TASK 1 - TECHNICAL REPORT

Cape Fear 02/03 Regional Watershed Plan

Task 1 – Existing Condition Assessment and Focus Area Identification

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Introduction

The mission of the North Carolina Division of Mitigation services is to provide cost-effective mitigation alternatives that improve the state’s water resources. As required by the federal mitigation rule, effective June 2008, the Division of Mitigation Services develops all mitigation using a watershed approach as defined in the *Compensatory Planning Framework*. To meet these requirements, Division of Mitigation Services has contracted VHB to prepare a Regional Watershed Plan for portions of Cape Fear 03003002 (Haw River) and 03003003 (Deep River) watersheds.

1.1 Background

North Carolina Division of Mitigation Services (DMS) is charged with providing cost-effective mitigation alternatives that improve the state’s water resources, while at the same time being responsible stewards of the state’s and taxpayers' money. Part of this effort involves conducting watershed planning projects throughout North Carolina to prioritize and concentrate mitigation efforts to restore streams, wetlands, and forested buffers for the purpose of offsetting unavoidable environmental damage from economic development.[1] The

[1] https://deq.nc.gov/about/divisions/mitigation-services

proposed watershed planning area for this Cape Fear 02/03 Regional Watershed Plan (RWP) (shown in Figure 1-1) encompasses 620 square miles and includes twenty-two 12-digit Hydrologic Unit Codes (HUCs). See Section 2 for further discussion of the study area and its hydrologic layout.

According to the 2016 National Land Cover Database (NLCD), the existing land use within the proposed planning area includes approximately 25% agricultural areas, 58% forested areas, and 6% developed areas, with the remainder of the study area a combination of shrub or grasses, open water, barren, or wetland areas. Section 2.2 discusses the land cover within the study area in more detail. The expectation of continued growth in this area will likely result in additional land use conversion. This RWP presents an opportunity to identify a range of watershed improvement and protection strategies ahead of potential impacts with the use of watershed data and stakeholder input.

1.2 Regional Watershed Plan Purpose

DMS initiated a RWP for a portion of the Cape Fear River Basin to aid in planning and prioritizing mitigation as described above. The ultimate objective of the RWP is to create a modeling strategy based on available data to evaluate the conditions of a watershed; link issues back to their underlying causes; and recommend strategies to preserve areas in good condition and to mitigate sources of inadequacies in, or barriers to, the three main functions of a watershed—hydrology, water quality, and habitat—as well as the resources themselves.

The other key objectives of the Cape Fear 02/03 RWP are as follows:

- Satisfy compensatory mitigation requirements on a programmatic level through watershed planning.
- Enhance the natural resources of North Carolina by addressing watershed needs through a process that utilizes the best available data and incorporates stakeholder input to maximize the potential watershed functional improvement.
- Prioritize watersheds where compensatory mitigation actions maximize functional improvement and promote synergy due to concentrated implementation of hydrology, water quality, and habitat projects.
- Develop a planning approach that is forward looking, identify watersheds which are likely to develop and identify linchpin watersheds that can cause cascading effects in a region with high development potential.
- Provide feedback to improve the DMS statewide Watershed Prioritization Model through cross-validation.

1.3 Task 1 Objectives

Task 1 of the RWP includes a high-level geospatial analysis of available datasets within the study area focusing on the following:

1.3.1 Data Collection

Stakeholder Engagement: Meetings with state and local government representatives, community members, Non-Governmental Organizations (NGOs), and resource agency representatives were held early in the planning process to determine available data and to learn more about the conditions within the watershed. Specifically, we were interested in gaining knowledge of other watershed initiatives, in identifying areas of anticipated growth, and in gathering data available for use in the planning process.

Existing Conditions Assessment: VHB compiled all data collected to date by DMS within this watershed planning area along with data from state agencies (NC Division of Water Resources, NC Natural Heritage Program), federal agencies (US Geologic Service, US Fish and Wildlife Service), local government, and the Environmental Systems Research Institute (ESRI) and other research institutions. During Task 1, VHB used this data to assess the existing conditions within the study area and utilized the results to identify areas good for preservation and areas more suited for mitigation projects. Table A-1 in Appendix A contains a comprehensive list of all data used during Task 1.

1.3.2 Task 1 Analysis

Preservation Areas: VHB evaluated the study area for beneficial environmental features that result in a high desirability and opportunity for preservation of existing resources. These areas will henceforth be referred to as Preservation Areas and will be catalogued but will not be studied in additional detail. See Section 3 for further discussion of the methodology and results of the Preservation Area analysis.

Land Use Conversion: VHB has identified areas with a high probability of land use conversion and incorporated these areas into the development of Focus Areas to provide a forward-looking strategy that will address potential issues within a watershed prior to further development. See Section 4 for further discussion of methodology and results of land use conversion analysis and how the results were carried forward into the identification of Focus Areas (Section 5).

Focus Areas: VHB has identified areas within the study boundary that are suited for detailed analysis of multiple factors that:

1. May contribute to issues within the watershed and inhibit the three primary functions of a watershed: water quality, habitat, and hydrology.
2. Have social or ecological features that may lead to higher resource value or higher opportunity for mitigation projects to be successful and beneficial.

These areas will henceforth be referred to as Focus Areas. Focus Areas are those clusters of catchments with the greatest resource value and/or potential for functional improvement and will be the priorities for further evaluation and management recommendations within the RWP. See Section 5 for further discussion of the methodology and results concerning the Focus Area analysis.

Focus Areas identified as a part of this report will be carried forward and analyzed in further detail during Task 3 to determine the underlying cause of issues within the watershed and assign mitigation strategies accordingly during Task 4.

1.3.3 Data Gaps and Proposed Solutions

During the planning process, as data was gathered and analyzed, areas of missing or insufficient information have been noted. Section 2.5 describes these data gaps and VHB's recommendations to fill them during subsequent Tasks in further detail. As the RWP continues, additional data gaps may be identified, so this is not a comprehensive list. If this occurs, VHB will document the data gap and will take steps to fill it in a subsequent report.

1.4 Report Layout

In this report, VHB will discuss the process and results of the above levels of analysis as follows:

- Section 2 will describe the existing conditions of the study area. It will also discuss available data, existing data gaps, and potential solutions to data gaps.
- Section 3 will discuss how the data described in Section 2 and other data was used in the analysis of the study area to identify Preservation Areas.
- Section 4 will detail conditions within the watershed that may contribute to the probability of land use conversion in the future.
- Section 5 will explain how VHB used the available data together with the land use conversion results from Section 4 to identify Focus Areas to be carried forward for additional analysis during Task 3.
- Section 6 will bring together the results from Section 3 to Section 5 and discuss the next steps of the RWP.

2

Existing Conditions

VHB carried out an initial analysis of existing conditions within the study area to establish a baseline and to prepare for the analysis and identification required for Task 1. These existing conditions were later utilized to identify areas of high-quality ecological value ideal for preservation as well as areas with known water quality and other environmental issues that require further analysis. During this process, VHB considered the layout of the study area as well as any upstream contributing watersheds, land cover within the study area, stream classifications and impaired water listings, and the presence of natural communities and habitat for significant species within the watershed.

2.1 Hydrology and Sub-watershed Delineation

The Cape Fear River Basin is one of seventeen major river basins in North Carolina, and one of only four that are contained entirely within the state. It is the largest and most industrialized river system in North Carolina, containing tributaries in a quarter of North Carolina's 100 counties and covering over 9,000 square miles from the Piedmont Region to the Coastal Plain and flows into the Atlantic Ocean through 32,000 acres of estuaries near the town of Cape Fear, NC. The river itself is 191 miles long and is created from the convergence of three other major rivers—the Haw River, the Deep River, and the Rocky River—which meet just below the B. Everett Jordan Dam at the outlet of Jordan Lake near the Lee-Chatham county line.

The Division of Mitigation Services has selected a 620 square mile portion (or 6.8%) of the Cape Fear River Basin for this Regional Watershed Plan. See Figure 2-1 for an overview of the study area and its hydrologic layout. The study area lies entirely within the Piedmont physiographic region of North Carolina and is comprised two sub-portions of the HUC-8 Haw River (03030002) and the Deep River (03030003) watersheds. The study area is located centrally in North Carolina, southeast of Greensboro, NC and west of Raleigh, NC. It contains parts of 7 counties: Alamance, Chatham, Guilford, Lee, Orange, Randolph, and Wake, in addition to the incorporated municipalities of Pittsboro, Siler City, Liberty, and Staley.

During their initial analysis, DMS used the National Hydrography Dataset (NHDPlusV2) to further divide the study area into catchments for analysis, with an average size of 0.5 square mile per catchment. VHB utilized the same scale for ease of comparison.[2]

A significant amount of the Cape Fear River Basin upstream of the RWP study area drains into and through our study area. Figure 2-2 gives an overview of this outside contributing drainage area.

2.2 Existing Land Cover

Land cover within the study area is varied across uses, from highly urbanized development to open farmland to natural, forested spaces. Figure 2-3 shows these land uses and how they are distributed across the study area.

The breakout of these areas within the RWP study area according to the 2016 National Land Cover Database is as follows:

[2] Some catchments in the DMS dataset along the edges of the RWP boundary were removed from the study area due to a clipping issue between the study area boundary and the NHDPlusV2 catchments that resulted in numerous erroneous catchments created from slivers of outside watersheds. In total, 176 edge catchments were removed from the 1480 catchments provided by DMS.

Table 2-1 Existing Land Cover

NLCD Land Use Classification	Area (acres)	Area (square miles)	Ratio of Total Study Area (%)
Deciduous Forest	124,546	194.6	31.4
Hay/Pasture	85,373	133.4	21.5
Mixed Forest	63,537	99.3	16.0
Evergreen Forest	54,992	85.9	13.9
Developed, Open Space	22,340	34.9	5.6
Herbaceous	12,740	19.9	3.2
Shrub/Scrub	10,057	15.7	2.5
Cultivated Crops	9,100	14.2	2.3
Developed, Low Intensity	5,251	8.2	1.3
Open Water	4,559	7.1	1.1
Woody Wetlands	2,223	3.4	0.5
Developed, Medium Intensity	1,512	2.4	0.4
Developed, High Intensity	559	0.9	0.1
Barren Land	373	0.6	0.1
Emergent Herbaceous Wetlands	160	0.3	0.1

Source: National Land Cover Database 2016

2.3 Surface Water Classifications and Water Quality

The existing water quality conditions within the study area were examined using geospatial data available from the North Carolina Department of Environmental Quality (DEQ) - Division of Water Resources (DWR). VHB first looked at overall surface water classification within the study area, and then identified the locations of impaired waters. Figures 2-4 and 2-5 show the primary and secondary classifications of streams within the study area, while Figure 2-6 maps the locations of impaired waters.

Surface Water Classification: NCDEQ DWR's stream classification program designates surface waters within the state for certain uses (fishing, swimming, drinking water supply) and assigns water quality regulations based on the assigned classification to protect those uses. Tributaries to North Carolina streams are assumed to have the same classifications as their receiving waterbodies unless otherwise classified.

The surface waters within the Cape Fear 02/03 RWP study area carry mainly Class C and Water Supply III, IV and V (WS) classifications, with some having secondary classifications of Nutrient Sensitive Waters (NSW) or Water Supply Critical Areas (CA). See Table 2-2 below for a description of all the applicable classifications within the study area boundary. Some of the classifications in the table may overlap. In the case of multiple classifications, the stream is included in the quantification of all applicable classifications shown in the table. For example, a stream reach that has a classification of WS-IV, B; NSW, CA is included in the stream length for Class B, WS-IV, NSW and CA.

Table 2-2 Surface Water Classification Within Study Area

Surface Water Classification	Description[3]	Stream Length in Study Area (mile)
Class C	Protected for uses such as secondary recreation, fishing, wildlife, fish consumption, aquatic life including propagation, survival and maintenance of biological integrity, and agriculture.	192.2
Class B	Protected for all Class C uses in addition to primary recreation. Primary recreational activities include swimming, skin diving, water skiing, and similar uses involving human body contact with water where such activities take place in an organized manner or on a frequent basis.	34.2
WS-III (Water Supply III)	Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I or II classification is not feasible. WS-III waters are also protected for Class C uses. WS-III designates moderate development within the watershed.	110.7
WS-IV (Water Supply IV)	Waters used as sources of water supply for drinking, culinary, or food processing purposes where a WS-I through III is not feasible. WS-III waters are also protected for Class C uses. WS-III designates moderate to high development within the watershed.	219.2
WS-V (Water Supply V)	Waters protected as water supplies which are generally upstream and draining to Class WS-IV waters or waters used by industry to supply their employees with drinking water or as waters formerly used as water supply. These waters are also protected for Class C uses.	103.6
NSW (Nutrient Sensitive Waters)	Supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation.	290.4
CA (Critical Areas)	Land adjacent to a water supply intake where risk associated with pollution is greater than from remaining portions of the watershed.	54.6

Source: NCDEQ DWR

Impaired Stream Classification: In addition to surface water classifications, the study area was also evaluated for the presence of impaired waters. NCDEQ DWR is required by the

[3] https://deq.nc.gov/about/divisions/water-resources/planning/classification-standards/classifications

Clean Water Act to assess and to report on water quality throughout the state. This assessment requires the collection of water quality data and comparison of these samples to the North Carolina water quality standard. The most recent assessment was completed in 2018. See Table 2-3 for descriptions of 303(d) categories.

Table 2-3 303(d) Category Descriptions

303(d) Category	Description[4]	Stream Length in Study Area (miles)
Category 1	Assessed parameter meeting criteria	311.6
Category 2	Not listed in 2018 IR documentation	0.0
Category 3	Unable to determine if meeting or exceeding criteria	89.9
Category 4	Exceeding criteria and TMDL not required	56.0
Category 5	Exceeding criteria and TMDL required	107.0

Source: NCDEQ DWR

For the purposes of this report, only Categories 4 and 5 were considered as an indicator for impaired streams in the Focus Area analysis. Approximately 164.0 miles, or 26% of streams within the Cape Fear 02/03 study area are considered impaired (56.0 miles of category 4 and 107.0 miles of category 5) based on the latest Integrated Report.

2.4 Habitat Assessment

VHB examined the prevalence of habitat areas of certain species of concern and various natural communities present within the study area. The presence of these habitats indicates beneficial conditions relevant to the subsequent identification of Preservation and Focus Areas.

2.4.1 North Carolina Ecoregions

Griffith et al. (2002) describe six different level IV ecoregions within the two combined watersheds, as listed in Table 2-4 below.[5]

[4] https://files.nc.gov/ncdeq/Water%20Quality/Planning/IR-Assessment-Process-2018.pdf

[5] Griffith, G.E., Omernik, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D.R., MacPherson, T.F., Glover, J.B., and Shelburne, V.B., 2002, Ecoregions of North Carolina and South Carolina, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

Table 2-4 Ecoregions in the Cape Fear 02/03 Watershed

Ecoregion Name	Ratio of Study Area (%)
Carolina Slate Belt Region	45.4%
Southern Outer Piedmont Region	29.0%
Triassic Basin Region	15.6%
Northern Inner Piedmont Region	8.2%
Sand Hills Region	1.7%
Rolling Coastal Plain Region	0.1%

Source: National Land Cover Database 2016

These ecoregions are described based on geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology.

The Carolina Slate Belt region, Triassic Basin region, and the Northern Inner Piedmont region are all part of the larger Carolina Piedmont unit. The Carolina Slate Belt extends from southern Virginia, across North and South Carolina, and into Georgia. Streams in this region are known to dry up because of the low water yield characteristics of the associated geology. The Triassic Basin region has an unusual geology for the Piedmont. Soils tend to be clayey with low permeability and are easily erodible leading to streams in this region being wider and prone to low base flows. The Northern Inner Piedmont tends to have mostly mesic soils in comparison to the thermic soils that occur in other regions of the Piedmont. Streams tend to have a higher gradient than those in the Outer Piedmont region.

The Sand Hills region and Rolling Coastal Plains region are both part of the larger Southeastern Plains unit. The Sand Hills region is a rolling to hilly region composed primarily of sands and clays. Stream flow in this region tends to be consistent, neither flooding nor drying up, because of the large infiltration capacity and ample ground water storage of the associated geology. The Rolling Coastal Plain region extends south from Virginia into North Carolina. Generally, relief, elevation, and stream gradients are greater than those in the Carolina Piedmont and soils tend to be better drained.

2.4.2 Species and Natural Communities of Concern

The North Carolina Natural Heritage Program (NCNHP) consolidates and maintains a database of rare species and natural communities in North Carolina.

Protected Species: There are five federally protected species within the Cape Fear 02/03 RWP study area. Table 2-5 lists these species and their status and Figure 2-7 shows the federally protected species within the study area. The Red-Cockaded Woodpecker and Bald Eagle are federally protected species within the study area but they are excluded in Figure 2-7 because these species are not high-priority species in mitigation considerations. Many others are only listed at the state level. Figure 2-8 shows the locations and survey accuracies of these species within the study area (they are too numerous to be shown specifically). A comprehensive list of all species of interest with occurrences in the study area is included in Table B-1 in Appendix B.

The NCNHP database includes element occurrence (EO) information on the location of these and other rare species and natural communities. The accuracy of EOs varies based on species type and survey effort, and an EO could be based on a single species occurrence or a single survey result.

Table 2-5 Federally Listed Species Within Study Area

Scientific Name	Common Name	Federal Status	Number of EOs Within Study Area
Fusconaia masoni	Atlantic Pigtoe	Proposed Threatened	3
Haliaeetus leucocephalus	Bald Eagle	Bald Eagle Protection Act	2
Notropis mekistocholas	Cape Fear Shiner	Endangered	4
Ptilimnium nodosum	Harperella	Endangered	2
Picoides borealis	Red-cockaded Woodpecker	Endangered	1

Source: NCNHP

Natural Communities: In addition to cataloguing habitat of various species of concern, NCNHP also keeps track of natural communities within the state of North Carolina. Figure 2-9 shows the locations and accuracies of these various natural communities. A natural community is defined by NHP as "a distinct and reoccurring assemblage of populations of plants, animals, bacteria, and fungi naturally associated with each other and their physical environment."[6] Table 2-6 below lists the various natural communities and their occurrences within the Cape Fear 02/03 RWP study area.

[6] https://www.ncnhp.org/documents/files/guide-classification-natural-communities-north-carolina-4th-approximation/open

Table 2-6 Natural Communities Within Study Area

Natural Community Name	Habitat Type	Number of EOs in Study Area
Basic Mesic Forest (Piedmont Subtype)	Upland	6
Dry-Mesic Basic Oak--Hickory Forest (Piedmont Subtype)	Upland	6
Dry-Mesic Oak--Hickory Forest (Piedmont Subtype)	Upland	18
Dry Basic Oak--Hickory Forest	Upland	3
Dry Oak--Hickory Forest (Piedmont Subtype)	Upland	12
Floodplain Pool	Wetland	7
Low Elevation Seep (Floodplain Subtype)	Wetland	2
Low Elevation Seep (Typic Subtype)	Wetland	2
Mesic Mixed Hardwood Forest (Piedmont Subtype)	Upland	14
Mixed Moisture Hardpan Forest	Upland	3
Piedmont Alluvial Forest	Wetland	13
Piedmont Basic Glade (Typic Subtype)	Upland	1
Piedmont Boggy Streamhead	Wetland	2
Piedmont Bottomland Forest (High Subtype)	Wetland	1
Piedmont Cliff (Acidic Subtype)	Upland	1
Piedmont Headwater Stream Forest (Typic Subtype)	Wetland	4
Piedmont Levee Forest (Typic Subtype)	Wetland	4
Piedmont Monadnock Forest (Typic Subtype)	Upland	4
Piedmont Swamp Forest	Wetland	1
Piedmont/Coastal Plain Heath Bluff	Upland	10
Piedmont/Mountain Semipermanent Impoundment (Open Water Subtype)	Wetland	2
Piedmont/Mountain Semipermanent Impoundment (Piedmont Marsh Subtype)	Wetland	2
Rocky Bar and Shore (Mixed Bar Subtype)	Wetland	5
Rocky Bar and Shore (Southern Wild Rice Subtype)	Wetland	1
Rocky Bar and Shore (Water Willow Subtype)	Wetland	9
Upland Depression Swamp Forest	Wetland	5
Upland Pool (Typic Piedmont Subtype)	Wetland	1
Xeric Hardpan Forest (Acidic Hardpan Subtype)	Upland	5
Xeric Hardpan Forest (Basic Hardpan Subtype)	Upland	1

Source: North Carolina Natural Heritage Program

2.5 Data

VHB compiled data from various sources during Task 1 of the RWP. This section, in conjunction with Appendix A, describes the sources of the data and any data gaps that VHB identified (see Section 2.5.2). Solutions to these data gaps and how VHB proposes to fill them are contained in Section 2.5.3. Additional data will be compiled for the detailed analysis to be executed during Task 3.

2.5.1 Available Data

VHB obtained and compiled data for Task 1 from a variety of sources.

These sources include government agencies from the municipal, county, state and federal levels of government, non-governmental organizations (NGOs), and private parties that may have an interest in the process and outcome of the Cape Fear 02/03 RPW. In conjunction with NCDMS, VHB held three calls at the start of the project with the identified stakeholders to collect and gather data. Some stakeholders submitted their own data, while other data was obtained from various websites.

Table A-1 in Appendix A details all datasets used in the Task 1 analysis and their sources.

2.5.2 Data Gaps

During the Task 1 data analysis, VHB kept note of data gaps that may require further review during the subsequent tasks.

Data gaps identified during Task 1 include:

- Habitat data – The NCNHP recognizes that their data is incomplete and may contain spatial data gaps due to the inconsistency of surveys within the study area. During Task 1, VHB considered habitat and natural community data available from NCNHP for Focus Area identification using the accuracy level as a filter. In addition to NCNHP data, VHB also utilized fish and benthic macroinvertebrate habitat data available from the NCDEQ DWR to supplement available habitat information. These datasets are limited and only contain data for specific monitoring sites within the study area.
- Population growth – The population growth data discussed in Section 4 were compiled from US Census data from the years 2000-2010. This is a decade out of date and would be a more accurate projection if more recent data were used. The RWP is interested in conditions considerably farther into the future (30 years or more), but data availability at this scale is lacking for efficient use.
- Zoning – VHB gathered zoning data for the counties and municipalities within the study area for use in the land use conversion analysis. Zoning data was available for every county except for Alamance County. Upon contacting a county official in charge of GIS data, VHB discovered that there is no available zoning data at the county level and that the only entities responsible for zoning are the municipalities within Alamance County, none of which are contained in the RWP study area. Due to the significant coverage of Alamance County within the study area and the unavailability of this data, VHB decided to focus on other indicators for land use conversion to account for the data gap, and zoning was taken out of consideration.

- State Transportation Improvement Program – VHB investigated future transportation projects planned by the North Carolina Department of Transportation (NCDOT) when considering how land use may change in the future. Upon an examination of this data, VHB determined that there were only a few datapoints within the RWP study area and that it would not significantly impact the results, so VHB removed the STIP data from analysis.
- Hydric Soils – Based on the USGS Web Soil Survey data of the study area, there are very few pockets of soils with a more than 40% chance of being hydric. Those that do have high hydric soil value are located primarily along stream corridors and in riverbeds. Ultimately, VHB left this out of the analysis as it provided little value to the results.
- Aquatic Species Passage – During initial data analysis in Task 1, VHB noted that in addition to existing hydraulic obstruction data, it would be helpful to know the locations of various federal and state listed critical species passage within the study area. As a first step, VHB quantified the ratio of obstructions per stream length in each catchment throughout the study area in order to identify areas that are hydrologically disconnected. More detailed data on the specific areas where aquatic species passage may be impaired would help pinpoint the best locations for mitigation efforts to improve aquatic wildlife in the study area.

2.5.3 Recommendations of Solutions to Fill Data Gaps

It is prudent for VHB to consider filling the data gaps discussed above to aid in the detailed analysis of underlying issues within the study area during Task 3 of the RWP. Potential solutions to the problems outlined above are listed below.

- Habitat data – Additional data may need to be obtained in the identified Focus Areas for more detailed analysis to occur during Task 3. Filling this data gap will require a combination of field habitat surveys and spatial interpolation for species of interest within the identified Focus Areas.
- Population growth – The next wave of Census data collection is ongoing at the time of this report and is due to be released to the public in the Spring of 2021. While this indicator was used mainly in the identification of Focus Areas and may not be as important during the Task 3 analysis, VHB will use the Spring 2021 data if it becomes available and explore ways to extrapolate existing data for a more distant projection. In addition to population growth, the expected change in development are predicted to have major impacts on land use conversions. In order to improve predictions for the latter in Task 3, VHB proposes to run the SLEUTH model with the Megasites (further discussed in Section 4) to get a better picture of how future land use conversion in the study area will propagate around existing or proposed urban development. VHB will also consider the FUTURES model available from North Carolina State University (NCSU) and how it could help analyze existing data to produce a more accurate view of future development within the study area.

- Hydric Soils – Although VHB decided against including the data available from the USGS Web Soil Survey in our analysis of Focus Areas, wetland restoration is a major part of mitigation efforts across North Carolina. During Task 3, VHB proposes conducting field surveys at locations within the Focus Areas where the data shows the potential for hydric soils to verify where these soils exist and how prevalent they are within the study area. This information can then be used in the development of management strategies, such as identifying areas of potential wetland restoration.
- Aquatic Species Passage – During Task 3, VHB will continue to reach out to the United States Fish and Wildlife Service (USFWS), the North Carolina Wildlife Resources Commission (NCWRC), and other agencies in order to obtain additional aquatic species passage data within our study area. A potential source is the Southeast Aquatic Resources Partnership (SARP). SARP maintains a database that includes dams, culverts, and other road crossings in conjunction with information on network connectivity, landscape condition, and presence of threatened and endangered aquatic organisms to provide information on prioritization of barriers. VHB will obtain and utilize this data to strengthen our assessment of hydrologic obstructions within the study area evaluated in this report.

Throughout the course of the RWP project, VHB will pay special attention to field work and other additional sources of data to help fill the above-mentioned data gaps. VHB will document all steps taken to fill the above identified data gaps in a subsequent report.

3

Preservation Areas

Preservation Areas are defined as catchments which exhibit intact riparian buffers, low levels of imperviousness cover, and a high level of forested and wetland area beneficial to habitat and water quality. VHB analyzed the study area at the catchment level and identified the areas of highest environmental quality that VHB recommends as noteworthy preservation opportunities for DMS and their partners. Various indicators were used to identify these areas; individual indicators were scored and combined to create a final score by which the catchments were assessed. Section 3.1 discusses the indicators and how they were chosen, and Section 3.2 describes the methodology utilized in the analysis.

3.1 Indicators of High-Quality Watersheds

Data was obtained from multiple sources, as described in Section 2, to evaluate and locate sources of high-quality environmental areas that may present opportunities for preservation. Catchments with a high amount of habitat area for state and federally listed plant and animal species, a high amount of natural area, a water supply watershed classification with a lower intensity of development, and a high ratio of wetland or forested area are indicative of high-quality watersheds. A high soil susceptibility to erosion, a low amount of managed area (i.e., a catchment that is not already protected for conservation purposes), and a low to moderate amount of impervious cover are indicative of areas that could benefit from proactive preservation efforts.

3.1.1 Ecological Indicators

Habitat Areas: This indicator identifies catchments with high presence of state-listed plant and animal species, federally listed plant and animal species, and natural communities in aquatic, upland, and wetland habitats. The habitat area indicator is an important factor in determining the Preservation Areas because it allows DMS to identify, preserve, and potentially expand habitat areas that are critical to the conservation of endangered or threatened species.

Natural Areas: This indicator identifies catchments with a high amount of natural areas as designated by NCNHP. The natural area indicator is an important factor in determining the Preservation Areas because it allows DMS to identify and to preserve natural areas that provide high-quality habitats for rare plant and animal species.

Water Supply Watershed: This indicator identifies catchments that are water supply watersheds. The water supply watershed indicator is an important factor in determining the Preservation Areas because it allows DMS to identify and to preserve areas that contribute to clean drinking water.

Soil Susceptibility to Erosion: This indicator identifies catchments with highly erodible areas in existing undisturbed land use areas. The soil susceptibility to erosion indicator is an important factor in determining the Preservation Areas because it allows DMS to identify and to preserve existing beneficial land cover that may be degraded by erosive soil conditions if disturbed.

Forested or Wetland Area: This indicator identifies catchments with a high amount of forested or wetland areas. The forested or wetland area indicator is an important factor in determining the Preservation Areas because it allows DMS to identify and to preserve wetlands and forested areas that serve valuable ecosystem and water quality functions.

3.1.2 Other Indicators

Managed Areas: Managed areas are defined as a diverse collection of properties and easements where conservation of biodiversity and ecosystem function are among the goals of the land management programs.[7] This indicator identifies catchments with low managed areas, or low protected areas for conservation purposes, as designated by NCNHP. The managed area indicator is an important factor in determining the Preservation Areas

[7] https://www.ncnhp.org/activities/conservation/managed-areas

because it allows DMS to identify potential new areas that are not already managed for preservation.

Impervious Cover: This indicator identifies catchments with low impervious cover. The impervious cover indicator is an important factor in determining the Preservation Areas because it allows DMS to identify and to preserve existing undeveloped areas.

Table 3-1 summarizes the indicators utilized for the Preservation Area analysis and their data sources. See Appendix A for a full and detailed list of all data utilized for this report.

Table 3-1 Preservation Area Indicators

Indicator	Description of Indicator	Data Source(s)
Habitat Areas	Indicates habitat occurrence of certain species of note within a catchment.	NCNHP Habitat Data
Natural Areas	Indicates presence of areas designated of significant natural importance that are high priorities for preservation but are not already protected.	NCNHP Natural Areas Data
Water Supply Watershed	Indicates the presence of water source classified and protected as a water supply source for human use (see classifications under Section 2.3 for more information).	NCDEQ DWR Surface Water Classifications
Soil Susceptibility to Erosion	Indicates undisturbed land with a high soil erodibility factor that, if disturbed, may contribute to erosion and water quality issues. These areas receive a higher Preservation Area score.	USDA NRCS 2016 NLCD
Forested or Wetland Area	Indicates amount of forested or wetland land cover beneficial for habitat and water quality in a given catchment.	USFWS 2016 NLCD
Managed Area	Indicates the amount of land already protected by conservation easements present in the catchment. Catchments with a low Managed Area ratio were given priority due to DMS's interest in preserving areas not already protected.	NCNHP Managed Areas
Impervious Cover	Indicates the percent impervious area in a catchment. Areas over 10% impervious were removed from Preservation Area consideration due to the increase in pollutant load and degradation of aquatic habitat.	2016 NLCD Impervious Cover

Source: Multiple. See Appendix A for more information.

3.2 Methodology for Indicator Selection and Analysis

This section describes the overall methodology, the key pre-processing details, and the total scoring schemes used in analyzing the Preservation Area indicators.

3.2.1 Overall Methodology

In general, available input data were pre-processed and used together along with logic-based formulas to generate scoring of that indicator for each catchment. Unless otherwise noted, ArcGIS Pro (version 2.5.2, ESRI Inc.) and its ModelBuilder application were used to develop the workflows to automate the geoprocessing. In general, the following steps were used to pre-process and to score the indicators:

1. If the input files were not provided as shapefiles (e.g., .kml, .csv, .tif, .xls, etc…), then they were first converted into the appropriate shapefiles (point, polyline, or polygon).
2. The input shapefile was clipped to the study area boundary in order to expedite the subsequent geoprocessing steps.
3. As needed, filters were applied on the select fields. As examples, please see the Habitat Area, Water Supply Watershed, and Soil Susceptibility to Erosion indicators.
4. Joining tools (e.g., union, merge, spatial join, intersect, summarize within, join field, etc.) were used to combine the input fields and any computed fields to the individual catchments in the study area.
5. Additional pre-processing computations were performed to obtain the desired field used in the scoring. The field to be scored was typically designed to be a ratio (e.g., critical habitat area over the catchment area), and the scoring scheme was designed to range between 0 and 1.
6. A total final score was computed by combining the individual indicator scores. If appropriate, weights and filters were applied. For example, weights were applied in the total final scores for Land Use Conversion and Focus Areas in Section 4 and 5, respectively. Post-scoring filters were also applied to the total final scores for Preservation Areas and Focus Areas in this Section and Section 5, respectively.
7. Total score and clustering results for the study area catchments are presented.

More pre-processing and scoring details are provided for each indicator in the following subsections. Quality control and quality assurance reviews were conducted throughout during the pre-processing and scoring model development.

3.2.2 Pre-Processing of Indicators

This section describes how and why each of the individual indicator scores were developed. Table 3-2 gives a summary of each indicator and their scoring metrics.

Habitat Area: This analysis excludes areas with unknown (accuracy equal to 6) or very low accuracy (accuracy equal to 5) using the NCNHP habitat area data. NCNHP defines accuracy as the estimated representational accuracy of the element occurrence in the mapped area. For example, an accuracy of 5 (very low) represents that less than 5% of the polygon (or mapped area) is estimated to be occupied by the element. In contrast, an accuracy of 1 (very high), 2 (high), 3 (medium), and 4 (low) represent estimated representational accuracy of the element occurrence greater than 95%, between 80 and 95%, between 20 and 80%, and between 5 and 20%, respectively. Therefore, the final habitat area score (HAB_SC) is calculated using a ratio of the habitat area (with accuracy less than or equal to 4) over the total catchment area. Given that some habitats areas may only occupy a small percentage of a catchment area, this scoring scheme was designed to ensure their representation in the total score (see scoring metric in Table 3-2).

Natural Area: The natural area score (NA_SC) is calculated using a ratio of the natural area over the total catchment area. Given that some natural areas may only occupy a small percentage of a catchment area, this scoring scheme was designed to ensure their representation in the total score (see scoring metric in Table 3-2).

Water Supply Watershed: In the study area, the water supply watershed classifications ranged between WS-III to WS-V according to the NCDEQ DWR surface water classifications (see Section 2.3). If a catchment had multiple streams with different water supply watershed classifications (e.g., WS-III and WS-IV), the lower (or less developed watershed) classification (in this case, WS-III) was taken to ensure that the most sensitive waters were represented in the water supply watershed score (WSW_SC, see scoring metric in Table 3-2).

Soil Susceptibility to Erosion: The soil data was obtained through the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), and its K factor rating for whole soil (or the susceptibility of soil to erosion and the rate of runoff) was used to identify the erodible soil. In the study area, a K factor rating for whole soil of greater than or equal to 0.4 was used as the threshold for highly erodible soil. This threshold was chosen because it typically represents soils with a high silt content that are easily detached, thereby producing high rates of runoff.[8] Undisturbed land within the highly erodible soil were defined as deciduous forest, evergreen forest, mixed forest, shrub/scrub, herbaceous, woody wetlands, and emergent herbaceous wetlands using the 2016 NLCD data. Altogether, the soil susceptibility to erosion score (KF_SC) is calculated using the area ratio of the highly erodible soil in undisturbed land use areas over the total catchment area (see scoring metric in Table 3-2).

Forested or Wetland Area: Wetland areas were defined as freshwater emergent wetlands or freshwater forested/shrub wetlands using the USFWS wetland file. The forested areas were defined as deciduous forest, evergreen forest, and mixed forest using the 2016 NLCD data. While the 2016 NLCD data contains wetland values, these values were not used because the USFWS wetland areas were more accurate. The final forested or wetland area score (WF_SC) is calculated using the ratio of the forested or wetland area over the total catchment area

[8] http://www.iwr.msu.edu/rusle/kfactor.htm

(see scoring metric in Table 3-2). Wetland and forested area contiguity were considered but not implemented because this was not expected to affect the indicator score significantly. Since the study area contained a large amount of wetland and forested area, any scoring increase for habitat contiguity would enhance all the catchments equally. Overall Preservation Area connectivity was accounted for in the clustering analysis (see Section 3.2.3).

Managed Area: The managed area score (MA_SC) is defined as one minus the ratio of the managed area over the total catchment area. This scoring scheme was designed to favor catchments with low managed areas because this indicates that the catchment is not protected from development or managed for conservation and can benefit from being preserved (see scoring metric in Table 3-2). A 50% or 0.5 ratio was chosen as the exceedance threshold whereby a catchment will receive a zero score to represent existing highly managed areas. Given that catchments in this study area skewed towards little to no managed areas, this exceedance threshold represents a conservative threshold in which only a few catchments (98 out of 1304 catchments) are excluded as potential preservation areas.

Impervious Cover: Using the 2016 NLCD impervious land cover file, impervious cover was defined as roads (primary, secondary, and tertiary), non-road impervious cover, and energy production sites in urban and rural areas. The impervious cover score (IA_SC) is calculated as the ratio of the impervious cover over the total catchment area (see scoring metric in Table 3-2). A 10% threshold, or 0.1 ratio, was chosen as the exceedance threshold whereby catchments will receive a zero score. This threshold was chosen because it represents the lower threshold at which aquatic degradation first occurs.[9]

[9] Schueler, Thomas R, 1995, The peculiarities of perviousness, *Watershed Protection Techniques 2*, 1: 233-38.

Table 3-2 Preservation Area Indicator Scoring

Indicator	Variable to be Scored	Scoring Metric	
Habitat Areas	HABRatio = Habitat area (accuracy ≤ 4) over total catchment area.	HABRatio = 0 --> 0 < HABRatio ≤ 0.25 --> 0.25 < HABRatio ≤ 0.5 --> HABRatio > 0.5 -->	HAB_SC = 0; HAB_SC = 0.5; HAB_SC = 0.75; HAB_SC = 1.
Natural Areas	NARatio = Natural area over total catchment area.	NARatio = 0 --> 0 < NARatio ≤ 0.25 --> 0.25 < NARatio ≤ 0.5 --> NARatio > 0.5 -->	NA_SC = 0; NA_SC = 0.5; NA_SC = 0.75; NA_SC = 1.
Water Supply Watershed	WSW_Class = Minimum WSW clafficifacation if a catchment had multiple classifications.	WSW_Class = 3 --> WSW_Class = 4 --> WSW_Class = 5 --> Otherwise -->	WSW_SC = 1; WSW_SC = 0.75; WSW_SC = 0.5; WSW_SC = 0.
Soil Susceptibility to Erosion	KFURatio = Erodible area (K factor ≥ 0.4 in undisturbed area) over the total catchment area.		KF_SC = KFURatio.
Forested or Wetland Area	WFRatio = Wetland or forested area over total catchment area.		WF_SC = WFRatio.
Managed Area	MARatio = Managed area over total catchment area.	MARatio ≤ 0.25 --> 0.25 < MARatio ≤ 0.5 --> MARatio > 0.5 -->	MA_SC = 1; MA_SC = 0.5; MA_SC = 0. Also used MARatio > 0.5 in Total Score filter.
Impervious Cover	IARatio = Impervious area over total catchment area.	IARatio ≤ 0.06 --> 0.06 < IARatio ≤ 0.10 --> IARatio > 0.10 -->	IA_SC = 1; IA_SC = 0.5; IA_SC = 0. Also used IARatio > 0.10 in Total Score filter.

Source: Multiple. See Appendix A for more information.

3.2.3 Total Score

Figure 3-1 shows the results of the Preservation Area total scores with the post-scoring filters applied. The Preservation Area total score was computed using the following:

$$\begin{aligned} Total\ Score = {} & Habitat\ Area\ Score + Natural\ Area\ Score + Water\ Supply\ Watershed\ Score \\ & + Soil\ Suceptibility\ to\ Erosion\ Score + Wetland\ or\ Forested\ Area\ Score \\ & + Managed\ Area\ Score + Impervious\ Cover\ Score \end{aligned}$$

where

$$Habitat\ Area\ Score\ = HAB\_SC$$
$$Natural\ Area\ Score = NA\_SC$$
$$Water\ Supply\ Watershed\ Score = WSW\_SC$$

$$Soil\ Susceptibility\ to\ Erosion\ Score = KF\_SC$$
$$Wetland\ or\ Forested\ Area\ Score = WF\_SC$$
$$Managed\ Area\ Score = MA\_SC$$
$$Impervious\ Cover\ Score = IA\_SC$$

Each indicator score was designed to range between 0 and 1. For the Preservation Area analysis, no indicator was determined to have more of an impact on the determined quality of a catchment than any other, so each indicator was given an equal weight of 1 in the final score to represent their equal importance in contributing to the final Preservation Area total score. Therefore, in this study area, the observed maximum total score is 6.7 (out of 7). Altogether, a high Preservation Area total score is indicative of a catchment with a high percentage of habitat areas, a high percentage of natural areas, a less developed water supply watershed, a high percentage of erodible soil in undisturbed areas, a high percentage of wetland or forested areas, a low percentage of existing managed areas, and/or a low percentage of impervious cover.

Post-scoring filters: The managed area and impervious cover indicators were also used as post-scoring filters to remove any catchment with a managed area ratio greater than 50% or an impervious cover ratio greater than 10%. These filters are highlighted in grey in Figure 3-1. Catchments with a high percentage of managed areas were excluded because they are already protected through existing land management efforts by other agencies or groups. As a consistency check, these catchments generally received a high total score using the above described method. The mean total score of the catchments with a managed area of greater than 50% is 4. On the other hand, catchments with a high percentage of impervious cover were excluded because they indicate areas with a high degree of aquatic habitat degradation, low potential for infiltration, and higher concentration of pollutants from runoff draining to streams. In addition, the Preservation Areas were reviewed in conjunction with the Megasite locations (see Section 4) to ensure that there were no recommendations for preservation that included any projected developments. Therefore, any catchment with any Megasite area was excluded from the Preservation Area total score and clustering analysis. Instead, these areas will be investigated in the Focus Area (see Section 5).

Cluster analysis: Clustering analysis was performed on the filtered total scores. While ArcGIS has a Cluster and Outlier Analysis tool, this was not used for several reasons. First, the cluster tool returned inconsistent results when compared to the actual total scores regardless of the spatial relationship parameter used (e.g., inverse distance, contiguity edges only, zone of difference, etc.). For example, the tool often included relatively low score catchments in high score clusters and relatively high score catchments in low score clusters. Second, the cluster tool required a certain number of catchments to consider a grouping a cluster (approximately 7 or 8), and this threshold appears to be too high for accurate cluster identification in the study area. In the study area, this grouping threshold problem was compounded by the fact that there were spatial gaps due to the Megasite and managed area filters used. As a result of these issues with the Cluster and Outlier Analysis tool, the Preservation Area clusters were identified using a high total score threshold (Total Score greater than 4). This threshold represents approximately an 80% probability that a given total score is less than 4 using cumulative distribution analysis. In addition to the thresholding analysis, high scoring standalone catchments were removed from the final high total score clusters so DMS can focus their attention and resources on larger, contiguous areas of high-quality environment.

3.3 Preservation Results and Recommendations

The goal of the above analysis was to identify areas with high resource value and bring forth recommendations for DMS and its partners to identify potential opportunities to preserve and to protect these areas from conditions which may cause harm to the natural resources. Figure 3-2 shows a map of the areas that VHB recommends as noteworthy for preservation considerations by DMS and its partners. Altogether, Figure 3-2 shows the final 188 catchments that were identified as the high total score Preservation Area clusters. This equates to 91 square miles, or approximately 15% of the study area. The results show the most prominent clusters are located along the two major river corridors in the study area: the Haw River to the north and the Rocky River to the south.

Focusing preservation effort in the areas recommended herein can result in long term benefits for the environmental well-being of the Cape Fear River Basin by protecting habitats that serve important ecosystem functions.

The final Preservation Area clusters and catchments with more than 50% managed areas were removed from the Focus Area analysis as described in Section 5. As these areas encompass quality habitat, undisturbed lands, and exhibit higher quality waters, or are already heavily managed, active management strategies would yield minimal functional uplift.

Section 6 discusses these results in conjunction with the Land Use Conversion and Focus Area results in Section 4 and Section 5, respectively.

4

Future Land Use

Development within the Cape Fear River Basin is expected to expand significantly in the coming decades. Development directly impacts water quality and habitat by increasing impervious cover within a watershed. It is important to focus on areas with a high probability of land use conversion when developing a watershed plan so that mitigation efforts can stay ahead of impacts brought by future development. As part of this Regional Watershed Plan, VHB was tasked with considering where this development may occur and how it may impact mitigation efforts by the Division of Mitigation Services. Section 4.1 discusses the importance of land use conversion to our analysis, Section 4.2 discusses the individual indicators and how they were chosen, and Section 4.3 discusses the methodology used in the analysis.

4.1 Implication on Habitat and Water Quality

Increased development negatively impacts the natural habitats for terrestrial and aquatic species. For example, deforestation or the denuding of riparian buffers along streams directly impacts the habitat of various plant and animal species.

At the same time, the increase of impervious cover in these areas can lead to lower infiltration and higher runoff. This in turn results in a higher concentration of pollutants that make their way into area streams, thus impacting aquatic species and the quality of water supply watersheds.

When considering how best to apply mitigation strategies within the Cape Fear 02/03 RWP study area, it is important to consider which areas may experience growth, thereby accelerating degradation of habitat and/or water quality.

4.2 Indicators of Future Land Use Change

In addition to the expansion of current development within the study area, North Carolina is home to multiple sites that are actively being marketed for Megasites, heavy industrialized developments. Of these seven Megasites throughout the state, three of them fall at least partially within the study area boundary: the Moncure Megasite, the Chatham-Siler City Megasite, and the Greensboro-Randolph Megasite. In addition, a large area of the incorporated municipality of Pittsboro is in the process of development as a planned community called Chatham Park. This community will be a mixture of residential and commercial development that will be located to the west of Jordan Lake in Chatham County. See Figure 4-1 for a map of these planned developments within the study area. Additional residential and commercial development is expected in the vicinity of these planned developments.

In addition to the expected Megasites, future probabilities of land use conversion were accounted for using the SLEUTH[10] (slope, land use, exclusion, urban extent, transportation, hillshade) model results. Specifically, the SLEUTH model shows the probability for development in each land pixel between 0 and 100% (in increments of 2.5%). Given the time that it takes to select, perform, and assess the effects of mitigation projects, the 2070 SLEUTH model results were used in the subsequent indicator analysis.

Several factors were utilized as filters to refine areas likely to experience future development. The filters applied include existing development and open water based on the 2016 NLCD inputs and areas where conservation easements are present based on the managed areas dataset from NCNHP. North Carolina also has an extensive Voluntary Agricultural District (VAD) Program, which protects certain farmland from non-farm development. Each county within the study area is a participant in this program, and locations of these protected areas were obtained from the counties that contain VADs within the study area.

[10] USGS, 2003, "Project gigalopolis: urban and land cover modeling," US Geological Survey, http://www.ncgia.ucsb.edu/projects/gig/.

Of the area that remains after filtering, there are many indicators that may predict future development. See Table 4-1 for a summary of indicators used for analysis. For a detailed description of the data utilized, see Table A-1 Appendix A.

Open Space: This indicator identifies catchments with a high amount of open space areas. The open space indicator is an important factor in determining land use conversion because it sets the base conditions for development to occur.

Road Density: This indicator identifies catchments with high road density networks. The road density indicator is an important factor in determining land use conversion because road networks are needed to support the growth of developments.

Projected Population Growth: This indicator identifies catchments with high projected population growth rates. The projected population growth is an important factor in determining land use conversion as the influx of population requires development of new homes which then spurs development of businesses to supply the growing population leading to the conversion of open space to built-upon area.

Expected Change in Development: This indicator identifies catchments with a high chance of projected development using the proposed Megasites and predicted land use conversion probabilities from the SLEUTH model. The expected change in development is an important factor in determining land use conversion because this represents planned or projected developments that will alter land use with a high degree of probability.

Table 4-1 Land Use Conversion Indicators

Indicator	Description of Indicator	Data Source(s)
Open Space	Indicates the space available within a given catchment for development.	2016 NLCD
Road Density	Indicates density of the transportation network within a catchment from which development may spur.	NCDOT Route Arcs
Projected Population Growth	Indicates areas of high and low projected population growth where development is most and least likely.	U.S. Census Bureau ESRI Population Growth Data
Expected Change in Development	Combines designated Megasites and other planned developments within the study area with further projected development from existing urban areas to indicate the areas with the highest likelihood of intensive development.	Greensboro Randolph Megasite Boundary CAM Megasite Boundary Moncure Megasite Boundary from Chatham County Zoning Data Chatham Park Development from Pittsboro Zoning Data SLEUTH 2070

Source: Multiple. See Appendix A for more information.

Section 4.3 discusses in more detail the methodology utilized to obtain these results. Section 5 discusses how the results were used in the Focus Area analysis and scoring.

4.3 Methods of Prediction of Land Use Change

This section describes the overall methodology, the key preprocessing details, and the total scoring schemes used in analyzing the land use conversion indicators. The purpose of this analysis is to examine the factors that lead to growth and development and to develop a method of predicting low, moderate, and high probabilities of land use conversion that may adversely impact the function of a watershed. This is an important indicator for the identification of Focus Areas so that mitigation efforts can be aimed to offset the impacts before they happen. Further discussion of how this indicator is included in the Focus Area analysis is described in Section 5.

4.3.1 Overall Methodology

The overall methodology is similar to the steps described in Section 3.2.1 for the Preservation Areas. There are two key differences:

1. Areas that were available for development were identified and used in the analysis of several land use conversion indicators.
2. Cluster analysis was not performed because the land use conversion total score results were used as inputs for the Focus Area analysis.

For several of the land use conversion indicators, it was deemed more appropriate to perform the analysis on the areas that were available for development. At each given catchment, the retained catchment area was determined by taking the difference between the total catchment area and the catchment area to be excluded. The catchment area to be excluded was determined using the NCNHP managed areas, the VAD areas from each county, and the existing developed and open water areas from the 2016 NLCD dataset. Note that the VAD areas are only excluded in determining the land use conversion score. VAD areas are not excluded in the Focus Area analysis (see Section 5) because mitigation can still be performed in these areas.

More pre-processing and scoring details are provided for each indicator in the following subsections. Quality control and quality assurance reviews were conducted throughout the pre-processing and scoring model development.

4.3.2 Pre-Processing of Indicators

This section describes how and why each of the indicator scores were developed.

Open Space: Open space areas were defined as the non-developed and non-open water areas using the 2016 NLCD data. The final open space score (OS_SC) is calculated using a ratio of the open space in the area available for development (as defined in Section 4.3.1) over the total catchment area (see scoring metric in Table 4-2).

Road Density: Road density is defined as the length of road in kilometers within each catchment over the total catchment area using the NC Department of Transportation route arcs data. In this study area, the road density ranged between 0 and 21.5 km/km^2. In order to represent this range of values between 0 and 1 for comparison with the other indicators, the road density score (RA_SC) is calculated by normalizing the road density by the maximum observed value (see scoring metric in Table 4-2).

Projected Population Growth: The projected population growth rate was determined using ESRI's five-year population data between 2020 and 2025.[11] In this study area, the population growth rate ranged between -0.26% and 8.45%. The projected population growth rate score (PG_SC) is calculated by separating the population growth rate into five increments based on their potential to drive land use conversion (see scoring metric in Table 4-2). For example, growth rates between 1% and 3% were determined to represent the natural growth rate associated with a moderate probability of land use conversions, or a score of 0.5. Growth rates below this range received a score lower than 0.5 to represent a lower probability of land use conversions, growth rates above this range received a score higher than 0.5 to represent a higher probability of land use conversions, and growth rates that were negative received a score of zero to represent no land use conversions.

Expected Change in Development: The projected development areas were identified using the Megasite locations and the 2070 SLEUTH model results. The expected change in development score (EC_SC) is calculated using an area-weighted ratio, and this is defined as the Megasite areas (weight = 1), the inner projected development areas (Inner Band with weight =1), and the outer projected development areas (Outer Band with weight = 0.75) over the total catchment area (see scoring metric on Table 4-2). The Megasite area represents the projected Megasite boundaries in the available area for development. The SLEUTH model results and Megasite areas were then superimposed to estimate the Inner Band and Outer Band. The Inner Band, representing a high chance of development around projected developments, was defined by the 100% chance of development areas in the 2070 SLEUTH data and an estimated half-mile buffer area around the Megasites. A half-mile buffer was used to be consistent with the approximate width of the 100% SLEUTH band. The Outer Band, representing a moderate chance of development, was defined by the SLEUTH 2.5% to 97.5% bands and a buffer between 0.5 and 0.75 miles from each Megasite. A quarter-mile buffer was used to be consistent with the approximate width of the 2.5% to 97.5% SLEUTH band. Both the Inner Band and Outer Band areas account for the available area for development.

[11] This was the best available data at the scale that was appropriate for the catchment analysis. Task 3 will address extending this horizon using the 2020 census data.

Table 4-2 Land Use Conversion Indicators

Indicator	Variable to be Scored	Scoring Metric	
Open Space	OSRatio = Open space area in retained catchment area (e.g., available for development) over total catchment area.		OS_SC = OSRatio/Max OSRatio. Max OSRatio = 1.
Road Density	RADensity = Length of road in km over total catchment area.		RA_SC = RADensity/Max RADensity. Max RA Density = 21.5 km/km^2.
Projected Population Growth	F2020_2025_Population__Annual_G (or Growth) = Projected population growth between 2020-2025 in decimal form (e.g., 1% growth = 0.01) by catchment.	Growth ≤ 0 --> 0 < Growth ≤ 0.01 --> 0.01 < Growth ≤ 0.03 --> 0.03 < Growth ≤ 0.04 --> Growth > 0.04 -->	PG_SC = 0; PG_SC = 0.25; PG_SC = 0.5; PG_SC = 0.75; PG_SC = 1.
Expected Change in Development	ECRatio = area weighted average computed from (1*Megasite Area + 1*Inner Band +0.75*Outer Band)/total catchment area.		EC_SC = ECRatio.

Source: Multiple. See Appendix A for more information.

4.3.3 Total Score

The total score for the land use conversion probability was computed using the following formula:

$$\begin{aligned} Total\ Score = {} & 0.5 * Open\ Space\ Score + 1 * Road\ Density\ Score \\ & + 1.5 * Projected\ Population\ Score \\ & + 2 * Expected\ Change\ in\ Development\ Score \end{aligned}$$

where

$$Open\ Space\ Score\ = OS\_SC$$
$$Road\ Density\ Score = RA\_SC$$
$$Projected\ Population\ Score = PG\_SC$$
$$Expected\ Change\ in\ Development\ Score = EC\_SC$$

Each indicator score was designed to range between 0 and 1 and increasing weights were assigned in order of an indicator's expected influence on driving land use conversions. The lowest weight (0.5) was given to the open space score because this was a necessary but insufficient condition for land use conversions. Intermediate weights (1.0 and 1.5) were given to the road density score and the projected population score because they typically support and drive development, respectively. The highest weight (2) was given to the expected change in development score because the projected developments have a higher probability in land user conversions. Therefore, in the study area, the observed maximum total score is 3.67 (out of 5). Altogether, a high land use conversion total score is indicative of a catchment with a high percentage of open spaces for development, a high road density network to facilitate development, a high population growth rate to drive development, and a high likelihood of expected change in land use towards development.

Binned Total Scores: The natural break[12] classification tool was used in ArcGIS Pro to separate the total scores into three categories of probability of land use conversion: low, moderate, and high. This classification scheme is designed to naturally group similar values together while maximizing the differences between the classes or bins. The crosswalk from the land use conversion total scores to the binned total scores is as follows:

Total Score ≤ 0.8 →	Binned Total Score = 0 (Low)
0.8 < Total Score ≤ 1.8 →	Binned Total Score = 0.5 (Moderate)
Total Score > 1.8 →	Binned Total Score = 1 (High)

Section 5 discusses in more depth how these binned total scores were factored into the analysis of Focus Areas.

4.4 Future Land Use Results and Implications

Based on the analysis described above, VHB assessed the likelihood of land use conversion throughout the study area. Figure 4-2 shows the three land use conversion categories corresponding to low, moderate, and high likelihood of future land conversion.

High probability of land use conversion is concentrated primarily in areas adjacent to existing development and significant planned developments throughout the study area. Based on the analysis, 165.3 square miles, or approximately 27%, of the study area have a high likelihood of development. 298.8 square miles, or approximately 48%, of the study area are considered to have a moderate chance of land use conversion, and an additional 156.7 square miles, or 25%, of the study area have a low chance of development. Note that the catchments identified as Preservation Areas are not excluded in these results. The Preservation Areas are excluded in the Focus Area analysis (Section 5), which accounts for the land use conversion through the Probability of Land Use Conversion indicator.

This analysis is crucial to the development of Focus Areas because of the negative impacts future development has on the surrounding environment, including habitat and water quality. Considering these results in the identification of Focus Areas will help DMS consider where mitigation efforts may be best concentrated to have the highest chance of managing streams, wetlands, and buffers prior to the development within the watershed. For this reason, the results from this analysis have been carried forward into the identification of Focus Areas described in Section 5.

[12] Jenks, George F., 1967, "The Data Model Concept in Statistical Mapping," International Yearbook of Cartography 7: 186-190. 3434342

Section 6 discusses these results in conjunction with the Preservation Area and Focus Area results described in Section 3 and Section 5, respectively.

5

Focus Areas

VHB has identified Focus Areas, which are defined as "one or more catchments that are identified as a focus for detailed assessment/modeling activities as well as the development and implementation of management strategies (projects and/or institutional measures) to address concentrated areas of key stressors or assets." These Focus Areas will be primary targets for more detailed analysis carried out in Task 3 of the RWP. If additional data becomes available during the course of this analysis, the Focus Area model will be updated for the entire study area. Section 5.1 discusses the individual indicators and how they were chosen, and Section 5.2 describes the methodology used in the analysis.

5.1 Indicator Selection and Analysis

VHB developed indicators with which to assess the condition of each catchment in the study area. Indicators for the high-level review of Focus Areas in Task 1 are related to whether a catchment has stressors present that would benefit from restoration, whether there are habitat areas or other ecological features that have resource value, and whether restoration would be feasible based on land use and other social factors. Indicators should be balanced between the three major categories and their subcategories:

- Stressor Indicators
  - Water Quality Indicators
  - Hydrology Indicators
  - Habitat Indicators
- Ecological Indicators
- Social Indicators

In contrast, additional indicators for the detailed analysis to be done in Task 3 will be considered based on links to specific watershed stressors and the restoration strategies that may be applicable to these issues present in the watershed. Furthermore, indicator selection for Task 3 will have the following goals:

- Characterize watershed health for comparison and prioritization using DMS' three functional categories: water quality, habitat, and hydrology;
- Identify the underlying cause of watershed stressor (current and/or future);
- Identify and prioritize where improvement is most needed or will provide the most functional uplift; and
- Identify potential restoration and enhancement strategies that will likely be successful.

5.1.1 Considerations During Indicator Selection

With the above in mind, VHB made a few other considerations during the Focus Area indicator selection process.

5.1.1.1 Catchment Level vs. Cumulative Effects of Watershed Stressors

Figure 2-2 shows the large amount of area coming into our study area from outside contributing watersheds. Certain indicators may have only catchment level impacts whereas some may have a cumulative effect on downstream reaches. Based on the types of indicators used, certain cumulative effects may have a higher impact on downstream conditions than others. For example, pollutants from upstream reaches of a stream network may further degrade subsequent downstream reaches. For the Focus Area analysis contained in this report, VHB considered incremental indicators for the identification of areas where mitigation might be more feasible. For example, the water quality indicators were developed and scored based on a catchment-level analysis. VHB will analyze the potential cumulative effect for each indicator in Task 3, and cumulative vs. incremental effects will be considered when assigning mitigation strategies in Task 4.

5.1.1.2 Urban vs. Rural Areas

While developing indicators, it was important to keep in mind how urban areas differ from rural areas and how this may contribute to the results of the analysis. For example, while impervious area may be an applicable indicator for an urban area with a high value, for a comparable rural area with a small amount of impervious area, this indicator may appear to place the rural area in better standing than the urban area even when this is not the case, thereby skewing the results of the analysis. Careful consideration was given to this possibility during indicator development to avoid skewing the analysis one way or another.

For this reason, nutrient loading was considered from all manmade sources of pollution to identify areas of high nutrient or sediment loading regardless of predominant land use for the high-level Focus Area identification carried out in Task 1. During Task 3 of the RWP, VHB will consider the sources of these pollutants separately and in more detail.

5.1.2 Indicators Selected for Focus Area Identification

This section describes the final indicators selected for Task 1 and their importance. Table 5-1 lists the final indicators selected for the Focus Area identification analysis in Task 1. For a detailed description of the data utilized, see Table A-1 in Appendix A. The Focus Areas identified using the methodology described below will be carried forward in Task 3. One of the goals of Task 3 is to further analyze the cumulative impact of these indicators. If appropriate, additional data sources and indicators will be considered at that time.

5.1.2.1 Stressor: Water Quality Indicators

The Incremental Total Nitrogen Loading by Incremental Area, Incremental Total Phosphorous Loading by Incremental Area, the Incremental Total Suspended Solids (TSS) Loading over Incremental Area, and the Impaired Streams indicators are grouped collectively as the water quality indicators. Per the US Geological Survey (USGS) Spatially Referenced Regression on Watershed (SPARROW) model, the incremental load is defined as the load coming from the land area (e.g., the incremental area) that drains directly to the reach without passing through another reach. Overall, a higher water quality indicator score indicates a potential for nutrient, sediment, and other pollutant impairments that could benefit from mitigation efforts.

Incremental Total Nitrogen Loading by Incremental Area: This indicator identifies catchments with a high nitrogen load from man-made sources. The nitrogen loading indicator is an important factor in determining the Focus Areas because it allows DMS to focus mitigation efforts on potential eutrophication and other water quality problems associated with elevated nitrogen loads.

Incremental Total Phosphorous Loading by Incremental Area: This indicator identifies catchments with a high phosphorous load from man-made sources. The phosphorus loading indicator is an important factor in determining the Focus Areas because it allows DMS to focus mitigation efforts on potential eutrophication and other water quality problems associated with elevated phosphorous loads.

Incremental Total Suspended Solids Loading by Incremental Area: This indicator identifies catchments with a high TSS load from man-made sources. The TSS loading indicator is an important factor in determining the Focus Areas because it allows DMS to focus mitigation efforts on potential contaminant transport, aquatic habitat quality, and sedimentation problems associated with elevated TSS loads.

Impaired Streams: This indicator identifies catchments with high stream impairments. The impaired streams indicator is an important factor in determining the Focus Areas because it allows DMS to focus mitigation efforts on potential water quality problems associated with pollutants regulated by the Clean Water Act.

5.1.2.2 Stressor: Habitat Indicators

The Ratio of Disturbed Land within Riparian, Soil Susceptibility to Erosion, Fish Habitat, Fish Biological Integrity Class, Benthic Macroinvertebrate Habitat, and Benthic Macroinvertebrate Biological Integrity Class indicators were selected as the representative habitat[13] indicators.

Ratio of Disturbed Land within Riparian Zone: This indicator identifies catchments with high disturbed land use areas within 100-feet of the riparian zone. The ratio of disturbed lands within riparian zone indicator is an important factor in determining the Focus Areas because it allows DMS to identify and to focus mitigation efforts on highly valuable habitat areas for aquatic and terrestrial organisms that may be under threat by land use conversions.

Soil Susceptibility to Erosion: This indicator identifies catchments with highly erodible areas in any land use areas, as opposed to the specific land use analysis for Preservation Areas described in Section 3 of the report. The soil susceptibility to erosion indicator is an important factor in determining the Focus Areas because it allows DMS to identify catchments that may continue to degrade due to erosive soil conditions if left unaddressed.

Fish Habitat: This indicator identifies catchments that contain streams with a low habitat quality rating for fish communities as defined by the NCDEQ DWR Biological Assessment Branch.[14] The habitat quality is assessed at select fish assessment stations and is a direct indicator of habitat quality using characteristics such as channel modification, amount of instream habitat, type of bottom substrate, pool variety, riffle frequency, length and width, bank stability, light penetration, and riparian zone width. The fish habitat indicator is an important factor in determining the Focus Area because it allows DMS to identify catchments with low or declining habitat quality.

Fish Biological Integrity Class: This indicator identifies catchments that contain streams with a poor biological integrity class rating for fish communities as defined by the NCDEQ DWR Biological Assessment Branch.[14] The biological integrity class is assessed at select fish assessment stations and its evaluation includes fish species richness, composition, abundance, and condition. Fish communities represent the higher levels of the aquatic food web, and their biological integrity class is another reflection of habitat quality. Therefore, the fish biological integrity class indicator is an important factor in determining the Focus Area because it allows DMS to identify catchments with poor ratings for fish communities.

[13] The Habitat indicator category should not to be confused with the Contains Habitat indicator within the Ecological Indicator category.

[14] https://files.nc.gov/ncdeq/document-library/IBI%20Methods.2013.Final.pdf

Benthic Macroinvertebrate Habitat: This indicator identifies catchments that contain streams with a low habitat quality rating for benthic macroinvertebrates as defined by the NCDEQ DWR Biological Assessment Branch.[15] The habitat quality is assessed at select benthic macroinvertebrate assessment stations and it is a direct indicator of habitat quality using characteristics such as channel modification, amount of instream habitat, type of bottom substrate, pool variety, riffle frequency, length and width, bank stability, light penetration, and riparian zone width. The benthic macroinvertebrate habitat indicator is an important factor in determining the Focus Area because it allows DMS to identify catchments with low or declining habitat quality.

Benthic Macroinvertebrate Biological Integrity Class: This indicator identifies catchments that contain streams with a poor biological integrity class rating for benthic macroinvertebrates as defined by the NCDEQ DWR Biological Assessment Branch.[15] The biological integrity class is assessed at select benthic macroinvertebrate assessment stations and its evaluation includes benthic macroinvertebrate richness, composition, abundance, and condition. Benthic macroinvertebrates represent the lower levels of the aquatic food web, and their biological integrity class is another reflection of habitat quality. Therefore, the benthic macroinvertebrate biological integrity class indicator is an important factor in determining the Focus Area because it allows DMS to identify catchments with poor ratings for benthic macroinvertebrates.

5.1.2.3 Stressor: Hydrology Indicators

The Hydraulic Obstructions per Stream Length and Stream Type indicators were selected as the representative hydrology indicators.

Hydraulic Obstructions per Stream Length: This indicator identifies catchments with a high number of hydraulic obstructions (e.g., culverts and pipes) by stream length. The hydraulic obstructions per stream length indicator is an important factor in determining the Focus Areas because it allows DMS to identify areas with potential streamflow (and hence aquatic species passage) problems due to excessive flow obstructions.

Stream Type: This indicator identifies catchments with perennial streams, as these offer a higher mitigation value than intermittent streams. The stream type indicator is an important factor in determining the Focus Areas because it allows DMS to prioritize mitigation efforts on perennial streams that are flowing year-round and can generate a higher degree of functional uplift from mitigation efforts.

5.1.2.4 Ecological Indicators

Ecological indicators help identify areas with valuable natural resources that would benefit from mitigation or preservation efforts. The Stream Order, Contains Habitat, and the Water Supply Watershed indicators are grouped collectively as the ecological indicators. A higher

[15] https://files.nc.gov/ncdeq/Water%20Quality/Environmental%20Sciences/BAU/NCDWRMacroinvertebrate-SOP-February%202016_final.pdf

ecological indicator score indicates a potential for ecological resources that could benefit from mitigation efforts.

Stream Order: This indicator identifies catchments with low stream orders that are closer to headwater streams. The stream order indicator is an important factor in determining the Focus Areas because it allows DMS to focus mitigation efforts on headwater streams that has the potential to benefit downstream catchments too.

Contains Habitat: This indicator identifies catchments with habitat areas containing state listed plant and animal species; federally listed plant and animal species; and natural communities in aquatic, upland, and wetland habitats as designated by NCNHP. The contains habitat indicator is an important factor in determining the Focus Areas because it could potentially provide DMS with information about where habitat expansion projects may be most feasible and as an additional safeguard against encroachments into habitats that are home to protected flora and fauna.

Water Supply Watershed: This indicator identifies catchments with water supply watersheds. The water supply watershed indicator is an important factor in determining the Focus Areas because it allows DMS to make positive mitigation impacts by preventing further degradation or improving the water supply watersheds as an ecological resource.

5.1.2.5 Social Indicators

Social indicators help identify whether there is opportunity for functional uplift in a given watershed. The Developed Area and Agricultural Area indicators are grouped collectively as the social indicators. A higher social indicator score indicates a potential for existing development and farming impacts that could benefit from mitigation efforts.

Developed Area: This indicator identifies catchments with low developed areas. The developed area indicator is an important factor in determining the Focus Areas because it allows DMS to identify less developed areas with a higher opportunity for mitigation efforts to make functional improvements.

Agricultural Area: This indicator identifies catchments with high agricultural areas. The agricultural area indicator is an important factor in determining the Focus Areas because it allows DMS to identify and mitigate areas with a high potential for agricultural runoff problems.

5.1.2.6 Other Indicators

Probability of Land Use Conversion: This indicator identifies catchments with a high probability of land use conversion. The probability of land use conversion indicator is an important factor in determining the Focus Areas because it allows DMS to get ahead of potential future watershed impacts associated with rapid land use conversions.

Table 5-1 Focus Area Indicators

Indicator	Indicator Category	Indicator Subcategory	Description of Indicator	Data Source(s)
Incremental Total Nitrogen Loading by Incremental Area	Stressor	Water Quality	Indicates the total nitrogen load from manmade sources within a catchment normalized by area that may affect water quality.	USGS SPARROW
Incremental Total Phosphorus Loading by Incremental Area	Stressor	Water Quality	Indicates the total phosphorus load from manmade sources within a catchment normalized by area that may affect water quality.	USGS SPARROW
Incremental Total Suspended Solids Loading by Incremental Area	Stressor	Water Quality	Indicates the total suspended solids load from manmade sources within a catchment normalized by area that may affect water quality.	USGS SPARROW
Impaired Streams	Stressor	Water Quality	Indicates stream impairment based on the 2018 Integrated Report and identifies stream reaches upstream of impaired streams.	NCDEQ DWR
Ratio of disturbed land within Riparian Zone	Stressor	Habitat	Indicates the portion of a riparian buffer zone that has been degraded or denuded from forested or wetland land use ideal for habitat.	USEPA Watershed Index Online (WSIO) RZ 2016 NLCD
Soil Susceptibility to Erosion	Stressor	Habitat	Indicates catchments with a high soil erodibility factor that may contribute to erosion and water quality issues.	USDA NRCS
Fish Habitat	Stressor	Habitat	Indicates fish habitat quality based on fish community assessment data.	NCDEQ DWR
Fish Biological Integrity Class	Stressor	Habitat	Indicates fish biological integrity class based on fish community assessment data.	NCDEQ DWR
Benthic Macroinvertebrate Habitat	Stressor	Habitat	Indicates benthic macroinvertebrate habitat quality based on benthic macroinvertebrate assessment data.	NCDEQ DWR
Benthic Macroinvertebrate Biological Integrity Class	Stressor	Habitat	Indicates benthic macroinvertebrate biological integrity class based on benthic macroinvertebrate assessment data.	NCDEQ DWR
Hydraulic Obstructions per Stream Length	Stressor	Hydrology	Indicates the extent to which a stream reach has been interrupted by pipes, culverts, and dams within the catchment.	NCDEQ DEMLR Dam Inventory NCDOT Structure Locations NCDOT Non NBIS Pipes
Stream Type	Stressor	Hydrology	Indicates whether a stream type is perennial or intermittent.	NHDPlusV2

Source: Multiple. See Appendix A for more information.

Table 5-1 (cont.) Focus Area Indicators

Indicator	Indicator Category	Indicator Subcategory	Description of Indicator	Data Source(s)
Stream Order	Ecological	N/A	Indicates whether a stream is located upstream or downstream in the study area based on stream order.	USGS NHDPlusV2
Contains Habitat	Ecological	N/A	Indicates whether a catchment contains critical or occupied habitat of a species of concern.	NCNHP Habitat Data
Water Supply Watershed	Ecological	N/A	Indicates whether a catchment contains surface waters protected for human use or consumption.	NCDEQ DWR Surface Water Classifications
Developed Area	Social	N/A	A higher % developed area (urban) indicates less opportunity for mitigation efforts.	2016 NLCD
Agricultural Area	Social	N/A	Higher % Ag indicates more need and opportunity for mitigation.	2016 NLCD
Probability of Land Use Conversion	N/A	N/A	A higher land use conversion percentage indicates a higher need for mitigation efforts.	(See Section 4)

Source: Multiple. See Appendix A for more information.

5.2 Focus Area Analysis

This section describes the overall methodology, the key preprocessing details, and the total scoring schemes used in analyzing the Focus Area indicators.

5.2.1 Overall Methodology

The overall methodology is similar to the steps described in Section 3.2.1 for the Preservation Areas. There are two key differences:

1. The total score was computed from the subtotal of the unique indicator categories: Water Quality, Habitat, Hydrology, Ecological, Social, and Land Use Conversion.
2. Post-scoring filters were applied on the total score to remove the Preservation Area clusters and the highly managed area (greater than 50%) catchments.

More pre-processing and scoring details are provided for each indicator in the following subsections. Quality control and quality assurance reviews were conducted throughout during the pre-processing and scoring model development.

5.2.2 Pre-Processing of Indicators

This section describes how and why each of the indicator scores were developed.

Incremental Total Nitrogen Loading by Incremental Area: The man-made incremental nitrogen load is computed using the USGS SPARROW incremental nitrogen loads that are attributable to wastewater point sources, swine operations, poultry operation, development, and farm fertilizer. The incremental nitrogen load attributable to atmospheric deposition was excluded because this represents natural conditions that were outside the control and scope of DMS' mitigation efforts. Therefore, the incremental total nitrogen loading by incremental area score (TNM_SC) is calculated using a ratio of the man-made incremental nitrogen load over the incremental area (or total catchment area) (see scoring metric in Table 5-2). This nitrogen loading ratio ranged between 0 and 156,433 kg/(yr*km^2) with a median value of 152 kg/(yr*km^2). Given that the nitrogen loading ratio contained several extremely high outliers, the scoring scheme was designed to rescale the loads on a basis of potentially impacting the receiving waters and needing mitigation. Using quantile analysis accounting for outliers, the sum of the upper limit of the third quartile and the interquartile range (517 kg/(yr*km^2)) was used as the representative maximum by which to normalize the nitrogen loading ratio. Any nitrogen loading ratio greater than 517 kg/(yr*km^2) received a score of 1 to represent a high load impact.

Incremental Total Phosphorous Loading by Incremental Area: The man-made incremental phosphorous load is computed using the USGS SPARROW incremental phosphorous loads that are attributable wastewater point sources, poultry operations, pasture and animal grazing, and farm fertilizer. The incremental phosphorous load attributable to phosphorus content of bed sediment in headwater streams and legacy soil phosphorus were excluded because they represent natural conditions that were outside the control and scope of DMS' mitigation efforts. Therefore, the incremental total phosphorous loading by incremental area score (TPM_SC) is calculated using a ratio of the man-made incremental phosphorous load over the incremental area (or total catchment area) (see scoring metric in Table 5-2). This phosphorous loading ratio ranged between 0 and 121,067 kg/(yr*km^2) with a median value of 24 kg/(yr*km^2). Given that the phosphorous loading ratio contained several extremely high outliers, the scoring scheme was designed to rescale the loads on a basis of potentially impacting the receiving waters and needing mitigation. Using quantile analysis accounting for outliers, the sum of the upper limit of the third quartile and the interquartile range (96 kg/(yr*km^2)) was used as the representative maximum by which to normalize the phosphorous loading ratio. Any phosphorous loading ratio greater than 96 kg/(yr*km^2) received a score of 1 to represent a high load impact.

Incremental Total Suspended Solids Loading by Incremental Area: The man-made incremental TSS load is computed using the USGS SPARROW incremental TSS load attributable to land use change disturbance, cropland practices, development, channel erosion, and streambank erosion. Therefore, the incremental total TSS loading by incremental area score (TSS_SC) is calculated using the ratio of the man-made incremental TSS load over the incremental area (or total catchment area) (see scoring metric in Table 5-2). This TSS loading ratio ranged between 0 and 51,677 Mg/(yr*km^2) with a median value of 7 Mg/(yr*km^2). Given that the TSS loading ratio contained several extremely high outliers, the scoring scheme was designed to rescale the loads on a basis of potentially impacting the receiving waters and needing mitigation. Using quantile analysis accounting for outliers, the sum of the upper limit of the third quartile and the interquartile range (43 Mg/(yr*km^2)) was used as the representative maximum by which to normalize the TSS loading ratio. Any TSS loading ratio greater than 43 Mg/(yr*km^2) received a score 1 to represent a high load impact.

Impaired Streams: The NCDEQ DWR 2018 Integrated Report 303d list was used to identify the impaired streams, and only impaired streams with a category 4 or 5 (See Table 2-3) were included in this analysis. This filtered list of impaired streams excluded pollutants such as mercury, other heavy metals, and pesticides, which are outside of the scope of DMS' mitigation efforts. The impaired streams score (IR_SC) is calculated using the normalized sum of the integrated score and the upstream score (see scoring metric in Table 5-2). The integrated score represents if a catchment contains a category 4 or 5 impaired stream, and the upstream score represents if a catchment was a contributing tributary to a downstream impaired stream. For example, an upstream category 4 stream would receive an integrated score of 1 and an upstream score of 0.5. The sum of these two scores was then normalized using1.5 (the maximum value possible) to obtain the impaired stream score. Overall, this scoring scheme was designed to favor upstream impaired catchments because mitigation efforts targeting upstream catchments has the potential to improve downstream conditions.

Ratio of Disturbed Land within Riparian Zone: The US Environmental Protection Agency's (USEPA) Watershed Index Online (WSIO) was used to identify the 100-feet buffer zone, and the 2016 NLCD data was used to identify the disturbed land uses. The disturbed land uses are defined as: developed, open space; developed, low intensity; developed, medium intensity; developed, high intensity; barren land; hay/pasture; and cultivated crop. The final ratio of disturbed land within riparian zone score (BC_SC) is calculated as the ratio of the disturbed land use area within the riparian zone over the total riparian zone area (see scoring metric in Table 5-2).

Soil Susceptibility to Erosion: The soil data was obtained through the USDA NRCS, and its K factor rating for whole soil (or the susceptibility of soil to erosion and the rate of runoff) was used to identify the erodible soil. In the study area, a K factor rating for whole soil of greater than or equal to 0.4 was used as the threshold for highly erodible soil. This threshold was chosen because it typically represents soils with a high silt content that are easily detached, thereby producing high rates of runoff.[8] Therefore, the soil susceptibility to erosion score (KF_SC) is calculated using the ratio of the highly erodible soil area over the total catchment area (see scoring metric in Table 5-2).

Fish Habitat: The fish habitat values were obtained from NCDEQ DWR. NCDEQ collects fish community data from select sampling stations across North Carolina, and a total of 12 fish assessment stations were identified within the study area. If multiple habitat values were collected at a sampling station, then the latest sampling results were retained for this indicator analysis. In the study area, the latest sampling dates for each unique station ranged between 2003 and 2018. In addition, a distance buffer of 200 meters was applied to each station. This buffer was used to be consistent with the fish assessment sampling guidance. Given that the observed fish habitat values ranged between a score of 51 and 91 (on a scale of 0 to 100, where 100 represents excellent habitat) in the study area, these habitat values were binned for the fish habitat score (FISHAB_SC). More specifically, a fish habitat score of 1 represents a habitat value less than 70; a score of 0.5 represents a habitat value greater than or equal to 70 and less than 85; and a score of 0 represents a habitat value greater than or equal to 85 (see scoring metric in Table 5-2). If multiple fish assessment stations were located within a catchment, then the station with the minimum habitat value was taken. This scoring scheme takes into consideration the range of scores observed in the study area and is designed to prioritize the more degraded habitats for mitigation considerations. Altogether, the fish habitat score by catchment is calculated by attributing the latest and minimum habitat value located within that catchment. Note that catchments without a fish assessment station or fish habitat quality score received a score of 0. This score of 0 is not an indication of habitat quality; rather, it is an indication of the lack of data. Section 6 will discuss how VHB plans to address this data gap moving forward.

Fish Biological Integrity Class: The fish biological integrity class ratings were obtained from NCDEQ DWR. These stations are the same as the fish assessment stations described in the fish habitat indicator. Therefore, the same pre-processing steps were applied to obtain the latest ratings and generate the buffered stations. Given that the fish biological integrity class can have a rating of not rated, not impaired, poor, fair, good-fair, good, and excellent, the fish biological integrity class score (FISBIO_SC) reflects these values in reverse scoring order. For example, a fish biological integrity class score of 1 represents a poor rating; a score of 0 represents an excellent rating; and the scores in between (in increments of 0.25) represent the fair, good-fair, and good ratings (see scoring metric in Table-2). Per NCDEQ's fish assessment standard operating procedures, not impaired and not rated values indicate that the biological integrity class was not evaluated at the site.[14] If multiple fish assessment stations were located within a catchment, then the station with the minimum fish biological integrity class rating (excluding not rated and not impaired) was taken. This scoring scheme is designed to prioritize sites with lower biological integrity class ratings for mitigation considerations. Altogether, the fish biological integrity class score by catchment is calculated by attributing the latest and minimum biological integrity class rating located within that catchment. Note that catchments without a fish assessment station or fish biological integrity score (e.g., not rated and not impaired) received a score of 0. This score of 0 is not an indication of biological integrity class; rather, it is an indication of the lack of data. Section 6 will discuss how VHB plans to address this data gap moving forward.

Benthic Macroinvertebrate Habitat: The benthic macroinvertebrate habitat values were obtained from NCDEQ DWR. NCDEQ collects benthic macroinvertebrate data from select sampling stations across North Carolina, and a total of 51 benthic macroinvertebrate stations were identified within the study area. Of the 51 stations, only 32 stations had habitat quality values. If multiple habitat values were collected at a sampling station, then the latest sampling results were retained for this indicator analysis. In the study area, the latest sampling dates for each unique station ranged between 2001 and 2018. In addition, a distance buffer of 200 meters was applied to each station. This buffer was used to be consistent with the benthic macroinvertebrate sampling guidance. Given that the observed benthic macroinvertebrate habitat values ranged between a score of 55 and 96 (on a scale of 0 to 100, where 100 represents excellent habitat) in the study area, these habitat values were binned for the benthic macroinvertebrate habitat score (BENHAB_SC). More specifically, a benthic macroinvertebrate habitat score of 1 represents a habitat value less than 70; a score of 0.5 represents a habitat value greater than or equal to 70 and less than 85; and a score of 1 represents a habitat value greater than or equal to 85 (see scoring metric in Table 5-2). If multiple benthic macroinvertebrate stations were located within a catchment, then the station with the minimum habitat value was taken. This scoring scheme takes into consideration the range of scores observed in the study area and is designed to prioritize the more degraded habitats for mitigation considerations. Altogether, the benthic macroinvertebrate habitat score by catchment is calculated by attributing the latest and minimum habitat value located within that catchment. Note that catchments without a benthic macroinvertebrate station or benthic macroinvertebrate habitat quality score received a score of 0. This score of 0 is not an indication of habitat quality; rather, it is an indication of the lack of data. Section 6 will discuss how VHB plans to address this data gap moving forward.

Benthic Macroinvertebrate Biological Integrity Class: The benthic macroinvertebrate biological integrity class ratings were obtained from NCDEQ DWR. These stations are the same as the benthic macroinvertebrate stations described in the benthic macroinvertebrate habitat indicator. Of the 51 benthic macroinvertebrate stations, only 39 stations had a rating between poor and excellent. The same pre-processing steps were applied to obtain the latest ratings and generate the buffered stations. Given that the benthic macroinvertebrate biological integrity class can have a rating of not rated, not impaired, poor, fair, good-fair, good, and excellent, the benthic macroinvertebrate biological integrity class score (BENBIO_SC) reflects these values in reverse scoring order. For example, a benthic macroinvertebrate biological integrity class score of 1 represents a poor rating; a score of 0 represents an excellent rating; and the scores in between (in increments of 0.25) represent the fair, good-fair, and good ratings (see scoring metric in Table-2). Per NCDEQ's benthic macroinvertebrate standard operating procedures, not impaired and not rated values (12 out of 51 stations) indicate that the biological integrity class was not evaluated at the site.[15] If multiple benthic macroinvertebrate stations were located within a catchment, then the station with the minimum benthic macroinvertebrate biological integrity class rating (excluding not rated and not impaired) was taken. This scoring scheme is designed to prioritize sites with lower biological integrity class ratings for mitigation considerations. Altogether, the benthic macroinvertebrate biological integrity class score by catchment is calculated by attributing the latest and minimum biological integrity class rating located within that catchment. Note that catchments without a benthic macroinvertebrate station or benthic macroinvertebrate biological integrity score (e.g., not rated and not impaired) received a score of 0. This score of 0 is not an indication of biological integrity class; rather, it is an indication of the lack of data. Section 6 will discuss how VHB plans to address this data gap moving forward.

Hydraulic Obstructions per Stream Length: The total number of dams, structures, and pipes were counted as hydraulic obstructions if they were within 250 ft of a stream or river using the NCDEQ Department of Energy, Mineral, and Land, Resources (DEMLR), NCDOT, and USGS NHDPlusV2 stream data. The NCDOT structures dataset was filtered to use culverts and pipes only. Bridges and other structures were excluded in this analysis because they are less likely to affect fish passage. The NHDPlusV2 dataset was also filtered to exclude any artificial pathways, such as canals, ditches, and pipelines. A stream buffer was then applied due to minor geolocation offsets between the obstructions and the stream. The final hydraulic obstructions per stream length score (HO_SC) is calculated using a normalized ratio of the total count of hydraulic obstructions per river kilometer within each catchment. Given that the hydraulic obstructions per stream length contained several extremely high outliers (maximum at 401 count/km), this score was designed to focus on potentially high impacts on flow passage (see scoring metric in Table 5-2). Using quantile analysis accounting for outliers, the sum of the upper limit of the third quartile and the interquartile range (0.9 count/km) was used as the representative maximum by which to normalize the hydraulic obstructions per stream length results. Any ratio greater than 0.9 count/km received a score of one to represent a high impact on flow passage.

Stream Type: The USGS NHDPlusV2 dataset was used to classify the stream type as perennial or intermittent. Only streams or rivers were considered in the study area. Artificial pathways, such as canals, ditches, and pipelines, were excluded from the stream type determination. The stream type score (ST_SC) is designed to favor perennial streams, which received a score of one (see scoring metric in Table 5-2). Intermittent streams received a score of zero.

Stream Order: The USGS NHDPlusV2 dataset was used to identify the streams orders, which can range from 1 to 7, by catchment. The stream order score (NHDP_SC) is scored in reverse to favor the catchments that were closer to the headwater streams (see scoring metric in Table 5-2).

Contains Habitat: The contains habitat indicator score (HAB_SC) is calculated based on the presence of habitats as described previously with 1-4 accuracy (see accuracy explanation in Section 3.2). Catchments containing habitat areas ranging from low to very high accuracy received a score equal to 1. The presence of habitats with very low/unknown accuracy or the absence of habitats received a score of 0 (see scoring metric in Table 5-2). This scoring scheme was designed to highlight the importance of habitat areas, regardless of size, in selecting the Focus Areas.

Water Supply Watershed: In the study area, the water supply watershed classifications ranged between WS-III to WS-IV according to the NCDEQ DWR surface water classifications (see Section 2.3). If a catchment had multiple streams with different water supply watershed classifications, the higher (or more developed watershed) classification was taken to ensure that the more stressed waters were represented the water supply watershed score (WSW_SC, see scoring metric in Table 5-2). By choosing the higher water supply watershed classification, this marks the key difference (and hence purpose) between the Preservation Area and Focus Area water supply watershed indicators.

Developed Area: Using the 2016 NLCD data, the developed land use areas were defined as: developed, open space; developed, low intensity; developed, medium intensity; developed, high intensity; and open water. The final developed area score (DA_SC) is calculated using one minus the normalized ratio of the developed area over the total catchment area (see scoring metric in Table 5-2). This scoring scheme was designed to favor catchments with a lower developed area because this represents a potential for a better return on mitigation investments than compared to highly developed areas. Given that most of the developed areas within each catchment are small compared to the total catchment size, quantile analysis accounting for outliers was used to identify a representative high developed area threshold. The sum of the upper limit of the third quartile and the interquartile range (0.2) was used as the representative maximum by which to normalize the developed area over total catchment area ratio. Any ratio greater than 0.2 received a normalized ratio of 1 (or score of 0) to represent a highly developed catchment.

Agricultural Area: This indicator identifies catchments with high agricultural areas. The agricultural area indicator is an important factor in determining the Focus Areas because it allows DMS to identify and mitigate areas with a high potential for agricultural runoff problems. The agricultural land use areas were defined as hay/pasture and cultivated crops using the 2016 NLCD data. The final agricultural area score (AG_SC) is calculated using a normalized ratio of the agricultural area over the total catchment area (see scoring metric in Table 5-2). Quantile analysis accounting for outliers was used to identify a representative high agricultural area threshold. The sum of the upper limit of the third quartile and the interquartile range (0.93) was used as the representative maximum by which to normalize the agricultural area over total catchment area ratio. Any ratio greater than 0.93 received a score of 1 to represent a high agricultural area.

Probability of Land Use Conversion: The binned total score from the land use conversion analysis (Section 4.2.3) was used as the probability of land use conversion score (LUC_SC) in this analysis (see scoring metric in Table 5-2).

Table 5-2 Focus Area Indicator Scoring

Indicator	Variable to Be Scored	Scoring Metric	
Incremental Total Nitrogen Loading by Incremental Area	TN_MPLITA = Man-made nitrogen load incremental total over incremental area.	TN_MPLITA ≤ 517 --> Otherwise -->	TNM_SC = TN_MPLITA/517; TNM_SC = 1. 517 kg/(yr*km^2) was selected as the representative maximum.
Incremental Total Phosphorus Loading by Incremental Area	TP_MPLITA = Man-made phosphorous load incremental total over incremental area.	TP_MPLITA ≤ 96 --> Otherwise -->	TPM_SC = TP_MPLITA/96; TPM_SC = 1. 96 kg/(yr*km^2) was selected as the representative maximum.
Incremental Total Suspended Solids Loading by Incremental Area	TSS_PLITA = Total suspended solids incremental load over incremental area.	TSS_PLITA ≤ 43 --> Otherwise -->	TSS_SC = TSS_PLITA/43; Otherwise TSS_SC = 1. 43 Mg/(yr*km^2) was selected as the representative maximum.
Impaired Streams	IR_US = Normalized Integrated score with upstream score = (Integrated + US_SC)/1.5.		IR_SC = IR_US.
Ratio of disturbed land within Riparian Zone	BCRatio = The intersecting area of the disturbed land use in riparian buffer over riparian buffer area in each catchment.		BC_SC = BCRatio.
Soil Susceptibility to Erosion	KFRatio = Erodible area (K factor ≥ 0.4) over the total catchment area.		KF_SC = KFRatio.
Fish Habitat	MIN_Habitat_Score (FH)= The minimum fish habitat value if multiple stations were in a catchment.	FH < 70 --> 70 ≤ FH < 85 --> FH ≥ 85 -->	FISHAB_SC = 1; FISHAB_SC = 0.5; FISHAB_SC = 0.
Fish Biological Integrity Class	MIN_BioNum (FB) = The minimum fish biological integrity rating if multiple stations were in a catchment.	FB = 1 Poor --> FB = 2 Fair --> FB = 3 Good-Fair --> FB = 4 Good --> FB = 5 Excellent --> FB = 77 Not Impaired --> FB = 88 Not Rated -->	FISBIO_SC = 1; FISBIO_SC = 0.75; FISBIO_SC = 0.5; FISBIO_SC = 0.25; FISBIO_SC = 0; FISBIO_SC = 0; FISBIO_SC = 0.
Benthic Macroinvertebrate Habitat	MIN_Total_Habitat__100_ (BH) = The minimum benthic macroinvertebrate habitat value if multiple stations were in a catchment.	BH < 70 --> 70 ≤ BH < 85 --> BH ≥ 85 -->	BENHAB_SC = 1; BENHAB_SC = 0.5; BENHAB_SC = 0.

Source: Multiple. See Appendix A for more information.

Table 5-2 (cont.) Focus Area Indicator Scoring

Indicator	Variable to Be Scored	Scoring Metric	
Benthic Macroinvertebrate Biological Integrity Class	MIN_LRateNum (BB) = The minimum benthic macroinvertebrate biological integrity class rating if multiple stations were in catchment.	BB = 1 Poor --> BB = 2 Fair --> BB = 3 Good-Fair --> BB = 4 Good --> BB = 5 Excellent --> BB = 77 Not Impaired --> BB = 88 Not Rated -->	BENBIO_SC = 1; BENBIO_SC = 0.75; BENBIO_SC = 0.5; BENBIO_SC = 0.25; BENBIO_SC = 0; BENBIO_SC = 0; BENBIO_SC = 0.
Hydraulic Obstructions per Stream Length	CTRKM = Count of total dams, pipes, and structure over river kilometer in each catchment.	CTRKM ≤ 0.9 --> Otherwise -->	HO_SC = CTRKM/0.9; HO_SC = 1. 0.9 count/km was selected as the representative maximum.
Stream Type	SRType = Stream classified as perennial or intermittent.	SRType = Perennial --> SRType = Intermittent -->	ST_SC = 1; ST_SC = 0.
Stream Order	NHD_SO = Stream order from the StreamOrde field.	NHD_SO = 1 --> NHD_SO = 2 or 3 --> NHD_SO = 4 or 5 --> NHD_SO = 6 or 7 -->	NHDP_SC = 1; NHDP_SC = 0.7; NHDP_SC = 0.3; NHDP_SC = 0.
Contains Habitat	HAB_YES = Presence of habitat (accuracy ≤ 4 = 1) and very low/unknown or absence of habitat (= 0).		HAB_SC = HAB_YES.
Water Supply Watershed	WSW_CLASS = Maximum WSW_Class if catchment had multiple streams.	WS_Class = 5 --> WSW_Class = 4 --> WSW_Class 3 --> Otherwise -->	WSW_SC = 1; WSW_SC = 0.75; WSW_SC = 0.5; WSW_SC = 0.
Developed Area	DARatio = The NLCD developed are over the total catchment area.	DARatio ≤ 0.2 --> Otherwise -->	DA_SC = 1 - DARatio/0.2; DA_SC = 0. 0.2 was selected as the representative maximum.
Agricultural Area	AGRatio = The NLCD agriculture area over the total catchment area.	AGRatio ≤ 0.93 --> Otherwise -->	AG_SC = AGRatio/0.93; AG_SC = 1. 0.93 was selected as the representative maximum.
Probability of Land Use Conversion	LUC = Binned total scores (e.g., 0, 0.5, and 1) from the Land Use Conversion analysis.		LUC_SC = TOT_SC_BIN.

Source: Multiple. See Appendix A for more information.

5.2.3 Total Score

Figure 5-1 shows the total scores for the Focus Areas with the Preservation Area clusters and the highly managed area (greater than 50%) excluded from the analysis. The Focus Area total score was determined from the sum of its subtotal scores:

$$\begin{aligned} Total\ Score = 2 * (Water\ Quality\ Score + Habitat\ Score + Hydrology\ Score) \\ + Ecological\ Score + Social\ Score + 2 * Land\ Use\ Conversion\ Score \end{aligned}$$

where the subtotal scores are:

$$\begin{aligned}
&Water\ Quality\ Score = (TNM_SC + TPM_SC + TSS_SC + IR_SC)/4 \\
&Habitat\ Score^{16} = (BC_SC + KF_SC + FISHAB_SC + FISBIO_SC + BENHAB_SC \\
&\qquad + BENBIO_SC)/6 \\
&Hydrology\ Score = (HO_SC + ST_SC)/2 \\
&Ecological\ Score = (NHDP_SC + HAB_SC + WSW_SC)/3 \\
&Social\ Score = (DA_SC + AG_SC)/2 \\
&Land\ Use\ Conversion\ Score = LUC_SC
\end{aligned}$$

Each contributing indicator score was designed to range between 0 and 1, and the subtotal scores were normalized by the number of contributing indicators so that they also range between 0 and 1. For the Focus Area total scores, different weights were assigned to the subtotal scores. The stressor indicators (water quality, habitat, and hydrology) and the land use conversion indicator both received a weight of 2. Higher weights were assigned to the stressor indicators because they are reflective of direct watershed impacts involving nutrients, sediments, other pollutants, buffer encroachments, erosive soils, fish habitat, fish biological integrity, benthic macroinvertebrate habitat, benthic macroinvertebrate biological integrity, and flow passage. Higher weights were also assigned to the land use conversion indicator due to the emphasis from DMS on getting ahead of future watershed problems. Overall, the observed maximum total score is 7.1 (out of 10) in the study area.

Post-scoring filters: Preservation Area clusters and the highly managed areas (where the managed area in a catchment is greater than 50%) were used as post-scoring filters to remove these catchments from the Focus Areas.

Cluster analysis: Clustering analysis was performed on the filtered total scores. While ArcGIS has a Cluster and Outlier Analysis tool, this was not used because it created inconsistent results when compared to the actual total scores (see Section 3.2.3 for more discussions on the cluster tool). Instead, the Focus Area clusters were identified using a total score threshold (Total Score greater than 4) and Megasite location considerations. First, in order to be conservative, a moderate total score threshold was used to capture more catchments and standalone catchments that exceeded this threshold were retained for further investigation in Task 3. Second, while the Land Use Conversion indicator was helpful in determining where land use is likely to occur within the study area, the clustering method did not always pick up the Megasite areas due to the combination of the many other indicators considered. Therefore, the Focus Area clusters were reviewed in conjunction with the Megasite locations

[16] This habitat score is different from the one used in Preservation Area analysis described in Section 4. This score should also not be confused with the Contains Habitat score within the Ecological Indicator category.

to ensure that these areas were a high priority to be examined for further analysis in Task 3. As such, any catchment with any Megasite area was included as a cluster regardless of their Focus Area Total Score or managed area composition. Overall, the combination of the Megasite and Total Score filter identified 341 catchments as Focus Areas, representing approximately 35% of the study area.

5.3 Focus Area Results and Recommendations

The goal of the above analysis was to identify areas with known water quality, hydrology, and habitat issues that also contain beneficial social and ecological factors that would be well lent to further, more detailed analysis of the sources and causes of watershed issues in Task 3 of the RWP. Figure 5-2 shows a map of the areas VHB recommends as Focus Areas.

Altogether, a total of 341 catchments was identified as Focus Areas. This represents 217.2 square miles, or approximately 35%, of the study area with either an elevated total score or Megasite area designation. The results show that the most prominent clusters occur near and around existing and projected developments. For example, there are two major Focus Area corridors along US 421 (which passes through Liberty, Staley, Siler City, and Goldston) and US 501 (which passes through Chapel Hill, Pittsboro, and Sanford).

These Focus Areas will be the primary targets for detailed analysis in Task 3. VHB recognizes that more information may come to light during the subsequent Tasks of this RWP that may require revisions to the recommended Focus Areas; therefore, VHB will take into consideration all data as it relates to the entire study area.

Section 6 discusses these results in conjunction with the Preservation Areas and Land Use Conversion results from Section 3 and 4, respectively.

6

Results and Next Steps

Based on the results of the analysis of indicator groups outlined above, catchments were placed into three categories: Preservation Areas, Focus Areas, and the remainder of the study area into a Non-Study category, which VHB has identified as areas which are not strong contenders for either scenario. This section will discuss the results from the Preservation Area, Land Use Conversion, and Focus Areas (Sections 3.3, 4.4, and 5.3, respectively) sections in more detail. While the entire study area will be analyzed by the model during Task 3, particular attention will be paid to the Focus Areas identified herein. VHB will remain open to the revision of Focus Areas as additional data and information is incorporated and analyzed.

6.1 Preservation Areas

Preservation is crucial to maintaining pristine watersheds before they can be developed. For example, preservation efforts can prevent urbanization that adversely impacts habitat and water quality throughout a watershed. Figure 5-2 shows the Preservation Area clusters in conjunction with the Focus Area clusters.

The discussion in Section 3 of this report describes how VHB has identified the areas of high environmental quality that should be targets for preservation. As previously discussed in Section 3.3, the resulting Preservation Areas VHB has identified make up 91 square miles, or approximately 15%, of the study area.

While the headwater areas further upstream in the study areas were expected to have a large amount of Preservation Areas, they are drier, tend to be wetland free, and are primarily developed or agricultural land uses. For these reasons, the larger rivers and their floodplains end up having larger expanses of forest cover that contribute to the positive habitat and water quality features ideal for preservation efforts. The largest clusters of high scoring catchments with the beneficial environmental features discussed above occur along the major river corridors in the study area, with smaller areas located throughout the study area. By focusing preservation efforts in these areas, DMS and their partners have the opportunity to expand areas that are already protected by conservation easements and prevent additional habitat and water quality degradation before it can occur.

6.2 Land Use Conversion

Land use conversion is an important factor to consider during Focus Area development due to the additional water quality, hydrological, and habitat impacts of development on a watershed. Figure 4.2 shows the distribution of land use conversion probability throughout the study area. VHB analyzed the probability of land use conversion within the study area using factors such as population growth, amount of open space available to be developed, and proximity to existing development, among others. See Section 4 for detailed discussion about indicators and scoring methodology.

Based on the factors described in Section 4, VHB divided the study area into three different categories. Areas with a high probability of land use conversion were given the highest priority in the identification of Focus Areas, areas with a moderate probability of land use conversion were given partial consideration, and areas with a low probability of land use conversion did not have an effect when analyzing and identifying Focus Areas.

As discussed in Section 4.4, a total of 165.3 square miles, or approximately 27% of the study area, are considered to have a high likelihood of land use conversion. These areas are mostly concentrated around existing development and significant proposed development within the study area. A total of 298.8 square miles, or approximately 48%, of the study area are considered to have a moderate likelihood of land use conversion. And a total of 156.7 square miles, or approximately 25%, of the study area are considered to have a low likelihood of land use conversion.

6.3 Focus Areas for Further Study

The goal of the Cape Fear 02/03 RWP is to identify areas with hydrological, habitat, and water quality issues that can be traced back to their underlying causes and to recommend mitigation strategies to address those issues. Currently, Focus Areas identified during Task 1 make up 217.2 square miles, or 35%, of the study area, as shown in Figure 5.2 and discussed in Section 5.3.

Large clusters of Focus Areas identified in this report are concentrated around areas with a high potential for land use conversion and along major US routes through the study area as discussed in Section 4 and Section 6.2. These areas are considered high priority for more detailed Focus Area analysis due to their heightened likelihood to experience land use changes that will adversely affect habitat and water quality in the area.

As shown in Figure 5-2 mentioned above, there are some locations within the Focus Areas where there are gaps, or "donut holes". Some of these areas are legitimate gaps due to low-scoring highly urbanized areas within otherwise high-scoring Focus Areas; others may need closer review during Task 3 to ensure that areas that should be included in the Focus Area analysis do not get excluded.

The clustering method used in Task 1 for preliminary identification of Focus Areas also resulted in some small, singular catchments getting tagged as Focus Areas, even when surrounding catchments did not. These catchments were included in the Focus Area figures in order to be conservative. These areas may warrant a closer review in Task 3 to determine if they offer less opportunity for mitigation as compared to their larger counterparts.

As discussed previously, these are preliminary findings to direct VHB in the execution of subsequent tasks and may be revised based on discovery of additional data and information later in the RWP process.

6.4 Non-Study Areas

While the identified Focus Areas will be the main concern for further analysis, the model developed during Task 3 will be set up in a way to allow the analysis of all catchments in the study area. Thus, areas that were not tagged as Preservation or Focus Areas during the Task 1 analysis will not be completely discarded from consideration. VHB will maintain an open-minded approach and consider all additional data in Task 3 that may require changes to the identified Focus Areas and will continue to refine them as necessary.

6.5 Next Steps

During Task 1, VHB identified catchments within the study area that were a high priority for preservation efforts by DMS, as well as catchments with a high level of stressor, ecological, and social factors that warrant additional consideration for mitigation efforts. The subsequent tasks will compare DMS' Targeted Resource Areas (TRA) with the Regional Watershed Plan, further explore the underlying watershed issues that are causing habitat and water quality degradation in the Focus Areas, and develop management strategies specifically targeted at addressing the identified watershed issues.

Task 2 will involve comparing the Focus Area results initially developed in this report and any revisions made during Task 3 with previous TRA analysis carried out by the Division of Mitigation Services. The purpose of this task will be to compare the methodology used by

DMS in their initial analysis and the methodology VHB used to identify Focus Areas during Task 1 of the RWP. The results of each will be considered to determine how and why they differ.

Task 3 will involve further study of Focus Areas identified in this report. In Section 2.5, VHB outlined data gaps and proposals to fill these data gaps, including field work. VHB will conduct this field work in a way that will supplement available data within the study area and to provide a wider range of available datapoints with which to verify the assumptions made in this report. **More specifically, a technical memo outlining the next steps will be developed prior to commencement of Task 3.** Action items in the technical memo may include (but is not limited to) discussions on the following:

Habitat Indicator Improvements:

- VHB will use the USDA hydric soil maps as a baseline and conduct surveys at sites near potential hydric soils in order to verify presence and prevalence for potential wetland restoration.
- VHB will conduct surveys at new habitat sites in order to fill in the gap and to expand the coverage of the existing fish assessment and benthic macroinvertebrate monitoring stations. Given the large size of the study area, VHB will also develop a spatial interpolation approach to best synthesize the existing and collected data. The field surveys and spatial analysis will improve the data quality and contribute to a more robust habitat score for Focus Area analysis.
- VHB will use the hydric and habitat field survey sites (which may be different) to spot-check and to verify the existing data on land use, riparian buffers, erosive soil conditions, and culvert sizes.

Hydrology Indicator Improvements:

- VHB will investigate the feasibility of using USGS Stream Stats to develop a predictive relationship between drainage area and culvert sizing. The purpose of this analysis is to identify culvert sites that may be undersized, thereby posing a greater risk to scour and erosion and stream connectivity.
- VHB will also use the USGS Stream Stats drainage areas to estimate base flow. If the base flow is high, then the construction or mitigation costs for upsizing the culvert may get out of the cost-effective range. As a result, this may be used as a filter for mitigation feasibility.
- VHB will continue to reach out to external entities in order to obtain additional information on hydrologic obstructions.

Land Use Conversion Indicator Improvements:

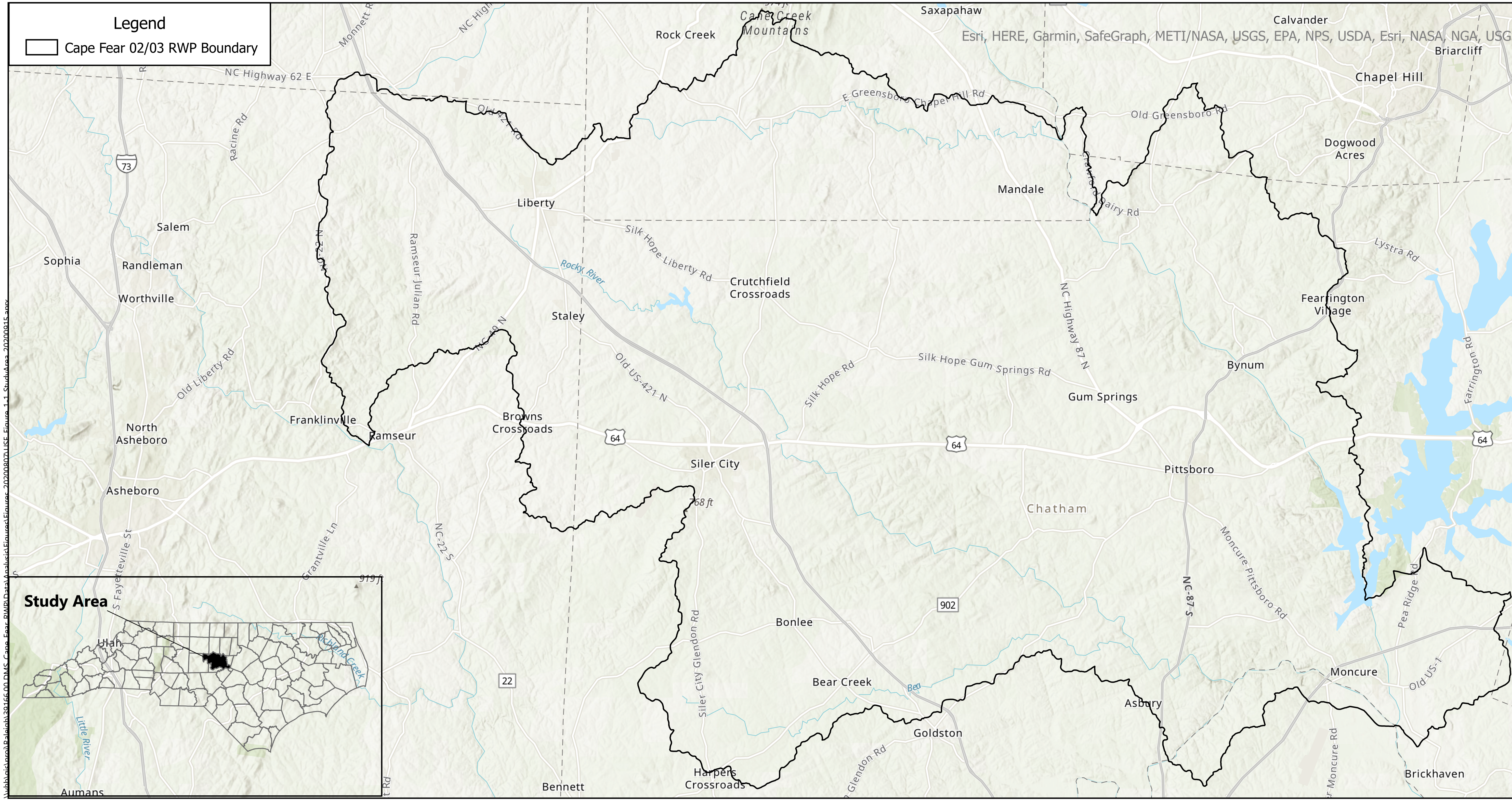
- VHB will investigate improving the population growth indicator by using the 2020 Census data when it becomes available. If it is not available, VHB will use historical population data and extrapolate the population growth prediction over a 30-year horizon.

- VHB will investigate improving the expected change in development indicator by running the SLEUTH model with the Megasites and/or using the NCSU FUTURES model to supplement these predictions.

Overall, this additional data collection and analysis will inform the geospatial analysis and model development to be carried out in Task 3 and will help determine the underlying causes of water quality, habitat, or hydrologic issues within the identified Focus Areas and greater study area.

Once these causes have been identified, VHB will assign appropriate mitigation measures during Task 4 based on the underlying issues assessed during Task 3. This will result in recommendations of specific strategies to combat water quality, hydrology, and habitat degradation issues within the study area.

December 2020 | **FIGURE 1-1**



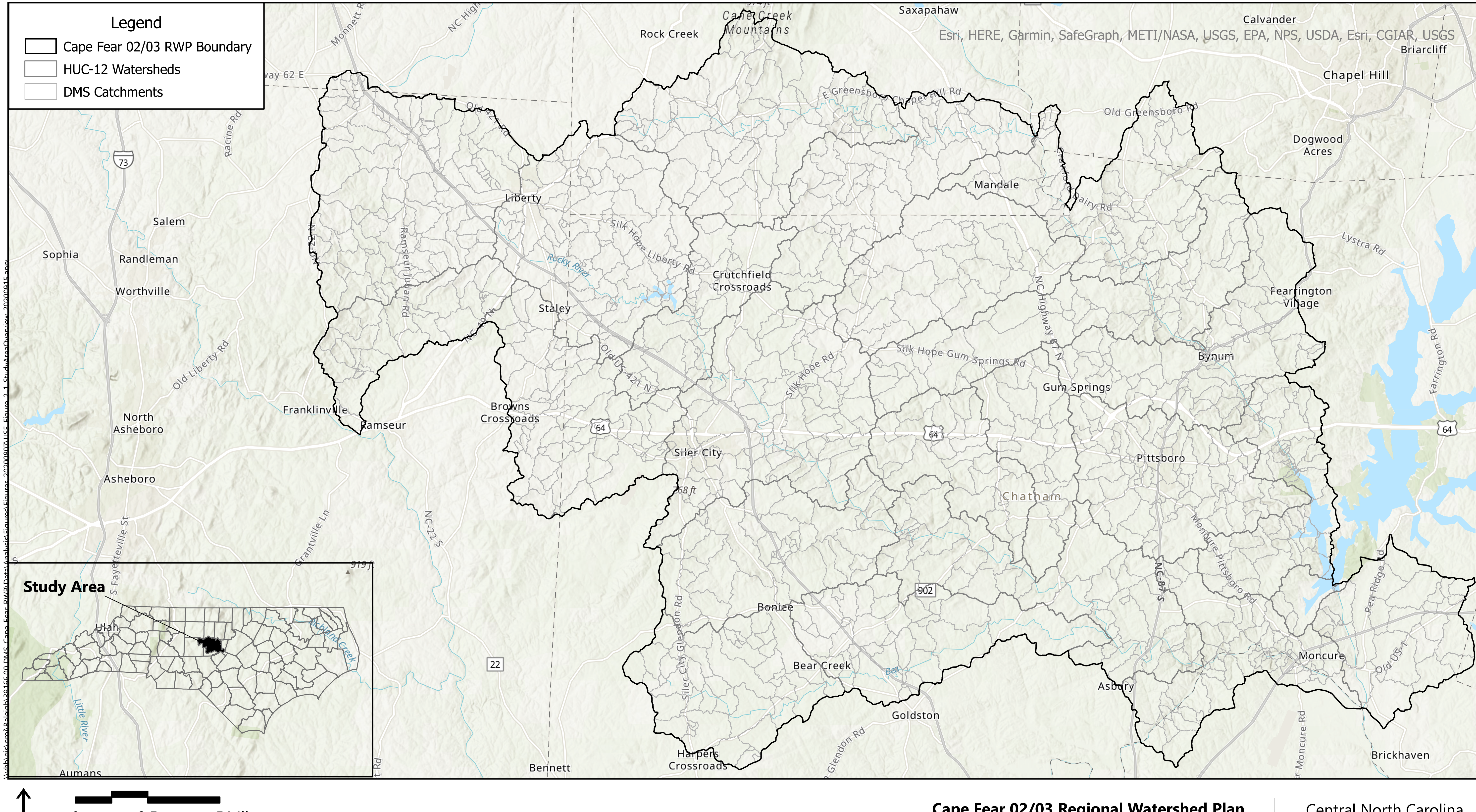
Prepared for:

Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Study Area Overview

Data Source: NC Division of Mitigation Services



Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

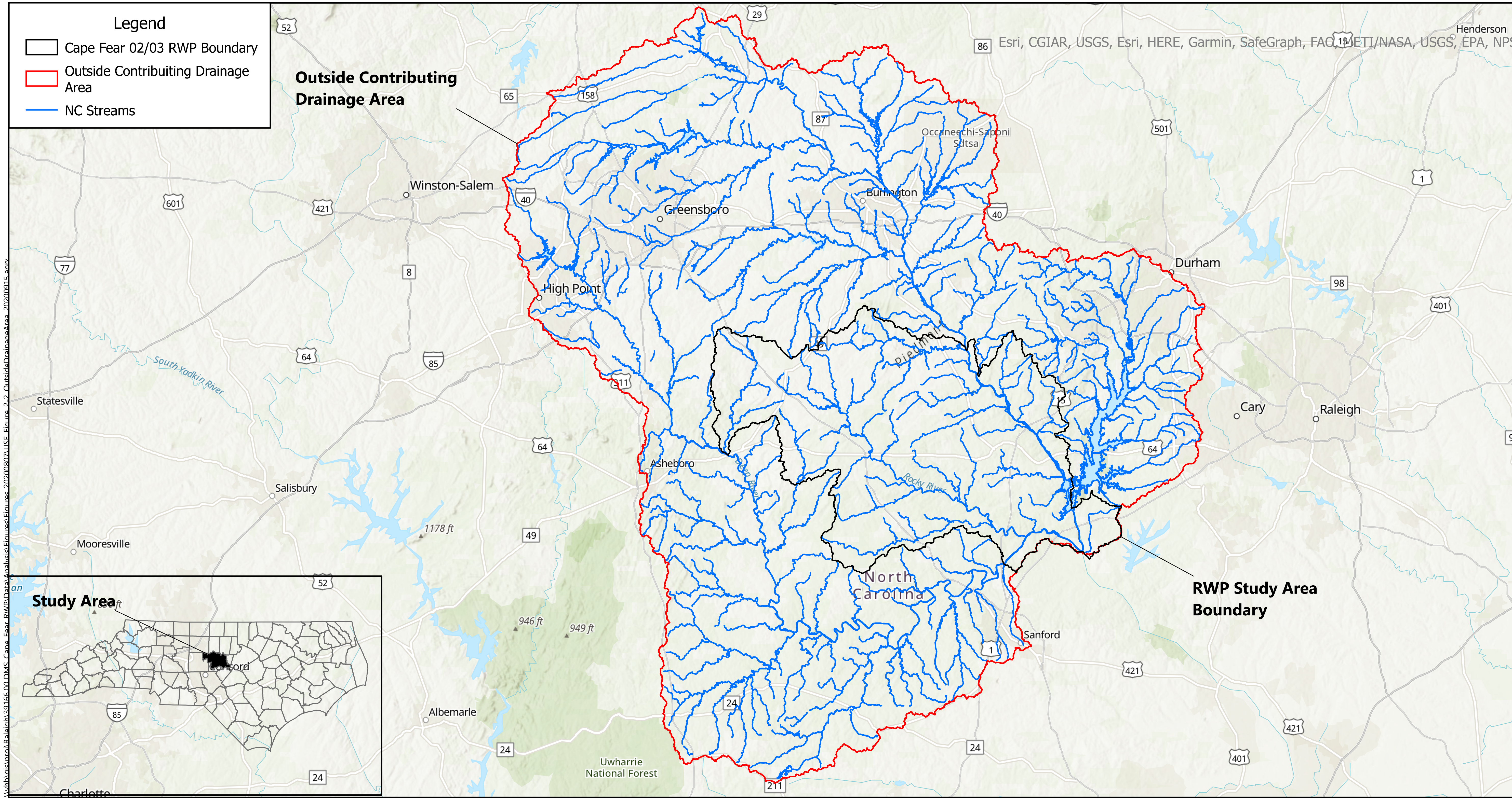
Prepared for: NC Mitigation Services ENVIRONMENTAL QUALITY

Prepared by: vhb

Study Area Hydrology

Data Source: NC Department of Environmental Quality

December 2020 | **FIGURE 2-2**



0 7.5 15 Miles

Prepared for: Prepared by:

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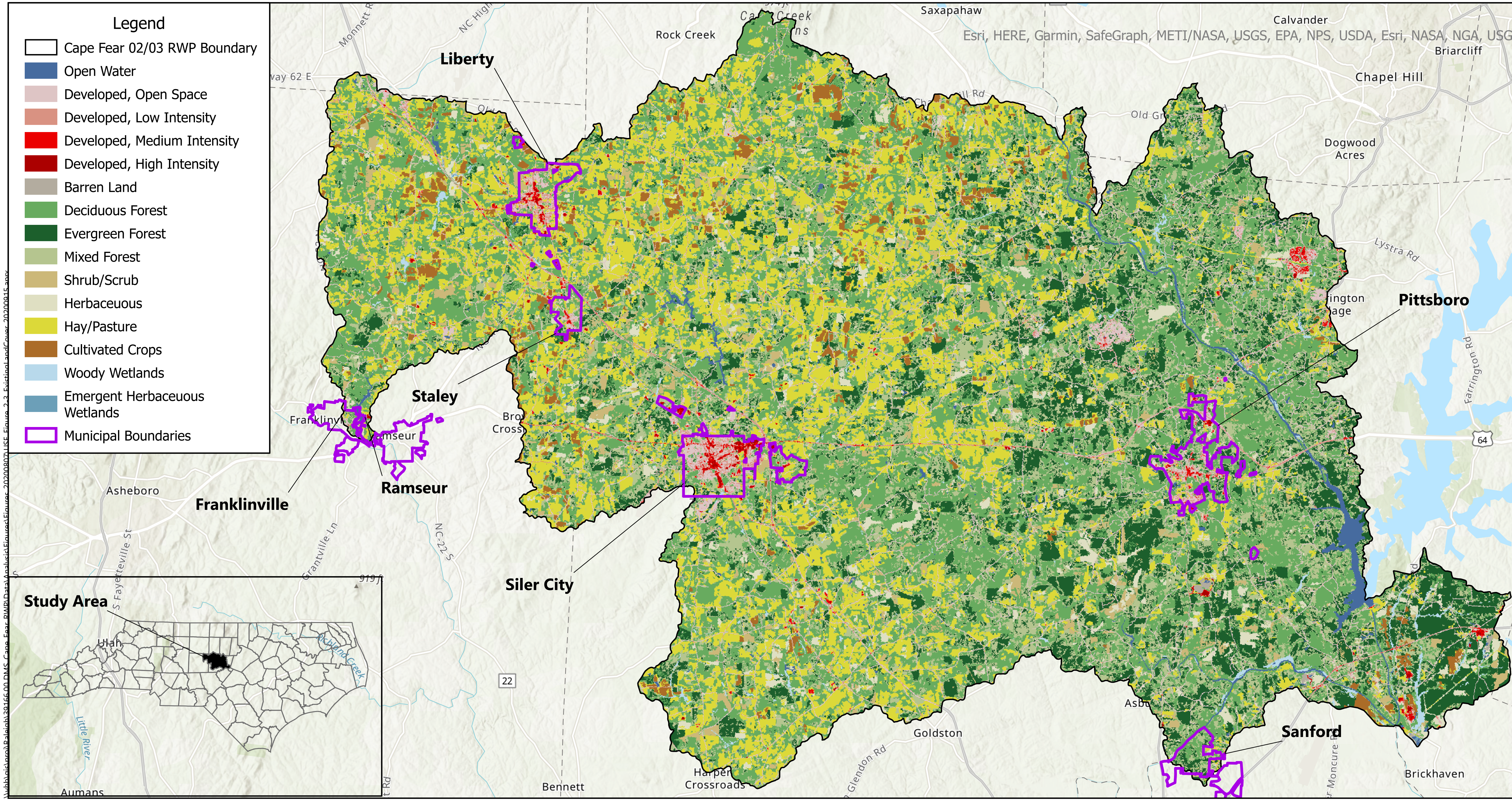
Outside Contributing Drainage Area

Data Source(s): USGS Streamstats
NC Division of Mitigation Services
NC Division of Water Resources

December 2020 | **FIGURE 2-3**



0 2.5 5 Miles

Prepared for:

Prepared by:

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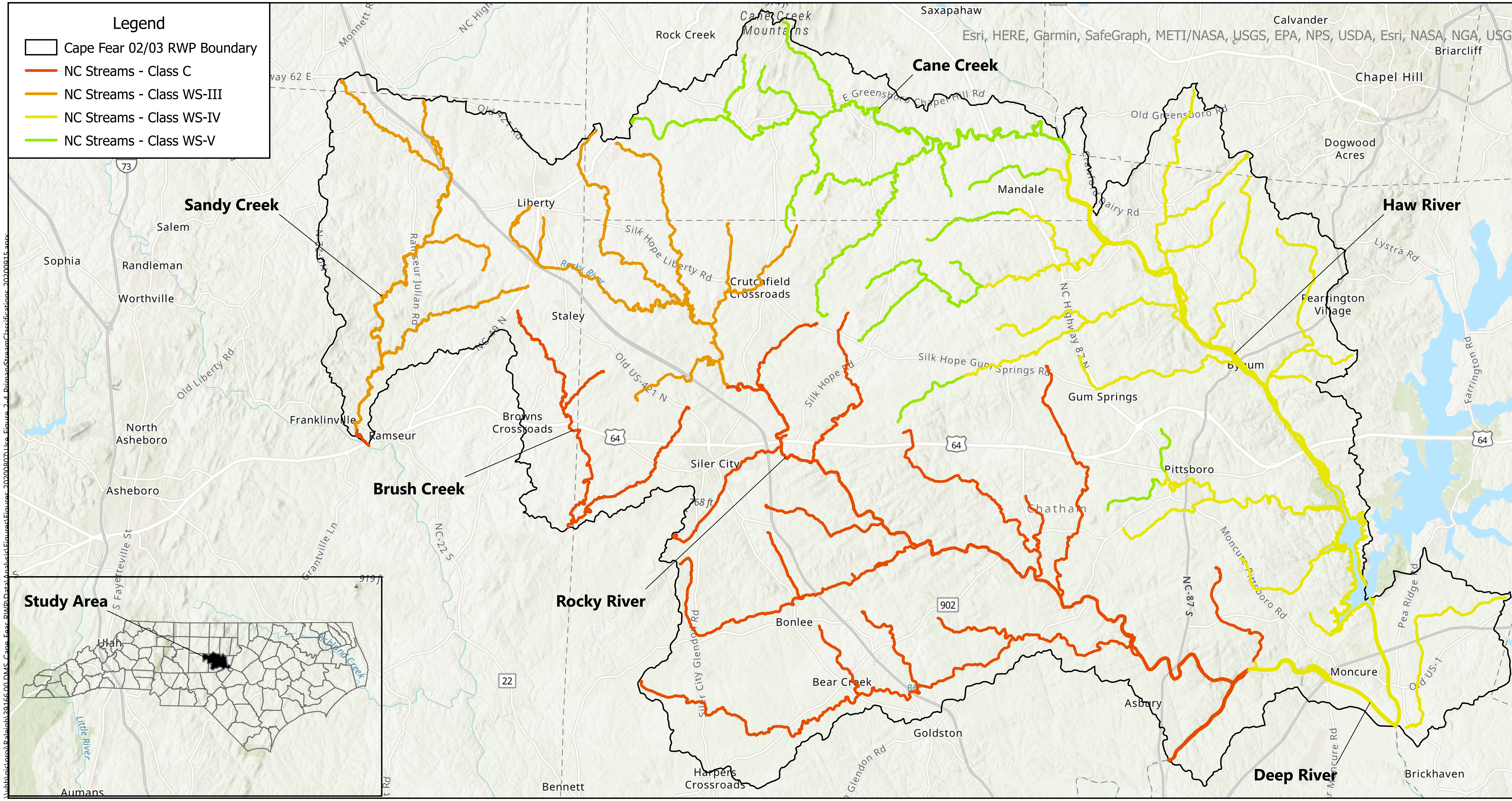
Existing Land Cover

Data Source(s): National Land Cover Database 2016

NC Department of Transportation



0 2.5 5 Miles

Prepared for: NC Mitigation Services Environmental Quality

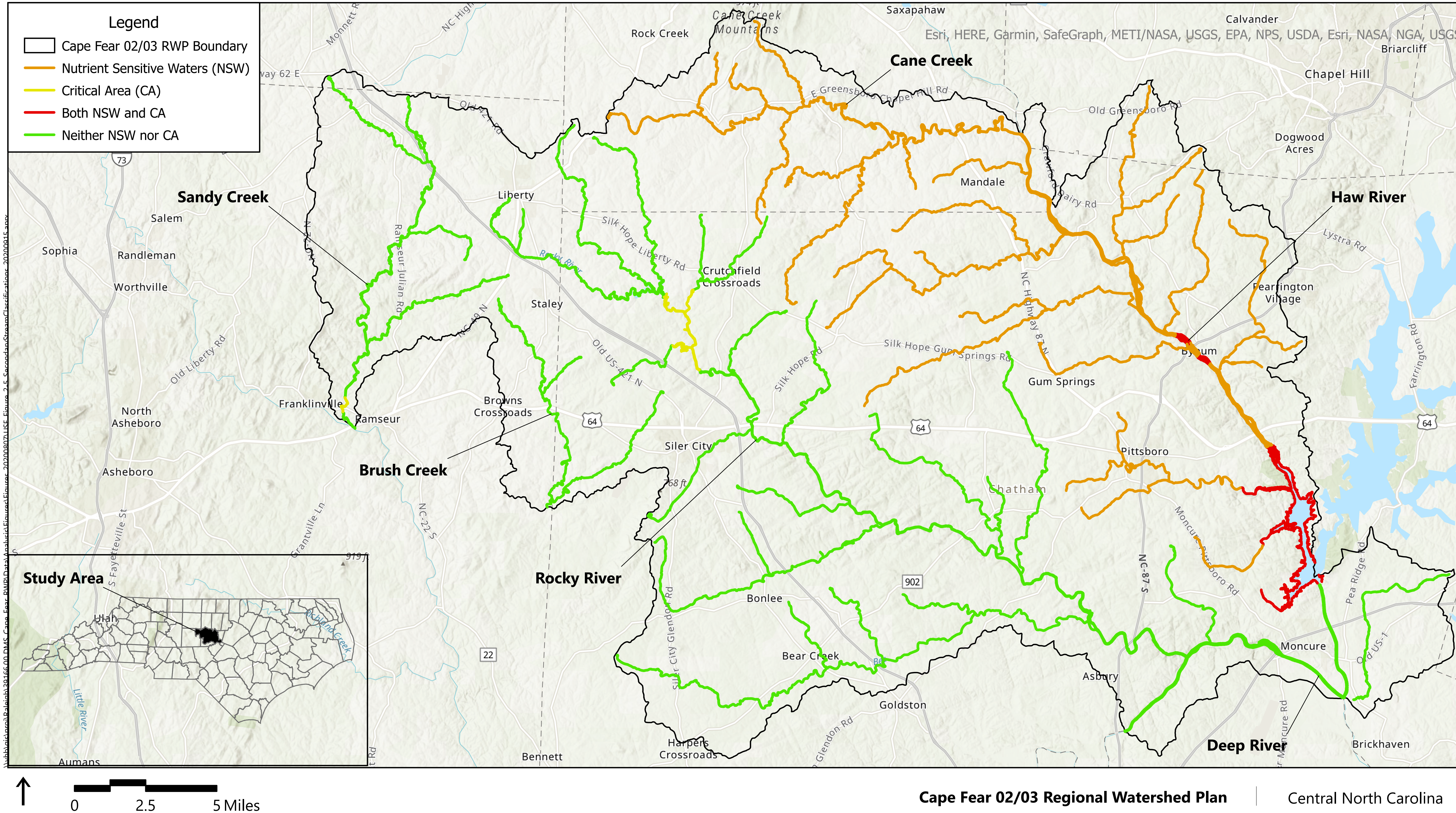
Prepared by: vhb

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Primary Surface Water Classifications

Data Source: NC Division of Water Resources

December 2020 | **FIGURE 2-5**



Prepared for:

Prepared by:

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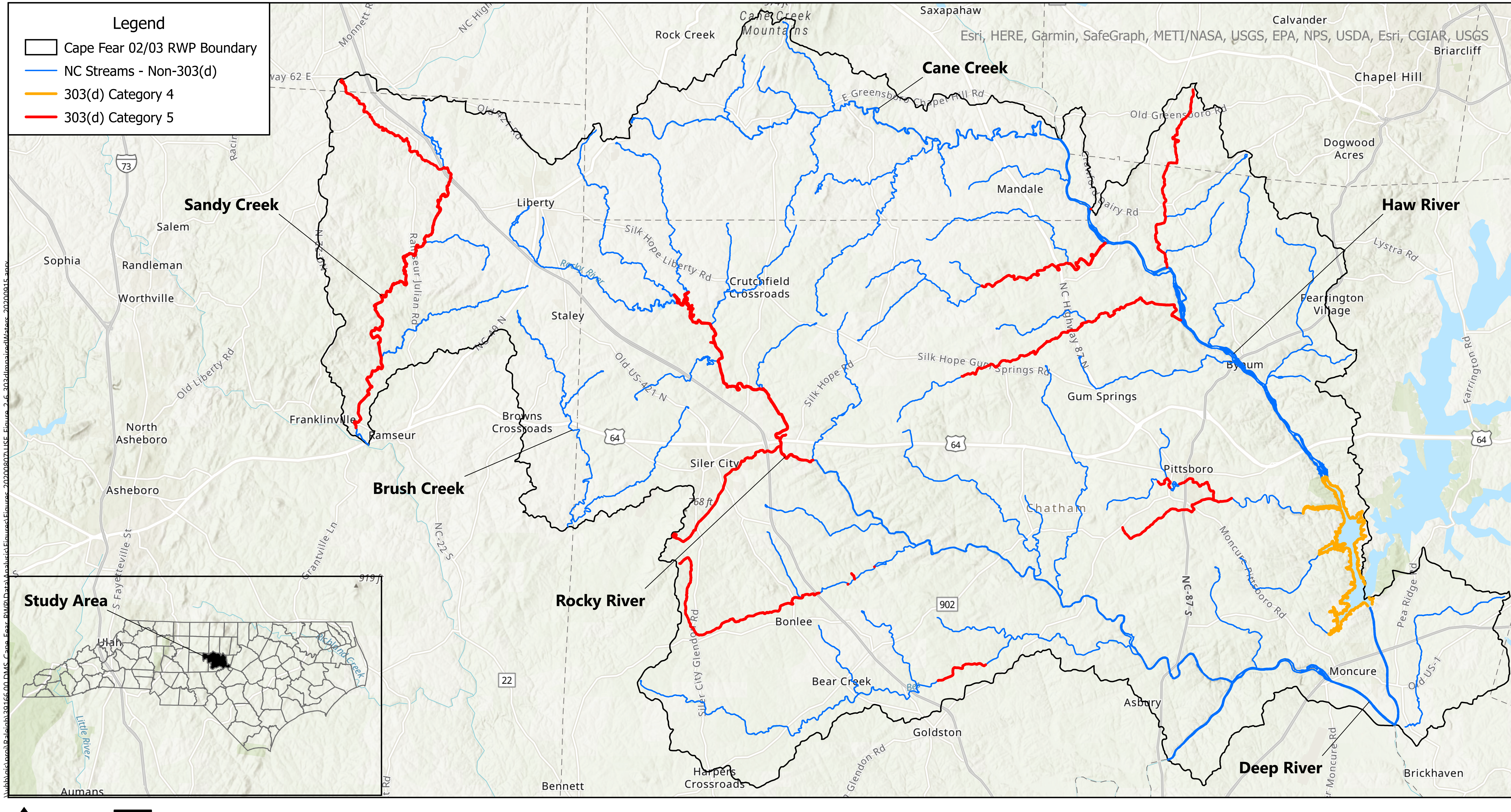
Secondary Surface Water Classifications

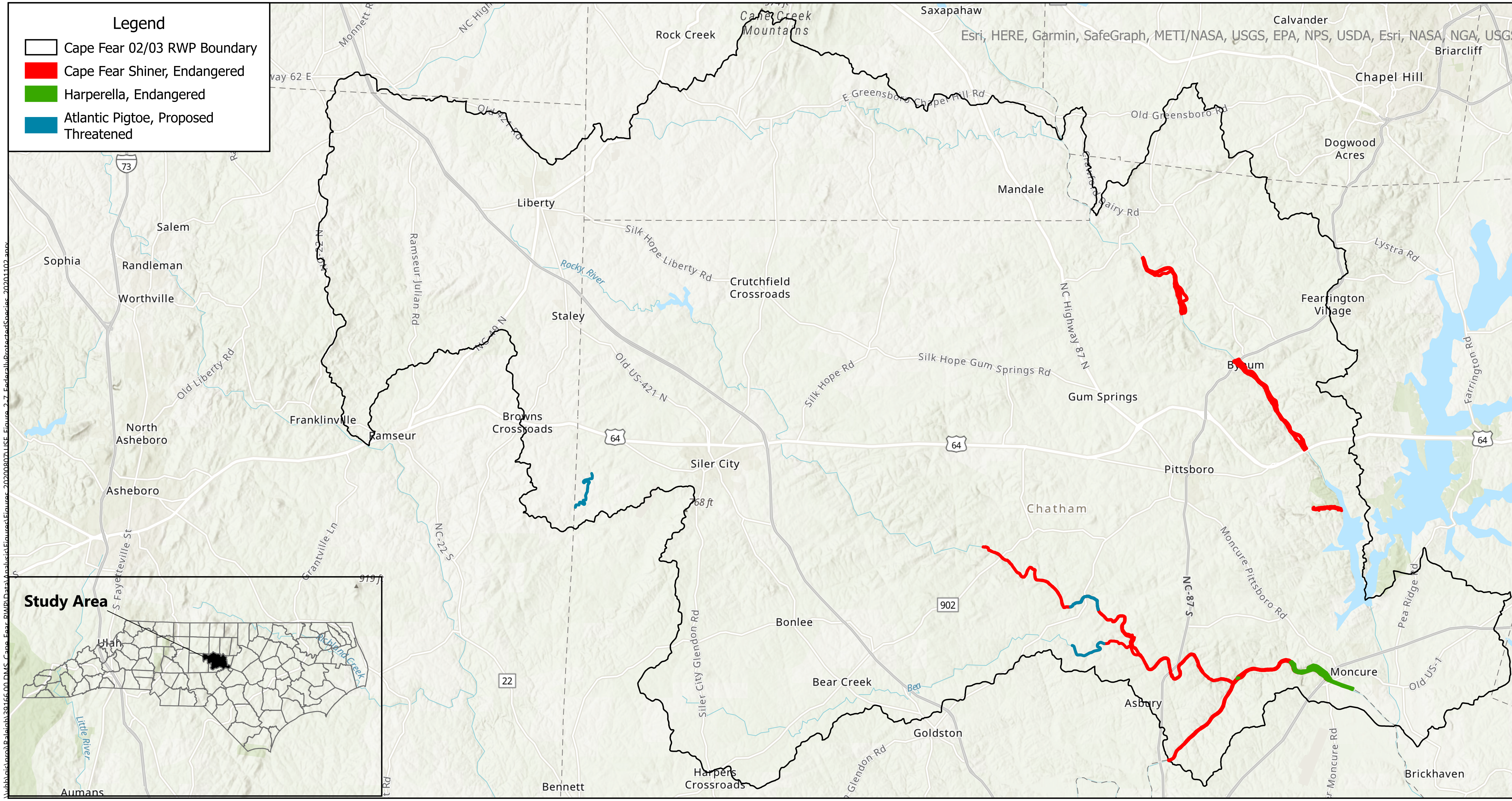
Data Source: NC Division of Water Resources



Prepared for: Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

303(d) Impaired Waters
Data Source: NC Division of Water Resources



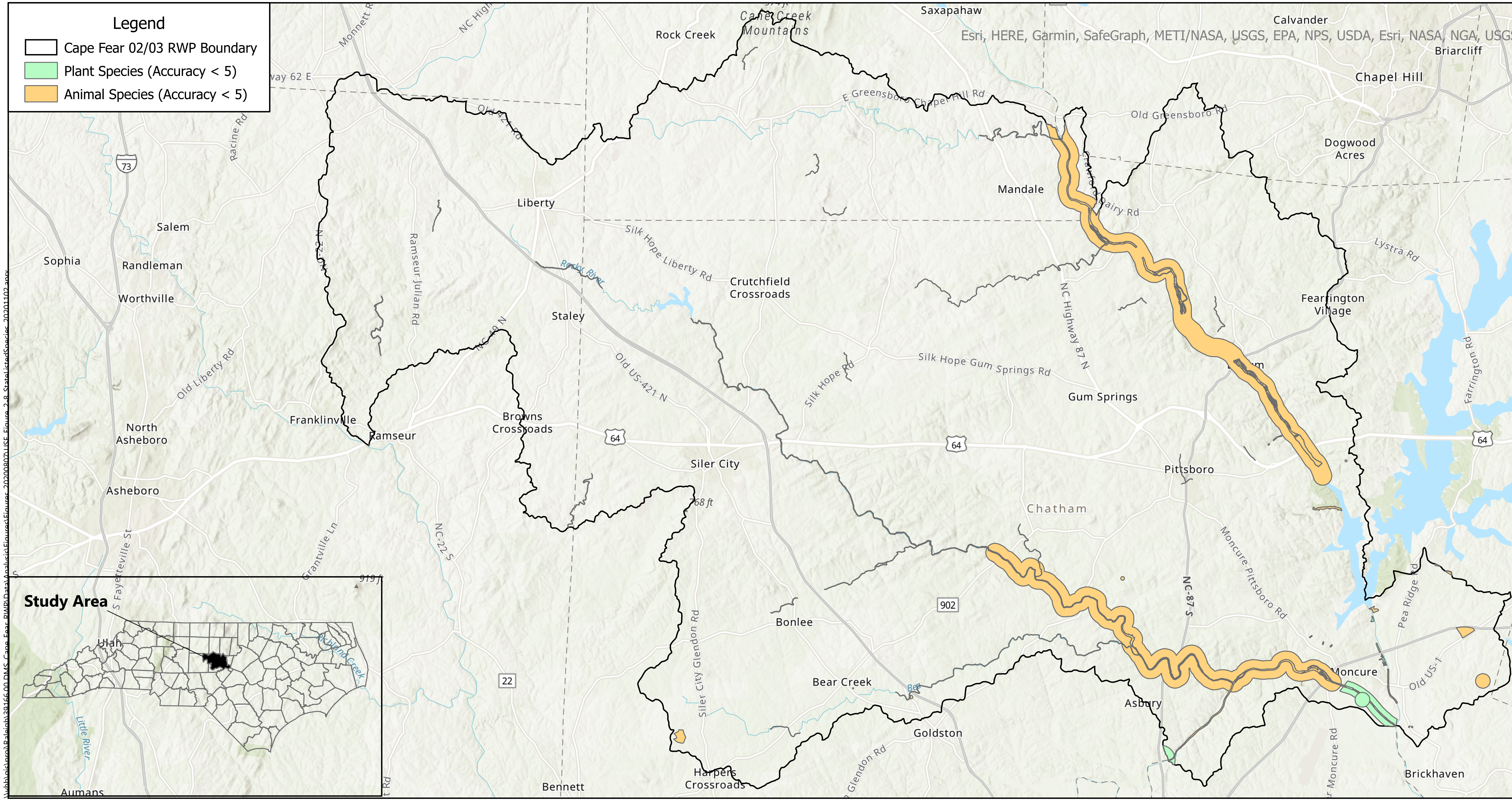
0 2.5 5 Miles

Prepared for: Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Federally Listed Species

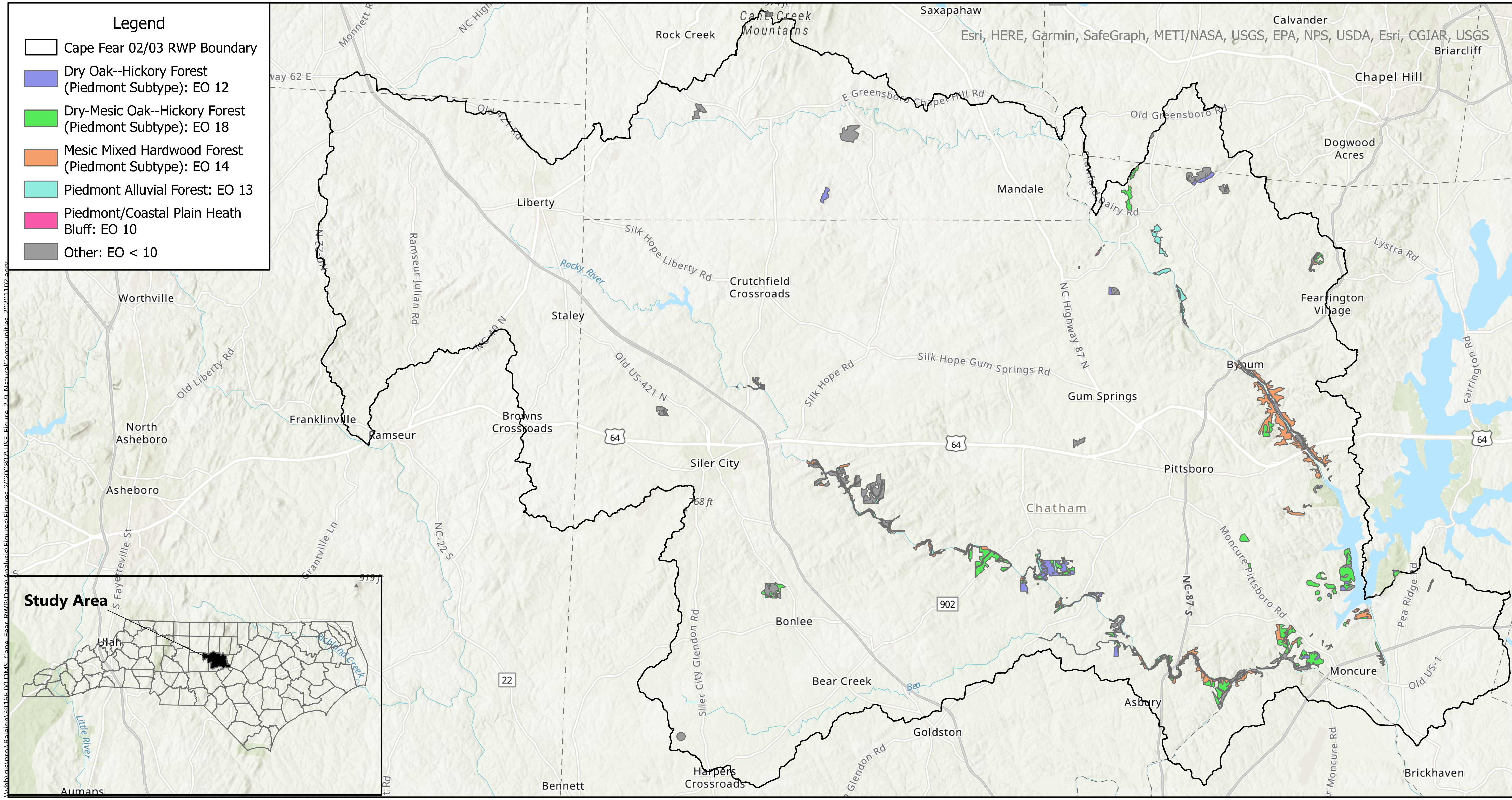
Data Source: NC Natural Heritage Program



Prepared for: Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Location and Accuracy of State-Only Listed Species
Data Source: NC Natural Heritage Program



Prepared for: Prepared by:

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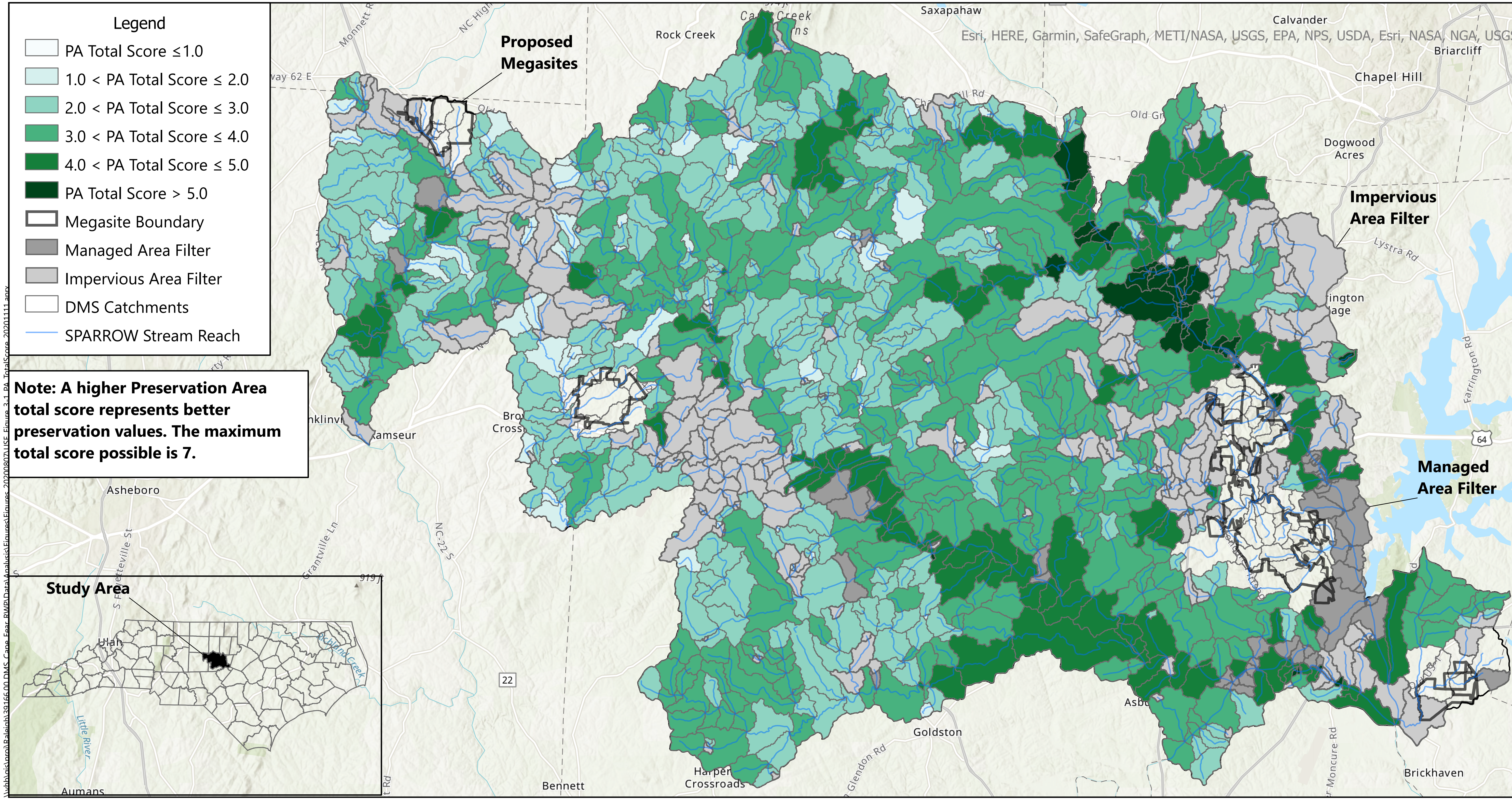
Locations and Accuracies of Natural Communities

Data Source: NC Natural Heritage Program



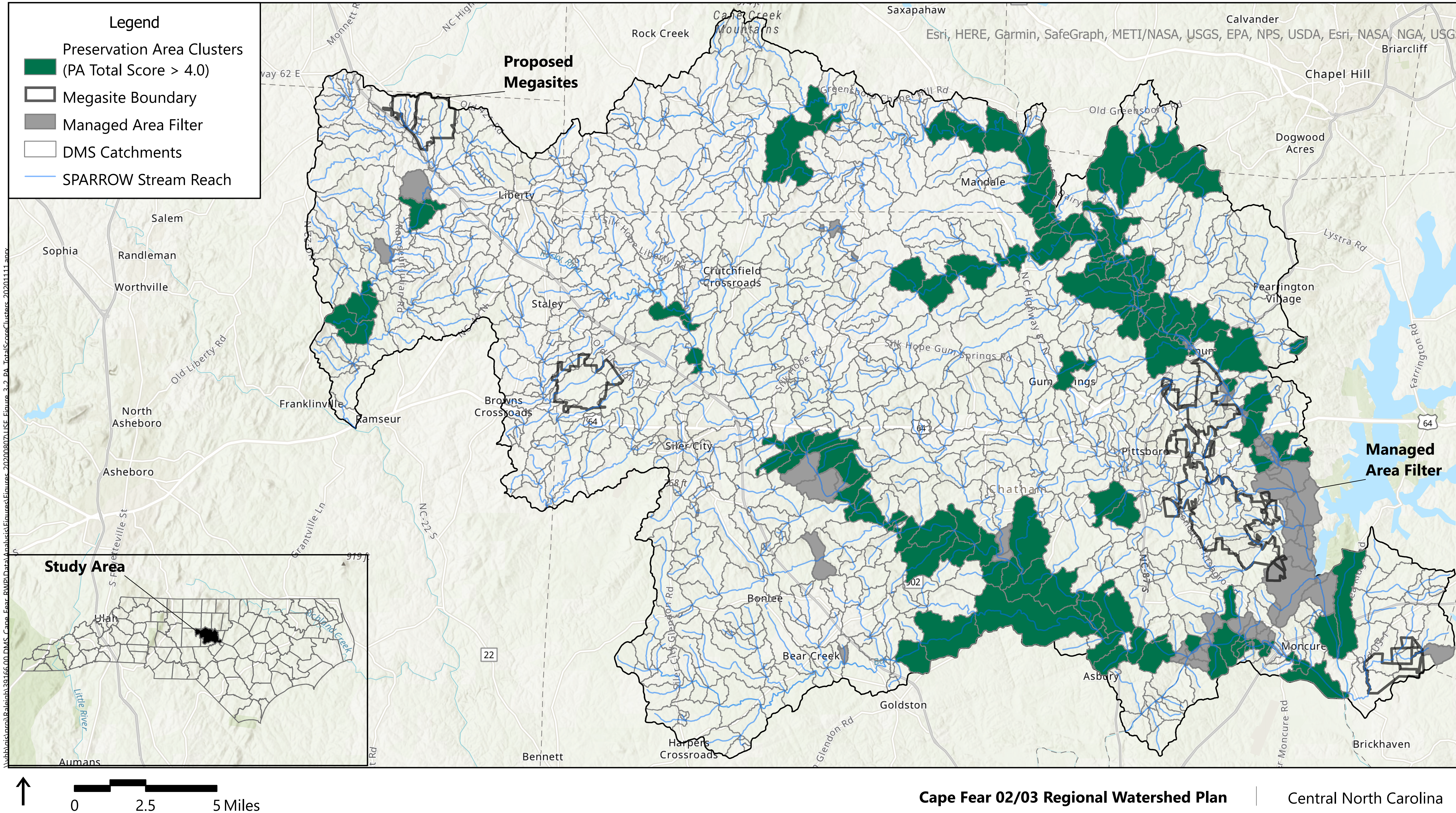
0 2.5 5 Miles

Prepared for: Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Preservation Area Total Score

Data Sources: Multiple



Prepared for: NC Mitigation Services Environmental Quality

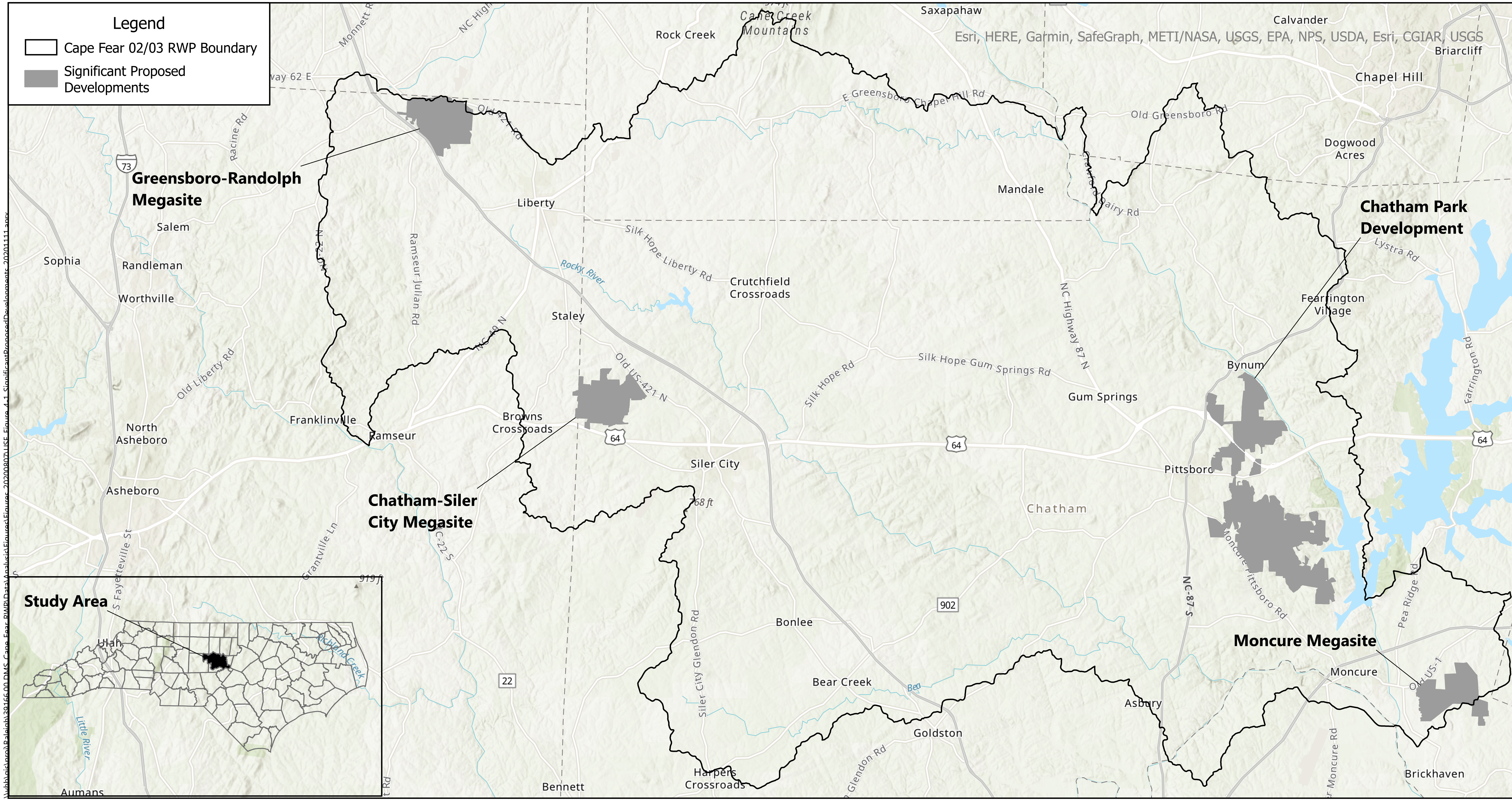
Prepared by: vhb

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Preservation Area Total Score Clusters

Data Sources: Multiple

December 2020 | **FIGURE 4-1**



↑

0 2.5 5 Miles

Prepared for: Prepared by:

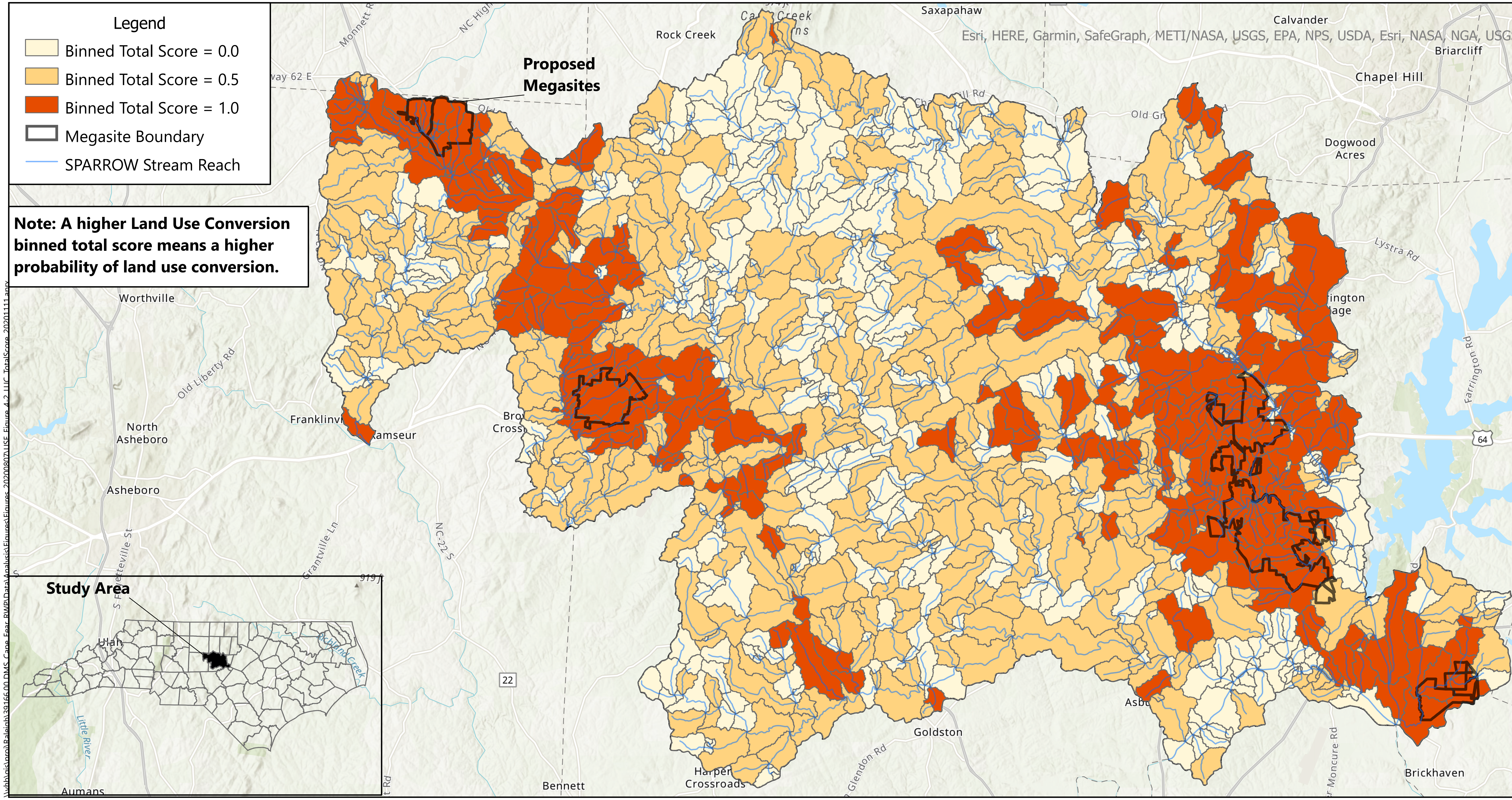
NC Mitigation Services ENVIRONMENTAL QUALITY

vhb

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Significant Proposed Developments

Data Source(s): Chatham County
Town of Pittsboro
Randolph County



Prepared for:

Prepared by:

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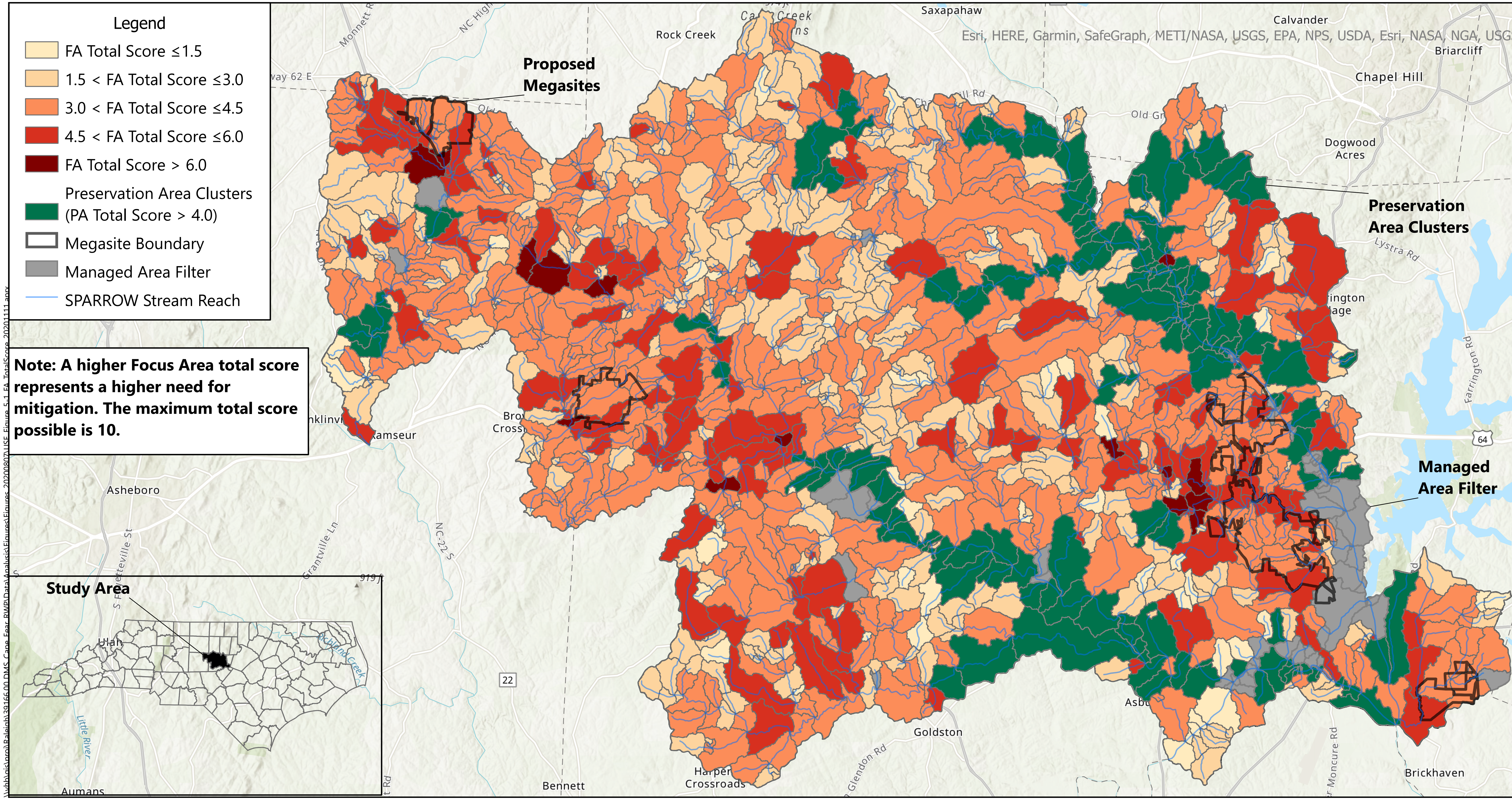
Land Use Conversion Binned Total Score

Data Sources: Multiple

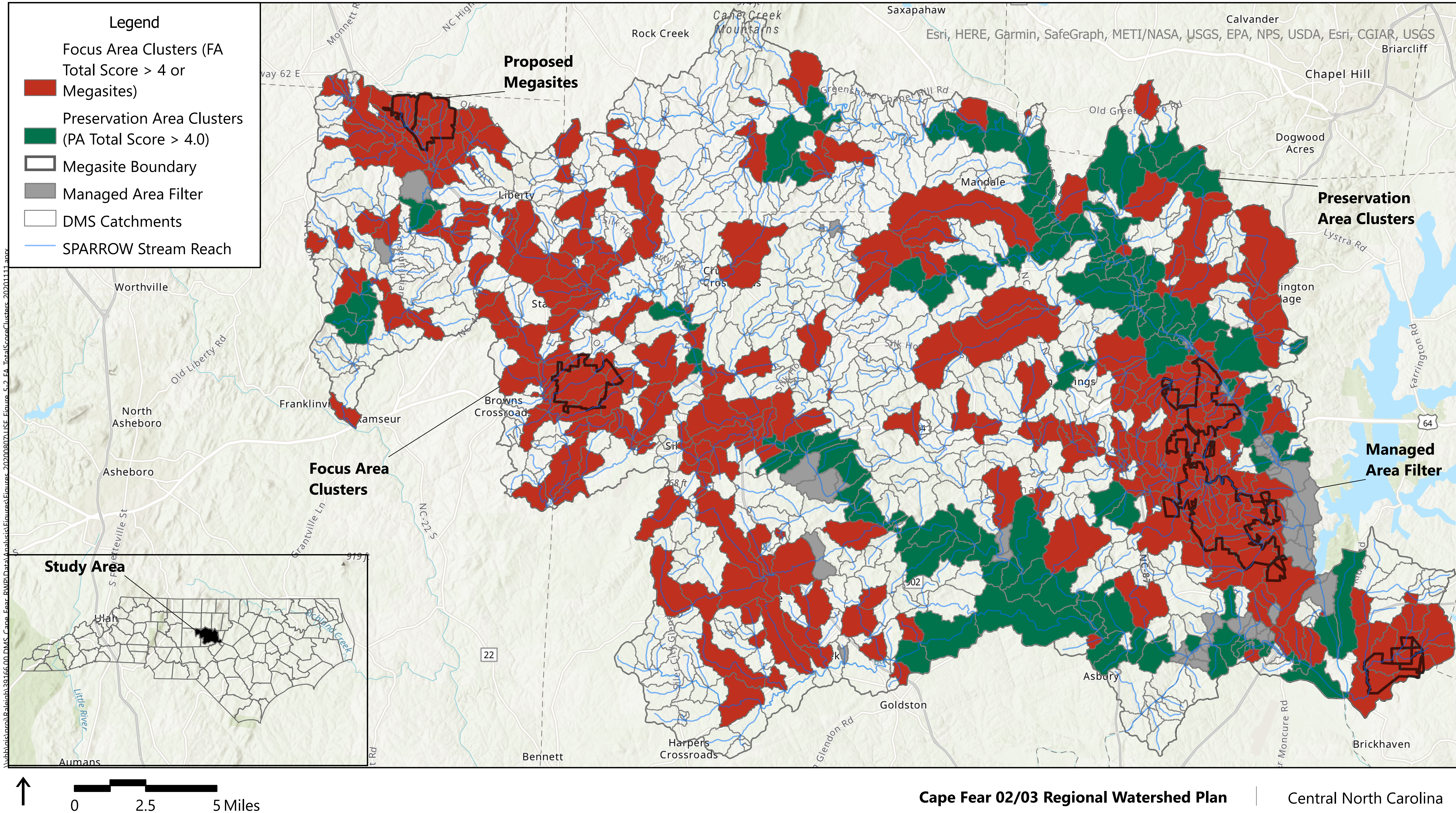


0 2.5 5 Miles

Prepared for: Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Focus Area Total Score
Data Sources: Multiple



Prepared for:

Prepared by:

Cape Fear 02/03 Regional Watershed Plan | Central North Carolina

Focus Area Total Score Clusters

Data Sources: Multiple

Appendix A

Table A-1 Task 1 Data Sources

Data Source	Agency	URL	Date of Download
North Carolina Municipal Boundaries	North Carolina Department of Transportation	https://connect.ncdot.gov/resources/gis/Pages/GIS-Data-Layers.aspx	9/15/2020
NC Route Arcs	North Carolina Department of Transportation	https://connect.ncdot.gov/resources/gis/Pages/GIS-Data-Layers.aspx	8/3/2020
NCNHP Managed Areas	North Carolina Natural Heritage Program	Received from NCNHP	5/7/2020
NCNHP Natural Areas	North Carolina Natural Heritage Program	Received from NCNHP	5/7/2020
NCNHP Habitat Data	North Carolina Natural Heritage Program	Received from NCNHP	7/31/2020
Stream Classifications	North Carolina Division of Water Resources	https://data-ncdenr.opendata.arcgis.com/datasets/surface-water-classifications	7/6/2020
2018 Integrated Report	North Carolina Division of Water Resources	https://data-ncdenr.opendata.arcgis.com/datasets/2018-integrated-report-final-full-resolution	7/6/2020
Cape Fear 02/03 Study Area Boundary	North Carolina Division of Mitigation Services	Received from DMS	
Chatham County Zoning	Chatham County	https://opendata-chathamncgis.opendata.arcgis.com/datasets/chatham-county-zoning	6/16/2020
SLEUTH Mosaic Geodatabase	United States Geological Survey Originally developed at University of Californa -	https://www.sciencebase.gov/catalog/item/56290d6de4b0d158f5926cd2	6/22/2020
Cape Fear 02/03 Study Area SPARROW Catchments	North Carolina Division of Mitigation Services - United States Geological Survey SPARROW	Received from DMS	12/20/2019
Cape Fear 02/03 NCSPARROW Reach COMIDS	North Carolina Division of Mitigation Services - United States Geological Survey SPARROW	Received from DMS	6/15/2020
2016 National Land Cover Database Land Cover Dataset for North Carolina	North Carolina State University	http://gisdata.lib.ncsu.edu/fedgov/mrlc/nlcd2016release/	6/18/2020
2016 National Land Cover Database Impervious Cover Dataset for North Carolina	North Carolina State University	http://gisdata.lib.ncsu.edu/fedgov/mrlc/nlcd2016release/	6/18/2020
North Carolina Wetlands	United States Fish and Wildlife Service	https://www.fws.gov/wetlands/data/data-download.html	6/16/2020
ESRI 2020-20205 Population: Annual Growth Rate		ArcGIS CommunityAnalyst, version 8.2	8/25/2020
Greensboro Randolph Megasite Boundary	Randolph County	Uploaded by stakeholder	5/5/2020
Chatham-Siler City (CAM) Megasite Boundary	Piedmont Triad Regional Council	Uploaded by stakeholder	5/5/2020
Pittzboro Zoning	Chatham County	https://opendata-chathamncgis.opendata.arcgis.com/datasets/chatham-county-pittsboro-zoning	7/15/2020
SPARROW Total Nitrogen/Total Phosporus Model	United States Geological Survey SPARROW	https://www.sciencebase.gov/catalog/item/5bb4dd11e4b08583a5da3a8b	6/15/2020
SPARROW Total Suspended Solids Model	United States Geological Survey SPARROW	https://www.sciencebase.gov/catalog/item/5bb4de01e4b08583a5da4477	6/15/2020
Riparian Zone	Environmental Protection Agency - Watershed Index Online	https://www.epa.gov/wsio/wsio-indicator-data-library	6/22/2020
NC Dam Inventory	North Carolina Division of Energy, Minerals, and Land Resources - Dam Safety	https://deq.nc.gov/about/divisions/energy-mineral-land-resources/energy-mineral-land-permits/dam-safety	6/19/2020
NCDOT Structures	North Carolina Department of Transportation	https://connect.ncdot.gov/resources/gis/Pages/GIS-Data-Layers.aspx	6/19/2020
Non-NBIS Pipes	North Carolina Department of Transportation	https://connect.ncdot.gov/sites/hydro/Reservoir/_layouts/15/DocIdRedir.aspx?ID=HTZKPH6SQWTJ-826991651-1	7/6/2020
Stream Order	NHDPlusV2	https://nhdplus.com/NHDPlus/NHDPlusV2_data.php	7/7/2020
Alamance County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020
Chatham County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020

Source: Multiple

Table A-1 (cont.) Task 1 Data Sources

Data Source	Agency	URL	Date of Download
Guilford County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020
Lee County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020
Orange County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020
Randolph County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020
Wake County Soil Survey	United States Department of Agriculture - Natural Resources Conservation Service	https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx	6/23/2020
Alamance County Farming Districts	Alamance County	Received from Alamance County	8/4/2020
Chatham County Voluntary Farm Districts	Chatham County	https://opendata-chathamncgis.opendata.arcgis.com/datasets/chatham-county-voluntary-ag-parcels	8/4/2020
Lee County Voluntary Agricultural Districts	Lee County	https://leecountync.gov/Departments/GISStrategicServices/DownloadGISLayers	8/5/2020
Orange County Voluntary Agricultural Districts	Orange County	http://www.orangecountync.gov/2057/Download-GIS-Data	8/5/2020
Randolph County Voluntary Agricultural Districts	Randolph County	Received from Randolph County	8/5/2020
Wake County Voluntary Agricultural Districts	Wake County	https://data-wake.opendata.arcgis.com/datasets/voluntary-agricultural-districts	8/4/2020
12-Digit HUC Watersheds	North Carolina Division of Water Resources	https://data-ncdenr.opendata.arcgis.com/datasets/12-digit-huc-subwatersheds	6/17/2020
Fish Habitat and Biological Integrity Class	North Carolina Division of Water Resources	https://data-ncdenr.opendata.arcgis.com/datasets/dwr-fish-community?geometry=-87.345%2C33.681%2C-73.470%2C36.820	11/4/2020
Benthic Biological Integrity Class	North Carolina Division of Water Resources	https://ncdenr.maps.arcgis.com/apps/webappviewer/index.html?id=7d4f2137e9154742bae16916e35a87a0	11/4/2020
Contributing Drainage Area Boundary	United States Geological Survey - StreamStats	https://streamstats.usgs.gov/ss/	6/15/2020

Source: Multiple

Appendix B

Table B-1 Species of Interest

Scientific Name	Common Name	Species Class	State Status	Federal Status	Number of EOs in Study Area
Lytrosis permagnaria	A Geometrid Moth	Animal	SR	N/A	1
Choroterpes basalis	A Mayfly	Animal	SR	N/A	1
Thermopopsis mollis	Appalachian Golden-banner	Plant	SC-V	N/A	1
Fusconaia masoni	Atlantic Pigtoe	Animal	E	PT	3
Peucaea aestivalis	Bachman's Sparrow	Animal	SC	N/A	1
Haliaeetus leucocephalus	Bald Eagle	Animal	T	BGPA	2
Sphingicampa bisecta	Bisected Honey Locust Moth	Animal	SR	N/A	1
Lindera subcoriacea	Bog Spicebush	Plant	SR-T	N/A	1
Alasmidonta varicosa	Brook Floater	Animal	E	N/A	2
Trifolium reflexum	Buffalo Clover	Plant	T	N/A	1
Phacelia covillei	Buttercup Phacelia	Plant	SR-T	N/A	10
Notropis mekistocholas	Cape Fear Shiner	Animal	E	E	4
Villosa vaughaniana	Carolina Creekshell	Animal	E	N/A	6
Etheostoma collis	Carolina Darter	Animal	SC	N/A	4
Cambarus davidi	Carolina Ladle Crayfish	Animal	SR	N/A	8
Moxostoma sp. 3	Carolina Redhorse	Animal	T	N/A	1
Lampsilis sp. 2	Chameleon Lampmussel	Animal	SR	N/A	3
Pontia protodice	Checkered White	Animal	SR	N/A	1
Somatochlora georgiana	Coppery Emerald	Animal	SR	N/A	1
Strophitus undulatus	Creeper	Animal	T	N/A	5
Villosa delumbis	Eastern Creekshell	Animal	SR	N/A	9
Enemion biternatum	Eastern Isopyrum	Plant	SC-V	N/A	2
Ligumia nasuta	Eastern Pondmussel	Animal	T	N/A	1
Ptilimnium nodosum	Harperella	Plant	E	E	2
Neonympha helicta	Helicta Satyr	Animal	SR	N/A	1

Varex jamesii	James's Sedge	Plant	SR-P	N/A	1
Fothergilla major	Large Witch-alder	Plant	SR-T	N/A	1
Villosa constricta	Notched Rainbow	Animal	T	N/A	11
Somatogyrus virginicus	Panhandle Pebblesnail	Animal	SR	N/A	1
Collinsonia tuberosa	Piedmont Horsebalm	Plant	SC-V	N/A	1
Phanogomphus quadricolor	Rapids Clubtail	Animal	SR	N/A	1
Lampsilis splendida	Rayed Pink Fatmucket	Animal	SR	N/A	1
Picoides borealis	Red-cockaded Woodpecker	Animal	E	E	1
Dichanthelium annulum	Ringed Witch Grass	Plant	SR-P	N/A	1
Toxolasma pulus	Savannah Lilliput	Animal	E	N/A	2
Gomphurus septima	Septima's Clubtail	Animal	SR	N/A	2
Eurybia spectabilis	Showy Aster	Plant	SR-O	N/A	1
Alasmidonta undulata	Triangle Floater	Animal	T	N/A	1

Source: North Carolina Natural Heritage Program