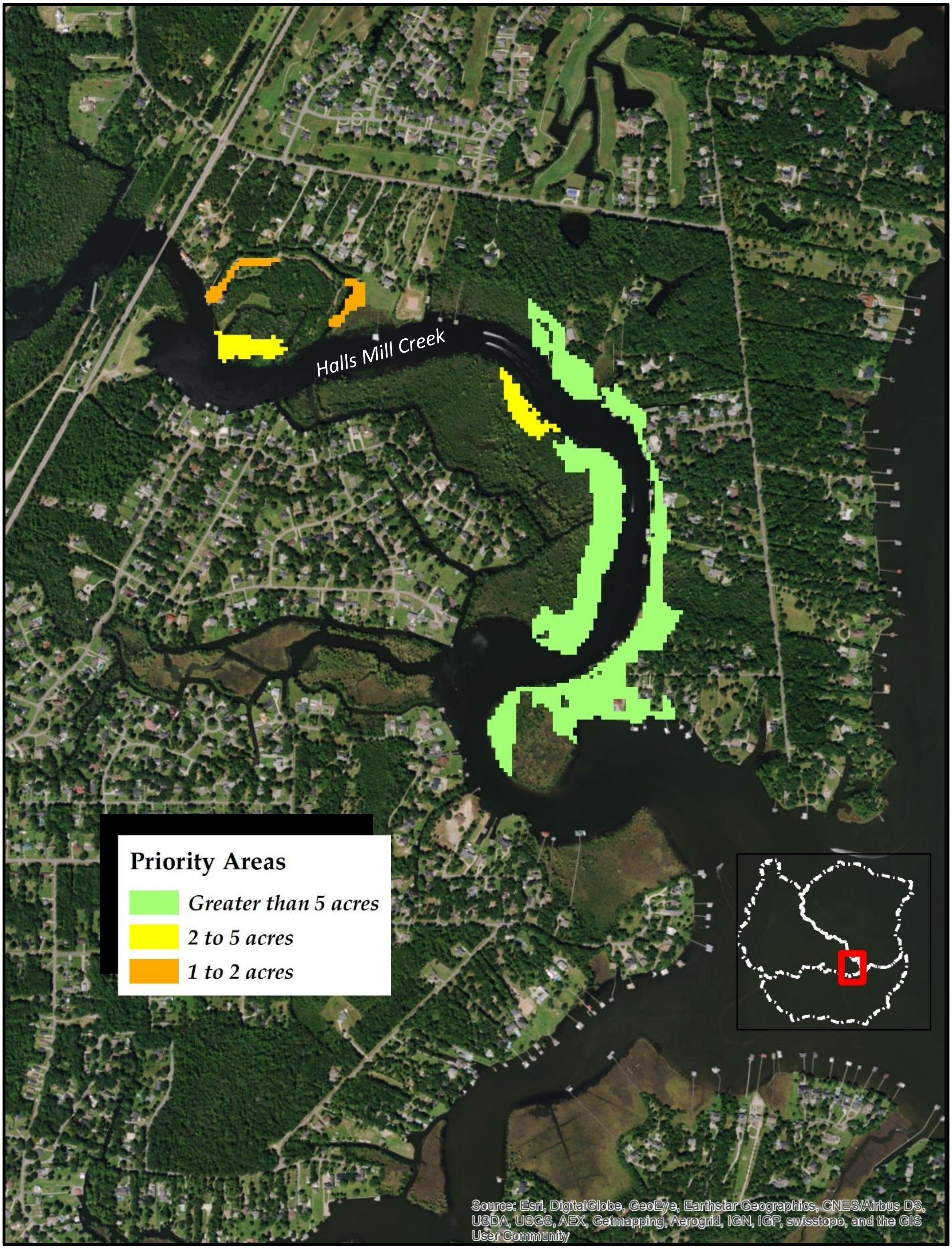


Figure 7.6.2: Halls Mill Creek Watershed priority habitat migration areas (ESA, 2016a)

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Figure 7.6.3: Lower Dog River Watershed priority habitat migration areas (ESA, 2016a)

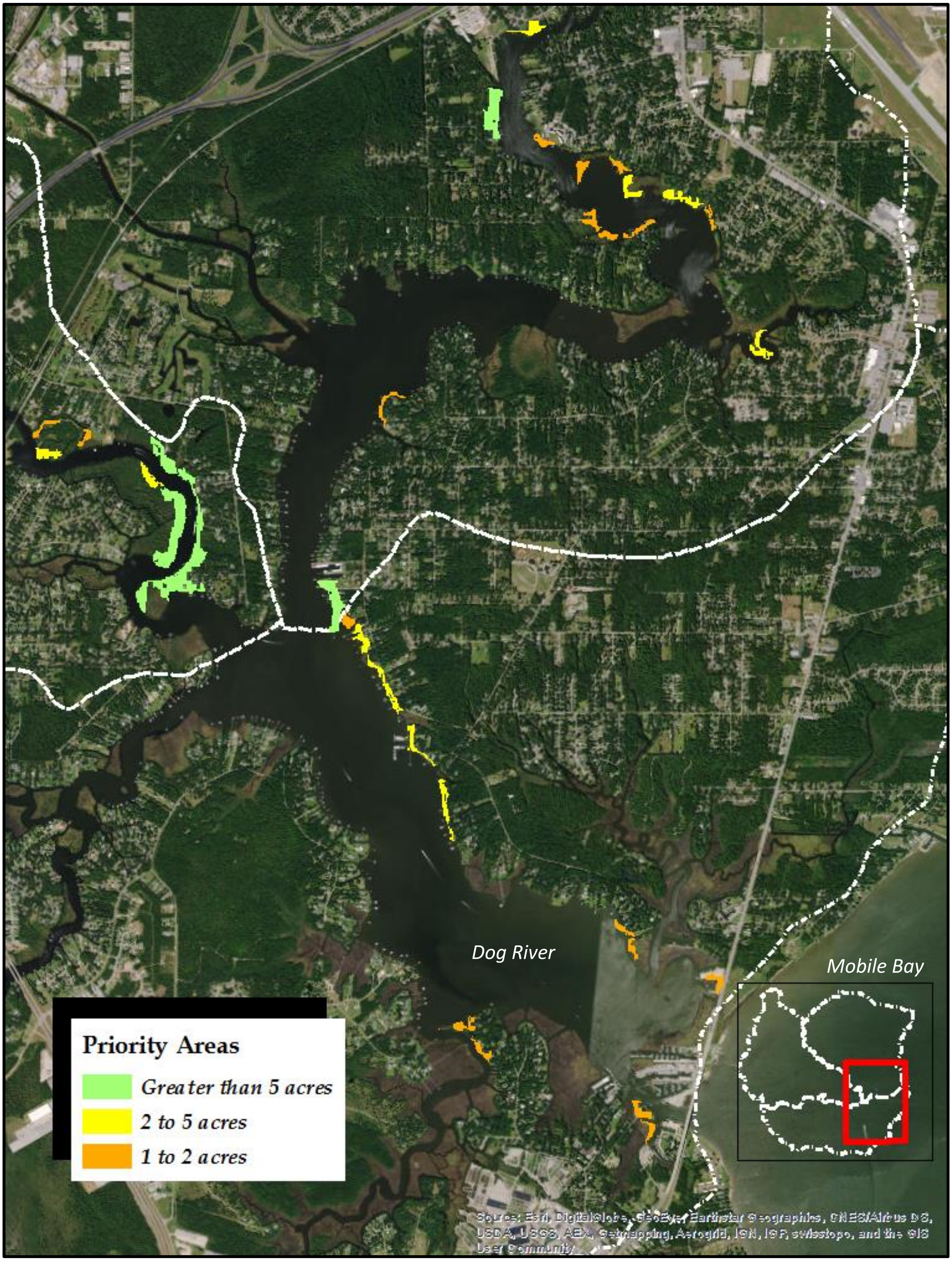

Figure 7.6.4: Priority habitat migration areas in the greater Dog River Watershed (ESA, 2016a)

7.7 IMPROVE ACCESS, EDUCATION, AND OUTREACH

Management of any natural resource is enhanced by public understanding, support, and participation of the stakeholders. Management measures to restore heritage and cultural connection between the Watershed and the community were selected to enhance access to Dog River and raise the overall awareness of water quality in the Watershed.

Recommended management measures to improve access, education, and outreach in the greater Dog River Watershed include, but are not limited to:

- Adding at least six (6) new access points (Section 7.7.1.1);
- Developing a boaters' guide to highlight local waterways and access points (Section 7.7.2); and
- Improving and promoting existing access points (motorized and non-motorized) and historic and cultural themes through signage and mapping (Section 7.7.3).

Additionally, there is a need for a holistic plan to establish a comprehensive strategy for providing access and recreation facilities, programs, and services for the public throughout all of Mobile County.

7.7.1 Improve Waterway Accessibility

Public access to coastal resources is important to the people who live near the coast. Increasing and improving public access to the natural resource is a goal of the MBNEP Comprehensive Conservation and Management Plan (CCMP). Public access to the ecosystems people value most also exposes them to their surroundings and is critical to establishing a connection between people and the environment. "Access is an important component of coastal protection, because the more connected people are to the resource, the more they will value and protect it" (MBNEP, 2012).

Public projects to improve access should include nature trails, scenic overlooks, boardwalks, historic markers, and new access points to Dog River. Additionally, DRCR along with an appointed watershed coordinator, discussed in Section7.8, should work closely with the USACE to promote channel dredging to enhance access. Dredging activities should be coordinated with potential beneficial re-use opportunities for coastal wetland/marsh replenishment in areas where sediment loads are inadequate. The City of Mobile is also improving and extending trails interconnecting the City through the Mobile Greenway Initiative. The Crepe Myrtle Trail passes through the Lower Dog River Watershed traveling from Helen Wood Park to Doyle Park. Plans are underway to extend this trail along Dog River. Relatedly, plans are underway for connectivity with parks in the northern part of the greater Dog River Watershed and along Three Mile Creek Trail.

7.7.1.1 Add Additional Access Points

In addition to supporting other partnerships and ongoing initiatives, a recommended management measure to enhance awareness and community connection with Dog River should include developing additional waterway access locations.

Figure 7.7.1 shows potential additional access locations that might be considered. Locations depicted in Figure 7.7.1 are undeveloped, City owned properties that have connections to the surface water network system in the greater Dog River Watershed (City of Mobile, 2017). The potential locations identified would increase and improve public access to the river and the estuary, providing additional opportunities for boating, fishing, picnicking, and bird watching.

Other potential access locations not shown in Figure 7.7.1 could have the potential of being established and their efforts should be supported; For example, an area East of Interstate 10 in the Malls Mill Creek Watershed known as Hippie Beach might also be considered a potential additional access location. Other potential additional access locations are provided by DRCR and Peninsula of Mobile in Figures 7.7.2 and 7.7.3, respectively.

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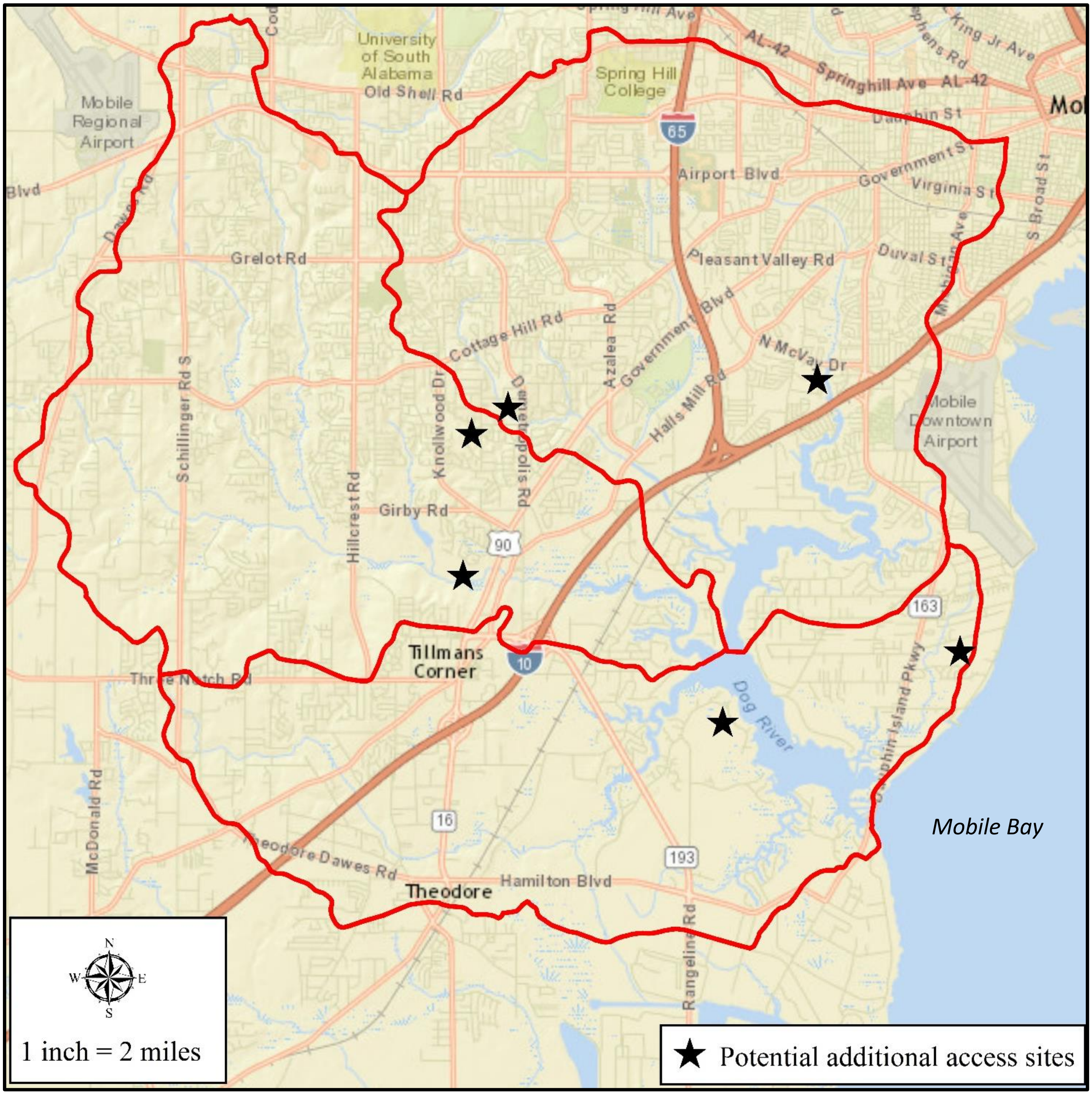

Figure 7.7.1: Potential additional access locations (City of Mobile, 2017)

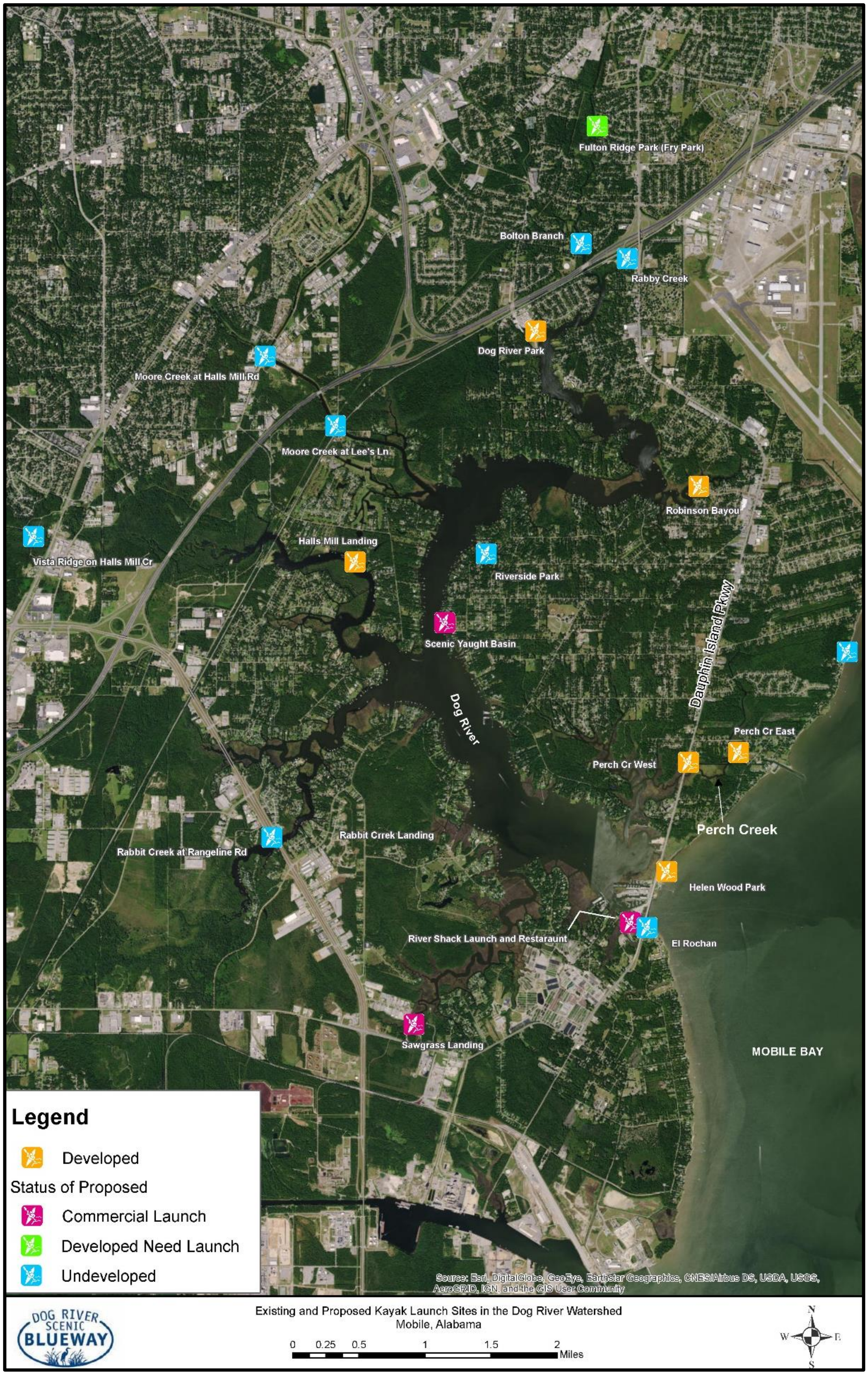

Figure 7.7.2: Existing and proposed kayak launch sites in the greater Dog River Watershed (from DRCR, 2017)

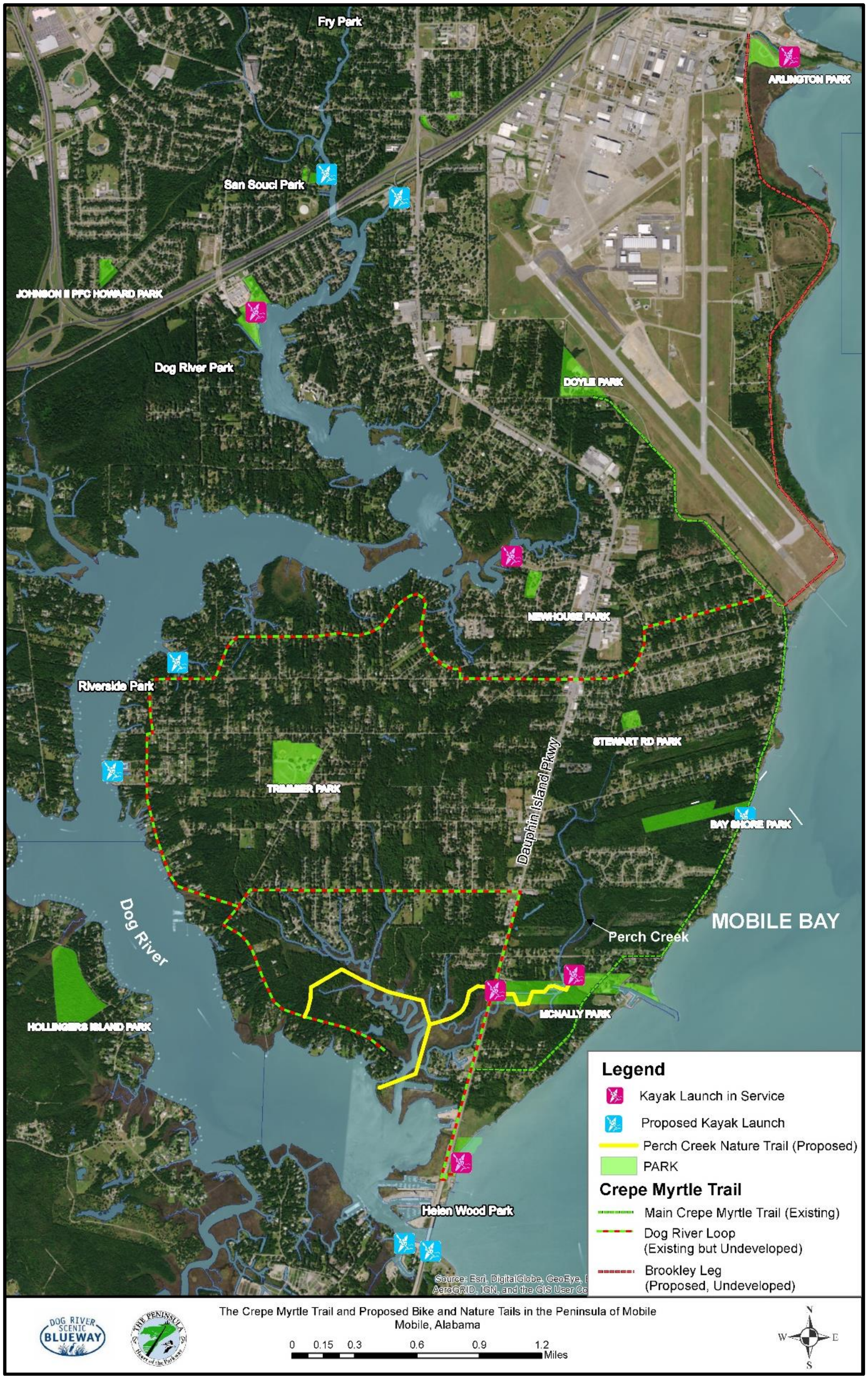

Figure 7.7.3: Existing and proposed trails and kayak launch sites in the greater Dog River Watershed (from DRCR, 2017)

7.7.2 Develop a Waterways Guide

It is recommended that a boaters' guide be developed to highlight local waterways and access points. The boaters' guide should include maps indicating access locations, historic sites, recreational opportunities, sport fishing, species found in each reach of the drainage, and relevant freshwater and marine rules and regulations such as fishing size limits, creel limits, safety rules, no-wake zones, and hours of operation for landings. This would complement previous efforts such as the Dog River Scenic Blueway Master Planning Workbook (DRCR, 2011) that had a defined mission to *"identify river and coastal access points, promote stewardship of sensitive environments, encourage cultural and historical awareness, and provide recreational opportunities for paddling enthusiasts and recreational boaters in Mobile's urban river and its tributaries."*

The intent of the boaters' guide would be a succinct document that could provide valuable information such as:

- Educational information about the greater Dog River Watershed;
- Boating regulations;
- Paddling safety tips;
- Commitment to stewardship (leave no trace philosophy outlined in the Blueway Master Plan);
- Information on designated boating/paddling trips that outline cultural, historical and ecologically sensitive areas; and
- Comprehensive maps that highlight trail features and amenities.

It is recommended that there be an online publication that can be routinely updated as further development occurs.

7.7.3 Signage

Through the development of this WMP and working closely with the vested stakeholders, there is a need to provide a stronger "connection" between the general public, the valuable resources found within the watersheds, and their role in its protection. It is recommended that continued outreach and public education remain a focal point throughout the greater Dog River Watershed. Many of the significant critical issues outlined in previous sections of this WMP could be improved by simply increasing public awareness and reinforcing that individual decisions, actions or in-actions can have far-reaching implications to protecting the ecological integrity of the Watershed. One significant way to better connect the general public to these resources includes educational signage. Examples of interpretive signage could include:

- What is a watershed?
- Identification of rivers, creeks and other waterways;
- Importance of not littering;
- Identification of critical wetland and ecologically sensitive habitat areas;
- Identification of key areas outlined in the boaters' guide;
- Identification of recreational, cultural and historical areas; and
- Educational kiosks of restoration project areas.

7.8 ESTABLISH A WATERSHED COORDINATOR POSITION

Successful implementation of the proposed management measures for the greater Dog River Watershed will require collaboration between all stakeholders (city, county, state, and federal agencies, local residents and local civic organizations like DRCR). To assist DRCR in stewarding this WMP it is recommended that a watershed coordinator position be created. An appointed watershed coordinator would work closely with DRCR to implement the management measures outlined by this plan while additionally concentrating on a regional and comprehensive perspective. A watershed coordinator staff position could be served through an existing organization such as DRCR or through an appointment within the City of Mobile or Mobile County. The primary responsibility of an appointed watershed coordinator would be to shepherd the efforts to promote, encourage, implement, and facilitate the recommended management measures of WMPs in the region. Establishment of a coordinator position would illustrate the community's resolve to serve as committed partners with vested interests in the long-term protection of the Watershed. In addition to working alongside DRCR, the watershed coordinator would also work alongside the MBNEP's Project Implementation Committee (PIC), which would allow for synergy and maximization of a coordinated regional approach to support and enhance existing efforts and implement new recommended measures of all WMPs within coastal Alabama.

7.9 IMPROVE REGULATORY INITIATIVES

The City of Mobile Post-Construction Stormwater Regulations state that inspections of post-construction stormwater management (PCSM) BMPs shall be completed by a Qualified Credentialed Inspector/Professional (QCI or QCP). Typical QCI training programs only include training on inspections during construction, but not training on PCSM BMPs. In addition, not all individuals covered by the definition of a QCP are qualified to inspect PCSM BMPs. It is recommended that the City revise post-construction regulations related to inspection of PCSM BMPs to ensure that all inspections are conducted by qualified QCPs.

The City of Mobile Stormwater Management and Flood Control Ordinance provides the City regulatory authority to charge stormwater user fees. The City, however, does not currently charge these fees. City jurisdiction includes a large portion of the greater Dog River Watershed, and charging these fees should be considered to fund new stormwater infrastructure and maintain and repair existing structures.

The majority of the greater Dog River Watershed is regulated by local ordinances and regulations, but the remainder has no post-construction stormwater control regulations. Federal and State agencies should consider updating their regulations to incorporate post-construction stormwater controls within all unincorporated areas of the greater Dog River Watershed. In addition, should additional County authority become available through new regulation, the County should consider post-construction stormwater requirements based on the size of the development and its potential impact on stormwater runoff.

The State of Alabama has established a 25-foot buffer requirement on wetlands and riparian buffers for all new construction sites greater than one acre. Although mitigation of impacted wetlands is typically required, required mitigation measures often occur outside of an impacted watershed, creating a net loss of these valuable resources within the watershed. A proactive approach is needed to protect, enhance, and preserve these resources by federal and state agencies to provide more emphasis on requiring mitigation measures where permitted impacts occur. In addition, the City and County should consider incorporating buffer and setback requirements for wetlands and riparian buffers to provide increased protection of these resources. This is reiterated in the *Map for Mobile* Plan (City of Mobile, 2015). The policies from *Map for Mobile* include: "maintain and protect open space and natural areas" and "minimize effects of development on our environmentally sensitive areas, including wetlands, shore lines and waterways" (City of Mobile, 2015). Given the importance of the natural resources to the City and County as a whole, enacting new regulations as needed to protect the natural resources are a priority management measure.

7.9.1 Improve LID Regulations

Recommendations for LID and stormwater management are supported in goals and policy within *Map for Mobile* within "Planning the Journey" (natural resources section) as well as the Peninsula of Mobile Corridor Plan.

The City of Mobile regulations currently contain requirements for controlling the volume of post-construction runoff, but do not have an emphasis on controlling stormwater quality. Although the City of Mobile regulations encourage the use of LID techniques, the regulations should be improved to require the use of these measures where possible. A holistic review of the current planning and zoning ordinances, with emphasis placed on smart growth and increased LID installations, are encouraged. In the future, all new development within the greater Dog River Watershed should embrace LID techniques and concepts whenever possible, and existing developments should retrofit stormwater runoff collection points. Financial incentives may be necessary to encourage LID. These incentives could include tax incentives or financial grants to help fund construction.

7.10 DEVELOP A WATER QUALITY MONITORING AND SAMPLING PLAN

A water quality monitoring and sampling plan is necessary to continue to document the overall health of the greater Dog River Watershed, track the success or failure of the implemented management measures, and determine where additional measures are necessary. The monitoring plan should encompass the greatest possible portion of the Watershed with the least number of samples while providing sufficient detail to identify probable source areas for elements of concern.

Throughout the development of this WMP, stakeholders expressed concern that existing water quality data were somewhat dated and scattered, and that a comprehensive current assessment of water quality conditions was needed to better understand existing conditions. It is recommended as a management measure that additional water quality data collection be conducted (at constant and consistent locations) under a long-term monitoring program. Permanent sample locations should be established to assure consistency over the 20-year life of this WMP and will allow for better analyses (identification of trends, significant changes to data output, etc.). Figure 7.10.1 shows historical and additional proposed water quality sample collection locations.

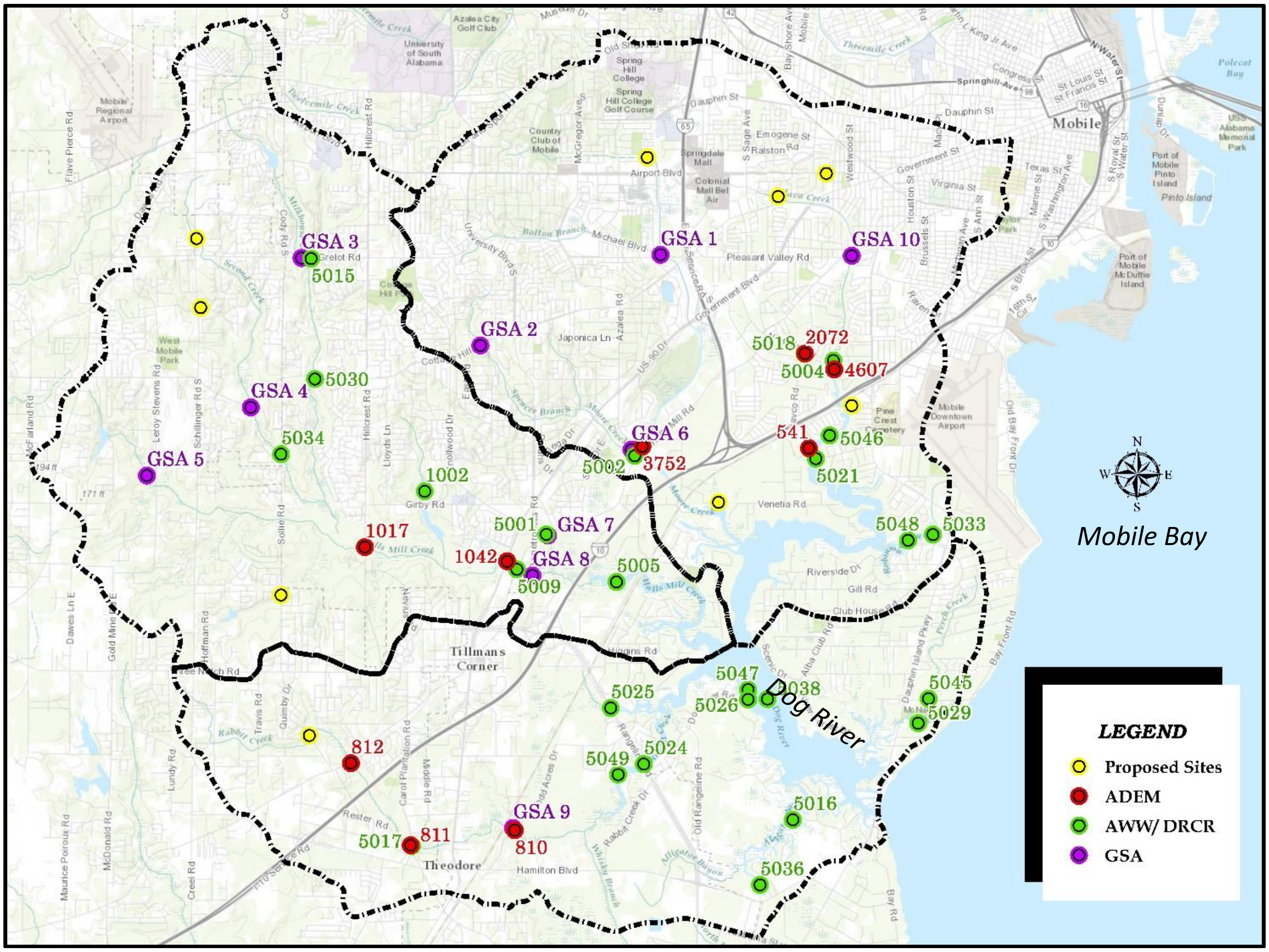

Figure 7.10.1: Priority water quality sample collection locations

To assure consistency, sampling should occur during the same time frame each quarter and under similar flow conditions. The objective of the initial sampling and analyses is to compare current conditions of the Watershed's streams to baseline conditions, document shoreline extent and stability in the estuary and intertidal zone, and perform an initial biological assessment of specific reaches within the Watershed.

Once watershed management measures are undertaken, the sampling will also be used to determine success of those management measures in improving conditions within the Watershed and to indicate where additional measures are needed. Additional information related to the monitoring and sampling plan can be found in Chapter 11 of this WMP.

8.0 REGULATORY FRAMEWORK

As part of the development of this Watershed Management Plan (WMP) for the greater Dog River Watershed in Mobile County, Alabama, a review of existing regulations at the federal, state, and local levels was conducted. The geopolitical boundaries of the greater Dog River Watershed include overlapping jurisdictions and adjacent portions of Mobile County, the City of Mobile, and the City of Mobile's five-mile planning jurisdiction with additional lands under State of Alabama and federal jurisdiction. Past and current status of developments, ordinances, inspections, and compliance issues were discussed with local government officials, as well as with representatives of Alabama Department of Environmental Management (ADEM), U.S. Army Corps of Engineers (USACE), and the WMP Steering Committee.

The laws, regulations, and ordinances reviewed in this WMP focus on water quality, stormwater, erosion and sediment control, coastal zone issues, wetlands, other "waters of the U.S.," and land disturbances. The list includes:

- Clean Water Act, 33 USC § 1251, et seq.
- Alabama Water Pollution Control Act, Ala. Code § 22-22-1, et seq.
- ADEM Admin Code Reg. 335-6-6 National Pollutant Discharge Elimination System (NPDES)
  335-6-10 (Water quality criteria)
  335-6-6 (NPDES)
  335-8-1 (Coastal area management)
- Mobile County Flood Damage Prevention Ordinance
- Mobile City Code Chapter 17: Storm Water Management and Flood Control
- City of Mobile Stormwater Management Program Plan
- Mobile County Stormwater Management Program Plan

Federal, state, and local regulations are regularly reviewed and updated. At this time, no known major regulation changes are planned; however, permits typically required for activities within the Watershed are regularly updated (typically every five years) and usually include some changes from the previously issued permits. Below is a summary of the current expiration dates for the federal, state, and local permits required for certain activities within the Watershed:

- USACE Nationwide Permits – March 18, 2022
- ADEM Construction Stormwater General Permit – March 31, 2021
- City of Mobile Municipal Separate Storm Sewer System (MS4) Individual Permit – September 30, 2019

- Mobile County Phase II MS4 General Permit – September 30, 2021

8.1 RELEVANT AUTHORITIES

In May 1991, the State of Alabama Legislature passed a law (Act No. 91-602) that provides for the creation of watershed management authorities in the state, with the expressed purpose of "developing and executing plans and programs relating to any phase of conservation of water, water usage, flood prevention, flood control, water pollution control, wildlife habitat protection, agricultural and timberland protection, erosion prevention, and control of erosion, floodwater and sediment damages" (AL Code§ 9-10A-1, 2013).

This body is non-regulatory; however, the law provides numerous powers and authorities to the Board of Directors of a watershed management authority, including the power to:

- Acquire lands or rights-of-way by purchase, gift, grant, bequest, or through condemnation proceedings;
- Construct, improve, operate, and maintain such structures and projects as may be necessary for the exercise of any authorized function of the Authority;
- Borrow money as is necessary for the performance of its functions;
- Make and execute contracts and other instruments necessary to the exercise of its powers;
- Act as agent for the State of Alabama or any of its agencies, the United States or any of its agencies, or any county or municipality in connection with the acquisition, construction, operation, or administration of any project within the boundaries of the Authority;
- Issue, negotiate, and sell bonds upon approval of the State Finance Director; and
- Accept money, services, or materials from national, state, or local governments.

8.1.1 Federal Authorities

Federal Water Pollution Control Act

The Federal Water Pollution Control Act was enacted in 1948, and was significantly reorganized and expanded in 1977. The Clean Water Act (CWA) became the Act's common name with the amendments in 1972. The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating water quality standards for surface waters. The CWA and its amendments provide the basis for the primary federal regulatory and permitting procedures relating to stormwater management in the greater Dog River Watershed. The most applicable sections of the CWA related to controlling stormwater runoff and erosion and sedimentation within the Watershed are listed below.

CWA § 404

This section establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. CWA Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities). The USACE is the primary permitting authority for impacts to waters of the United States, including wetlands. Permit applications are reviewed and evaluated based on the environmental criteria set forth in the CWA Section 404(b)(1) guidelines and regulations promulgated by the U.S. Environmental Protection Agency (EPA). The permits must also meet State water quality standards and coastal area requirements and must be consistent with each program.

CWA § 402

This section authorizes permitting under the NPDES program with EPA having primary permitting authority. The NPDES program requires dischargers to obtain permits prior to discharging pollutants into waters of the United States. The NPDES program covers point source discharges from industrial facilities; MS4s; concentrated animal feeding operations (CAFO); publicly-owned treatment works (POTW); combined sewer overflows (CSO) and sanitary sewer overflows (SSO); and construction, non-coal/non-metallic mining and dry processing less than five acres, other land disturbance activities, and areas associated with these activities.

Through delegation from the EPA, ADEM has the authority to administer the NPDES program. Through ADEM Admin. Code Reg. 335-6-6 the Department regulates and permits certain point source discharges. Through ADEM Admin Code Reg. 335-6-6, ADEM regulates discharges from construction, non-coal/non-metallic mining and dry processing less than five acres, other land disturbance activities, and areas associated with these activities. This regulation also imposes requirements for controlling erosion, sedimentation, and other potential sources of pollution from these activities through the use of best management practices. This regulation also outlines requirements for inspections, reporting, and enforcement actions.

The EPA promulgated the *Effluent Limitations Guidelines and Standards for the Construction and Development Point Source Category* in December 2009. The rule requires owners and operators of permitted construction activities to adopt certain requirements including the implementation of erosion and sediment controls, stabilization of soils, management of dewatering activities, implementation of pollution prevention measures, provision and maintenance of a buffer around surface waters, prohibition of certain discharges, and utilization of surface outlets for discharges from basins and impoundments. The 2009 rule also included the establishment of numeric limitations on the allowable level of turbidity in discharges from certain construction sites. In 2014, the EPA made several revisions to the 2009 rule requirements including defining "infeasible" and removing the numeric turbidity effluent limitation and monitoring requirements.

In addition to the activities listed above, ADEM is also the delegated authority from the EPA to regulate discharges from MS4s. ADEM requires municipalities and other large operators of MS4s, such as the Alabama Department of Transportation (ALDOT), to obtain and comply with terms of an NPDES permit to control the discharges from such systems.

CWA § 303(D)

Under Section 303(d) of the 1972 CWA, states, territories, and authorized tribes are required to develop lists of impaired waters. These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop total maximum daily loads (TMDLs) for these waters. The TMDLs are used to establish limits for the amount and type of pollutant discharges that the receiving streams can handle without experiencing further degradation.

Within the greater Dog River Watershed, Halls Mill Creek is listed on the Alabama § 303(d) list for siltation because of its sediment load concentrations. The TMDL is currently pending for Halls Mill Creek. Once a TMDL is established, additional research may be warranted to determine additional measures that can be implemented to meet the required TMDL. Additionally, TMDLs have been approved for several other pollutants and named surface water systems in the greater Dog River Watershed and are further described in Section 5.1.2.3.

Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) of 1972, administered by the National Oceanic and Atmospheric Administration (NOAA), provides for the management of the nation's coastal resources, including the Great Lakes. The goal is to "preserve, protect, develop, and, where possible, to restore or enhance the resources of the nation's coastal zone" (Public Law 92-583). The CZMA outlines three national programs, the National Coastal Zone Management Program, the National Estuarine Research Reserve System, and the Coastal and Estuarine Land Conservation Program (CELCP). The National Coastal Zone Management Program aims to balance competing land and water issues through state and territorial coastal management programs, and the reserves serve as field laboratories that provide a greater understanding of estuaries and how humans impact them. The CELCP provides matching funds to state and local governments to purchase threatened coastal and estuarine lands or obtain conservation easements.

The Alabama Coastal Area Management Program (ACAMP) was approved and has been in effect since 1979. The federal provisions require that CWA Sections 404 and 402 permits comply with this program. Additional information related to ACAMP is found in the State Authorities section as well as Section 9.7.1.

8.1.2 State Authorities

A comprehensive program of environmental management for the state was established in 1982 when the Alabama Legislature passed the Alabama Environmental Management Act. The law created the Alabama Environmental Management Commission and established ADEM, which absorbed several commissions, agencies, programs, and staffs that had been responsible for implementing environmental laws. ADEM administers all major federal environmental laws, including the CWA. The ADEM assumed these responsibilities only after demonstration that State laws and regulations are at least equivalent to federal standards and that the State has matching funds and personnel available to administer the programs. In addition, the Alabama Department of Conservation and Natural Resources (ADCNR) and the Alabama Department of Economic and Community Affairs (ADECA) Office of Water Resources (OWR) may also have jurisdiction over certain actions that affect state waters and natural resources.

Alabama Water Pollution Control Act

The Alabama Water Pollution Control Act (AWPCA), Alabama Code § 22-22-1, is the state's version of the CWA. The Act provides the framework for the adoption of rules establishing water quality standards, the adoption of effluent limitation guidelines, a system for issuance of permits, which shall include effluent limitations for each discharge for which a permit is issued, and such other rules as necessary to enforce water quality standards adopted by ADEM.

Water Quality Criteria

As outlined in CWA § 401(a), CWA § 404 permit applications must be reviewed by the ADEM to ensure that the proposed permitted action is consistent with the State's water quality program. This review is to ensure that any discharge of dredged or fill material will not cause or contribute to a violation of the State's water quality standards. State water quality standards are outlined in ADEM Admin. Code Reg. 335-6-10.

Construction Site Stormwater

The CWA and federal regulations require construction site operators to obtain NPDES permit coverage for regulated land disturbances and associated discharges of stormwater runoff to state waters. Effective April 1, 2016, ADEM established the new General NPDES Permit No. ALR100000 for discharges associated with regulated construction activity that will result in land disturbance equal to or greater than one acre, or from construction activities involving less than one acre, and which are part of a common plan of development or sale equal to or greater than one acre. This permit replaced the previous General NPDES Permit No. ALR100000 which expired on March 31, 2016. The General Permit falls under the authority of ADEM Admin. Code Reg. 335-6-6, along with the other actions regulated by the NPDES program.

Construction site operators and/or owners seeking coverage under this general permit must submit a Notice of Intent (NOI) in accordance with the permit requirements. Operators and/or owners of all regulated construction sites must implement and maintain effective erosion and sediment controls in accordance with a Construction Best Management Practices Plan (CBMPP) prepared and certified by a Qualified Credentialed Professional (QCP). For priority construction sites, which include any sites that discharge to (1) a waterbody listed on the most recently EPA approved 303(d) list of impaired waters for turbidity, siltation, or sedimentation; (2) any waterbody for which a TMDL has been finalized or approved by EPA for turbidity, siltation, or sedimentation; (3) any waterbody assigned the Outstanding

Alabama Water use classification in accordance with ADEM Admin. Code Reg. 335-6-10-.09; and (4) any waterbody assigned a special designation in accordance with ADEM Admin. Code Reg. 335-6-10-.10, the CBMPP must be submitted to ADEM for review along with the NOI. A Qualified Credentialed Inspector (QCI) or QCP must conduct regular inspections of regulated construction activities to ensure effective erosion and sediment controls are being maintained.

State MS4 NPDES Program

The MS4 NPDES Program, administered by ADEM, requires certain designated municipalities and other entities to obtain an MS4 permit (either Phase I or Phase II). Portions of Mobile County are located within a Phase II MS4 permitted area and the corporate boundaries of the City of Mobile are covered under a Phase I MS4 permit. The Phase II MS4 General Permit was issued September 6, 2016, and coverage under that permit was granted to the Mobile County Commission, and became effective October 1, 2016 (Permit #ALR040043). The Phase II MS4 General Permit expires September 30, 2021. ADEM issued NPDES Permit No. ALS000007 to the City of Mobile for discharges from its MS4, which became effective on October 1, 2014 and expires on September 30, 2019.

CWA § 303(D)

ADEM is required by the EPA to designate waters for which technology-based limits alone do not ensure attainment of applicable water quality standards. This list is to be submitted to the EPA on April 1st of each even-numbered year. Impairments include things such as nutrients, pesticides, pathogens, metals, organic enrichment, and siltation, among other things, and can be caused by point sources or non-point sources. The impaired waters must then be sampled and a TMDL amount or limit must be calculated. The greater Dog River Watershed has been determined to have six impaired streams, and five have an approved TMDL. Any activity within the greater Dog River Watershed should take into consideration the cause of the listing and determine if the proposed action is contributing to the impairment. If a proposed activity is contributing to the impairment, the best available technology should be considered to minimize the potential of contributing to the impairment of Dog River.

Coastal Zone Management

ACAMP, Alabama Code § 9-7-1 et seq., requires approval by ADEM for most construction and development activities within the coastal area through regulations established in ADEM Admin. Code Reg. 335-8. The inland boundary of the coastal area in Alabama is the continuous 10-foot contour where the land surface elevation reaches 10 feet above sea level. The coastal area includes all land lying seaward of the 10-foot contour. ACAMP is a joint effort of the ADCNR-State Lands Division (SLD) and the ADEM Coastal Program. The ADCNR-SLD is responsible for planning and policy development, while the ADEM is responsible for permitting, monitoring, and enforcement activities. A significant portion of ADEM's permitting, monitoring, and enforcement activities in the coastal area are related to determining federal consistency for projects and activities that require federal permits, such as Section 404 permits issued by the USACE.

8.1.3 Mobile County Authorities

Mobile County Flood Damage Prevention Ordinance (March 2010)

The Mobile County Flood Damage Prevention Ordinance applies to all areas of special flood hazard within the jurisdiction of Mobile County. Although the primary focus of the Ordinance is to regulate activities within designated flood hazard zones, the Ordinance does include regulations that also help protect water quality. The Ordinance includes measures to control the alteration of natural floodplains, stream channels, and natural protective barriers that are involved in the accommodation of floodwaters. The protection of these areas is important to the overall water quality of the greater Dog River Watershed.

Mobile County Subdivision Regulations (Amended April 2005)

The Mobile County subdivision regulations are administered by the Mobile County Commission. These regulations apply to every subdivision of land in all unincorporated areas of Mobile County that do not lie within the planning jurisdiction of any municipal planning commission. The primary purpose of the regulations is to establish procedures and guidelines for the development of subdivision or proposed additions to existing subdivisions related to minimum size of lots; the planning and construction of streets, roads, and drainage features; and the installation of water and sewer facilities. Portions of the Regulation, Sections 4, 7, and 8, include provisions related to water quality. Section 4.12 of the Regulation requires the design of subdivisions to implement measures to protect streams and other water bodies. This section also requires a written statement that all applicable federal and state permits have been acquired prior to the approval of construction plans. Section 7.5 of the Regulation requires that good engineering practice, judgement, and criteria be employed to control stormwater runoff, and water detention shall be employed where required by such good engineering practice, judgement, and criteria. This section also requires that best management practices be used during construction. Section 8.1 of the Regulation includes stormwater detention requirements for any watershed that contains a public drinking water source. The detention requirements include a maximum release rate equivalent to the 10-year storm pre-development rate, and a minimum detention capacity for the volume of a 50-year post development storm.

Mobile County MS4 Phase II Permit (September 2016)

The Phase II MS4 General Permit was issued September 6, 2016. Coverage under this permit was granted to the Mobile County Commission and became effective October 1, 2016 (Permit #ALR040043). The Phase II MS4 General Permit expires September 30, 2021. The MS4 permit for Mobile County requires the implementation, maintenance, and enforcement of a stormwater management program plan to reduce the discharge of pollutants to and from the MS4 to the maximum extent practical, thus protecting water quality.

Mobile County Stormwater Management Program Plan (October 2013)

The Mobile County Stormwater Management Program Plan was prepared by the Mobile County Commission as part of the requirements of the County's NPDES MS4 Permit. The plan was created to protect water quality by reducing, to the maximum extent practicable, the discharge of pollutants in stormwater. The plan documents that no state law, ordinance, or other regulatory mechanism exists to provide the Mobile County Commission the authority to inspect and enforce the implementation of proper erosion and sediment controls, controls for other wastes from construction sites or post-construction stormwater management controls. The plan states that if non-compliance with the standards established by ADEM regarding erosion and sediment controls are identified, a representative of the stormwater management program should contact ADEM for assistance with enforcement.

8.1.4 City of Mobile Authorities

Mobile City Code Chapter 17 – Stormwater Management and Flood Control (June 2, 2014)

This ordinance includes measures to control land disturbance activities and stormwater drainage facilities within the corporate limits of the City of Mobile. The primary goal of the ordinance is to promote public health, safety, and general welfare, and to comply with federal and state regulations and programs which regulate stormwater management and flooding. The ordinance includes land disturbance permit requirements for all residential sites that disturb 4,000 square feet or more. All subdivision, commercial, and industrial sites that disturb land are required to obtain a land disturbance permit. The permit requires the development and implementation of an erosion and sediment control plan and requires that post-construction runoff mimics pre-construction runoff. The ordinance also includes regulations related to stormwater drainage within the city. This section includes the implementation of a storm drainage service charge for each lot or parcel within the city. The primary consideration in establishing the service charge is each property's contribution to runoff. Additional consideration is given for properties that provide their own stormwater management facilities, which may have their storm drainage service charges reduced. However, a storm water drainage service charge is not currently being collected by the City.

City of Mobile Stormwater Management Program Plan (June 2016)

The City of Mobile Stormwater Management Program Plan was prepared as part of the requirements of the City's NPDES MS4 Permit (Permit #ALS000007). The plan was created to control the quality of stormwater discharged from the City of Mobile's MS4 and includes pollution prevention measures, stormwater monitoring, use of legal authority, and other appropriate means. The plan provides detailed information of the requirements for obtaining a land disturbance permit, as well as goals for revising permit requirements to ensure the City is in compliance with the MS4 permit. The plan also includes requirements for post-construction runoff control. Post-construction runoff control requires that developers submit an "As-Built Certification" that includes flow calculations documenting that post-construction runoff mimics pre-construction runoff.

8.2 REGULATORY OVERLAP

Federal, state, and local regulations overlap within the greater Dog River Watershed. Federal and state water quality regulations apply to all areas within the Watershed, the City of Mobile MS4 permit applies to the majority of the Watershed, and the Mobile County MS4 permits apply to the portions of the Watershed located outside of the Mobile City limits. Land disturbance activities within the Watershed must have:

- A CWA §404 permit with review by all agencies and the public, if not authorized by a NWP (if disturbance activity proposes to fill jurisdictional waters of the U.S.);
- ADEM water quality certification (if disturbance activity proposes to fill jurisdictional waters of the U.S.);
- ADEM Coastal Program approval (if within the coastal area);
- ADEM General NPDES Permit No. ALR100000 (if disturbances are equal to or greater than 1 acre); and
- City of Mobile Land Disturbance Permit (if located within the boundaries of the City of Mobile MS4 Permit).

The City of Mobile has extraterritorial jurisdiction that extends up to five miles beyond its boundaries for planning purposes, and overlap into the county, but not adjacent municipalities. This extraterritorial boundary is for planning purposes only; therefore, only the federal, state, and county water quality regulations apply to these areas. All regulations state that where there is an overlap in jurisdiction within the Watershed, the more stringent requirements apply.

The regulatory matrix in Table 8.2 compares the current regulations within the Watershed and is based on several critical elements of effective stormwater management. The matrix considers four primary review categories: Construction Phase Stormwater Management, Post-Construction Stormwater Management, Protection of Jurisdictional Waters of the United States, and Coastal Area Protection. Table 8.2 summarizes the results of the review of regulations and ordinances for the three entities having jurisdiction within the Watershed. Footnotes are provided to reference the regulations and ordinances from which the information is derived.

Table 8.2: Current regulations within the greater Dog River Watershed

	ADEM	Mobile County	City of Mobile
Construction Phase Stormwater Management	Yes	No[6]	Yes
Design Standards	AL Handbook*[1]	N/A	AL Handbook**[9]
Design Storm Event	2yr - 24hr[1]	N/A	Not specified
Site Size	≥1 acre[2]	N/A	> 4,000 sqft[10]
Stabilization Times	13 days[1]	N/A	10 days[12]
Inspection Requirements	1/month or 3/4" rain[1]	N/A	Yes[11]
BMP Maintenance/Repair Times	5 days[1]	N/A	24hrs – 5 days[12]
Non-Compliance Reporting	Yes[3]	N/A	No
Turbidity Monitoring	No	N/A	No
Buffer Requirement	Yes – 25 feet[1]	N/A	Yes, size not specified[12]
Post-Construction Stormwater Management	No	In special watersheds[6]	Yes
SW Quality	N/A	No	Yes
SW Quantity	N/A	Yes	Yes
Design Storm	N/A	10yr/50yr[6,7]	1.2" in 24hrs[12]
Site Size	N/A	Any	> 1 acre[12]
Inspection Requirements	N/A	No	Annually[12]
Maintenance	N/A	Designated[6]	Developer/owner[12]
Reporting	N/A	5 yrs or ownership change	Annually[12]
Calculation Method	N/A	Not specified	Not specified
Waters of the U.S. Protection			
Permit Requirement	In coastal areas[4]	ADEM/USACE	ADEM/USACE
Setback Requirement	No	No	No
Buffer Requirement	No	Yes, variable[6,8]	Yes, size not specified[12]
Coastal Area Protection	Yes[4]	No	No

Footnotes:
1. ADEM NPDES General Permit #ALR100000, Part III
2. ADEM NPDES General Permit #ALR100000, Part I
3. ADEM NPDES General Permit #ALR100000, Part IV
4. ADEM Admin. Code Reg. 335-8 (Coastal Area Management Program)
5. The Mobile County Stormwater Management Program Plan explains that the Mobile County Commission has no authority to inspect and enforce the implementation of proper erosion and sediment controls.
6. Mobile County Subdivision Regulations, Section 8
7. Maximum release rate equivalent to the 10-year pre-development rate/detention capacity to accommodate volume from a 50 year post development storm.
8. Buffer Zone is within 100 feet of public drinking water source; within 50 feet of perennial streams & their associated wetlands; & within 25 feet of natural drainage features & their associated wetlands. Only applies to Section 8 of the Mobile County Subdivision Regulations.
9. City of Mobile Engineering Department Land Disturbance Permit Checklist 11. City of Mobile Stormwater Management Program Plan
10. Mobile City Code Chapter 17: Storm Water Management and Flood Control (June 2, 2014)
11. The City of Mobile Stormwater Management Program Plan states that qualifying sites are inspected every two months at a minimum, and priority construction sites are inspected monthly at a minimum.
12. The City of Mobile Stormwater Management Program Plan
*Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas, March 2009
**Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas, Latest Version

The City of Mobile has regulations and ordinances to control land disturbance activities (including permitting, inspections, enforcement, and post-construction runoff control requirements). These regulations and ordinances are applicable in the large portion of the greater Dog River Watershed that lies within the City of Mobile corporate limits. The remaining area of the Watershed is within the jurisdiction of the County. Although portions of the Watershed are located within the boundaries of the Mobile County MS4, the County lacks authority to establish regulations and ordinances related to the inspection of construction sites and enforcement actions for non-compliance. The Watershed also relies on federal and State agencies to set standards and enforce water quality regulations.

8.3 REGULATORY DEFICIENCIES

Observation 1

The City of Mobile Post-Construction Stormwater Regulations states that inspections of post-construction stormwater management BMPs shall be completed by a QCI or QCP. The QCI training programing only includes training on inspections during construction and does not include training of post-construction BMPs. In addition, not all individuals covered by the definition of a QCP are qualified to inspect post-construction BMPs.

Observation 2

The City of Mobile Stormwater Management and Flood Control Ordinance provides the City regulatory authority to charge stormwater user fees. The City, however, does not currently charge these fees.

Observation 3

Except as it relates to flood control, there are currently no federal or state post-construction stormwater management controls, which leaves these regulations to fall under local government jurisdiction. While a large portion of the Watershed is regulated by local ordinances and regulations, the remainder of the Watershed has no post-construction stormwater control regulations.

Observation 4

The State of Alabama has recently established a 25-foot buffer requirement related to wetlands and riparian buffers for all new construction sites greater than one acre. Federal and state permits are regularly issued, allowing wetlands, streams, and riparian buffers to be impacted. Although mitigation for these impacts are typically required, mitigation measures often occur outside of an impacted watershed, creating a net loss of these valuable resources within the Watershed.

8.4 ENFORCEMENT

The majority of the greater Dog River Watershed falls within the Mobile City limits where the City of Mobile has inspection and enforcement power for water quality concerns. This provides additional support to the federal and state agencies with enforcement rights helping identify water quality concerns within the Watershed in a timely manner.

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9.0 IMPLEMENTATION PROGRAM

A variety of management measures are needed to improve the health of the greater Dog River Watershed. A clear and concise strategic approach will be necessary to successfully implement these measures. This approach should involve all stakeholders within the greater Dog River Watershed, as well as the city, county, state, and federal agencies including but not limited to those listed in Table 9.1.

Coordination of so many stakeholders would be greatly enhanced by the establishment of a watershed coordinator position, discussed in Section 7.8. The strategies listed below will help to successfully implement the management measures recommended by this Watershed Management Plan (WMP). Many of these actions can be concurrently executed.

Table 9.1: Greater Dog River Watershed Stakeholders

Alabama Clean Water Partnership (ACWP)	Heron Lake Rotary Club
Alabama Coastal Fisherman's Association	Lloyd's Station Community Group
Alabama Coastal Foundation (ACF)	Local residents
Alabama Department of Conservation and Natural Resources (ADCNR)	Local civic organizations
	McAleer Tunstall Commercial Real Estate
Alabama Department of Environmental Management (ADEM)	Milling Commercial Realty
	Mobile Airport Authority
Alabama Forestry Commission (AFC)	Mobile Area Water and Sewer System (MAWSS)
Alabama Department of Transportation (ALDOT)	Mobile Baykeeper
Alabama Power	Mobile Bay Canoe and Kayak Club
Alabama State Port Authority	Mobile Bay National Estuary Program (MBNEP)
Alabama Water Watch (AWW)	Mobile City Council
Archdiocese of Mobile	Mobile County Commission
Auburn University Marine Extension and Research Center (AUMERC)	Murphy High School
	National Fish and Wildlife Foundation (NFWF)
Bender Realty	Natural Resources Conservation Service (NRCS)
City of Mobile	Navco Park Vikings
Dauphin Way Baptist Church	Planning Next
Davidson High School	Plauche Landscape Architecture
Dog River Clearwater Revival	River Park Community Action
Dog River Marina	Rogers and Willard Builders
Dog River Park Athletic Association	Shorecombers
Geological Survey of Alabama (GSA)	The Peninsula of Mobile
Golf Course Superintendents Association of America	U.S. Army Corps of Engineers (USACE)
	U.S. Fish and Wildlife Service (USFWS)
Government Street Baptist Church	White-Spunner Realty Inc.
Grand Mariner Marina	Whitney National Bank

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9.1 MANAGEMENT STRATEGIES

The issues and problems threatening the health of the greater Dog River Watershed occur throughout the entire Watershed and extend across political boundaries. All of the water bodies in the greater Dog River Watershed are connected, such that construction in the headwaters of a stream affects runoff, flows, and water quality throughout the Watershed. A majority of the greater Dog River Watershed is in the jurisdiction of the City of Mobile, so site inspections and enforcement of management ordinances are the City's responsibility. Stakeholders should consider forming a focus group within Dog River Clearwater Revival (DRCR) to develop a collaborative initiative with the City to routinely monitor activities within the Watershed. Collaboration with an appointed watershed coordinator may be the most effective way to promote, encourage, implement, and facilitate recommended management measures.

The appointed watershed coordinator should plan to provide additional support to the MBNEP, as well as the entities with enforcement responsibilities in the greater Dog River Watershed – the City, and federal and state agencies. Additionally, organizations who monitor water quality should expedite the process of voicing water quality concerns to the appropriate regulatory agencies so that these agencies can implement necessary enforcement actions.

Establishment of a watershed coordinator position illustrate the community's resolve to serve as vested and committed partners in the watershed management process, and significantly enhances the viability of applications for available federal, state, local, and private grant assistance needed for the implementation of management measures.

The appointed watershed coordinator should work with DRCR and representatives from stakeholder groups listed in Table 9.1. The MBNEP Project Implementation Committee (PIC) is an established group comprising many of the agencies and/or entities identified in Table 9.1. An appointed watershed coordinator working alongside the PIC and DRCR, should champion implementation and management efforts of the greater Dog River Watershed.

9.2 INTERIM MILESTONES

Interim milestones should be established to support detailed scheduling and task tracking. The interim milestones should identify specific goals, and the time frame within which those milestones should be accomplished. Milestones can be loosely organized into short-term (one to two years), mid-term (two to five years), and long-term (five to ten years or longer) categories.

Short-Term Milestones

- Establish a watershed coordinator position.
- Get WMP adopted by the City of Mobile.
- Apply for and receive funding.
- Establish the Public Education and Outreach Program.
- Establish a formal Monitoring Program.

Mid-Term Milestones

- Initiate a formal Monitoring Program.
- Initiate identified Management Measure projects.
- Encourage necessary legislative and regulatory actions.
- Continue to identify opportunities and apply for funding.

Long-Term Milestones

- Reduce the volume of trash deposited in the greater Dog River Watershed.
- Reduce measured sediment loads.
- Reduce concentrations of specific water-quality pollutants identified as critical issues.
- Complete projects prescribed in the WMP.
- Continue to identify opportunities and apply for funding.

9.3 IMPLEMENTATION SCHEDULE

Implementation of recommended management measures should begin immediately following approval of the greater Dog River WMP. 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 watershed coordinator position within the first six months.
- Apply for and solicit funding within the first year.
- Establish the Public Education and Outreach Program within the first year.
- Establish a formal Monitoring Program as soon as funding becomes available.
- Implement priority management measures as funding becomes available.

9.4 INDICATORS TO MEASURE PROGRESS

Criteria for determining the success of management measures in improving watershed conditions must be established. 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.

Sediment Loading

Erosion and sedimentation rates in Dog River and its tributaries far exceed expected background erosion rates estimated by the GSA (Cook and Moss, 2012), revealing the need to develop a management measure that targets a reduction of sediment loading rates. Therefore, the Watershed Management Team (WMT) and the Steering Committee collaborated to determine a quantifiable and achievable management measure to control sedimentation in the Watershed. The established implementation management measure identified to control sedimentation includes reducing sediment loading rates in increments of 10 to 25% every five years until they fall to no more than 1.5 times the estimated background geologic erosion rate, and should be measured within two to ten years because reductions in sediment loadings are mid- and long-term milestones.

Nutrient Loading/Dissolved Oxygen/ Chlorophyll-a

The general classification of nutrients encompasses nitrogen (total, organic, and inorganic), phosphorous (total, organic, and inorganic), and total organic carbon. Table 9.4.1 lists the established Total Maximum Daily Loads (TMDL) for nitrogenous biological oxygen demand (NBOD) that have been approved by ADEM for water bodies within the greater Dog River Watershed.

The criteria for success of implemented management measures to control nutrient loading should be a reduction of concentrations of the individual components that comprise nutrients until the concentrations are within the good to fair range as defined by Chapter 5 of the WMP 90% of the time. Nutrients also have a significant impact upon dissolved oxygen and Chlorophyll-a concentrations, consequently, improvements in the concentrations of those two parameters can also be used as criteria for success of implemented management measures to control nutrient loading. Improvements in nutrient loadings are mid-term and long-term milestones, and thus should be measurable within two to ten years.

Table 9.4.1: TMDL for NBOD

Impaired Water Body	Parameter	TMDL	Units
Rabbit Creek	NBOD	989	kg/yr
Dog River	NBOD	106,641	kg/yr

NBOD - Nitrogenous Biological Oxygen Demand; kg/yr - kilograms per year

Bacteria and Pathogens

Table 9.4.2 lists the established TMDL for pathogens that have been approved by ADEM for water bodies within the greater Dog River Watershed. Criteria for the reduction of bacteria in the surface waters of the greater Dog River Watershed are based upon the ADEM standards for Fish and Wildlife Coastal Maximum and Swimming Coastal Maximum. The objective of the proposed management measures is to reduce bacteria counts in the surface waters of Dog River and its tributaries, and the criteria for success are the counts being less than the appropriate ADEM standards 90% of the time. Improvements in bacteria counts are mid-term and long-term milestones and should be measurable within ten years.

Table 9.4.2: TMDL for Pathogens

Impaired Water Body	Parameter	TMDL	Units
East Bolton Branch	Fecal Coliform	1.66 E+10	col/day
West Bolton Branch	Fecal Coliform	8.37 E+11	col/day
East Eslava Creek	Fecal Coliform	2.01 E+10	col/day
Rabbit Creek	Fecal Coliform	8.3 E+10	counts/day
Dog River	Fecal Coliform	7.2 E+11	counts/day

col/day -

Metals

The source for metals of concern in the surface waters of the greater Dog River Watershed is excessive erosion and urban runoff. The objective of proposed management measures is to reduce erosion by limiting urban runoff. Criteria for success of the management measures are a reduction in the sedimentation rate and a reduction in the dissolved metals concentration in the surface waters of the greater Dog River Watershed. Reduction of concentrations should be confirmed utilizing non-parametric statistical analyses of datasets obtained before and after the implementation of management measures. Improvements in metal concentrations are mid- and long-term milestones and should be measurable within ten years.

9.5 ESTIMATION OF COSTS AND TECHNICAL ASSISTANCE NEEDED

The costs to implement the proposed management measures and to monitor the results will be significant. At least $124,597,000 over 20 years will be required to fully implement the WMP as presented; estimated costs are listed on Table 9.5. DRCR will require the assistance of numerous government agencies and private organizations. In particular, technical guidance from the MBNEP, ADEM, GSA, MAWSS, City of Mobile, and Mobile County will be required. Sampling and analyses of sediment loads, water-quality, bacteria, and habitat surveys will have to be contracted to qualified firms or agencies.

Table 9.5: Estimated implementation costs

Chapter/ Section	Project Name	Example/ Potential Project Locations	Watershed	Linear Feet (ft)	Acre (ac)	Number of Units	Estimated Cost per Unit	Total Estimated Cost ($)	Total Estimated Cost Low-High
Overall Watershed									
7.1	**Watershed Hydrologic Model and Program**		**Greater Dog River**	**-**	**-**	**-**	**-**	**$100,000 - $190,000**	**Low – High**
7.2.4	**Invasive Species Management Program**		**Greater Dog River**	**-**	**-**	**-**	**-**	**TBD**	**-**
7.8	**Watershed Coordinator Position**		**Greater Dog River**	**-**	**-**	**-**	**-**	**TBD**	**-**
7.7.2	**Waterways Guide**		**Greater Dog River**	**-**	**-**	**-**	**-**	**$75,000**	**-**
7.10	**Water Quality Monitoring and Sampling Program**		**Greater Dog River**	**-**	**-**	**~ 50**	**$200,000/yr $275,000/yr**	**$4,000,000 – $5,500,000**	**Low (over 20 yrs) – High (over 20 yrs)**
BMPs									
7.2.1	**Litter Control Traps**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**-**	**2 (low) - 6 (high)**	**$260,000**	**$520,000 - $1,560,000**	**Low – High**
	LT-1	Bolton Branch/ Montlimar Canal Litter Trap	UDR	-	-	1	$260,000	$260,000	-
	LT-2	Moore Creek Litter Trap	UDR	-	-	1	$260,000	$260,000	-
	LT-3	Spring Creek Litter Trap	HMC	-	-	1	$260,000	$260,000	-
	LT-4	Milkhouse Creek Litter Trap	HMC	-	-	1	$260,000	$260,000	-
	LT-5	Rabbit Creek	LDR	-	-	1	$260,000	$260,000	-
	LT-6	Rattlesnake Bayou	LDR	-	-	1	$260,000	$260,000	-
7.2.2	**Wastewater Improvements**	**Overall Watershed Goal**	**Greater Dog River**	**TBD**	**-**	**TBD**	**TBD**	**$110,000,000- $125,000,000**	**Low – High**
		CC Williams WWTP (Aeration Basins) Improvements	-	-	-	TBD	TBD	$25,000,000	-
		Eslava Creek Trunk Sewer Improvements and SWAT	UDR	TBD	-	TBD	TBD	$35,000,000 - $40,000,000	Low - High

Chapter/ Section	Project Name	Example/ Potential Project Locations	Watershed	Linear Feet (ft)	Acre (ac)	Number of Units	Estimated Cost per Unit	Total Estimated Cost ($)	Total Estimated Cost Low-High
		Eslava Creek Force Main Improvements	UDR	TBD	-	TBD	TBD	$50,000,000 - $60,000,000	Low - High
		Other Renewal and Improvement Projects throughout the Watershed	Greater Dog River	TBD	-	TBD	TBD	TBD	TBD
LIDs									
7.3.1	**Bioretention**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**5.0**	**-**	**$326,700 – $1,306,800**	**$1,633,500 – $6,534,000**	**Low – High**
	Swales	Moore Creek Example	UDR	-	0.23	-	$326,700 – $1,306,800	$75,141 – $300,564	Low - High
	Cells (BRCs)	Spring Creek Example	HMC	-	1.39	-	$326,700 – $1,306,800	$454,113 - $1,816,452	Low - High
7.3.2	**Constructed Stormwater Wetlands (CSWs)**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**20.0**	**-**	**$100,000 – $150,000**	**$2,000,000 – $3,000,000**	**Low – High**
	CSW-1	Eslava Creek Example	UDR	-	1.72	-	$100,000 – $150,000	$172,000 - $258,000	Low - High
	CSW-2	Perch Creek Example	LDR	-	0.25	-	$100,000 – $150,000	$25,000 - $37,500	Low - High
Preservation									
7.4.1	**Preservation**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**1,000**	**-**	**$2,500 - $3,800**	**$2,500,000 – $3,800,000**	**Low – High**
	WP-1	Halls Mill Creek (Interstate 10) Example	HMC	-	275	-	$2,500 - $3,800	$687,500 - $1,045,000	Low - High
	WP-2	Halls Mill Creek (Hillcrest Rd) Example	HMC	-	325	-	$2,500 - $3,800	$812,500 - $1,235,000	Low - High
	WP-3	Rabbit Creek Example	LDR	-	175	-	$2,500 - $3,800	$437,500 – $665,000	Low - High

Chapter/ Section	Project Name	Example/ Potential Project Locations	Watershed	Linear Feet (ft)	Acre (ac)	Number of Units	Estimated Cost per Unit	Total Estimated Cost ($)	Total Estimated Cost Low-High
Restoration and Protection									
7.5.1	**Riparian Buffer ****	**Overall Watershed Goal**	**Greater Dog River**	**20,000**	**Low – High**	**-**	**$2,500/ac**	**$141,000 - $421,250**	**Low – High**
	RB-1	Alligator Bayou Example	LDR	1,111	2.55 – 7.65	-	$6,375 - $19,125	$6,375 - $19,125	Low - High
	RB-2	Montlimar Canal (Heron Lakes) Example	UDR	3,496	8.03 – 24.08	-	$20,075 - $60,200	$20,075 - $60,200	Low - High
	RB-3	West Bolton Branch (WP Davidson High School) Example	UDR	2,591	5.95 – 17.84	-	$14,875 - $44,600	$14,875 - $44,600	Low - High
	RB-4	West Eslava Creek (Country Club) Example	UDR	2,096	4.81 – 14.43	-	$12,025 - $36,075	$12,025 - $36,075	Low - High
	RB-5	East Eslava Creek (Eagle Dr) Example	UDR	3,020	6.93 – 20.80	-	$17,325 - $50,200	$17,325 - $50,200	Low - High
	RB-6	East Bolton Branch (McVay Dr) Example	UDR	574	1.32 – 3.95	-	$3,300 - $9,875	$3,300 - $9,875	Low - High
	RB-7	West Eslava Creek (Spring Hill) Example	UDR	3,245	7.45 – 23.35	-	$18,625 - $55,875	$18,625 - $55,875	Low - High
	RB-8	Halls Mill Creek (Hippie Beach) Example	HMC	272	0.62 – 1.87	-	$1,550 - $4,675	$1,550 - $4,675	Low - High
	RB-9	Halls Mill Creek (Dutchman Woods Dr) Example	HMC	789	1.81 – 5.43	-	$4,525 - $13,575	$4,525 - $13,575	Low - High
	RB-10	Milkhouse Creek (Airport Blvd) Example	HMC	345	0.79 – 2.38	-	$1,975 - $5,950	$1,975 - $5,950	Low - High
	RB-11	Milkhouse Creek (Old Shell Rd) Example	HMC	364	0.84 – 2.51	-	$2,100 - $6,275	$2,100 - $6,275	Low - High

Chapter/ Section	Project Name	Example/ Potential Project Locations	Watershed	Linear Feet (ft)	Acre (ac)	Number of Units	Estimated Cost per Unit	Total Estimated Cost ($)	Total Estimated Cost Low-High
	RB-12	Moore Creek Example	UDR	4,832	11.09 – 33.28	-	$27,725 - $83,200	$27,725 - $83,200	Low - High
	RB-13	Spencer Branch Example	UDR	1,042	2.39 – 7.18	-	$5,975 - $17,950	$5,975 - $17,950	Low - High
	RB-14	Spring Creek Example	HMC	794	1.82 – 5.47	-	$4,550 - $13,675	$4,550 - $13,675	Low - High
7.5.2	**Stream Restoration**	**Overall Watershed Goal**	**Greater Dog River**	**6,000**	**-**	**-**	**$400 – $500**	**$2,400,000 - $3,000,000**	**Low – High**
	SR-1	Spring Creek (Cottage Hill Rd) Example	HMC	750	-	-	$400 – $500	$300,000 – $375,000	Low - High
	SR-2	Spring Creek (Timberland Dr) Example	HMC	875	-	-	$400 – $500	$350,000 - $437,500	Low - High
	SR-3	Unnamed Tributary to Rattlesnake Bayou Example	LDR	3,400	-	-	$400 – $500	$1,360,000 - $1,700,000	Low - High
7.5.3.1	**Living Shorelines**	**Overall Watershed Goal**	**Greater Dog River**	**3,000**	**-**	**-**	**$100 – $200**	**$300,000 – $600,000**	**Low – High**
	LS-1	Alligator Bayou Example – Bayou Rd	LDR	200	-	-	$100 - $200	$20,000 - $40,000	Low - High
	LS-2	Moore Creek Example	UDR	100	-	-	$100 - $200	$10,000 - $20,000	Low - High
	LS-3	Halls Mill Creek Example	HMC	250	-	-	$100 - $200	$25,000 - $50,000	Low - High
Access									
7.7.1.1	**Create Additional Access locations**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**-**	**6**	**$30,000 – $150,000**	**$180,000 - $900,000**	**Low – High**
	A-1	Highcrest Park – Spencer Branch	UDR	-	-	1	$30,000 – $150,000	$30,000 – $150,000	Low - High

Chapter/ Section	Project Name	Example/ Potential Project Locations	Watershed	Linear Feet (ft)	Acre (ac)	Number of Units	Estimated Cost per Unit	Total Estimated Cost ($)	Total Estimated Cost Low-High
	A-2	San Souci Park – Eslava Creek	UDR	-	-	1	$30,000 – $150,000	$30,000 – $150,000	Low - High
	A-3	Timberlane Park – Spring Creek	HMC	-	-	1	$30,000 – $150,000	$30,000 – $150,000	Low - High
	A-4	Vista Ridge Park – Halls Mill Creek	HMC	-	-	1	$30,000 – $150,000	$30,000 – $150,000	Low - High
	A-5	Bay Shore Park – Perch Creek	LDR	-	-	1	$30,000 – $150,000	$30,000 – $150,000	Low - High
	A-6	Hollingers Island Park – Unnamed tributary to lower Dog River	LDR	-	-	1	$30,000 – $150,000	$30,000 – $150,000	Low - High
7.7.3	**Signage**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**-**	**TBD**	**TBD**	**$35,000**	**-**
Resiliency									
7.6.2	**Habitat Migration**	**Overall Watershed Goal**	**Greater Dog River**	**-**	**47.5**	**-**	**$15,000 – $35,000**	**$712,500 – $1,662,500**	**Low – High**
	HM -UDR	Potential Habitat Migration Areas in Upper Dog River	UDR	-	33.66	-	$15,000 – $35,000	$504,900 - $1,178,100	Low - High
	HM-HMC	Potential Habitat Migration Areas in Halls Mill Creek	HMC	-	39.35	-	$15,000 – $35,000	$590,250 - $1,377,250	Low - High
	HM-LDR	Potential Habitat Migration Areas in Lower Dog River	LDR	-	22.29	-	$15,000 – $35,000	$334,350 - $780,150	Low - High
GRAND TOTAL									
								$124,597,000	**Low**
								$152,277,750	**High**

**Potential areas for riparian buffer may also be considered as sites for other recommended management measures (BMPs, LIDs, stream restoration, living shorelines, etc.)

9.6 EDUCATION PROGRAM

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 greater Dog River Watershed. The outreach program should include scheduled presentations to schools, civic organizations, the Mobile County Commission, the Mobile City Council, and other organizations as necessary. Signage has already been posted on major thoroughfares to inform drivers they are entering the greater Dog River Watershed. Signage should be updated, repaired, and replaced as necessary. Informational signage at boat landings and public access points should encourage the public to help preserve and protect Dog River through good stewardship. Trash containers and dumpsters with appropriate signage should be located and maintained at public access points and other strategic locations as a reminder to keep the greater Dog River 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 Dog River and the problems impacting the River and its Watershed.
- Develop the public's sense of ownership of Dog River, along with an understanding of the value of the greater Dog River 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 greater Dog River Watershed.

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 greater Dog River WMP goals and objectives.

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 Dog River WMP. This stakeholder group should be informed of the opportunity presented by the WMP to unify the public with the concept of protecting Dog River 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 greater Dog River WMP, develop and implement WMP recommendations, and encourage stricter enforcement of regulations related to litter and 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 greater Dog River Watershed.
- Signage to identify the greater Dog River Watershed's historic biological diversity.

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 greater Dog River Watershed should be motivated to support the WMP, as all businesses within the greater Dog River 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.

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 greater Dog River 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. The program includes two segments. The first segment is a three-week, in-class video-and-question competition. The second is a video production competition as part of the Mobile County Public School System's Academy Awards Program. A previous competition involved twelve schools in the Mobile County Public School System located in the Dog River Watershed. The four high schools and their eight feeder schools are: Murphy, BC Rain, Davidson, Williamson, Burns, Calloway Smith, Phillips, Pillans, Clark-Shaw, Denton, and Scarborough. Additional details are presented in Chapter 2 of this plan.

Academic institutions can develop multiple curriculums for grades K-12 and beyond; create grade school field trip opportunities throughout the greater Dog River 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.

Local Resource Managers

Local resource managers provide services related to water supply and wastewater treatment to greater Dog River Watershed residents and can assist in guiding water quality management within the Watershed. The actions recommended in this WMP will improve water quality of Dog River 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 Dog River preservation and restoration efforts, assisting with outreach and communication, and sponsoring community events.

Media

Newspapers, television news programs, on-line news sources, social media (Twitter, Facebook, etc.), and radio stations are significant sources of information for the public. The WMP sets the stage for a better future for the greater Dog River 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 stories describing accomplishments of DRCR, advertising cleanup or anti-littering events and campaigns, and sharing stories about the involvement of local leaders in the WMP.

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, litter reduction 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 greater Dog River 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 anti-littering 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 to establish a watershed coordinator to assist DRCR in leading the stewardship of the Dog River WMP. 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 Greater Dog River Watershed. However, DRCR should coordinate WMP implementation with an appointed watershed coordinator who works in close collaboration with the MBNEP.

DRCR and the appointed watershed coordinator should work with local governmental officials and regulatory agencies to implement the WMP recommendations. DRCR should continue to 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 greater Dog River Watershed. DRCR or an appointed watershed coordinator 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.

9.7 LOCAL PROGRAMS

9.7.1 Alabama Coastal Area Management Program (ACAMP)

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.

ADCNR, State Lands Division, Coastal Section staff work jointly with staff from the Alabama Department of Environmental Management (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 Alabama Coastal Nonpoint Pollution Control Program (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 Watershed Management Plan we endorse full and continued support of ACAMP.

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/.

9.7.2 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 greater Dog River 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.

9.7.3 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 create a local volunteer monitoring program. The Alabama Water Watch (AWW) and DRCR organizations are 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.

The goals of the greater Dog River Watershed volunteer monitoring program are 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 Chapter 11. 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 Chapter 11.

9.7.4 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.

9.7.5 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.

9.7.6 Create a Clean Water Future

The Create a Clean Water Future organization, (http://www.cleanwaterfuture.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.

9.8 MONITORING PROGRAM

A monitoring program must be developed and used to determine the overall health of the greater Dog River Watershed. Specific monitored parameters, locations, and schedules are addressed in Chapter 11 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.

9.9 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 greater Dog River WMP 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.

Short-Term Milestone Period (0 – 2 years)

- Has DRCR or watershed coordinator assigned duties and responsibilities?
- Has the necessary funding been quantified, sources identified, and received?
- Has the Public Education and Outreach Program been organized and implemented?
- Has the Monitoring Program been established and a qualified entity identified to carry out the program?

Mid-Term Milestone Period (2 – 5 years)

- Has the Monitoring Program been successfully implemented?
- Have any management measures been implemented?
- Did the level of public interest and participation rise to the level of helping to achieve the WMP goals?
- Has additional funding been identified and secured?

Long-Term Milestone Period (5 – 10 years)

- Have specific projects and management measures proposed in the WMP been fully implemented and completed?
- Have there been reductions in the sediment and nutrient loading rates?
- Have water quality conditions improved?
- Have water quality improvements and loading rate reductions met stated goals?

9.10 NEW DATA RECOMMENDATIONS

The temporal, spatial, and parametric coverage of ambient surface water quality data from Dog River and its tributaries vary substantially across the period of record, and there are very few stations that have been monitored consistently over a long period of time. Although there is sufficient historic and recent data to adequately characterize the general status and trends in surface water quality, recommendations for improved water quality monitoring have been developed and are presented in Chapter 11. Informational gaps that are addressed in these recommendations include the following:

- Establishment of long-term stations with consistent parametric coverage to support long-term tracking of status, trends, and regulatory compliance.

- Assessment of loadings of nutrients and other pollutants based on routine simultaneous measurements of flow and concentrations at primary tributary inflows.
- Microbial source tracking to identify sources (e.g., human, dogs, cattle, etc.) of observed bacterial violations.
- Discharge and sediment loading data compilation in Moore Creek near Halls Mill Road at Latitude 30.6275 North and Longitude -88.13737 West. During the GSA data collection period for the "Analysis of Discharge and Sediment Loading Rates in Tributaries of Dog River in the Mobile Metropolitan Area" study researchers were unable to capture data along this area of interest due to site conditions.
- Establishment of continuous discharge data sites.
- Assessment of sediment loadings specific to each watershed.
- Assessment of the flora, fauna, and protected and invasive species specific to each watershed.
- Complete and accurate channel lining data collection.
- Detailed investigation of the historical and cultural assets of the Watershed.
- Field verification of impervious surface data.
- Evaluation of the impacts of sea level rise on local infrastructure.

These informational gaps are discussed further in Chapter 11 of this document.

Initial Implementation of Management Measures

Implementation of recommended management measures should begin immediately following the approval of the greater Dog River WMP. Initial implementation should focus on the most critical issues and the prioritized management measures identified in this WMP.

1. **Develop a comprehensive watershed hydrologic model and program**.
   Create a hydrologic model of the Watershed that will help determine where recommended preservation, restoration, and conservation activities will have the greatest impacts for improving the health and resiliency of the Watershed. Establish a thorough program that can train decision makers to make accurate assessments affecting stormwater runoff and improvements.

2. **Preserve remaining bottomland hardwood wetlands**.
   Natural wetland areas provide critical ecological habitat and filter contaminants from entering Dog River and Mobile Bay. The protection of these natural wetland areas helps ensure water quality and habitat conditions do not continue to degrade and the benefits currently provided by these areas (flood control and retention) are not lost.

3. **Develop a long-term water quality monitoring and sampling plan**.
   Establish a long-term monitoring program to collect water quality data at permanent sample locations to assure consistency over an approximate 20-year time period. This will allow for better analyses (identification of trends, significant changes to data output, etc.) and determine the success of implemented management measures within the Watershed and indicate where additional measures are needed.

4. **Implement stormwater management improvements to target identified critical issues**.
   Implement litter control measures (installation of 2-6 additional litter traps), reduce pathogens (implement wastewater improvements to reduce sanitary sewer overflows), and encourage low impact development (bioretention, constructed wetlands, retrofits, etc.).

5. **Restore critical habitats** to provide ecological benefits and improve water quality (infiltration, flood control, treatment, decrease sedimentation, etc.). Restoration efforts include in-stream and riparian buffer stream restoration, living shorelines, and invasive species management.

6. **Improve public access to the water** through additional boat/kayak launches, trail systems, parks, and greenways.

7. **Implement strategies for adaptation to provide greater resiliency** through increased planning and targeted efforts to allow for habitat migration.

10.0 FUNDING SOURCES

10.1 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 (WMP) will require the long-term commitment of significant financial resources and community support. The design, construction, and maintenance of stormwater improvements, purchase of land for offline storage, modification and protection of shoreline to reduce erosion, and/or the purchase and preservation of tracts of land to create greenspace buffers, wetlands, or floodplains to protect stream quality will require significant and reliable funding. The jurisdictional areas of political entities that might provide funding do not necessarily follow or encompass watershed boundaries; therefore, a public-private partnership may be the most effective way to accomplish management goals.

To acquire the funding necessary to undertake significant restoration, preservation, and/or management projects, political and private entities should 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 watersheds. However, increases in watershed recovery efforts by communities around the nation have substantially increased the competition for these resources.

Financial structures and sources that could provide funding for the management issues and projects identified in this WMP are discussed below. Some financial structures could be helpful across the entire Watershed and some within limited areas. Many would require public-private partnerships and cooperation among landowners, organizations, and governments, rather than imposition by governmental entities.

The following alternatives for funding and financing projects in the greater Dog River Watershed are discussed (with the sections in which they are discussed indicated parenthetically):

- Stormwater utility fees (10.2)
- Property, sales, or other taxes (general funds) (10.3)
- Federal grants, loans, and revenue sharing (10.4)
- State of Alabama Revolving Loan Fund (10.4.3)
- “Green” stimulus funding (10.5)
- Non-governmental organization and other private funding (10.6)
- Mitigation banks (10.7)
- Impact fees (10.8)

- Special assessments (10.9)
- System development charges (10.10)
- Environmental tax shifting (10.11)
- Capital improvement cooperative districts (10.12)
- Alabama improvement districts (10.13)
- Regional collaboration opportunities (10.14)
- RESTORE Act (10.15)
- Natural Resource Damage Assessment (10.16)
- National Fish and Wildlife Foundation Gulf Coast Environmental Benefit Fund (10.17)
- Gulf Coast Conservation Grants Program (10.18)
- Coastal Ecosystem Resiliency Grants Program (10.19)
- Gulf of Mexico Energy Security Act (GOMESA) (10.20)
- EPA Healthy Watersheds Consortium Grant (10.21)
- Five Star Restoration Program (10.22)
- Clean Water Act Section 319(h) (10.23)
- Wetlands Program Development Grants (10.24)

10.2 STORMWATER UTILITY FEES

The U.S. Environmental Protection Agency (EPA) indicates the most stable source of funding for stormwater management is a stormwater utility fee (EPA, 2008). Stormwater utility fees provide equitable and transparent sources of funding for stormwater management. A stormwater utility fee would provide a stable, predictable, long-term funding mechanism dedicated to stormwater management improvements. A 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 (Spitzer, 2010).

Stormwater utility authorities are used extensively in many areas of the country. In the State of Alabama, the authority to create a local stormwater utility typically must be granted to a county by legislative statute. However, municipalities that have approved municipal separate storm sewer systems (MS4) ordinances (like the City of Mobile) may levee stormwater utility fees.

The stormwater user fee typically appears as a separate line item on residential or commercial water and sewer bills, as a special assessment on property tax bills, or as a stand-alone bill making these fees highly visible to the general public. The concept of stormwater management is difficult for the average citizen to grasp and can result in skepticism about the need for stormwater user fees. The user fee is often seen as a tax and can be subject to legal challenges. Therefore, local stormwater ordinances must be carefully crafted to prevent such challenges.

Stormwater user fees can be based on parcel size 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, treatment of stormwater, or for watershed stewardship activities. 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 shut-off or by tax liens placed on the owner's property. Most stormwater utilities allow exemptions for certain categories of property. Streets and highways, undeveloped land, and railroad rights-of-way are typically exempt from paying stormwater user fees (Spitzer, 2010 and Leo and Tillery, 2010).

The State of Florida has been aware of the critical importance of water management since the 1970s. In 1986, the City of Tallahassee implemented a stormwater utility; the first in the southeastern United States. There are approximately 300 stormwater utilities in the southeastern United States, with about half located in the State of Florida. The City of Pensacola is the closest municipality to south Alabama with a stormwater utility fee. The City assesses a monthly rate of $5.70 per 2,998 sq. ft. A stormwater management authority operating in Jefferson County, Alabama includes 21 cities located within and in the surrounding area. The Authority imposes a monthly rate of $0.42 per parcel (2013 Southeast Stormwater Utility Survey). Excluding Florida-based stormwater authorities, a 2013 survey of stormwater utilities in the Southeast (2013 Southeast Stormwater Utility Survey) found that of those who responded:

- 97% operate based on user fees;
- 79% use impervious surfaces as the basis for the fee;
- The average stormwater utility rate was $3.59 per month;
- The average revenue was $3,964,000 per year;
- 75% reported that a public information effort was essential or helpful to their mission;
- 47% are combined with a Department of Public Works;
- 13% operated as a separate Authority distinct from local government;
- 77% served only a municipality;
- 10% served a watershed or some other defined area; and
- The average population served was 97,500.

10.3 PROPERTY, SALES, OR OTHER TAXES (GENERAL FUND)

The use of public "general funds" to finance projects is considered undesirable because no dedicated source of continuing and consistent funding would be created. This limits the success of funding watershed management plans (WMP), as these programs would have to compete with maintenance and construction projects for funding. Environmental projects are often considered less essential than priorities such as police, fire, and emergency medical personnel. Environmental projects are also vulnerable to budget cuts (Spitzer, 2010). Finally, there is no single or central authority to administer greater Dog River Watershed projects as the Watershed falls under two jurisdictions – the City of Mobile and Mobile County.

10.4 FEDERAL GRANTS, LOANS, AND REVENUE SHARING

10.4.1 Introduction

The United States Federal Government offers numerous grants, loans, and revenue-sharing opportunities 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. A composite list of federal funding opportunities follows.

The Clearinghouse for Federal Grant Opportunities (also known as Grants.gov) is a central storehouse for information about more than 1,000 grant programs providing approximately $500 billion in annual awards. The EPA Catalog of Federal Funding Sources for Watershed Protection is a searchable database of financial assistance sources available to fund a variety of watershed protection projects. Also, 53 specific funding programs offered by nine different federal agencies are summarized in Table 10.4.

Table 10.4: Federal agencies offering funding programs

Acronym	Agency	Number of Programs
EPA	Environmental Protection Agency	12
FEMA	Federal Emergency Management Agency	2
NOAA	National Oceanic and Atmospheric Administration	2
USACE	U.S. Army Corps of Engineers	2
USDA	U.S. Department of Agriculture	12
NFWF	National Fish and Wildlife Foundation	12
USDOI	U.S. Department of the Interior	4
USFWS	U.S. Fish and Wildlife Service	6
USGS	U.S. Geological Survey	1

10.4.2 Advantages and Limitations of Grant Funding

Several of the potential funding sources are appropriate for projects, studies, or issues involving coastal and estuarine areas. These funding sources should be considered because of the intertidal nature of the Watershed and Mobile Bay. Cooperation with federal agencies providing large grants and study opportunities that can lead to the funding of additional construction projects should be pursued. Grants are popular because the funds received do not have to be repaid. However, grants discourage consideration of long-term costs such as maintenance, adaptive management, and operation. Additionally, grants are very competitive and awarded on merit; the considerable effort required to produce a grant application may not be rewarded with funding. Grants may also require matching funds and contributions that are difficult to obtain.

10.4.3 State Revolving Funds

The EPA State Revolving Fund (SRF) loan program offers a reliable source of funding (Berahzer, 2010). There are separate SRF programs for "Clean Water" and "Drinking Water". Funds are provided annually to each state by the federal government with the states providing a 20% matching amount. In order to receive funding, a project must be on the state's annual "Intended Use Plan" (IUP) list. The IUP contains a "comprehensive" list and a shorter "fundable" or "priority" list. A public comment process is required for the IUP. Since 2007, the SRF has moved beyond the traditional "water treatment works" projects and has begun to emphasize nonpoint sources and estuary protection as funding priorities.

The following information regarding the State of Alabama Revolving Fund was accessed on October 4, 2016 on the Alabama Department of Environmental Management (ADEM) website (http://www.adem.state.al.us/programs/water/ srf.cnt):

> "*The Clean Water State Revolving Fund (CWSRF) and the Drinking Water State Revolving Fund (DWSRF) are low-interest loan programs intended to finance public infrastructure improvements in Alabama. The programs are funded with a blend of state and federal capitalization funds. ADEM is responsible for administering the CWSRF and DWSRF, performing the required technical/environmental reviews of projects, and disbursing funds to recipients.*"

Benefits of an SRF Loan

- The SRF offers a loan interest rate substantially lower than the prevailing municipal bond rate available to "AAA" rated municipalities;
- The interest rate is fixed with a 20-year payback (extended term may be available);
- Loan repayment does not begin until construction completion date (capitalized interest accrues); and
- The loan recipient is not required to pay any ongoing trustee expenses or rebate expenses normally associated with a local bond issue.

Projects Eligible for Funding

Projects that strengthen compliance with federal and state regulations and enhance protection of public health are eligible for consideration to receive an SRF loan. The engineering, inspection, and construction costs are eligible for reimbursement if a project qualifies. Among the projects which qualify for funding are:

- Publicly-owned water or wastewater treatment works;
- Sewer rehabilitation;
- Interceptors, collectors, and pumping stations;
- Decentralized wastewater treatment;
- Drinking water storage facilities;
- New/rehabilitated water source wells;
- Water transmission/distribution mains;
- Consolidation/water system interconnection;

- Water conservation and reuse projects;
- Green infrastructure;
- Streambank restoration;
- Green roofs;
- Permeable pavements;
- Rain gardens and biofiltration products;
- Brownsfield remediation; and
- Watershed and estuary protection projects.

10.5 "GREEN" STIMULUS FUNDING

Under the 2009 American Recovery and Reinvestment Act (i.e., Stimulus Act), the EPA introduced, as a part of its SRF Loan Program, a Green Project Reserve, and maintained this funding mechanism in FY 2010. The Green Project Reserve stipulates that at least 20% of the SRF funds shall be used by the states for projects that address green infrastructure, water or energy improvements, or other environmentally innovative activities (Berahzer, 2010). Some green infrastructure projects may fit into either the "Clean Water" or "Drinking Water" divisions of the SRF program. In general, the combination of the Green Project Reserve and the additional subsidization could lead to better financing terms for stormwater projects.

ADEM has issued its FY 2016 IUP for the Clean Water SRF and the Drinking Water SRF. ADEM continues to accept applications – especially for green infrastructure projects. Applications received during the current funding cycle will be held for available funding if any of the applicants on the funding list fail to comply with all requirements of the SRF and ARRA or if additional funding becomes available.

Many stormwater projects and Low Impact Development (LID) strategies may be considered "green" under this funding category. Examples include porous pavement, bioretention facilities, rain gardens, green roofs/walls/streets, wetlands restoration, constructed wetlands, urban retrofit programs, infiltration basins, landscaped swales, downspout disconnection, and tree planting. Land acquisition services and the actual cost for the purchase of land or easements may also be included in the scope of this definition.

10.6 NON-GOVERNMENTAL ORGANIZATIONS AND OTHER PRIVATE FUNDING

Private foundations and corporations may be another source of funding for improvements. Several funding sources are available from non-governmental organizations (NGOs) and other private entities.

Three of the listings are searchable electronic databases of foundation and corporate grants in various fields: (1) the Chronicle of Philanthropy Guide to Grants; (2) the Community of Science Database; and (3) the Foundation Center. Local governmental entities and non-profit agencies involved with the Watershed should investigate these databases with specific project objectives in mind.

The Kodak American Greenways Program, RBC Bank Blue Water Project Grants, and Surdna Foundation Sustainable Environmental Grants offer specific funding opportunities for environmental improvement projects related to watershed protection and Green

Infrastructure (GI). These programs are included here because of their direct applicability to ongoing efforts in the Watershed.

10.7 MITIGATION BANKS

A mitigation bank is a designated and approved wetland or stream area created, restored, enhanced, or preserved and set aside in perpetuity to compensate for future unavoidable impacts to wetlands and waters of the United States. Credits are purchased at the bank as compensatory mitigation for other development projects, ideally within the same watershed. Mitigation banking provides opportunities for a county or city to partner with land owners and land trusts, accrue financial resources for community improvements, create natural amenities in an urban setting, and enhance education about restoration and water quality (Leo and Tillery, 2010).

Authorized under federal environmental law and regulations, a mitigation bank provides an asset that can be sold to developers and government entities whose projects require mitigation of stream or wetland damage. If formed for all or part of an affected watershed, a mitigation bank effectively allows the sale of credits that can be used to offset some portion of the expenses associated with creation of the mitigation bank. The regulatory process involves a prospectus and public notice, the development of a banking instrument, restrictive covenants, and coordination with various agencies with jurisdiction over the process.

Advantages

Instead of relying on local assessments, fees, taxes or other public revenues, mitigation banks can be useful to fully or partially finance large-scale, expensive projects, and may generate funding from outside the affected area. Mitigation banks would allow a municipality, county, or non-governmental entity to become a generator of mitigation credits instead of being a consumer of those credits. The credits generated may be used for internal needs or sold on the open market to external entities, such as developers, whose projects require a Section 404 wetland permit from the U.S. Army Corps of Engineers and require stream or wetland mitigation. Credits may be used as a revenue source to implement restoration projects and maintain compliance with the requirements of National Pollutant Discharge Elimination System (NPDES) permits related to Total Maximum Daily Loads (TMDL). It may be possible for funds raised through the sale of mitigation credits to partially or completely offset the costs of some watershed management projects.

Disadvantages

To be effective, ownership or control of a large site on which to implement the mitigation bank is required. In most cases, this method of funding also requires regulatory approval and significant capital to pay the initial costs of creating the improved streambeds or wetlands. It is unlikely that the projected flow of funds would support the initial financing without other credit support. Considerable time and effort may be required to properly initiate and implement mitigation banks. Requirements include a credit release schedule, monitoring requirements, biotic success criteria, maintenance and adaptive management, monitoring, and reporting requirements.

Possible Use

If one or more public bodies are willing and able to bear the risk of financing, later sales of mitigation credits could offset their initial expenses, as well as repay the debt. The mitigation bank site should be watershed-based, have the potential to provide environmental benefits, and be in a service area with the potential for development (i.e., to promote the sale of future credits).

10.8 IMPACT FEES

Impact fees are paid by developers (usually at the time of development) to obtain a building permit. The fee is designed to reimburse the government for the additional impact a development may have on the community. Impact fees may be for transportation (i.e., increased impact on roads and bridges as a result of constructing a development), water and sewer (i.e., the impact on the system capacity as a result of increased volume and demand), as well as other public infrastructure impacts. Typically, a direct relationship between the development and the impact fee must exist. Impact fees, which often must be authorized by statute, are used for capital improvements, not for maintenance. They are a one-time, up-front fee for new construction (Mustian, 2010).

Because impact fees are an unreliable and unstable long-term funding source for maintenance and improvements, they are not the most viable option for implementation of the WMP and associated projects. Developers resent impact fees, and timely expenditure of funds can also be an issue. As previously noted, the greater Dog River Watershed falls within the jurisdiction of both the City of Mobile and Mobile County, and there is not a central authority to administer impact fees.

10.9 SPECIAL ASSESSMENTS

A special assessment is a charge levied for the benefit a particular property receives for a specific public improvement. The cost and benefit must be related to the property itself. Special assessments may be based on property area or frontage. Special assessments are distinguishable from taxes, but they have been challenged in court. They may be used to fund capital and operating costs. In some states, special assessments may be placed on the tax rolls that achieve the same status as ad valorem taxes. However, assessing governmental property and property owned by non-profits that are not on the tax rolls may pose a challenge. Collection of special assessments can be spread over time.

Special assessment fees for the maintenance of public sewers and septic tanks have been assessed in some communities. In the Chesapeake Bay area of Maryland, the Bay Restoration Fund (BRF) has a $2.50 per month wastewater fee that provides over $65 million per year for upgrades to wastewater treatment plants and $12.6 million per year for septic tank repair and cover crops (Berahzer, 2010).

10.10 SYSTEM DEVELOPMENT CHARGES

System development charges (also known as connection fees or tie-in charges) are one-time fees commonly charged to new customers to cover the costs for additional maintenance or for service extensions. The amount of the new customer's system development charge is typically calculated based on the potential demand the new customer will place on the system. Stormwater system development charges can also be used. The amount of a customer's stormwater system development charge is typically determined by the area of the customer's property (EPA, 2008).

10.11 ENVIRONMENTAL TAX SHIFTING

Environmental tax shifting is a creative concept proposed by environmental groups to redirect tax code incentives to support energy conservation and to sustain the environment. Examples include: (1) a pay-to-pave tax could be levied on newly paved surfaces on a per-square-foot basis; and (2) the discontinuance of the state tax exemptions for fertilizer and pesticide sales. The income from these measures could then be directed toward environmental projects (EPA, 2008). One limitation to an environmental tax shifting approach is the lack of routine public or political support necessary for acceptance and implementation.

10.12 CAPITAL IMPROVEMENT COOPERATIVE DISTRICTS

Authorized under Chapter 99B of Title 11, Code of Alabama, capital improvement cooperative districts can be formed by one or more governmental entities, including counties, municipalities, public utilities and public corporations such as industrial or commercial development authorities. Once formed, the districts can finance and construct various capital improvements and can then enter arrangements such as leases or contracts to make the improvements available to users. The members of the district (i.e., the public bodies) can also contribute funding to finance the projects.

Mobile County and the City of Mobile could create a vehicle to collectively finance and make improvements on a watershed basis by forming a cooperative district to facilitate that effort. Each entity could contribute to the costs incurred, either directly or through the payment of shares of the debt service on bonds issued by the district.

Advantages

Cooperative districts offer great flexibility. They can comprise various public bodies with an interest in the project. They support projects that can be financed by any of its members, and therefore, they may be able to acquire, construct, and improve a larger number of capital items for both public and private use. Cooperative districts can protect a governmental body from the potential liability of ownership of an improvement.

Disadvantages

Cooperative districts lack the authority to assess private users. They can charge for services or facilities only on a bilateral basis in which the benefiting parties agree on the charges upfront contractually. Thus, they are most effective when providing a service or facility (i.e., utilities or even buildings for private use) needed by potential users who agree to be assessed a fee for the service or facilities. It is difficult to obtain public support as property owners do not generally want to voluntarily pay for improvement projects on public property.

10.13 ALABAMA IMPROVEMENTS DISTRICTS

Authorized under Chapter 99A of Title 11, Code of Alabama, improvement districts are formed by a county or municipality upon application by all the affected landowners. Once formed, they can acquire, construct, and install a wide range of public infrastructure and can assess the landowners for their pro rata shares of the cost of the improvements. The assessments constitute liens against the land. Depending on the range of projects undertaken, the improvement districts can effectively become subunits of government for providing services beyond those typically provided. For instance, they have been widely used for residential or multi-use developments to provide for the initial and maintenance costs of infrastructure not provided by local government.

The authority to assess and to create liens on property provides a powerful financing alternative. Improvement districts are also ideally suited to construct and own public infrastructure. However, landowners' consent may be impossible to achieve in an area as large as the greater Dog River Watershed.

If a project is proposed that affects a single significant property, or especially a project required for the development or redevelopment of the property, an improvement district could be used to finance the project. It would be the responsibility of the property owner to pay the improvement district. For instance, if the large portion of a watershed, or a large shopping center, was being developed that required drainage or retention facilities beyond the normal requirements, an improvement district could be a good vehicle.

10.14 REGIONAL COLLABORATION OPPORTUNITIES

There are regional collaboration opportunities applicable to watershed projects. The EPA Region 4 sponsors four: the Green Infrastructure Partnership, Smart Growth Implementation Assistance, and Watershed Protection and Restoration Assistance collaboration opportunities. The fourth collaborative opportunity is through the Gulf of Mexico Alliance (GOMA); a partnership of the states of Alabama, Florida, Louisiana, Mississippi, and Texas.

The primary goal of the Green Infrastructure Partnership is to reduce runoff volumes and sewer overflow events through the widespread use of green infrastructure management practices that help maintain natural hydrologic functions by absorbing and infiltrating precipitation where it falls.

The Smart Growth Implementation Assistance program is an annual, competitive solicitation open to state, local, regional, and tribal governments (and non-profit organizations that have partnered with a governmental entity) to incorporate smart growth techniques into their future developments.

Through the Watershed Protection and Restoration Assistance Partnership, the staff of EPA Region 4 works with state and local governments and watershed organizations to facilitate protection and restoration efforts in targeted watersheds.

The goal of the GOMA is to significantly increase regional collaboration to enhance the ecological and economic health of the Gulf of Mexico. Priority issues for this group include water quality, habitat conservation and restoration, ecosystem integration and assessment, nutrients and nutrient impacts, coastal community resilience, and environmental education.

10.15 RESOURCES AND ECOSYSTEMS SUSTAINABILITY, TOURIST OPPORTUNITIES, AND REVIVED ECONOMIES OF THE GULF COAST STATES ACT (RESTORE ACT)

The federal 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 United States the Gulf Coast Restoration Trust Fund (Trust Fund) consisting of 80% 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 United States, 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:

- 35% of the funds are divided equally among the five Gulf 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.

- 30% of the funds will be administered for restoration and protection as established by the Comprehensive Plan developed by the Gulf Coast Ecosystem Restoration Council.

- 30% 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.

- 2.5% 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.

- 2.5% of the funds are dedicated to the Centers of Excellence Research Grants Program. The funding is distributed through the states to non-governmental entities to establish "Centers of Excellence" to focus on the following disciplines: coastal and deltaic sustainability; restoration and protection; fisheries, wildlife ecosystem research, and monitoring; offshore energy development; sustainable and resilient growth; and comprehensive observation, monitoring, and mapping in the Gulf.

Figure 10.15 provides a flowchart outlining the dissemination of the criminal, civil, and administrative fines associated with Deepwater Horizon oil spill as they pertain to allocation and distribution in the State of Alabama (Ocean Conservancy, 2017).

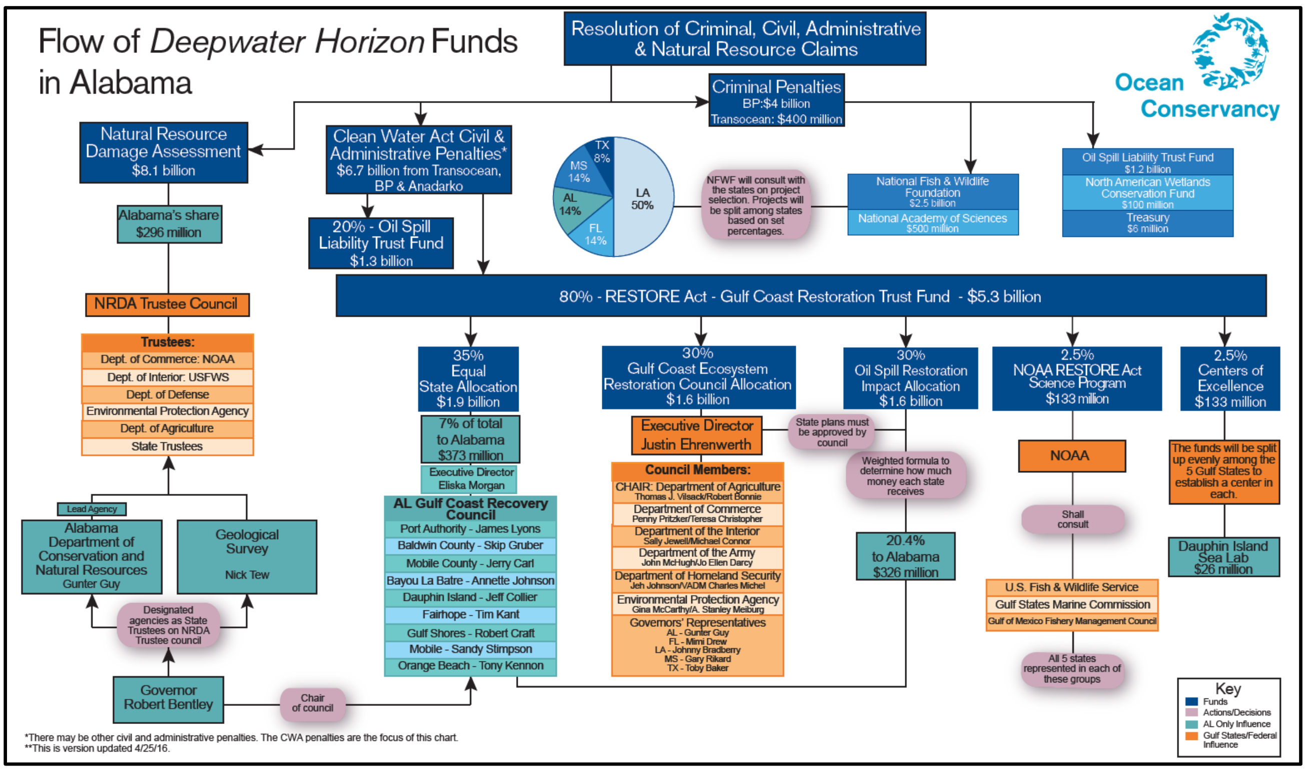

Figure 10.15: Flowchart of Deepwater Horizon funds in Alabama (from Ocean Conservancy, 2017)

"The Alabama Gulf Coast Recovery Council was created with the passage of the Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act of 2012 (RESTORE Act and Summary of RESTORE Act). This legislation was passed by Congress to steer a percentage of the civil penalties levied against the responsible parties of the 2010 Deepwater Horizon incident directly to the Gulf Coast states to

assist with recovery efforts. With the third phase of the trial beginning in late January 2015, the amount of penalties that may be available to the State of Alabama and the timing of their availability remains uncertain" (ADCNR, 2013).

On "December 6, 2016, the Council released the Project Evaluation and Selection Process for Multiyear Implementation Plan (MIP) development documents and announced focus areas for the First-Round MIP" (ADCNR, 2013). The Council announced a deadline of January 13, 2017 to have project suggestions entered in the portal for funding consideration for the First-Round MIP (ADCNR, 2013).

The law specifically states that Alabama's 10-member council will be chaired by Alabama's Governor and co-chaired by the Director of the Alabama State Port Authority. Other members will be the Chairman of the Baldwin County Commission, the President of the Mobile County Commission, and the mayors of Bayou La Batre, Dauphin Island, Fairhope, Gulf Shores, Mobile, and Orange Beach. The Act further stipulates that qualifying projects must reflect at least one of the following criteria:

- Restoration and protection of the natural resources, ecosystems, fisheries, marine and wildlife habitats, beaches, and coastal wetlands of the Gulf Coast region.
- Mitigation of damage to fish, wildlife, and natural resources.
- Implementation of a federally-approved marine, coastal, or comprehensive conservation management plan, including fisheries monitoring.
- Workforce development and job creation.
- Improvements to or on state parks located in coastal areas affected by the Deepwater Horizon oil spill.
- Infrastructure projects benefitting the economy or ecological resources, including port infrastructure.
- Coastal flood protection and related infrastructure.
- Planning assistance.
- Administrative costs (limited to not more than 3% of a state's allotment).
- Promotion of tourism in the Gulf Coast Region, including recreational fishing.
- Promotion of the consumption of seafood harvested from the Gulf Coast Region.

On December 17, 2012, the Council adopted their by-laws (amended December 8, 2014), and on May 10, 2013, they passed a resolution adopting a "Strategy Map" and tapped the Alabama Department of Conservation and Natural Resources (ADCNR) to serve as the Administrator (ADCNR, 2013). The "Memorandum of Understanding with ADCNR" was subsequently adopted by the Council during the August 15, 2013 meeting (amended December 8, 2014) (ADCNR, 2013). The Council released their draft “Project Submission Form Guide” for public comment on October 8, 2013; the “Project Submission Portal” went live on the Alabama Coastal Restoration website (http://www.alabamacoastalrestoration.org/) in late March, 2014 (ADCNR, 2013). The U.S. Department of Treasury issued the RESTORE Act Interim Final Rule on August 13, 2014, which allows the Council to move forward in determining a project selection process. The regulations became effective on October 14, 2014 (ADCNR, 2013).

10.16 NATURAL RESOURCES DAMAGE ASSESSMENT (NRDA)

NRDA is the legal process that federal agencies, states, and tribal governments use to evaluate the impacts of oil spills (like the Deepwater Horizon oil spill), hazardous waste sites, and ship groundings that occur on natural resources (NOAA, 2014). The NRDA process evaluates wildlife, habitats and human resources that are impacted by the release of contaminants and then restores them (NOAA, 2014). “Ultimately, the results of a NRDA are used to procure the cost of those damages from the responsible party, and then the procured funds are used to restore injured habitats and resources” (USFWS, 2016).

In April 2016, a federal court approved a settlement among the United States, the five Gulf states, and BP, where BP agreed to pay up to $8.8 billion for natural resource damages. The NRDA and its related funding for the Deepwater Horizon oil spill settlement is being overseen by a council of NRDA Trustees comprised of the following federal and state government representatives:

- US Department of the Interior
- US Department of Commerce
- US Environmental Protection Agency
- US Department of Agriculture
- State Trustees from the five Gulf State (AL, FL, LA, MS, and TX)

The funds allocated through NRDA for the natural resources restoration program in the State of Alabama are being managed by the Alabama Trustee Implementation Group (Alabama TIG). The ADCNR and the Geological Survey of Alabama (GSA) are the designated agencies for the State of Alabama Trustees to collaborate with the NRDA federal Trustee Council; together they form the Alabama TIG. Figure 10.16 shows the NRDA related funding that State of Alabama will receive (approximately $296 million). Of the $296 million being allocated for the State of Alabama, approximately $59 million has already been allocated to early restoration projects, which leaves approximately $237 million for future restoration projects (ELI, 2017).

Allocation of Alabama Restoration Area Funds

This table shows the restoration goals and types for the Alabama Restoration Area.

Restore and Conserve Habitat	
Wetlands, Coastal, and Nearshore Habitats	$65,000,000
Habitat Projects on Federally Managed Lands	$3,000,000
Early Restoration (through Phase IV)	$28,110,000
Restore Water Quality	
Nutrient Reduction (nonpoint source)	$5,000,000
Replenish and Protect Living Coastal and Marine Resources	
Sea Turtles	$5,500,000
Marine Mammals	$5,000,000
Birds	$30,000,000
Early Restoration Birds	$145,000
Oysters	$10,000,000
Early Restoration Oyster	$3,329,000
Provide and Enhance Recreational Opportunities	
Provide and Enhance Recreational Opportunities	$25,000,000
Early Restoration of Recreational Loss	$85,505,305
Monitoring, Adaptive Management, Administrative Oversight	
Monitoring and Adaptive Management	$10,000,000
Administrative Oversight and Comprehensive Planning	$20,000,000
Total NRD Funding for Alabama Restoration Area	$295,589,305

Figure 10.16: Allocation of NRDA Restoration Funds for Alabama (NOAA, 2017)

10.17 NATIONAL FISH AND WILDLIFE FOUNDATION (NFWF) GULF ENVIRONMENTAL BENEFIT FUND (GEBF)

In early 2013, a U.S. District Court approved two plea agreements resolving certain criminal cases against British Petroleum and Transocean that arose from the 2010 Deepwater Horizon explosion and oil spill. The agreements directed a total of $2.544 billion to the NFWF to fund projects benefiting the natural resources of the Gulf Coast affected by the spill. Over the next five years, NFWF's newly established GEBF will receive a total of $1.272 billion for barrier island and river diversion projects in Louisiana; $356 million each for natural resource projects in Alabama, Florida, and Mississippi; and $203 million for similar projects in Texas.

Notwithstanding any other provision of law, the Secretary of the Treasury shall deposit into the Fund amounts equal to but not less than 80% of any amounts collected by the United States as penalties, settlements, or fines under Sections 309 and 311 of the Federal Water Pollution Control Act (33 U.S.C. 1319, 1321) in relation to the blowout and explosion of the mobile offshore drilling unit Deepwater Horizon that occurred on April 20, 2010 that resulted in hydrocarbon releases into the environment.

A qualifying state shall use all amounts received under this section, including any amount deposited in a trust fund that is administered by the state and dedicated to uses consistent with this section, in accordance with all applicable federal and state law, only for one or more of the following purposes:

(A) Projects and activities for the conservation, protection, or restoration of coastal areas, including wetlands.

(B) Mitigation of damage to fish, wildlife, or natural resources.

(C) Planning assistance and the administrative costs of complying with this section.

(D) Implementation of a federally-approved marine, coastal, or comprehensive conservation management plan.

In the State of Alabama, the GEBF will be used to support projects that remedy harm to natural resources (habitats, species) where there has been injury to, or destruction of, loss of, or loss of use of those resources resulting from the oil spill. Projects are expected to occur within reasonable proximity to where the impacts occurred, as appropriate.

10.18 GULF COAST CONSERVATION GRANTS PROGRAM (GCCGP)

The GCCGP, (http://www.nfwf.org/gulfconservation/Pages/home.aspx), is a new program supporting priority conservation needs of the Gulf that are not otherwise expected to be funded under NFWF's GEBF or other funding opportunities associated with the Deepwater Horizon oil spill (e.g., RESTORE, NRDA). Additionally, unlike the other funding programs associated with the Deepwater Horizon oil spill, this program's overall annual funding level is relatively modest at approximately $3 million to $5 million and individual grant awards are anticipated to range between $50,000 and $250,000.

The program seeks to advance innovative restoration concepts and approaches, build capacity through strategic engagement of youth and veterans, and fund species and habitat projects benefitting Gulf coastal ecosystems and communities. The GCCGP is supported with federal funding from Natural Resources Conservation Service (NRCS), and private funding from Southern Company Power of Flight, the Shell Marine Habitat Program, and other sources.

NFWF regularly solicits proposals to support conservation projects that enhance coastal watersheds of the Gulf Coast and bolster priority fish and wildlife populations, while strengthening resiliency within the coastal region.

10.19 COASTAL ECOSYSTEM RESILIENCY GRANTS PROGRAM

The National Oceanic and Atmospheric Administration (NOAA) has developed the Coastal Ecosystem Resiliency Grants Program, (http://www.habitat.noaa.gov/funding/coastalresiliency.html), to build resilience of coastal ecosystems and communities. Coastal Ecosystem Resiliency awards will fund projects that develop healthy and sustainable coastal ecosystems through habitat restoration and conservation. Priority will be given to projects that:

- Provide sustainable and lasting ecological benefits and resiliency to extreme weather events, a changing climate, and allow for adaptation to known or potential climate change impacts;
- Implement on-the-ground restoration actions that result in immediate beneficial impacts;
- Demonstrate collaboration among multiple stakeholders;
- Receive approval from the state governor; and
- Result in socioeconomic benefits associated with restoration of healthy and resilient coastal ecosystems.

10.20 GULF OF MEXICO ENERGY SECURITY ACT (GOMESA)

On December 20, 2006, the Gulf of Mexico Energy Security Act of 2006 (Pub. Law 109-432) (http://www. boem.gov/Oil-and-Gas-Energy-Program/Energy- Economics/econ/GOMESA-pdf.aspx) was signed into law. The Act significantly enhances outer continental shelf (OCS) oil and gas leasing activities and revenue sharing in the Gulf of Mexico (GOM). The Act shares leasing revenues with Gulf oil and gas-producing states and the Land and Water Conservation Fund (LWCF) for coastal restoration projects; bans oil and gas leasing within 125 miles of the Florida coastline in the Eastern Planning Area, and a portion of the Central Planning Area, until 2022; and allows companies to exchange certain existing leases in moratorium areas for bonus and royalty credits to be used on other GOM leases.

The Act created revenue-sharing provisions for the four Gulf oil- and gas-producing states of Alabama, Louisiana, Mississippi, and Texas, and their coastal political subdivisions (CPSs). The GOMESA funds are to be used for coastal conservation, restoration, and hurricane protection. There are two phases of GOMESA revenue sharing:

Phase I

Beginning in Fiscal Year 2007 (FY07), 37.5% of all qualified OCS revenues, including bonus bids, rentals, and production royalties, were shared among the four states and their coastal political subdivisions from those new leases issued in the 181 Area in the Eastern planning area (also known as the 224 Sale Area) and the 181 South Area. Additionally, 12.5% of revenues are allocated to the LWCF.

Phase II

The second phase of GOMESA revenue sharing begins in Fiscal Year 2017 (FY17). It expands the definition of qualified OCS revenues to include receipts from GOM leases issued either after December 20, 2006, in the 181 Call Area, or, in 2002–2007, GOM Planning Areas, subject to withdrawal or moratoria restrictions. There is a revenue-sharing cap of $500 million.

10.21 EPA HEALTHY WATERSHEDS CONSORTIUM GRANT

The U.S. EPA announced a $3.75 million grant to support local projects to protect and sustain healthy watersheds (http://www.epa.gov/hwp/ healthy-watersheds-consortium-grant). The EPA has made an official award to the U.S. Endowment for Forestry and Communities, Inc. (Endowment) to support the coordinated efforts of the Endowment and its partner organizations. The Healthy Watersheds Consortium Grant Program goal is to accelerate strategic protection of healthy, freshwater ecosystems and their watersheds (http://www.usendowment.org/partnerships/healthywatershedsconsor.html).

10.22 FIVE STAR RESTORATION PROGRAM

The EPA supports the Five-Star Restoration Program by providing funds to the NFWF, the National Association of Counties, NOAA's Community-based Restoration Program, and the Wildlife Habitat Council. These groups are then able to make subgrants to support community-based wetland and riparian restoration projects. Competitive projects must have a strong on-the-ground habitat restoration component with long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference is given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. "Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments" (Private Landowner Network, 2015). It is desirable that each project involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution. The 2016 funding for this program is $250,000.

10.23 CLEAN WATER ACT SECTION 319(H)

Section 319(h) of the Federal Clean Water Act funds projects or programs that aim to reduce nonpoint sources (NPS) of pollution and lead to measurable improvements in water quality. Minimum requirements for funding include: 1) Implementation of watershed-based plan that address EPA's Nine Elements for Watershed Planning; and 2) a minimum of 40% non-federal match through local funds, in-kind services, or other non-federal sources. Grant proposals should focus on implementation of NPS components of TMDL causes and sources in approved TMDLs or section 303(d)-listed streams.

Eligible elements for projects may include:

- Projects of State-wide Importance;
- Education/Information Programs;
- Technical Assistance/Planning;

- Best Management Practices (BMP);
- Implementation of Local Regulatory Programs;
- Groundwater Protection;
- Assessment;
- Training;
- Watershed Projects/Watershed Resource Restoration; and
- Development and/or Implementation of Total Maximum Daily Loads (TMDLs).

10.24 WETLANDS PROGRAM DEVELOPMENT GRANTS

The EPA funds Wetland Program Development Grants to encourage comprehensive wetlands program development by promoting the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. Projects should build the capacity of states, tribes, and local governments to effectively protect wetland and riparian resources. Projects funded under this program support building or refining a wetlands program through four core elements: regulation, monitoring/assessment, voluntary restoration/protection, and water quality standards for wetlands. Estimated 2016 funding for this program is $19.2 million.

10.25 SUMMARY

There are considerable financial support opportunities to supply funds for the management measures recommended in this WMP. However, because the greater Dog River Watershed falls within two governmental jurisdictions, it lacks a central authority to administer many of the potential funding sources. Establishment of a public-private partnership may provide additional funding options for watershed management. Additionally, a partnership clearly illustrates to the grants market the communities' active resolve to serve as vested and committed partners in the watershed management process. This endeavor would significantly enhance the viability, competitiveness, and position of this WMP as it pursues federal, state, local, and private grant assistance needed for implementation.

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11.0 MONITORING AND SAMPLING PLAN

A monitoring plan is necessary to continue to document the overall health of the greater Dog River Watershed, track the success or failure of the implemented management measures, and determine where additional measures are necessary. The monitoring plan should encompass the greatest possible portion of the Watershed with the least number of samples while providing sufficient detail to identify probable source areas for elements of concern.

The monitoring plan should clearly define the objectives of a sampling plan and identify which known and potential issues within each of the Watershed areas are being evaluated. Standard sampling and analyses protocols accepted by state and federal agencies should be used to collect and analyze data. Data collected during monitoring should be used to assess the effectiveness of recommended management measures once completed, and the success of those measures in accomplishing the goals and objectives stated in Chapter 1 of this Watershed Management Plan (WMP). The monitoring program should include, at a minimum, the described activities provided in the subsequent sections of this chapter.

11.1 MONITORING

Following approval of this WMP and the establishment of a watershed coordinator position Dog River Clearwater Revival (DRCR) should implement a quarterly monitoring program for most water quality parameters. To assure consistency, the quarterly sampling should occur during the same time frame each quarter and under similar flow conditions. Permanent sample locations should be established to assure consistency over the 20-year life of this WMP. The WMT identified nutrient loading, sedimentation, excessive stormwater runoff, and trash as critical issues affecting the health of the greater Dog River Watershed. In addition, some shoreline reaches, saltwater marshes, and intertidal zones within the estuary and tributaries of the greater Dog River Watershed are "at risk" from sea level rise. Extensive data collection and analysis prior to the WMP study established baseline conditions for most water quality parameters and sediment loading. A biological assessment component should be added to the suite of parameters monitored to establish baseline conditions for habitats, populations, and diversity of aquatic organisms. The first monitoring events should be conducted as soon as funding is available.

The objective of the initial sampling and analyses are to compare current conditions in watershed streams to baseline conditions, document shoreline extent and stability in the estuary and intertidal zone, and perform an initial biological assessment of specific reaches within the Watershed.

Once watershed management measures are undertaken, the sampling will also be used to determine success of those management measures in improving conditions within the Watershed and to indicate where additional measures are needed.

Data collected should be archived in both paper and electronic format. An interactive geographical information system (GIS) database should be developed that facilitates electronic mapping and data query. Data collected during monitoring should be documented and summarized in an annual report submitted to the Mobile Bay National Estuary Program (MBNEP), City of Mobile, Mobile County Commission, Alabama Department of Environmental Management (ADEM), and DRCR. When sufficient data is available, trend analyses should be included in the annual report.

11.2 WATERSHED CONDITIONS AND ANALYTICAL PARAMETERS

The following water quality parameters can be used to indicate the overall health of the greater Dog River Watershed: (1) sediment loading and turbidity, (2) total nitrogen, (3) dissolved inorganic nitrogen, (4) total phosphorus, (5) dissolved inorganic phosphorus, (6) chlorophyll-a, (7) Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), (8) bacteria, (9) total organic carbon, and (10) metals. In addition, standard field parameters such as temperature, pH, specific conductance, turbidity, dissolved oxygen, and salinity should be collected. In locations where the depth of water is sufficient, field parameters should be collected at specific depth intervals to create depth profiles. Biological assessments should include population surveys of vertebrate and invertebrate species and habitat analyses. Analyses of coastal zone shorelines should be performed in a consistent manner using photographs taken year after year from the same location and orientation, and with time sequenced, geo-referenced aerial photographs if they are available.

11.2.1 Standard Field Parameters

Whenever water quality samples are collected, standard procedure should include collection of a suite of concurrent field measurements used to help interpret the analytical data. These are known as “field parameters”. The exact suite of measurements will vary, but at a minimum should include temperature, pH, specific conductance, salinity, dissolved oxygen, and turbidity.

11.2.2 Sediment Loading and Turbidity

The Geological Survey of Alabama (GSA) completed a sediment loading study of the Dog River Watershed in 2012 (Cook and Moss, 2012). As stated in the report, “land use and hydrologic characteristics, not area, are the controlling factors that determine sediment load transport”, and “sediment loads estimated for the Upper Dog River Watershed (Spencer Branch and Eslava Creek), and Halls Mill Creek Watershed (Spring Creek) are among the highest of about 55 streams assessed by the GSA” (Cook and Moss, 2012).

Over the next 20 years, total suspended solids, bed sediment, total sediment load, and turbidity measurements should be measured quarterly at specific sampling locations. Turbidity measurements should be collected under a variety of flow conditions. All data collection and analyses should utilize GSA data collection protocols. Management measure success will be assessed, in part, by the degree to which sediment loading rates are reduced or remain stable as the percentage of developed land in the Watershed increases (Chapter 7).

11.2.3 Total Nitrogen

Total nitrogen concentration in water is a combined measure of inorganic nitrogen (nitrites, nitrates and ammonia) and organic nitrogen. Organic nitrogen levels derive from sewage runoff, animal manure, and decomposition of aquatic organisms, while inorganic nitrogen concentrations derive from erosion and residential runoff (fertilizers). Nitrogen concentrations in some areas of the greater Dog River Watershed exceed the levels at which excessive algae growth may occur. Excessive algae growth causes low dissolved oxygen concentrations and odiferous, unsightly water. The success of management measures will be assessed, in part, by the degree to which total nitrogen concentrations in the Watershed are reduced or stabilized.

11.2.4 Dissolved Inorganic Nitrogen

Dissolved inorganic nitrogen (DIN) is needed by plants to grow and reproduce. DIN sources are primarily anthropogenic, including urban runoff and fertilizers. A measure of DIN provides an assessment of human sources of nitrogen, and correlates those sources to land use and observed water quality. The success of management measures will be assessed, in part, by the degree to which DIN concentrations in the surface water system are reduced or stabilized.

11.2.5 Total Phosphorus

The total phosphorus concentration is a measure of both organic and inorganic forms. Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column). Natural and human sources of phosphorus include soil and rocks, wastewater, fertilizers, septic systems, animal manure, disturbed land areas, and drained wetlands (EPA, 2017). Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can create accelerated plant growth, algae blooms, low dissolved oxygen, and death of fish, invertebrates, and other aquatic animals. The measured phosphorus concentrations in some water samples collected during the WMP study exceeded the concentrations that may cause excessive algae growth. The success of management measures will be assessed, in part, by the degree to which the concentration of phosphorus in the surface water system is reduced or stabilized.

11.2.6 Dissolved Inorganic Phosphorus

Dissolved inorganic phosphorus (DIP) is the form that plants need to grow and reproduce. The sources of inorganic phosphorus include soil and rocks, fertilizers, and disturbed land areas (EPA, 2017). The soils and rocks within the greater Dog River Watershed are composed primarily of silica, iron, sodium, calcium, potassium, and magnesium. They would not be a major source of inorganic phosphorus. An important source of inorganic phosphorus in the greater Dog River Watershed may be fertilizers applied to lawns. As urban development in the Watershed continues, runoff from lawns may constitute an even greater source than at present. Collection and analyses of water samples for DIP will allow correlation between sources and land use, and can be used to indicate if management measures have been successful in reducing or controlling sources of phosphorus.

11.2.7 Chlorophyll-a

Measurements of nutrient concentrations (nitrogen and phosphorus) within the waters of the greater Dog River Watershed provide insight into their availability for use by aquatic plants like algae. Additional monitored parameters, such as chlorophyll-a, are used to estimate algal biomass or the abundance of aquatic vegetation. Chlorophyll-a is an indirect measure of the ability of aquatic vegetation to utilize available nutrients, used because it is easier to measure than algal biomass. There is generally a good agreement between planktonic primary production and algal biomass. Annual measurements should be made to determine trends in Chlorophyll-a concentrations in the tributary waters and estuary of Dog River. Changes in Chlorophyll-a concentration in the estuary would indicate the effectiveness of management measures in limiting nutrient inputs into the greater Dog River Watershed.

11.2.8 Dissolved Oxygen, Salinity, and Temperature Profiling

The collection of routine field parameters has already been discussed. However, in addition to routine data collection, depth profiles of dissolved oxygen, salinity, and temperature should be determined at selected monitoring locations to provide data about the stratification of water in the estuary and portions of Dog River and its tributaries. Stratification of water quality is important to aquatic life, especially if dissolved oxygen levels are very low near the bottom of the water column. Typical reasons for low dissolved oxygen are algae blooms caused by excessive nutrient concentrations, high water temperature, die-off and decomposition of aquatic vegetation (also driven by excessive nutrient levels), and decomposition of any organic material, including terrestrial leaves and grass clippings.

11.2.9 Bacteria

Dog River and its tributaries are utilized for recreation, swimming, and fishing. The introduction of pathogens into the surface water because of sanitary sewer overflows and stormwater runoff is a critical issue within the Watershed. Monitoring for fecal coliform and enterococcus bacteria should be part of the monitoring plan for the Watershed. Reductions in bacteria counts would indicate the effectiveness of management measures in limiting and reducing pathogen inputs (reduction of SSOs) into the greater Dog River Watershed.

11.2.10 Biological Assessments

The purpose of the biological assessment will be to characterize and grade the overall health of the ecosystem along specific reaches of Dog River and its tributaries. Biological assessments should utilize a standard protocol established by a state or federal agency, such as the U.S.

Environmental Protection Agency's (EPA's) *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish.*

Biological assessments should be performed at selected water quality monitoring stations and should include population surveys of fish communities and benthic invertebrate species and characterization of stream habitat. This information will be necessary to determine if the management measures recommended by this WMP (Chapter 7) are meeting the goals of the MBNEP Comprehensive Conservation Management Plan (CCMP) for 2013-2018, specifically to "improve ecosystem function and resilience through protection, restoration, and conservation of habitats". The information will also be necessary to assess whether goals of this WMP, presented in Chapter 1 Section 4, are being met, which are to:

1. Improve water quality by addressing:
    - Sediment
    - Trash
    - Nutrients
    - Pathogens
2. Protect and restore critical habitats to support:
    - Good water quality
    - Healthy populations of fish and wildlife
3. Improve resiliency to address:
    - Habitat migration
    - Increased flooding and critical infrastructure
    - Increased economic resiliency
4. Improve access points:
    - New water access locations
    - Access signage
    - Interpretive signage of historic and culture themes
    - Guides to local waterways and access points

11.2.11 Total Organic Carbon (TOC)

Potential sources of TOC include natural organic matter (leaves and grass) and anthropogenic sources, like petrochemicals, solvents, and pesticides. Elevated TOC concentrations could spur excessive algae growth and create the potential for low dissolved oxygen in Dog River and its tributaries. Monitoring TOC concentrations would indicate the effectiveness of the management measures in limiting unfiltered runoff into the surface waters of the Dog River estuary.

11.2.12 Metals

As with many other potential contaminants, metals in the environment derive from both natural and anthropogenic sources. For example, aluminum and iron can originate from eroding sediments and iron bacteria. Conversely, lead, cadmium, copper, and nickel are not typically from natural sources in the Alabama coastal plain. The presence of these metals is most likely due to human activities. Monitoring metal concentrations would indicate the success, or lack thereof, of the management measures in limiting unfiltered urban runoff into the surface waters of Dog River, as the percentage of developed land in the Watershed increases.

11.2.13 Coastal Shoreline Assessment

Analyses of at-risk coastal zone shorelines should be performed on an annual basis using photographs taken periodically from the same location and orientation, and with time-sequenced, geo-referenced aerial photographs. These techniques will allow evaluation of the success of implemented coastal zone projects and programs, and identification of shorelines that are experiencing erosion or habitat loss due to sea level rise.

11.3 SAMPLE COLLECTION LOCATIONS

The temporal, spatial, and parametric coverage of the ADEM, Alabama Water Watch (AWW)/DRCR, and Mobile Area Water and Sewer System (MAWSS) monitoring programs vary substantially over the period of record. There are few stations with consistent data over a long period of time. Figure 11.3.1 shows all of the historical sampling sites in the greater Dog River Watershed and surrounding area. All ten (10) of the data collection stations utilized by the GSA during the 2012 study, along with additional ADEM and AWW/DRCR data collection stations are listed in Table 11.3. Potential priority sample collection locations identified in Table 11.3 are displayed in Figure 11.3.2.

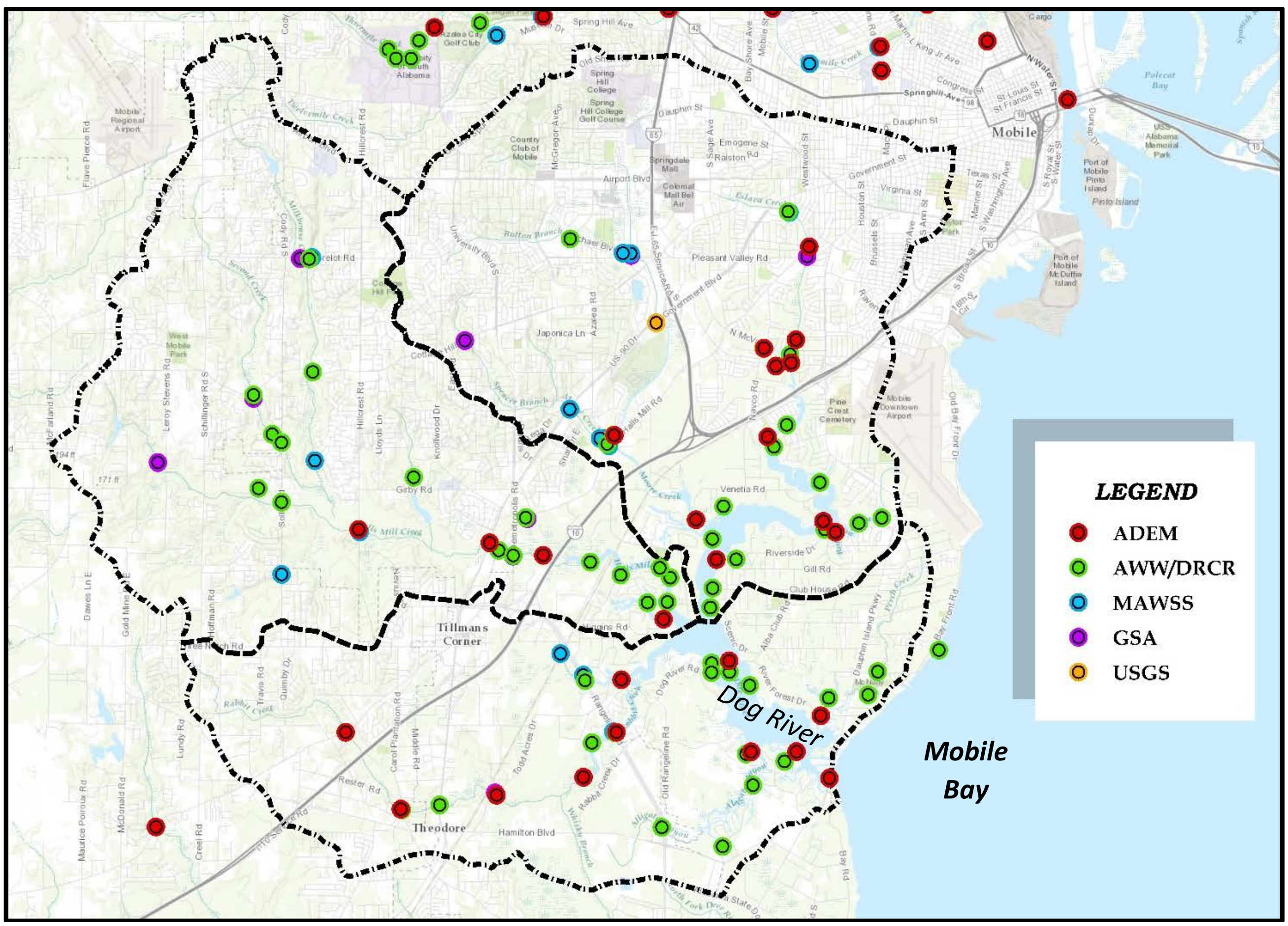

Figure 11.3.1: Historical sample collection locations

Table 11.3: Quarterly sampling locations in the greater Dog River Watershed

Sample Location ID	Watershed	Drainage	Coordinates (Lat., Long)
GSA Site 1	Upper Dog River	Bolton Branch	30.662, -88.132
GSA Site 2		Spencer Branch	30.646, -88.168
GSA Site 6 ADEM 3752 AWW/DRCR 5002		Moore Creek	30.628, -88.137 30.629, -88.135 30.627, -88.137
GSA Site 10		East Eslava Creek	30.662, -88.093
ADEM 541 AWW/DRCR 5021		Dog River	30.628, -88.102 30.627, -88.100
ADEM 4607 AWWA/DRCR 5004		East Eslava Creek	30.642, -88.097 30.644, -88.097
ADEM 2072 AWW/DRCR 5018		Bolton Branch	30.645, -88.103 30.645, -88.103
AWW/DRCR 5046		Dog River	30.631, -88.097
AWW/DRCR 5048 AWW/DRCR 5033		Robinson Bayou	30.613, -88.082 30.614, -88.077
New Site		West Eslava Creek north of Airport Road	30.679, -88.135
New Site		East Eslava Creek east of I-65	30.672, -88.108
New Site		Woodcock Creek @ Airport Road	30.676, -88.099
New Site		Unnamed Tributary near Pinecrest Cemetery	30.636, -88.093
New Site		Unnamed Tributary at Wooley Road	30.619, -88.12
GSA Site 3 AWW/DRCR 5015	Halls Mill Creek	Milkhouse Creek	30.661, -88.204 30.661, -88.202
GSA Site 4		Second Creek	30.635, -88.214
GSA Site 5		Halls Mill Creek	30.623, -88.235
GSA Site 7 AWW/DRCR 5001		Spring Creek	30.613, -88.154 30.613, -88154
GSA Site 8 ADEM 1042 AWW/DRCR 5009		Halls Mill Creek	30.606, -88.157 30.608, -88.162 30.607, -88.160
AWW/DRCR 1002		Milkhouse Creek	30.621, -88.179
AWW/DRCR 5005		Halls Mill Creek	30.605, -88.140
AWW/DRCR 5030		Milkhouse Creek	30.64, -88.201
AWW/DRCR 5034		Second Creek	30.627, -88.208
ADEM 1017		Halls Mill Creek	30.611, -88.191
New Site		Second Creek	30.664, -88.225
New Site		Unnamed Tributary to Second Creek	30.652, -88.224
New Site		Unnamed Tributary at Sollie Road	30.602, -88.208

11

Sample Location ID	Watershed	Drainage	Coordinates (Lat,, Long)
GSA Site 9 ADEM 810	Lower Dog River	Rabbit Creek	30.562, -88.161 30.562, -88.161
ADEM 811 AWW/DRCR 5017		Rabbit Creek	30.559, -88.181 30.559, -88.181
ADEM 812		Rabbit Creek	30.573, -88.193
AWW/DRCR 5025		Alligator Bayou	30.583, -88.141
AWW/DRCR 5024		Perch Creek	30.573, -88.135
AWW/DRCR 5049		Rabbit Creek	30.571, -88.140
AWW/DRCR 5047		Dog River	30.586, -88.114
AWW/DRCR 5026		Dog River	30.585, -88.114
AWW/DRCR 5038		Dog River	30.585, -88.110
AWW/DRCR 5016		Alligator Bayou	30.564, -88.105
AWW/DRCR 5036		Alligator Bayou	30.552, -88.111
AWW/DRCR 5045		Perch Creek	30.585, -88.077
AWW/DRCR 5029		Perch Creek	30.581, -88.079
New Site		Rabbit Creek near Hayfield Road	30.578, -88.202
ADEM - Alabama Department of Environmental Management; AWW/DRCR – Alabama Water Watch/ Dog River Clearwater Revival; GSA - Geological Survey of Alabama			

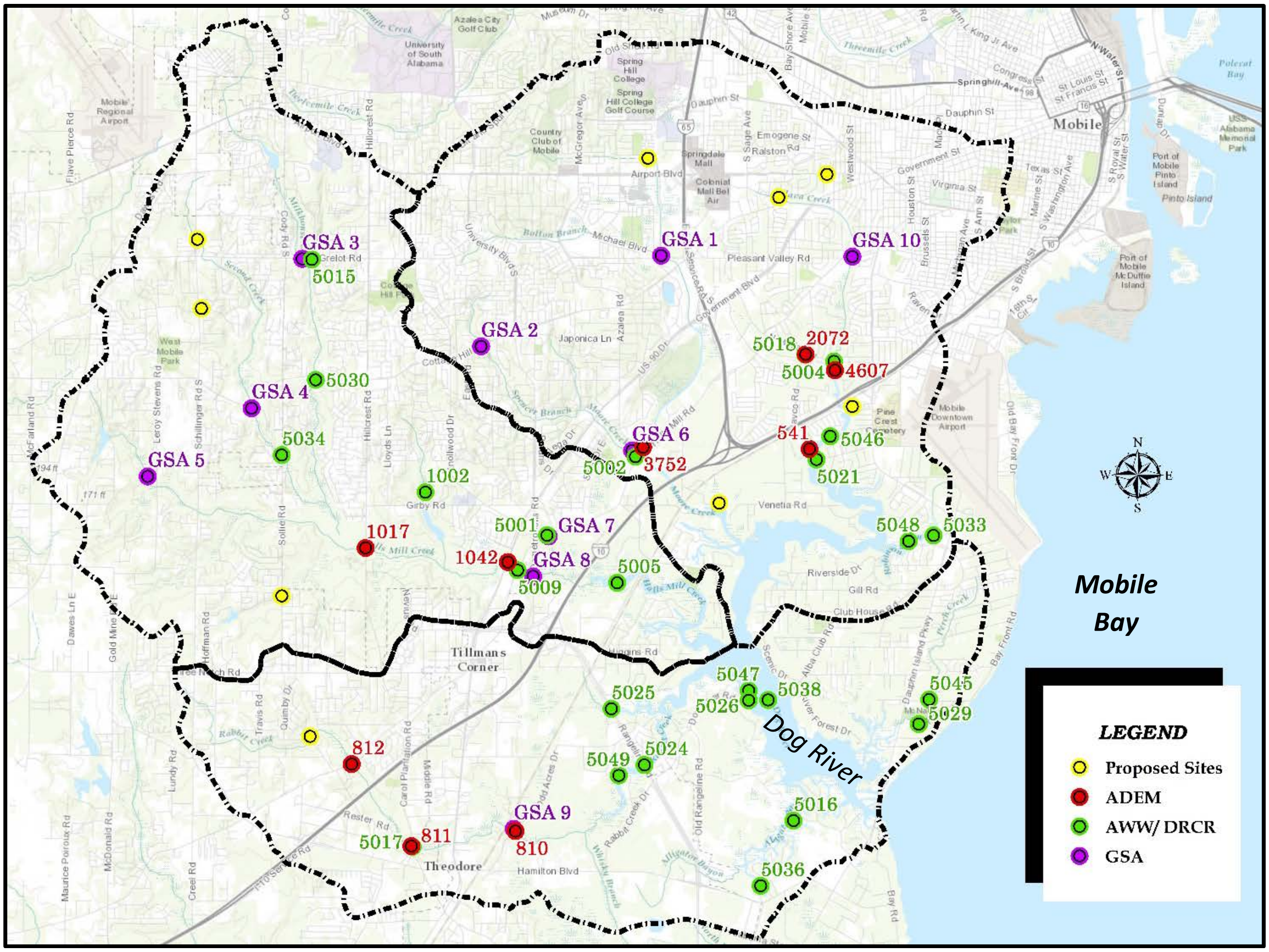

Figure 11.3.2: Potential priority sample collection locations

11.4 IMPLEMENTATION SCHEDULE

The implementation schedule for the WMP should be prepared and maintained by DRCR and an appointed watershed coordinator. The schedule should be modified as needed to address each of the specific management measures contained in Chapter 7 of this WMP as they are implemented. Each management measure should be listed as a major task in the implementation schedule, with all subtasks being listed to help organize and complete the necessary sampling. The schedule should include the start and projected end dates for each task, and the personnel assigned to each task.

The implementation schedule should be reviewed annually and updated as needed. The status of the implementation schedule should be reported annually to the Mobile County Commission, City of Mobile, and MBNEP as part of the annual report. The schedule will serve as an important tool to assess the status of the WMP and to identify where corrective actions are needed to address problems encountered in the implementation of the WMP.

11.5 ANTICIPATED COSTS

The estimated cost for an adequate monitoring program ranges from $200,000 to $275,000 each year. Following approval of this WMP and establishment of a watershed coordinator position, the specific costs of the monitoring program should be determined by DRCR by developing more detailed scopes of work for the monitoring program, and soliciting bids for completion of the detailed scope of work. It should be possible to fund the monitoring costs through grants or other funding sources identified in Chapter 10 of this WMP. The GSA and the U.S. Geological Survey (USGS) have cooperative programs that allow them to share annual costs of collecting environmental data.

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