



# **AQUATIC SPECIES SURVEY REPORT**

## **Complete 540 Triangle Expressway Southeast Extension**

### **Wake, Johnston, & Harnett Counties**

STIP Project Nos. R-2721, R-2828, and R-2829

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## 1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT), in cooperation with the Federal Highway Administration (FHWA), proposes transportation improvements to NC 540, a project known as the “Complete 540 – Triangle Expressway Southeast Extension,” in Wake and Johnston Counties, North Carolina. Project construction will impact streams within the Neuse River Basin and the Cape Fear River Basin, which could potentially result in impacts to aquatic species. Surveys had previously been conducted for this project in the Swift Creek watershed (part of the Neuse River Basin) and documented in Freshwater Mussel Survey Report: Triangle Expressway Southeast Extension (Catena Group 2012). Since those surveys were completed, the Future Land Use Study Area (FLUSA) for the Complete 540 Project was extended into additional areas and watersheds not surveyed for the original report. The FLUSA, which includes portions of Wake, Johnston, and Harnett Counties, as well as the limits of the study area from the initial report, are provided in Figure 1.

As of April 6, 2017, the US Fish and Wildlife Service (USFWS) list eight federally protected species as occurring in Wake, Johnston, and Harnett Counties (Table 1). Yellow Lance (*Elliptio lanceolata*) was proposed as threatened on April 5, 2017, and as such will be included in the Biological Assessment (BA) being prepared for the project. Additionally, the USFWS is expected to publish findings on three other petitioned aquatic species that potentially warrant listing as Threatened or Endangered species under the Endangered Species Act of 1973, as amended. These three species have been reported in watersheds within the FLUSA: Atlantic Pigtoe (*Fusconaia masoni*), Carolina Madtom (*Noturus furiosus*), and Neuse River Waterdog (*Necturus lewisi*). If the finding recommends the other three species for listing, it is anticipated that they would be proposed for listing before April 2018. Given the high potential that some, or all, of these species will become listed prior to the completion of the Final Environmental Impact Statement (FEIS), it was determined to be prudent to include the baseline for these three species in the BA.

**Table 1. Federally Listed Species; Wake, Johnston, and Harnett Counties, North Carolina**

Scientific Name	Common Name	Status	County
<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	E	W, J
<i>Elliptio lanceolata</i>	Yellow Lance	Proposed	W, J
<i>Elliptio steinstansana</i>	Tar River Spinymussel	E	J
<i>Fusconaia masoni</i>	Atlantic Pigtoe	Petitioned	W, J, H
<i>Haliaeetus leucocephalus</i>	Bald Eagle	BGPA	W, J, H
<i>Lysimachia asperulaefolia</i>	Rough-leaved Loosestrife	E	H
<i>Myotis septentrionalis</i>	Northern Long-eared Bat	T	W
<i>Necturus lewisi</i>	Neuse River Waterdog	Petitioned	W, J
<i>Notropis mekistocholas</i>	Cape Fear Shiner	E	H
<i>Noturus furiosus</i>	Carolina Madtom	Petitioned	W, J
<i>Picoides borealis</i>	Red-cockaded Woodpecker	E	W, J, H
<i>Rhus michauxii</i>	Michaux’s Sumac	E	W, J

BGPA – Bald and Golden Eagle Protection Act, T – Threatened, E – Endangered, W – Wake, J- Johnston, H - Harnett

This report was prepared to provide the survey results of the additional areas within the FLUSA and to provide species information for the Proposed Yellow Lance and the Petitioned Atlantic Pigtoe, Carolina Madtom, and Neuse River Waterdog to be included in the BA.

## **1.1 Elemental Occurrences in the FLUSA**

According to the NC Natural Heritage Program database (NCNHP 2017), accessed May 24, 2017, there are two element occurrences (EO) of Dwarf Wedgemussel (DWM) in the FLUSA, one current and one historical (Figure 2-1). The Swift Creek/White Oak Creek/Middle Creek population (EO ID: 13799) was first observed in March 1991 and last observed in 2016 by Three Oaks. A historical occurrence (EO ID: 7699), located in the mainstem Neuse River, was first and last observed in 1951.

There are three current EOs for the Yellow Lance in the FLUSA (Figure 2-2). In Swift Creek, EO ID: 21894, was first observed in August 1992 and last observed in November 2015. Downstream of this EO in Swift Creek is another EO (EO ID: 21890), which was first observed in March 1991 and last observed in July 2002. There is an EO in Middle Creek (EO ID: 21892), which was first observed in September 1992 and officially last observed in July 1999; however, an individual was found in 2011 (Catena 2012). It is unclear why this record is not currently reflected in the NCNHP database.

There are four EOs for the Atlantic Pigtoe in the FLUSA, three current and one historical (Figure 2-3). The EO in Swift Creek/White Oak Creek/Little Creek (EO ID: 11695) was first observed in March 1991 and last observed in November 2015. An EO in Middle Creek (EO ID: 4770) was first observed in May 1992 and last observed in June 2003, until an individual was found during this survey effort. An EO upstream in Middle Creek (EO ID: 34956) was first and last observed in July 2004. A historical EO in Walnut Creek (EO ID: 11071) was first and last observed in 1951. Additionally, a historical EO in Black Creek (EO ID: 4370), located directly downstream of the FLUSA, was first and last observed in 1951.

There are two historical EOs for the Carolina Madtom in the FLUSA (Figure 2-4). The EO in Swift Creek/Middle Creek (EO ID: 9621) was first observed in June 1961 and last observed in May 1985. The EO in Neuse River/Crabtree Creek (EO ID: 10676) was first observed in July 1897 and last observed in August 1902.

There are four EOs for the Neuse River Waterdog in the FLUSA, including two current and two historical (Figure 2-5). The Swift Creek/Middle Creek (EO ID: 1633) population was first observed in April 1979 and last observed in February 2017, as part of this survey effort. Middle Creek above I-40 (EO ID: 34764) contains another Neuse River Waterdog record; and was first observed in February 2001 and last observed in February 2014. Further upstream in Middle Creek is a historical EO (ID: 8258) that was first and last observed in March 1954. The other historical EO (ID: 8259) is in the mainstem Neuse River and was first observed in April 1919 and last observed in January 1987.

## **2.0 WATERS IMPACTED**

The project will impact streams in both the Upper Neuse River Basin and the Cape Fear River Basin. Subbasins in the Neuse River Basin are Middle Creek (HUC# 0302020109), Swift Creek (HUC# 0302020110), Walnut Creek-Neuse River (HUC# 0302020111), Milburnie Lake-Neuse River (HUC# 0302020107), Crabtree Creek (HUC# 0302020108), and Black Creek (HUC#

0302020112). Subbasins in the Cape Fear River Basin are Buckhorn Creek-Cape Fear River (HUC# 0303000401), Buies Creek-Cape Fear River (HUC# 0303000405), and Upper South River (HUC# 0303000601).

## 2.1 303(d) Classification

The North Carolina Department of Environmental Quality (NCDEQ, formerly NC Department of Environment and Natural Resources, NCDENR) - Division of Water Resources 2014 Final 303(d) list of impaired streams includes 18 streams within the Neuse River Subbasins of the FLUSA (Table 2, Figure 3, NCDENR 2014). As of the writing of this report, the 2016 303(d) list had not been finalized, though a draft was submitted to the United States Environmental Protection Agency. If the draft list is finalized, there are potentially several streams that will be delisted (see notes below Table 2).

**Table 2. Neuse River Basin Impaired (Category 5) Streams 2014.**

Stream	AU Number	Length/Area	Reason for Rating	Parameter (Year)
<b>Middle Creek (HUC# 0302020109)</b>				
Middle Creek	27-43-15-(1)b1	3 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (2008)
Middle Creek	27-43-15-(1)b2	1.6 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (2012)
Middle Creek	27-43-15-(4)a1	4.5 FW Miles	Poor Bioclassification	Fish Community (2014)
Terrible Creek	27-43-15-8-(2)	7.8 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (2012)
<b>Swift Creek (HUC# 0302020110)</b>				
Swift Creek	27-43-(1)d	2.4 FW Miles	Poor Bioclassification	Ecological/Bio Int Benthos (2008)
Swift Creek (Lake Benson)	27-43-(5.5)a	0.9 FW Miles	Poor Bioclassification	Ecological/Bio Int Benthos (2008)
UT to Swift Creek (Lake Benson)	27-43-(5.5)but7	2.7 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (2014)
Swift Creek	27-43-(8)a	20.6 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (2012)
Little Creek	27-43-12	11.4 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (1998)
<b>Walnut Creek-Neuse River (HUC# 0302020111)</b>				
Walnut Creek*	27-34-(4)b	3.7 FW Miles	Exceeding Criteria	Copper (2008)
Walnut Creek	27-34-(4)b	3.7 FW Miles	Exceeding Criteria	PCB Fish Tissue Advisory (2012)
Neuse River*	27-(22.5)c	3.9 FW Miles	Exceeding Criteria	Copper (2008)
Neuse River	27-(22.5)c	3.9 FW Miles	Exceeding Criteria	PCB Fish Tissue Advisory (2010)
Beddingfield Creek	27-37	3.7 FW Miles	Fair Bioclassification	Ecological/Bio Int, Benthos (2014)
Neuse River*	27-(36)	4.3 FW Miles	Exceeding Criteria	Copper (2008)
Neuse River*	27-(36)	4.3 FW Miles	Exceeding Criteria	Zinc (2008)
Neuse River*	27-(38.5)	9.7 FW Miles	Exceeding Criteria	Copper (2012)

**Table 2. Neuse River Basin Impaired (Category 5) Streams 2014 (continued).**

Stream	AU Number	Length/Area	Reason for Rating	Parameter (Year)
<b>Black Creek (HUC# 0302020112)</b>				
None				
<b>Milburnie Lake-Neuse River (HUC# 0302020107)</b>				
None				
<b>Crabtree Creek (HUC# 0302020108)</b>				
Crabtree Creek	27-33-(10)c	2.75 FW Miles	Exceeding Criteria	PCB Fish Tissue Advisory (2012)

FW – Freshwater Miles, Bio Int – Biological Integrity \* Indicates potential delisting based on Draft 2016 303(d) List

The 2014 303(d) list of impaired streams includes five streams within the Cape Fear subbasins of the FLUSA (Table 3, Figure 3, NCDENR 2014). Kenneth Creek will potentially be delisted for certain parameters with the finalization of the draft 2016 303(d) list (see notes below Table 3).

**Table 3. Cape Fear River Basin Impaired (Category 5) Streams 2014.**

Stream	AU Number	Length/Area	Reason for Rating	Parameter (Year)
<b>Buckhorn Creek-Cape Fear River (HUC# 03030004010)</b>				
None				
<b>Buies Creek-Cape Fear River (HUC# 0303000405)</b>				
Kenneth Creek*	18-16-1-(2)	3.88 FW Miles	Fair Bioclassification	Ecological/Bio Int Benthos (1998)
Kenneth Creek*	18-16-1-(2)	3.88 FW Miles	Exceeding Criteria	pH (2012)
Kenneth Creek	18-16-1-(2)	3.88 FW Miles	Exceeding Criteria	Dissolved Oxygen (2014)
Neills Creek (Neals Creek)	18-16-(0.3)	2.65 FW Miles	Poor Bioclassification	Ecological/Bio Int Benthos (2006)
Neills Creek (Neals Creek)	18-16-(0.7)a	1.98 FW Miles	Poor Bioclassification	Ecological/Bio Int Benthos (2006)
<b>Upper South River (HUC# 0303000601)</b>				
None				

FW-Freshwater Miles, Bio Int – Biological Integrity \* Indicates potential delisting based on Draft 2016 303(d) List

## 2.2 National Pollutant Discharge Elimination System Dischargers

The National Pollutant Discharge Elimination System (NPDES) provides permits for the discharge of pollutants into Waters of the United States under the Clean Water Act. There are 28 NPDES individual permit discharges and 53 NPDES general permit discharges in the Neuse River subbasins within the study area (Table 4, Figure 3, USEPA 2017). Individual NPDES permits are issued on a case by case basis and are site specific. General permits, on the other hand, cover discharges with similar operations and types of discharges that are applicable state-wide. The requirements of a general permit are defined and known by the permittee. In general, an individual permit will take longer to be issued than a general permit (NCDEQ: Permitting Process). There are two NPDES individual permit discharges and 16 NPDES general permit discharges in the Cape Fear River subbasins within the study area (Table 5, Figure 3, USEPA 2017).

**Table 4. NPDES Individual Permitted Discharges in the Upper Neuse River Subbasin within FLUSA**

Permit	Facility	Receiving Stream	Flow (GPD)	Owner
<b>Middle Creek (HUC# 0302020109)</b>				
NC0064050	Apex WRF	Middle Creek	3,600,000	Town of Apex
NC0022217	Apex Terminal	Middle Creek	Not limited	Motiva Enterprises LL
NC0062740	Briarwood Farms WWTP	Middle Creek	40,000	Aqua NC, Inc.
NC0082996	Hollybrook WTP	Middle Creek	Not limited	Aqua NC, Inc.
NC0088862	Sunset Forest Subdivision Well #1	Basal Creek	Not limited	Aqua NC, Inc.
NC0086690	Stansted Well #2 (WTP)	Basal Creek	Not limited	Aqua NC, Inc.
NC0065102	South Cary WRF	Middle Creek	16,000,000	Town of Cary
NC0062715	Crooked Creek WWTP	Middle Creek	150,000	Aqua NC, Inc.
NC0061638	Amherst WWTP	Middle Creek	53,000	Carolina Water Service, Inc. of North Carolina
NC0066150	Brighton Forest WWTP	Middle Creek	117,000	Town of Fuquay-Varina
NC0066516	Terrible Creek WWTP	Terrible Creek	6,000,000	Town of Fuquay-Varina
NC0073679	Oak Hollow WTP	Middle Creek	Not limited	Carolina Water Service, Inc. of North Carolina
NC0087998	Rand Meadows Phase II	Juniper Branch	Not limited	Aqua NC, Inc.
NC0088714	Lassiter Farm Subdivision WTP	Ditch Branch	Not limited	Aqua NC, Inc.
NC0088889	Hopson Downs Subdivision Well #4	Basal Creek	Not limited	Aqua NC, Inc.
<b>Swift Creek (HUC# 0302020110)</b>				
NC0060526	Pope Industrial Park	Swift Creek	8,000	Pope Industrial Park II Ltd Partnership
NC0088285	Dempsey E Benton WTP	Swift Creek	Not limited	City of Raleigh Public Utilities Department
NC0055701	Nottingham WTP	Swift Creek	Not limited	Aqua NC, Inc.
NC0049034	Mount Auburn Training Center	White Oak Creek	2,400	Wake County
NC0025453	Little Creek WRF	Neuse River	2,500,00	Town of Clayton
<b>Walnut Creek-Neuse River (HUC# 0302020111)</b>				
NC0038784	Neuse River Village WWTP	Neuse River	35,000	Aqua NC, Inc.
NC0040266	Knightdale Estates MHP WWTP	Neuse River	25,000	Knightdale Estate MHP LP
NC0056391	Cross Creek Mobile Estates	Neuse River	70,000	Aqua NC, Inc.
NC0065706	Cottonwood/Baywood WWTP	Poplar Creek	115,000	Crosby Utilities, Inc.
NC0051322	Ashley Hills WWTP	Poplar Creek	495,000	Carolina Water Service Inc. of NC
NC0062219	Kings Grant Subdivision WWTP	Poplar Creek	210,000	Carolina Water Service Inc. of NC
NC0029033	Neuse River Resource Recovery Facility	Neuse River	75,000,000	City of Raleigh Public Utilities Department
NC0064378	Willowbrook WWTP	Beddingfield Creek	60,000	Carolina Water Service Inc. of NC
<b>Black Creek (HUC# 0302020112)</b>				
None				
<b>Milburnie Lake-Neuse River (HUC# 0302020107)</b>				
None				
<b>Crabtree Creek (HUC# 0302020108)</b>				
None				

WRF = Water Reclamation Facility, WTP = Water Treatment Plant, WWTP = Wastewater Treatment Plant



**Table 5. NPDES Individual Permitted Discharges in the Cape Fear River Subbasin within FLUSA**

Permit	Facility	Receiving Stream	Flow (GPD)	Owner
<b>Buckhorn Creek-Cape Fear River (HUC# 03030004010)</b>				
NC0063096	Holly Springs WWTP	Utley Creek	8,000,000	Town of Holly Springs
NC0055051	Avocet WWTP	Buckhorn Creek	90,000	Aqua NC, Inc.
<b>Buies Creek-Cape Fear River (HUC# 0303000405)</b>				
None				
<b>Upper South River (HUC# 0303000601)</b>				
None				

WWTP = Wastewater Treatment Plant

### 3.0 TARGET FEDERALLY PROTECTED SPECIES DESCRIPTIONS

#### 3.1 *Alasmidonta heterodon* (Dwarf Wedgemussel)

##### 3.1.1. *Species Characteristics*

The DWM was originally described as *Unio heterodon* (Lea 1829). Simpson (1914) subsequently placed it in the genus *Alasmidonta*. Ortmann (1919) placed it in a monotypic subgenus *Prolasmidonta*, based on the unique soft-tissue anatomy and conchology. Fuller (1977) believed the characteristics of *Prolasmidonta* warranted elevation to full generic rank and renamed the species *Prolasmidonta heterodon*. Clarke (1981) retained the genus name *Alasmidonta* and considered *Prolasmidonta* to be a subjective synonym of the subgenus *Pressodonta* (Simpson 1900).

The specific epithet *heterodon* refers to the chief distinguishing characteristic of this species, which is the only North American freshwater mussel that consistently has two lateral teeth on the right valve and only one on the left (Fuller 1977). All other laterally dentate freshwater mussels in North America normally have two lateral teeth on the left valve and one on the right. The DWM is generally small, with a shell length ranging between 25 millimeters (mm) (1.0 inch) and 38 mm (1.5 inches). The largest specimen reported by Clarke (1981) was 56.5 mm (2.2 inches) long, taken from the Ashuelot River in New Hampshire. The periostracum is generally olive green to dark brown; nacre bluish to silvery white, turning to cream or salmon colored towards the umbonal cavities. Sexual dimorphism occurs in DWM, with the females having a swollen region on the posterior slope, and the males are generally flattened. Clarke (1981) provides a detailed description of the species.

Nearly all freshwater mussel species have similar reproductive strategies; a larval stage (glochidium) becomes a temporary obligatory parasite on a fish. Many mussel species have specific fish hosts, which must be present to complete their life cycle. Based upon laboratory infestation experiments, Michaelson and Neves (1995) determined that potential fish hosts for the DWM in North Carolina include the Tessellated Darter (*Etheostoma olmstedi*) and the Johnny Darter (*E. nigrum*). McMahon and Bogan (2001) and Pennak (1989) should be consulted for a general overview of freshwater mussel reproductive biology.

### *3.1.2. Distribution and Habitat Requirements*

The historic range of the DWM is confined to Atlantic slope drainages from the Peticodiac River in New Brunswick, Canada, south to the Neuse River in North Carolina. Occurrence records exist from at least 70 locations, encompassing 15 major drainages, in 11 states and one Canadian Province (USFWS 1993). When the recovery plan for this species was written, the DWM was believed to have been extirpated from all but 36 localities, 14 of them in North Carolina (USFWS 1993). The most recent assessment (2013 5-Year Review) indicates that the DWM is currently found in 16 major drainages, comprising approximately 75 "sites" (one site may have multiple occurrences). At least 45 of these sites are based on less than five individuals or solely on relict shells. It appears that the populations in North Carolina, Virginia, and Maryland are declining as evidenced by low densities, lack of reproduction, or inability to relocate any individuals in follow-up surveys. Populations in New Hampshire, Massachusetts, and Connecticut appear to be stable, while the status of populations in the Delaware River watershed affected by multiple flood events between 2004 and 2006 are still being studied (USFWS 2013).

Strayer et al. (1996) conducted range-wide assessments of remaining DWM populations, and assigned a population status to each of the populations. The status rating is based on range size, number of individuals and evidence of reproduction. Seven of the 20 populations assessed were considered "poor," and two others are considered "poor to fair" and "fair to poor," respectively. In North Carolina, populations are found in portions of the Neuse and Tar River basins; however, they are believed to have been extirpated from the mainstem of the Neuse River.

The DWM inhabits creeks and rivers of varying sizes (down to approximately two meters wide), with slow to moderate flow. A variety of preferred substrates have been described that range from coarse sand, to firm muddy sand to gravel (USFWS 1993). In North Carolina, DWMs often occur within submerged root mats along stable streambanks. The wide range of substrate types used by this species suggests that the stability of the substrate is likely as important as the composition.

### *3.1.3. Threats to Species*

The cumulative effects of several factors, including sedimentation, point and non-point discharges, and stream modifications (impoundments, channelization, etc.) have contributed to the decline of this species throughout its range. Except for the Neversink River population in New York, which has an estimated population of over 80,000 DWM individuals, all other populations are generally small in numbers and restricted to short reaches of isolated streams. The low numbers of individuals and the restricted range of most of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event or activity (Strayer et al. 1996). Catastrophic events may consist of natural events such as flooding or drought, as well as human influenced events such as toxic spills associated with highways, railroads, or industrial-municipal complexes.

Siltation resulting from substandard land-use practices associated with activities such as agriculture, forestry, and land development has been recognized as a major contributing factor to degradation of mussel populations. Siltation has been documented to be extremely detrimental

to mussel populations by degrading substrate and water quality, increasing potential exposure to other pollutants, and by direct smothering of mussels (Ellis 1936, Marking and Bills 1979). Sediment accumulations of less than one inch have been shown to cause high mortality in most mussel species (Ellis 1936). In Massachusetts, a bridge construction project decimated a population of the DWM because of accelerated sedimentation and erosion (Smith 1981).

Sewage treatment effluent has been documented to significantly affect the diversity and abundance of mussel fauna (Goudreau et al. 1988). Goudreau et al. (1988) found that recovery of mussel populations may not occur for up to two miles below points of chlorinated sewage effluent.

The impact of impoundments on freshwater mussels has been well documented (USFWS 1992a, Neves 1993). Construction of dams transforms lotic habitats into lentic habitats, which results in changes in aquatic community composition. The changes associated with inundation adversely affect both adult and juvenile mussels as well as fish community structure, which could eliminate possible fish hosts for upstream transport of glochidia (parasitic larval form). Muscle Shoals on the Tennessee River in northern Alabama, once the richest site for naiads (mussels) in the world, is now at the bottom of Wilson Reservoir and covered with 19 feet of muck (USFWS 1992b). Large portions of all the river basins within the DWM's range have been impounded. This is believed to be a major factor contributing to the decline of the species (Master 1986).

The introduction of exotic species such as the Asian Clam (*Corbicula fluminea*) and Zebra Mussel (*Dreissena polymorpha*) has also been shown to pose significant threats to native freshwater mussels. The Asian Clam is now established in most of the major river systems in the United States (Fuller and Powell 1973) including those streams still supporting surviving populations of the DWM. Concern has been raised over competitive interactions for space, food and oxygen with this species and native mussels, possibly at the juvenile stages (Neves and Widlak 1987, Alderman 1995). The Zebra Mussel, native to the drainage basins of the Black, Caspian, and Aral Seas, is an exotic freshwater mussel that was introduced into the Great Lakes in the 1980s and has rapidly expanded its range into the surrounding river basins, including those of the South Atlantic slope (O'Neill and MacNeill 1991). This species competes for food resources and space with native mussels; and is expected to contribute to the extinction of at least 20 freshwater mussel species if it becomes established throughout most of the eastern United States (USFWS 1992b). The Zebra Mussel is not currently known from any river supporting DWM population, nor is it found in the Neuse River basin.

## **3.2 *Elliptio lanceolata* (Yellow Lance)**

### *3.2.1. Species Characteristics*

The Yellow Lance was described from the Tar River at Tarboro, North Carolina in 1828, by I. Lea (Lea 1828). Johnson (1970) synonymized this species with 25 other named species of lance-shaped *Elliptio* mussels into *Elliptio lanceolata* species complex. Genotypic and phenotypic analysis suggests that some of these formally described species are valid, including *Elliptio lanceolata* (Bogan et al. 2009). This species differs from other lanceolate *Elliptios* by having a “waxy” bright yellow periostracum that lacks rays. Some older specimens are brown towards the posterior end of the shell. The periostracum can also have brown growth rests. Yellow

Lances have a distinct pallial line and adductor muscle scars. The posterior ridge is distinctly rounded and curves dorsally towards the posterior end. The nacre ranges from an iridescent blue on the posterior end, sometimes becoming white or salmon colored on the anterior end. The lateral teeth are long, with two on the left and one on the right. Each valve also has two pseudocardinal teeth. On the left valve one tooth is before the other with the posterior tooth tending to be vestigial. On the right valve, the two teeth are parallel and the more anterior one is vestigial (Adams et al 1990).

The Yellow Lance is a tachytictic (short-term) breeder, brooding young in early spring and releasing glochidia in early summer. White Shiner (*Luxilus albeolus*) and Pinewoods Shiner (*Lythrurus matuntinus*) are potential fish hosts for Yellow Lance (Eads and Levine 2009).

### 3.2.2. *Distribution and Habitat Requirements*

The taxonomy of this species has changed several times and, therefore, so has its range. The Yellow Lance is currently thought to be distributed in the Atlantic Slope river basins from the Neuse River Basin in North Carolina north to the Rappahannock River Basin in Virginia, except for the Roanoke River Basin, the Patuxent River Basin in Maryland, and possibly the Potomac River Basin in Virginia and Maryland (USFWS 2017). It is in considerable decline throughout its range; however, extant populations still occur in all historic river basins, except possibly the Potomac (USFWS 2017). This species has been found in multiple physiographic provinces, from the foothills of the Appalachian Mountains, through the Piedmont, and into the Coastal Plain. It is found in small streams to large rivers, in substrates primarily consisting of clean sand, and occasionally gravel, with high dissolved oxygen content (USFWS 2017, Adams et al 1990). No remaining populations appear below point source pollution or other nutrient-rich areas (Alderman 2003). Associate mussel species include Atlantic Pigtoe, Tar River Spiny mussel (*Elliptio steinstansana*), Yellow Lampmussel (*Lampsilis cariosa*), Notched Rainbow (*Villosa constricta*), Triangle Floater (*Alasmidonta undulata*), Paper Pondshell (*Utterbackia imbecillis*), Eastern Lampmussel (*Lampsilis radiata*), Creeper (*Strophitus undulatus*), and other Elliptio species (Adams et al 1990).

### 3.2.3. *Threats to Species*

Threats to the Yellow Lance and many other species are similar to those described above for the DWM. Factors that influence long term viability of this species are discussed in detail in the USFWS Yellow Lance Species Status Review (2017).

### 3.2.4. *Species Listing*

Yellow Lance was petitioned for federal listing under the Endangered Species Act of 1973, as amended (ESA) within the 2010 Petition to List 404 Aquatic, Riparian and Wetland Species from the Southeastern United States by the Center for Biological Diversity (CBD 2010), and is state listed as Endangered in North Carolina. On April 5, 2017, the USFWS proposed listing Yellow Lance as threatened. Following the proposal, there was a 60-day comment period for the public to provide input to help USFWS in making its final decision. The USFWS usually has

one year after a species is proposed for listing under the ESA to make a final determination on listing the species as threatened or endangered.

## 4.0 OTHER TARGET SPECIES DESCRIPTIONS

### 4.1 *Fusconaia masoni* (Atlantic Pigtoe)

#### 4.1.1. *Species Characteristics*

The Atlantic Pigtoe was described by Conrad (1834) from the Savannah River in Augusta, Georgia. Although larger specimens exist, the Atlantic Pigtoe seldom exceeds 50 mm (about 2 inches) in length. This species is tall relative to its length, except in headwater stream reaches where specimens may be elongated. The hinge ligament is relatively short and prominent. The periostracum is normally brownish, has a parchment texture, and young individuals may have greenish rays across the entire shell surface. The posterior ridge is biangulate. The interdentum in the left valve is broad and flat. The anterior half of the valve is thickened compared with the posterior half, and, when fresh, nacre in the anterior half of the shell tends to be salmon colored, while nacre in the posterior half tends to be more iridescent. The shell has full dentation. In addition to simple papillae, branched and arborescent papillae are often seen on the incurrent aperture. In females, salmon colored demibranchs are often seen during the spawning season. When fully gravid, females use all four demibranchs to brood glochidia (VDGIF 2014).

The Atlantic Pigtoe is a tachytictic (short-term) breeder, brooding young in early spring and releasing glochidia in early summer. The Bluegill (*Lepomis macrochirus*) and Shield Darter (*Percina peltata*) have been identified as potential fish hosts for this species (O'Dee and Waters 2000). Additional research has found Rosefin Shiner (*Lythrurus ardens*), Creek Chub (*Semotilus atromaculatus*), and Longnose Dace (*Rhynchithys cataractae*) are also suitable hosts (Wolf 2012). Eads and Levine (2011) found White Shiner, Satinfin Shiner (*Cyprinella analostana*), Bluehead Chub (*Nocomis leptcephalus*), Rosyside Dace (*Clinostomus funduloides*), Pinewoods Shiner, Creek Chub, Swallowtail Shiner (*Notropis procne*), and Mountain Redbelly Dace (*Chrosomus oreas*) to also be suitable hosts for Atlantic Pigtoe.

#### 4.1.2. *Distribution and Habitat Requirements*

Johnson (1970) reported the range of the Atlantic Pigtoe extended from the Ogeechee River Basin in Georgia north to the James River Basin in Virginia; however, recent curation of the H. D. Athearn collection uncovered valid specimens from the Altamaha River in Georgia (Sarah McRae, USFWS, personal communication). It is presumed extirpated from the Catawba River Basin in North and South Carolina south to the Altamaha River Basin. The general pattern of its current distribution indicates that the species is currently limited to headwater areas of drainages and most populations are represented by few individuals. In North Carolina, aside from the Waccamaw River, it was once found in every Atlantic Slope river basin. Except for the Tar River, it is no longer found in the mainstem of the rivers within its historic range (Savidge et al. 2011). It is state listed as Endangered in Georgia, South Carolina, and North Carolina, and as Threatened in Virginia. It has a NatureServe rank of G2 (imperiled).

The Atlantic Pigtoe has been found in multiple physiographic provinces, from the foothills of the Appalachian Mountains, through the Piedmont and into the Coastal Plain, in streams less than one meter wide to large rivers. The preferred habitat is a substrate composed of gravel and coarse sand, usually at the base of riffles; however, it can be found in a variety of other substrates and lotic habitat conditions.

#### *4.1.3. Threats to Species*

Threats to the Atlantic Pigtoe are similar to those described for the DWM and have contributed to the decline of this species throughout its range. Atlantic Pigtoe appears to be particularly sensitive to pollutants and requires clean oxygen-rich water for all stages of life. All remaining Atlantic Pigtoe populations are generally small in numbers and restricted to short reaches of isolated streams. The low numbers of individuals and the restricted range of most of the surviving populations make them extremely vulnerable to extirpation from a single catastrophic event.

#### *4.1.4. Species Listing*

Atlantic Pigtoe was petitioned for federal listing under the Endangered Species Act of 1973, as amended within the 2010 Petition to List 404 Aquatic, Riparian and Wetland Species from the Southeastern United States by the CBD (CBD 2010), and is listed as Endangered in North Carolina by North Carolina Wildlife Resource Commission (NCWRC).

## **4.2 *Noturus furiosus* (Carolina Madtom)**

### *4.2.1. Species Characteristics*

The Carolina Madtom (a small catfish) was described at Milburnie, near Raleigh, NC in the Neuse River by Jordan and Meek (Jordan 1889). The Carolina Madtom reaches a maximum size of 132 mm (5.2 inches). Compared to other Madtoms within its range, it has a relatively short stout body and a distinctive color pattern of three to four dark saddles along its back that connect a long black stripe on the side running from the snout to the tail. The adipose fin is mostly dark, making it appear that the fish has a fourth saddle. The Madtom is tan on the rest of its body and yellow to tan between the saddles. The adipose fin and caudal fin are fused together, a distinguishing characteristic from other members of the catfish family (Ictaluridae). There are no speckles on the Madtom's belly, and the tail has two brown bands that follow the curve of the tail. The Carolina Madtom, like other catfish, has serrae on its pectoral fins and is thought to have the most potent venom of any of the catfish species (NCWRC 2010).

### *4.2.2. Distribution and Habitat Requirements*

The Carolina Madtom is endemic to the Piedmont/Inner Coastal Plain portion of the Tar/Pamlico and Neuse River basins. It occurs in creeks and small rivers in habitats generally consisting of very shallow riffles with little current over coarse sand and gravel substrate (Lee et al. 1980). Burr et al (1989) found most records came from medium to large streams, i.e. mainstem Neuse and Tar Rivers and their major tributaries. The population in the Trent River system (part of the Neuse River basin) is isolated from the rest of the Neuse River basin by salinity levels, so it is

therefore considered a separate population, though it has not been detected in Trent River in the last five years (Sarah McRae, USFWS, personal communication). In the lower portions of these rivers, Carolina Madtom is usually found over debris piles in sandy areas. During nesting season, May to July, Madtoms prefer areas with plenty of cover to build their nests with shells, rocks, sticks, bottles, and cans being suitable cover types. Males guard the nests, in which females may lay between 80 and 300 eggs.

Carolina Madtom is found in water that ranges from clear to tannin-rich, which is usually free-flowing. It is generally rare throughout its range and is apparently in decline. The Tar River population has historically been more robust than the Neuse River population (Burr et al. 1989), which has shown declines in recent years (Midway 2008). The Little River of the Neuse River Basin has the largest population of Carolina Madtom in the Neuse River Basin, with records from 2016 indicating it is present (Sarah McRae, USFWS, personal communication). A few specimens have been collected from Swift Creek, within the Neuse River Basin. Fishing Creek and Swift Creek of the Tar River Basin are also productive systems for Carolina Madtom populations, with around 14 specimens collected in the mid-1980s from Swift Creek (water levels in Fishing Creek prevented sampling during that study). In 2016, a total of 17 individuals were recorded in Swift Creek, and a total of four individuals were recorded in Fishing Creek (Sarah McRae, USFWS, personal communication). The Carolina Madtom has been observed in at least 36 localities (Burr et al 1989).

The Carolina Madtom has a lifespan of about four years, with sexual maturity being reached at around two years in females and three years in males. Sampling for Carolina Madtom is most effective at dawn and dusk when they are most active and feeding (Mayden and Burr 1981). Their diet consists mostly of benthic macroinvertebrates, which they collect by scavenging along the bottom of streams.

#### *4.2.3. Threats to Species*

Identified threats to the Carolina Madtom include water pollution and construction of impoundments (Burr et al. 1989). It is susceptible to threats due to its limited range and low population densities (Angermeier 1995, Burr and Stoekel 1999). As a bottom-dwelling fish, Carolina Madtom is susceptible to habitat loss when stream bottoms are impacted by urbanization, impoundments, deforestation, etc.

#### *4.2.4. Species Listing*

Because of its limited distribution, Carolina Madtom is listed as Special Concern and is Proposed Threatened in North Carolina. It was petitioned for federal listing under the Endangered Species Act of 1973, as amended within the 2010 Petition to List 404 Aquatic, Riparian and Wetland Species from the Southeastern United States by the CBD (CBD 2010).

### 4.3 *Necturus lewisi* (Neuse River Waterdog)

#### 4.3.1. *Characteristics*

The Neuse River Waterdog is a fully aquatic salamander and was first described by C.S. Brimley in 1924 as a subspecies of the Common Mudpuppy (*N. maculosus*); it was elevated to species status in 1937 by Percy Viosca, Jr.

The Neuse River Waterdog ranges in size from 15.24 to 22.86 centimeters (cm) (6 to 9 inches) in length; record length is 27.94 cm (11 inches). It has a somewhat stocky, cylindrical body with smooth skin, a rather flattened, elongate head with a squared-off nose, and small limbs. The tail is vertically flattened with fins on both the top and bottom. Distinct from most salamanders, the Neuse River Waterdog has four toes on each foot. The Neuse River Waterdog is a rusty brown color on the dorsal side and dull brown or slate colored on the ventral side. Both dorsal and ventral sides are strongly spotted, but the ventral side tends to have fewer and smaller markings; spots are dark bluish to black. They also have a dark line running through the eye. Adults are neotenuous and retain three bushy, dark red external gills usually seen in larval amphibians. Both male and female are similar in appearance and can be distinguished only through differences in the shape and structure of the cloaca (Beane and Newman 1996; Conant and Collins 1998; EDGE of Existence 2016).

Individuals become sexually mature at approximately five to six years of age. Breeding normally occurs in the spring. The male deposits a gelatinous spermatophore that is picked up by the female and used to fertilize between 30 and 50 eggs. The fertilized eggs are attached to the underside of flat rocks or other submerged objects and guarded by the female until they hatch in June or July (Conant and Collins 1998; EDGE of Existence 2016).

#### 4.3.2. *Distribution and Habitat Requirements*

The Neuse River Waterdog is found only in the Neuse and Tar River basins of North Carolina (AmphibiaWeb 2006; Beane and Newman 1996; Frost 2016).

The Neuse River Waterdog inhabits rivers and larger streams, where it prefers leaf beds in quiet waters. This species needs high levels of dissolved oxygen and good water quality. The Neuse River Waterdog is generally found in backwaters off the main current, in areas with sandy or muddy substrate. Adults construct retreats on the downstream side of rocks or in the stream bank where they remain during the day. This species is active during the night, leaving these retreats to feed. The Neuse River Waterdog is carnivorous, feeding on invertebrates, small vertebrates, and carrion. The Neuse River Waterdog is most active during winter months even when temperatures are below freezing. During summer months, it will burrow into deep leaf beds and is rarely found. It has been suggested that this inactivity in summer may be an adaptation to avoid fish predators, which are more active at these times. In addition, the Neuse River Waterdog produces a defensive, toxic skin secretion that is assumed to be distasteful to predators (AmphibiaWeb 2006; Beane and Newman 1996; Conant and Collins 1998; EDGE of Existence 2016; NatureServe Explorer 2016).



### 4.3.3. Threats to Species

Any factors that reduce water quality are all threats to the Neuse River Waterdog. These can include changes that result in siltation and pollution reducing habitat quality (e.g. channelization, agricultural runoff, and industrial and urban development). Impoundments are also a threat to the dispersal of the species as it is unable to cross upland habitat; Neuse River Waterdogs do not climb and are unlikely to use fish passages (NatureServe Explorer 2016).

### 4.3.4. Species Listing

The Neuse River Waterdog was petitioned for federal listing under the Endangered Species Act of 1973, as amended within the 2010 Petition to List 404 Aquatic, Riparian and Wetland Species from the Southeastern United States by the CBD (CBD 2010).

## 5.0 SURVEY EFFORTS

### 5.1 Freshwater Mussel Surveys

Surveys were conducted by Three Oaks personnel on the following dates:

Personnel	10/4/16	10/19/16	11/1/16	11/2/16	11/3/16	11/4/16	2/1/17	2/2/17	2/7/17	2/8/17	3/21/17	4/14/17	5/18/17
Tim Savidge (Permit # 16/17-ES0034)			X	X	X	X						X	X
Tom Dickinson (Permit # 16/17-ES00343)	X	X		X	X		X	X	X	X	X		
Chris Sheats	X	X					X	X	X	X			
Evan Morgan	X		X	X	X								
Nathan Howell											X	X	
Mary Frazer				X		X						X	
Brian Watson				X	X	X							
John Roberts		X											
Nancy Scott				X	X								
Lizzy Stokes-Cawley												X	X
John Fridell													X
Hannah Slyce													X

#### 5.1.1. Survey Locations

Survey locations were selected based on previous survey data, proximity to the FLUSA, habitat requirements of the target species and field conditions.

#### 5.1.2. Methodology

Areas of appropriate habitat were searched, concentrating on the stable habitats preferred by the target species. The survey team spread out across the creek into survey lanes. Visual surveys were conducted using glass bottom view buckets (bathyscopes). Tactile methods were

employed, particularly in streambanks under submerged rootmats. All freshwater bivalves were recorded and returned to the substrate. Timed survey efforts provided Catch Per Unit Effort (CPUE) data for each species. Relative abundance for freshwater snails and freshwater clam species were estimated using the following criteria:

- (VA) Very abundant > 30 per square meter
- (A) Abundant 16-30 per square meter
- (C) Common 6-15 per square meter
- (U) Uncommon 3-5 per square meter
- (R) Rare 1-2 per square meter
- (P-) Ancillary adjective “Patchy” indicates an uneven distribution of the species within the sampled site.

### 5.1.3. Mussel Survey Results

Mussel survey results are reported in the following sections. Each survey reach is given a unique site identification number consisting of the survey date and the initials of the person leading the survey. This identification number is provided in each section title.

#### 5.1.3.1 Black Creek 161004.2ted

This survey in Black Creek was conducted for 3 person hours near the Jackson-King Road crossing, extending upstream to an in-stream Beaver (*Castor canadensis*) dam and associated wetland complex (Figure 4). Habitat consisted of a low velocity run and slackwater. Substrate was dominated by sand with clay banks. Water clarity was light tannic. The stream channel ranged from 12 to 20 feet wide with relatively stable banks up to 3 feet high. A wide forested buffer surrounded the site.

**Table 6. CPUE for Freshwater Mussels Black Creek 161004.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio</i> spp.*	Elliptio mussels	178	59.33/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	R
<i>Campeloma decisum</i>	Pointed Campeloma	~	C

\* *E. complanata*, *E. cistellaeformis* and *E. ictarina* forms present, with gradation in-between

#### 5.1.3.2 Black Creek 161004.3ted

This survey was conducted for 1.5 person hours below Panther Lake upstream of the Old Stage Road crossing (Figure 4). Habitat consisted of the lake tailrace extending into a Beaver-impounded swamp downstream. Substrate was dominated by sand and gravel/cobble. Water clarity was light tannic. The stream channel was approximately 12 feet wide with banks exhibiting some erosion and undercutting up to 2 feet high. A moderate forested buffer and Beaver-impounded wetland complex surrounded the site.

**Table 7. CPUE for Freshwater Mussels Black Creek 161004.3ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	13	8.67/hr
<i>Pyganodon cataracta</i>	Eastern Floater	1	0.67/hr
<i>Utterbackia imbecillis</i>	Paper Pondshell	1	0.67/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A

## 5.1.3.3 Black Creek 161019.1ted

This survey in Black Creek was conducted for 2 person hours below the Raleigh Road crossing (Figure 4). Habitat consisted of run and slackwater with substrate dominated by coarse sand and gravel. Water clarity was tannic. The stream channel ranged from 20 to 30 feet wide with stable banks up to 3 feet high. A wide, mature forested buffer surrounded the site.

**Table 8. CPUE for Freshwater Mussels Black Creek 161019.1ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio</i> spp.*	Elliptio mussels	242	121.00/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A
<i>Campeloma decisum</i>	Pointed Campeloma	~	C

\* *E. complanata*, *E. cistellaeformis*, and *E. icterina* forms present, with gradation in-between

## 5.1.3.4 Black Creek 161019.2ted

This survey in Black Creek was accessed from private land and conducted for 1.8 person hours (Figure 4). Habitat consisted primarily of run with substrate dominated by fine sand. Water clarity was tannic. The stream channel ranged from 20 to 35 feet wide with stable banks up to 3 feet high. A wide, mature forested buffer surrounded the site.

**Table 9. CPUE for Freshwater Mussels Black Creek 161019.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio</i> spp.*	Elliptio mussels	43	23.89/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	C

\* *E. complanata*, *E. cistellaeformis*, and *E. icterina* forms present, with gradation in-between

### 5.1.3.5 Black Creek 161019.3ted

This survey in Black Creek was conducted for 2 person hours upstream of the NC 50 crossing (Figure 4). Habitat consisted primarily of run with substrate dominated by compact fine sand and detritus. Water clarity was light tannic. The stream channel ranged from 20 to 25 feet wide with stable banks up to 3 feet high. A wide, mature forested buffer surrounded the site. Mussels were found in very low densities for the available habitat.

**Table 10. CPUE for Freshwater Mussels Black Creek 161019.3ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	26	13.0/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	R
<i>Campeloma decisum</i>	Pointed Campeloma	~	R

### 5.1.3.6 Black Creek 161019.4ted

This survey in Black Creek was conducted for 2.25 person hours downstream of the Old Fairground Road crossing (Figure 4). Habitat consisted of deeper run and pool with primarily sand and clay substrate. Water clarity was light tannic. The stream channel ranged from 20 to 35 feet wide with eroded banks 3 to 6 feet high. The channel was heavily scoured in areas with large deposits of woody debris. A wide, forested floodplain buffer surrounded the site.

**Table 11. CPUE for Freshwater Mussels Black Creek 161019.4ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	44	19.56/hr
<i>Utterbackia imbecillis</i>	Paper Pondshell	1	0.44/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	R

### 5.1.3.7 Middle Creek 161102.1ted

This survey in Middle Creek was conducted for 5.5 person hours in a reach extending upstream from the NC 50 crossing (Figure 4). Habitat consisted of a sequence of riffle, run, and pool with primarily sand substrate. The stream channel ranged from 30 to 40 feet wide with variably stable to eroded banks 3 to 10 feet high. Stable patches of cobble and gravel as well as clay and rootmats along stream banks were associated with higher mussel density and diversity. Stream conditions were low and clear. A moderately wide, mature, forested buffer was present to surrounding residential development.

**Table 12. CPUE for Freshwater Mussels Middle Creek 161102.1ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta undulata</i>	Triangle Floater	4	0.73/hr
<i>Elliptio complanata</i>	Eastern Elliptio	172	31.27/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	3	0.55/hr
<i>Elliptio icterina</i>	Variable Spike	91	16.55/hr
<i>Lampsilis radiata</i>	Eastern Lampmussel	4	0.73/hr
<i>Strophitus undulatus</i>	Creeper	5	0.91/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A

## 5.1.3.8 Middle Creek 161102.2ted

This survey in Middle Creek was conducted for 2.25 person hours in a short reach upstream from NC 50 as accessed from surrounding residential development (Figure 4). Habitat consisted of run with mixed sand, gravel, and cobble substrate. The stream channel ranged from 20 to 30 feet wide with relatively stable banks 3 to 6 feet high. Stream conditions were low and clear. A moderately wide, mature, forested buffer was present and extended to surrounding residential development.

**Table 13. CPUE for Freshwater Mussels Middle Creek 161102.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	91	40.44/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	3	1.33/hr
<i>Elliptio icterina</i>	Variable Spike	37	16.44/hr
<i>Elliptio</i> sp c.f. <i>mediocris</i>	No common name	1	0.44/hr
<i>Strophitus undulatus</i>	Creeper	2	0.89/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A

## 5.1.3.9 Middle Creek 161102.3ted

This survey in Middle Creek was conducted for 1.5 person hours upstream from Barber Bridge Road (Figure 4). Habitat consisted of a sequence of run and pool with primarily unconsolidated sand substrate. The stream channel ranged from 15 to 30 feet wide with unstable banks 6 to 10 feet high. A large amount of recent windthrow and woody debris deposits were present. Stream conditions were low and clear. A wide forested buffer surrounded the reach.

**Table 14. CPUE for Freshwater Mussels Middle Creek 161102.3ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	16	10.67/hr
<i>Elliptio icterina</i>	Variable Spike	3	2.00/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

## 5.1.3.10 Black Creek 161103.1ted

This survey in Black Creek was conducted for 4.6 person hours below the Raleigh Road crossing (Figure 4). Habitat consisted of run and pool with substrate dominated by coarse sand and gravel. Water clarity was light tannic. The stream channel ranged from 20 to 30 feet wide with stable banks up to 3 feet high. A wide, mature forested buffer surrounded the site.

**Table 15. CPUE for Freshwater Mussels Black Creek 161103.1ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio</i> spp.*	Elliptio mussels	163	35.43/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A
<i>Campeloma decisum</i>	Pointed Campeloma	~	C

\* *E. complanata*, *E. cistellaeformis*, and *E. icterina* forms present, with gradation in-between

## 5.1.3.11 Black Creek 161103.2ted

This survey in Black Creek was conducted for 2.6 person hours below the Raleigh Road crossing (Figure 4). Habitat consisted of run and riffle with substrate dominated by coarse sand and gravel. Water clarity was light tannic. The stream channel ranged from 20 to 30 feet wide with stable banks up to 3 feet high. A wide, mature forested buffer surrounded the site.

**Table 16. CPUE for Freshwater Mussels Black Creek 161103.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio</i> spp.*	Elliptio mussels	268	103.08/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A
<i>Campeloma decisum</i>	Pointed Campeloma	~	U

\* *E. complanata*, *E. cistellaeformis*, and *E. icterina* forms present, with gradation in-between

### 5.1.3.12 Middle Creek 161103.3ted

This survey in Middle Creek was conducted for 2.25 person hours in a sharp bend with steep surrounding topography and rocky outcroppings (Figure 4). Habitat consisted of deeper run with mixed sand, gravel, and cobble substrate. The stream channel ranged from 30 to 40 feet wide with relatively stable banks up to 3 feet high. Stream conditions were low and clear. A moderately wide, mature forested buffer was present to surrounding residential development.

**Table 17. CPUE for Freshwater Mussels Middle Creek 161103.3ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta undulata</i>	Triangle Floater	1	0.44/hr
<i>Elliptio complanata</i>	Eastern Elliptio	101	44.89/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	6	2.67/hr
<i>Elliptio icterina</i>	Variable Spike	26	11.56/hr
<i>Strophitus undulatus</i>	Creeper	7	3.11/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A

### 5.1.3.13 Middle Creek 161103.4ted

This survey in Middle Creek was conducted for 2.35 person hours upstream from the Middle Creek 1061103.3ted site (Figure 4). Habitat consisted of a sequence of riffle, run and pool with primarily mixed sand and gravel substrate. The stream channel ranged from 30 to 40 feet wide with relatively unstable banks up 3 to 6 feet high. Stream conditions were low and clear. A moderately wide, mature forested buffer was present to surrounding residential development.

**Table 18. CPUE for Freshwater Mussels Middle Creek 161103.4ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	64	27.23/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	2	0.85/hr
<i>Lampsilis radiata</i>	Eastern Lampmussel	1	0.43/hr
<i>Strophitus undulatus</i>	Creeper	1	0.43/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	A

### 5.1.3.14 White Oak Creek 161101.1tws

This survey in White Oak Creek was conducted for 4.4 person hours within a former Beaver marsh downstream of NC 42 (Figure 4). Beaver dams appear to have been breached for several months. Habitat consisted of riffle, run, and pool with mixed sand and pebble substrate. The stream channel ranged from 5 to 7 feet wide with relatively stable banks up to 1 foot high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear.

A wide (greater than 500 feet), forested/shrub brush buffer was present on each side of White Oak Creek throughout the survey reach. The buffer abuts a residential development about 600 feet upslope from the left descending bank.

**Table 19. CPUE for Freshwater Mussels White Oak Creek 161101.1tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	189	42.95
<i>Elliptio icterina</i>	Variable Spike	8	1.82
<i>Lampsilis radiata</i>	Eastern Lampmussel	1	0.23
<i>Pyganodon cataracta</i>	Eastern Floater	14	3.18
<i>Utterbackia imbecillis</i>	Paper Pondshell	1	0.23
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	P-C

#### 5.1.3.15 White Oak Creek 161101.2tws

This survey in White Oak Creek started at the end of 161101.1tws and continued through a large overwash area just below the NC 42 bridge (Figure 4). The survey was conducted for 4.1 person hours. Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel ranged from 5 to 8 feet wide with unstable banks up to 1 foot high. Stream conditions were normal and clear. A moderately wide forested buffer was present to surrounding residential and commercial development.

**Table 20. CPUE for Freshwater Mussels White Oak Creek 161101.2tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	283 (14 shells)	69.02
<i>Elliptio congaraea</i>	Carolina Slabshell	22 (4 shells)	5.37
<i>Elliptio icterina</i>	Variable Spike	14 (2 shells)	3.41
<i>Elliptio roanokensis</i>	Roanoke Slabshell	(1 shell)	0
<i>Lampsilis radiata</i>	Eastern Lampmussel	16 (4 shells)	3.90
<i>Pyganodon cataracta</i>	Eastern Floater	20 (11 shells)	4.88
<i>Utterbackia imbecillis</i>	Paper Pondshell	10 (1 shell)	2.44
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	P-C

#### 5.1.3.16 White Oak Creek 161101.3tws

This survey in White Oak Creek was conducted upstream of NC 42 in the tailrace of Austin Pond (Figure 4). The survey was conducted for 2.76 person hours. Habitat consisted of riffle,



run, and pool with a cobble and sand substrate. The stream channel ranged from 5 to 13 feet wide with unstable banks ranging from 1 to 1.25 feet high. Stream conditions were normal and clear. A moderately wide forested buffer was present to surrounding residential development.

**Table 21. CPUE for Freshwater Mussels White Oak Creek 161101.3tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	121	43.84
<i>Elliptio icterina</i>	Variable Spike	7	2.54
<i>Lampsilis radiata</i>	Eastern Lampmussel	1	0.36
<i>Pyganodon cataracta</i>	Eastern Floater	19	6.88
<i>Utterbackia imbecillis</i>	Paper Pondshell	14	5.07
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	P-U

#### 5.1.3.17 Middle Creek 161102.1tws

This survey in Middle Creek was conducted downstream of Smith Road (SR 1507) for 5.13 person hours (Figure 4). Habitat consisted of riffle, run, and pool with an unconsolidated sand and pebble substrate. The stream channel ranged from 11 to 14 feet wide with unstable banks ranging from 3 to 4 feet high. Stream conditions were normal and clear. A wide forested buffer was present to surrounding agriculture and residential development.

**Table 22. CPUE for Freshwater Mussels Middle Creek 161102.1tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	63	12.28
<i>Elliptio congaraea</i>	Carolina Slabshell	4	0.78
<i>Elliptio icterina</i>	Variable Spike	3	0.58
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	P-U
<i>Elimia catenaria</i>	Gravel Elimia	~	P-U

#### 5.1.3.18 Middle Creek 161102.2tws

This survey in Middle Creek was conducted downstream of Smith Road (SR 1507) beginning at the end of 161102.1tws for 3.27 person hours (Figure 4). Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel ranged from 11 to 13 feet wide with banks ranging from 2.5 to 4 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A wide forested buffer was present to surrounding agriculture and residential development.

**Table 23. CPUE for Freshwater Mussels Middle Creek 161102.2tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	85	25.99
<i>Elliptio congaraea</i>	Carolina Slabshell	15	4.59
<i>Elliptio icterina</i>	Variable Spike	5	1.53
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	U
<i>Elimia catenaria</i>	Gravel Elimia	~	P-C

## 5.1.3.19 Middle Creek 161102.3tws

This survey in Middle Creek was conducted downstream of Smith Road (SR 1507) beginning at the end of 161102.2tws for 5.27 person hours (Figure 4). Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel ranged from 10 to 14 feet wide with banks ranging from 3 to 4 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A wide forested buffer was present to surrounding agriculture and residential development. One individual of the targeted Atlantic Pigtoe was found.

**Table 24. CPUE for Freshwater Mussels Middle Creek 161102.3tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	133	25.24
<i>Elliptio congaraea</i>	Carolina Slabshell	20	3.80
<i>Elliptio fisheriana</i>	Northern Lance	7	1.33
<i>Elliptio icterina</i>	Variable Spike	21	3.98
<i>Elliptio roanokensis</i>	Roanoke Slabshell	1	0.19
<i>Fusconaia masoni</i>	Atlantic Pigtoe	1	0.19
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	P-U
<i>Elimia catenaria</i>	Gravel Elimia	~	P-C

## 5.1.3.20 Middle Creek 161102.4tws

This survey in Middle Creek was conducted downstream of Smith Road (SR 1507) beginning at the end of 161102.3tws for 4 person hours (Figure 4). Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel ranged from 10 to 14 feet wide with banks ranging from 3 to 4 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A moderately wide forested buffer was present to surrounding agriculture and residential development.

**Table 25. CPUE for Freshwater Mussels Middle Creek 161102.4tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	37	9.25
<i>Elliptio congaraea</i>	Carolina Slabshell	23	5.75
<i>Elliptio icterina</i>	Variable Spike	2	0.50
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	P-U
<i>Elimia catenaria</i>	Gravel Elimia	~	P-U

## 5.1.3.21 Middle Creek 161103.1tws

This survey in Middle Creek was conducted downstream of Crantock Road (SR 1504) for 3.5 person hours (Figure 4). Habitat consisted of riffle and run with a gravel and sand substrate. The stream channel ranged from 11 to 14 feet wide with banks ranging from 3 to 4.25 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A moderately wide forested/shrub-brush buffer was present to surrounding agriculture.

**Table 26. CPUE for Freshwater Mussels Middle Creek 161103.1tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	77	22.00
<i>Elliptio congaraea</i>	Carolina Slabshell	143	40.86
<i>Elliptio icterina</i>	Variable Spike	15	4.29
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Elimia catenaria</i>	Gravel Elimia	~	P-C

## 5.1.3.22 Middle Creek 161103.2tws

This survey in Middle Creek was conducted downstream of Crantock Road (SR 1504) starting at the endpoint of 161103.1tws for 2.6 person hours (Figure 4). Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel ranged from 12 to 14 feet wide with banks ranging from 2.5 to 4 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A moderately wide forested/shrub-brush buffer was present to surrounding agriculture. Relict shells of the Dwarf Wedgemusel, Yellow Lance, Atlantic Pigtoe and Notched Rainbow were found along a recently eroded bank. These four species have become increasingly rare in the Swift/Middle Creek subbasin. These shells were very fragile and many fell apart once they were handled. It is possible that these shells were buried within the bank for several years, and were recently exposed as the bank eroded. While the presence of relict shells is often considered to represent extant populations, these particular shells should not be considered to represent recent occupancy.

**Table 27. CPUE for Freshwater Mussels Middle Creek 161103.2tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	0 (1 shell)	0
<i>Elliptio complanata</i>	Eastern Elliptio	31	11.92
<i>Elliptio congaraea</i>	Carolina Slabshell	17	6.54
<i>Elliptio icterina</i>	Variable Spike	1	0.38
<i>Elliptio lanceolata</i>	Yellow Lance	0 (2 shells)	0
<i>Fusconaia masoni</i>	Atlantic Pigtoe	0 (1 shell)	0
<i>Villosa constricta</i>	Notched Rainbow	0 (1 shell)	0
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Elimia catenaria</i>	Gravel Elimia	~	P-C

## 5.1.3.23 Middle Creek 161103.3tws

This survey in Middle Creek was conducted upstream of Crantock Road (SR 1504) starting at the endpoint of 161103.2tws for 4.15 person hours (Figure 4). Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel ranged from 11 to 18 feet wide with banks ranging from 2.5 to 3.75 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A narrow to moderately wide forested/shrub-brush buffer was present to surrounding agriculture and residential structures.

**Table 28. CPUE for Freshwater Mussels Middle Creek 161103.3tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	149	35.90
<i>Elliptio congaraea</i>	Carolina Slabshell	39	9.40
<i>Elliptio fisheriana</i>	Northern Lance	1	0.24
<i>Elliptio icterina</i>	Variable Spike	18	4.34
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Elimia catenaria</i>	Gravel Elimia	~	P-U

## 5.1.3.24 Middle Creek 161103.4tws

This survey in Middle Creek was conducted upstream of Crantock Road (SR 1504) starting at the endpoint of 161103.3tws for 2.85 person hours (Figure 4). Habitat consisted of run and pool with a sand and pebble substrate. The stream channel ranged from 11 to 13 feet wide with banks ranging from 2.5 to 3.75 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A narrow to moderately wide forested/shrub-brush buffer was present to surrounding agriculture.

**Table 29. CPUE for Freshwater Mussels Middle Creek 161103.4tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	57	20.00
<i>Elliptio congaraea</i>	Carolina Slabshell	17	5.96
<i>Elliptio icterina</i>	Variable Spike	9	3.16
<i>Lampsilis radiata</i>	Eastern Lampmussel	1	0.35
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Elimia catenaria</i>	Gravel Elimia	~	P-U

5.1.3.25 Middle Creek 161104.1tws

This survey in Middle Creek was conducted downstream of Barber Bridge Road (SR 2739) for 3 person hours (Figure 4). Habitat consisted of run and pool with a sand and cobble substrate. The stream channel ranged from 7 to 10 feet wide with banks ranging from 2.5 to 3.5 feet high. Banks were unstable. Stream conditions were normal and slightly turbid. A wide forested buffer was present to surrounding residential development.

**Table 30. CPUE for Freshwater Mussels Middle Creek 161104.1tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta undulata</i>	Triangle Floater	1	0.33
<i>Elliptio complanata</i>	Eastern Elliptio	15	5.0
<i>Strophitus undulatus</i>	Creeper	4	1.33
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

5.1.3.26 Middle Creek 161104.2tws

This survey in Middle Creek was conducted upstream of Barber Bridge Road (SR 2739) starting at the endpoint of 161104.1tws for 6 person hours (Figure 4). Habitat consisted of riffle, run, and pool with a sand and cobble substrate. The stream channel ranged from 7 to 10 feet wide with banks ranging from 2.5 to 3 feet high. Banks were unstable. Stream conditions were normal flow and slightly turbid. A narrow to moderately wide forested/shrub-brush buffer was present to surrounding residential development.

**Table 31. CPUE for Freshwater Mussels Middle Creek 161104.2tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta undulata</i>	Triangle Floater	4	0.67
<i>Elliptio complanata</i>	Eastern Elliptio	146	24.33
<i>Elliptio congaraea</i>	Carolina Slabshell	1	0.17
<i>Elliptio icterina</i>	Variable Spike	62	10.33
<i>Strophitus undulatus</i>	Creeper	1	0.17
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	P-C

#### 5.1.3.27 UT Black Creek 170201.1ted

This survey was conducted for 0.75 person hour in a short flowing reach between impoundments (Figure 4). Habitat consisted of silt/mud backwaters of the downstream impoundment transitioning into a sequence of riffle, run, and pool with gravel and sand dominated substrate, much of which had been recently redeposited or washed out by Hurricane Matthew. In the flowing section, the stream ranged from 10 to 15 feet wide. Where present, banks were heavily scoured. There was no buffer present to surrounding residential development and road along portions of the evaluated reach. No evidence of mollusks was observed.

#### 5.1.3.28 Black River 170201.2ted

This survey was conducted for 0.5 person hour in limited flowing areas below instream Beaver dams (Figure 4). The Black River in the surveyed section consisted of a wide cypress swamp floodplain, most of which had no discernable flow due to Beaver impacts. Substrates in these Beaver dam tailraces consisted primarily of silt and mud with occasional patches of sand and clay underlain. A wide, forested floodplain buffer surrounded the site. No evidence of mollusks was observed.

#### 5.1.3.29 Neills Creek 170201.3ted

This survey was conducted for 1.5 person hours upstream of the Chalybeate Springs Road (SR 1441) crossing (Figure 4). Habitat consisted of a moderate gradient sequence of riffle, run, and pool with a predominately sand and quartz substrate. The stream channel ranged from 9 to 20 feet wide with banks 2 to 4 feet high that exhibited areas of erosion and undercutting. A wide forested buffer surrounded the site. No evidence of mollusks was observed.

#### 5.1.3.30 Buckhorn Creek 170201.4ted

This survey was conducted for 1.0 person hour downstream of the Sweet Springs Road (SR 1117) crossing (Figure 4). Habitat consisted of a moderate gradient sequence of riffle, run, and pool with a predominately gravel and sand substrate. The stream channel ranged from 20 to 25 feet wide with unstable banks 10 to 15 feet high. A wide forested buffer surrounded the site.

**Table 32. CPUE for Freshwater Mussels Buckhorn Creek 170201.4ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	24	24.0/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

## 5.1.3.31 Hectors Creek 170202.1ted

This survey was conducted for 1.5 person hours downstream of the Rawls Church Road (SR 1415) crossing (Figure 4). Habitat consisted of a sequence of riffle, run, and pool with sand, gravel, and cobble substrate. The stream channel ranged from 10 to 15 feet wide with banks exhibiting some erosion and undercutting 3 to 6 feet high. A wide, forested buffer surrounded the site.

**Table 33. CPUE for Freshwater Mussels Hectors Creek 170202.1ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	1	0.67/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

## 5.1.3.32 Kenneth Creek 170202.2ted

This survey was conducted for 2.5 person hours downstream of the Rawls Church Road (SR 1415) crossing (Figure 4). Habitat consisted of a sequence of riffle, run, and pool with a variable mix of silt, sand, gravel, and cobble substrates. A few stabilizing outcrops of bedrock were also present. The stream channel ranged from 20 to 30 feet wide with eroded banks 6 to 12 feet high; recent scour and substrate redeposits, most likely attributable to hurricane Matthew, were present throughout. A moderately wide forested buffer surrounded the site.

**Table 34. CPUE for Freshwater Mussels Kenneth Creek 170202.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	63	25.2/hr
<i>Villosa delumbis</i>	Eastern Creekshell	2	0.8/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

### 5.1.3.33 Kenneth Creek 170202.3ted

This survey was conducted for 0.75 person hour upstream of the Chalybeate Springs Road (SR 1441) crossing (Figure 4). Habitat consisted of deeper run and pool with a mix of silt, sand, and gravel substrate. The stream channel ranged from 12 to 20 feet wide with eroded banks 10 to 12 feet high. The channel was heavily scoured, often to saprolite. A narrow to moderately wide forested buffer surrounded the site. No mussel evidence was observed.

**Table 35. CPUE for Freshwater Mussels Kenneth Creek 170202.3ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
N/A	N/A	~	~
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

### 5.1.3.34 Hectors Creek 170202.4ted

This survey was conducted for 1.33 person hours upstream of the Baptist Grove Road (SR 1427) crossing (Figure 4). Habitat consisted of a shallow sequence of primarily run and pool with substrates of fine sand, gravel, and bedrock. The stream channel ranged from 12 to 20 feet wide with relatively stable banks 3 to 6 feet high. A wide, forested buffer surrounded the site.

**Table 36. CPUE for Freshwater Mussels Hectors Creek 170202.4ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	16	12.0/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	U
<i>Campeloma decisum</i>	Pointed Campeloma	~	R

### 5.1.3.35 Little White Oak Creek 170207.1ted

This survey was conducted for 1.0 person hour downstream of the Friendship Road (SR 1149) crossing (Figure 4). Habitat consisted of a shallow sequence of riffle, run, and pool with primarily sand and pebble substrate. The small stream channel ranged from 10 to 15 feet wide with variably stable to unstable banks up to 6 feet high. A wide, forested floodplain buffer surrounded the site. No mollusks were observed during the efforts.

### 5.1.3.36 White Oak Creek 170207.2ted

This survey was conducted for 1.25 person hours upstream of the New Hill Road (SR 1152) crossing (Figure 4). Downstream and through the road crossing the stream presented as pool habitat with no visible flow. Habitat in the evaluated reach consisted of lotic sequence of run and pool with primarily silt, sand, and pebble substrates. The stream channel ranged from 20 to



30 feet wide with eroded banks up to 6 feet high. The channel was heavily scoured in areas with large deposits of woody debris. A wide, forested floodplain buffer surrounded the site. No mollusks were observed during the survey.

#### 5.1.3.37 Kenneth Creek 170207.3ted

This survey was conducted for 2.53 person hours upstream of the Rawls Church Road (SR 1415) crossing (Figure 4). Habitat consisted of a sequence of riffle, run, and pool with a variable mix of silt, sand, gravel, and cobble substrates. The stream channel ranged from 15 to 25 feet wide with generally unstable banks 6 to 12 feet high. A wide forested buffer surrounded the site.

**Table 37. CPUE for Freshwater Mussels Kenneth Creek 170207.3ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	33	13.04/hr
<i>Villosa delumbis</i>	Eastern Creekshell	4	1.58/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

#### 5.1.3.38 Big Branch 170207.4ted

This survey was conducted for 1.5 person hours downstream of the Woods Creek Road (SR 1154) crossing (Figure 4). Habitat consisted of a shallow sequence of riffle, run, and pool with primarily unconsolidated sand substrate. The small stream channel ranged from 10 to 15 feet wide with banks exhibiting some erosion and undercutting 3 to 6 feet high. A relatively narrow forested buffer surrounded the site; managed pine plantation and a golf course were present in the immediate area beyond the site. No mollusks were observed during the efforts.

#### 5.1.3.39 Little Creek 170208.1ted

This survey was conducted for 7.16 person hours in a reach accessed from a gas line right of way off Creekside Drive (Figure 4). Habitat consisted of a riffle, run, and pool sequence with substrates of silt, sand, gravel, and clay. A large amount of woody debris was present in pools and along banks in areas. The stream channel ranged from 15 to 25 feet wide with variably stable to eroded banks 3 to 6 feet high. A wide, forested floodplain buffer was present to surrounding agricultural and residential land uses.

**Table 38. CPUE for Freshwater Mussels Little Creek 170208.1ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	210	29.33/hr
<i>Elliptio icterina</i>	Variable Spike	48	6.70/hr
<i>Elliptio</i> sp c.f. <i>mediocris</i>	No common name	4	0.56/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	2	0.28/hr
<i>Strophitus undulatus</i>	Creeper	2	0.28/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	R

5.1.3.40 Cary Branch 170208.2ted

This survey was conducted for 1.2 person hours downstream of the Rex Road (SR 1127) crossing (Figure 4). Habitat consisted of a sequence of riffle, run, and pool with primarily sand, gravel, and clay substrates. The stream channel ranged from 15 to 20 feet wide with eroded banks 6 to 10 feet high. The channel was heavily scoured in areas. A wide, forested buffer surrounded the site.

**Table 39. CPUE for Freshwater Mussels Cary Branch 170208.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	1	0.83/hr
<i>Uniomereus carolineanus</i>	Florida Pondhorn	4	3.33/hr

5.1.3.41 Neuse River 170321.1ted

This survey consisted of a concentrated search for live mussels in run habitat and river margins near an island upstream of the US 64 Business crossing and shoreline searches for shells in muskrat middens downriver from Milburnie dam to the island (Figure 4). Active surveys for live mussels were conducted for 1.0 person hour during which the species below were found. Habitat consisted of run and pool with primarily sand substrate, silt margins, and areas of gravel, cobble, and boulder. The river channel was generally over 100 feet wide with variably stable banks ranging from 10 to 12 feet high. A narrow to moderately wide forested floodplain buffer was present to surrounding greenway and residential land uses.

**Table 40. CPUE for Freshwater Mussels Neuse River 170321.1ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta undulata</i>	Triangle Floater	1	1.0/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	4	4.0/hr
<i>Elliptio complanata</i>	Eastern Elliptio	40	40.0/hr
<i>Elliptio icterina</i>	Variable Spike	2	2.0/hr
<i>Elliptio roanokensis</i>	Roanoke Slabshell	47	47.0/hr
<i>Lampsilis radiata</i>	Eastern Lampmussel	2	2.0/hr
<i>Pyganadon cataracta</i>	Eastern Floater	1	1.0/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	VA

## 5.1.3.42 Neuse River 170321.2ted

This survey was conducted for 7 person hours downstream of the Poole Road crossing (Figure 4). Surveys were concentrated on shallow river margins and runs known to be occupied by the Green Floater (*Lasmingona subviridis*) and other rare associates. Habitat consisted primarily of silt and sand with areas of gravel, cobble, and boulder in higher velocity runs. A large amount of woody debris was present. The river channel was generally over 100 feet wide with variably stable banks ranging from 10 to 12 feet high. A wide, mature forested floodplain buffer surrounded the site.

**Table 41. CPUE for Freshwater Mussels Neuse River 170321.2ted**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmidonta undulata</i>	Triangle Floater	0 (2 shell)	~
<i>Elliptio congaraea</i>	Carolina Slabshell	8	1.14/hr
<i>Elliptio complanata</i>	Eastern Elliptio	16	2.29/hr
<i>Elliptio roanokensis</i>	Roanoke Slabshell	157	22.43/hr
<i>Lampsilis radiata</i>	Eastern Lampmussel	9	1.29/hr
<i>Lasmingona subviridis</i>	Green Floater	0 (1 shell)	~
<i>Utterbackia imbecillis</i>	Paper Pondshell	1	0.14/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	VA
<i>Campeloma decisum</i>	Pointed Campeloma	~	R
<i>Elimia catenaria</i>	Gravel Elimia	~	R

## 5.1.3.43 Black Creek 170414.1tws

This survey in Black Creek was conducted for 2 person hours above the Federal Road (SR 1331) crossing (Figure 4). Habitat consisted of run and pool with substrate dominated by sand and pebble. Water clarity was light tannic. The stream channel was approximately 13 feet wide with

banks up to 2 feet high. Some erosion and undercutting was present along the banks. A moderate forested buffer surrounded the site.

**Table 42. CPUE for Freshwater Mussels Black Creek 170414.1tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	76	38.0/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	C

5.1.3.44 Neuse River 170414.2tws

This survey was conducted for 3 person hours downstream of the Poole Road (SR 1007) crossing (Figure 4). Habitat consisted primarily of riffle and run with substrate dominated by gravel and cobble in higher velocity runs. Water conditions were slightly turbid during the survey. The stream channel was approximately 100 feet wide with stream banks approximately 8 feet high. Some erosion and undercutting was present along the banks. A moderate forested floodplain buffer surrounds the site.

**Table 43. CPUE for Freshwater Mussels Neuse River 170414.2tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Alasmodonta undulata</i>	Triangle Floater	0 (1 shell)	~
<i>Elliptio cistellaeformis</i>	Box spike	10	3.33/hr
<i>Elliptio complanata</i>	Eastern Elliptio	92	30.67/hr
<i>Elliptio congaraea</i>	Carolina Slabshell	6	2.0/hr
<i>Elliptio icterina</i>	Variable Spike	14	4.67/hr
<i>Elliptio roanokensis</i>	Roanoke Slabshell	104	34.67/hr
<i>Lampsilis radiata</i>	Eastern Lampmussel	7	2.33/hr
<i>Lasmigona subviridis</i>	Green Floater	1 (1 shell)	0.33/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C

5.1.3.45 Little Creek 170518.1tws

The Little Creek survey at Steel Bridge Road (SR 1562) was conducted for 4 person hours (Figure 4). Habitat consisted of riffle, run, and pool with substrate dominated by sand and cobble. Little Creek was approximately 20 feet wide with bank height of approximately 3 feet. Some erosion and undercutting was present along the banks. During the survey, the water was light tannic. There was a moderate forested buffer surrounding the survey site.

**Table 44. CPUE for Freshwater Mussels Little Creek 170518.1tws**

Scientific Name	Common Name	#live (#shell)	Abundance/ CPUE
<b>Freshwater Mussels</b>			<b>CPUE</b>
<i>Elliptio complanata</i>	Eastern Elliptio	189	47.25/hr
<i>Elliptio icterina</i>	Variable Spike	19	4.75/hr
<i>Elliptio</i> sp c.f. <i>mediocris</i>	No common name	2	0.50/hr
<b>Freshwater Snails and Clams</b>			<b>Relative Abundance</b>
<i>Corbicula fluminea</i>	Asian Clam	~	C
<i>Campeloma decisum</i>	Pointed Campeloma	~	C

## 5.2 Carolina Madtom Surveys

Fish surveys targeting the Carolina Madtom were conducted by Three Oaks personnel on the following dates:

	4/12/17	4/13/17	4/14/17	5/11/17	5/17/17	5/18/17	5/19/17
<b>Personnel</b>							
Tim Savidge (Permit # 16-ES0034)		X	X		X	X	X
Tom Dickinson (Permit # 16/17-ES00343)	X			X			
John Fridell					X	X	X
John Roberts	X	X		X			
Nathan Howell		X	X	X			
Mary Frazer	X	X	X				
Matt Haney (NCDOT)		X					
Lizzy Stokes-Cawley			X		X	X	X
Hannah Slyce					X	X	X
Nancy Scott	X			X			

### 5.2.1. Survey Locations

Survey locations were selected based on previous survey data, proximity to the FLUSA, habitat requirements for the target species and field conditions.

### 5.2.2. Methodology

Two fish survey methodologies were employed. The primary methodology used was based on the NCWRC Carolina Madtom protocol, which involved conducting visual surveys in varying reaches of target streams. The survey team spread out across the creek into survey lanes with each surveyor covering no more than approximately 5 meters of wetted width. Visual surveys were conducted using mask and snorkel and/or glass bottom view buckets (bathyscopes). All habitat types in the survey reach (riffle, run, pool, slack-water, etc.) were sampled. Instream debris (rocks, logs, bark, mussel shells, leaf packs, bottles and other artificial cavities) was

repositioned to look for inhabitants. Presence of fish species observed was noted at each survey location.

Electrofishing was also employed at some locations. In some instances, this method was used to supplement and assess the effectiveness of the visual surveys. In these instances, electrofishing surveys were conducted in the exact reach where a visual survey had previously been conducted. In other situations, where habitat conditions were not conducive for visual surveys (i.e. very shallow riffles, very swift runs, etc.) electrofishing was the sole methodology. Fish Surveys were conducted using a single Smith Root LR-24 backpack electrofishing unit and dip nets. Crew members not operating the electrofishing units collected stunned fish with dip nets. Passive seining, with two biologists holding the seine in riffle and run habitat while the other biologists shocked downstream into the seine, was employed at the Middle Creek site above Crantock Road. All habitat types in the survey reach (riffle, run, pool, slack-water, etc.) were sampled, with special attention given to habitats preferred by the Carolina Madtom. Stunned fish were placed into buckets and were identified, counted and released onsite.

### 5.2.3. Visual Fish Survey Results

#### 5.2.3.1 Swift Creek 170412.1ted

This survey in Swift Creek was conducted for 7.67 person hours as accessed from Swift Creek Nursery off Cleveland Road (Figure 5). Habitat consisted of run and riffle with substrate dominated by gravel, sand, and cobble. Water clarity was clear. The stream channel was approximately 50 feet wide with banks up to 12 feet high. A wide, forested buffer surrounded the site.

**Table 45. Freshwater Fish Observed at Swift Creek 170412.1ted**

Scientific Name	Common Name
<i>Anguilla rostrata</i>	American Eel
<i>Etheostoma flabellare</i>	Fantail Darter
<i>Etheostoma nigrum</i>	Johnny Darter
<i>Etheostoma vitreum</i>	Glassy Darter
<i>Hypentelium nigricans</i>	Northern Hogsucker
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Noturus insignis</i>	Margined Madtom
<i>Notropis sp.</i>	a Shiner
<i>Percina roanoka</i>	Roanoke Darter

#### 5.2.3.2 Swift Creek 170412.2ted

This survey in Swift Creek was conducted for 2.0 person hours upstream from Barber Mill Road (SR 1555, Figure 5). Habitat consisted of run and riffle with substrate dominated by gravel, sand, and cobble. Water clarity was clear. The stream channel was approximately 60 feet wide with banks up to 10 feet high. A moderate forested buffer surrounded the site.

**Table 46. Freshwater Fish Observed at Swift Creek 170412.2ted**

Scientific Name	Common Name
<i>Etheostoma nigrum</i>	Johnny Darter
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill

#### 5.2.3.3 Swift Creek 170412.3ted

This survey in Swift Creek was conducted for 2.0 person hours upstream from Barber Mill Road (SR 1555, Figure 5). Habitat consisted of run and pool with substrate dominated by gravel, sand, and cobble. Water clarity was clear. The stream channel was approximately 60 feet wide with banks up to 10 feet high. A moderate forested buffer surrounded the site.

**Table 47. Freshwater Fish Observed at Swift Creek 170412.3ted**

Scientific Name	Common Name
<i>Etheostoma nigrum</i>	Johnny Darter
<i>Hypentelium nigricans</i>	Northern Hogsucker
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Percina roanoka</i>	Roanoke Darter

#### 5.2.3.4 Swift Creek 170517.2tws

This survey in Swift Creek was conducted for 2.67 person hours above the Steel Bridge Road (SR 1562) crossing (Figure 5). Habitat consisted of run and riffle with substrate dominated by cobble and gravel. Water clarity was clear. The stream channel was approximately 35 feet wide with banks up to 7 feet high. A moderate forested buffer surrounded the site.

**Table 48. Freshwater Fish Observed at Swift Creek 170517.2tws**

Scientific Name	Common Name
<i>Anguilla rostrata</i>	American Eel
<i>Cyprinella analostana</i>	Satinfin Shiner
<i>Etheostoma olmstedii</i>	Tessellated Darter
<i>Ictalurus punctatus</i>	Channel Catfish
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Noturus insignis</i>	Margined Madtom

#### 5.2.3.5 Little Creek 170518.1tws

The Little Creek survey location located at Steel Bridge Road (SR 1562) was conducted for 2.0 person hours (Figure 5). Habitat consisted of riffle, run, and pool with substrate dominated by sand and cobble. Little Creek was approximately 20 feet wide with bank height of approximately 3 feet. Some erosion and undercutting was present along the banks. During the survey, the water was light tannic. There was a moderate forested buffer surrounding the survey site.

**Table 49. Freshwater Fish Observed at Little Creek 170518.1tws**

Scientific Name	Common Name
<i>Anguilla rostrate</i>	American Eel
<i>Etheostoma olmstedii</i>	Tessellated Darter
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Lythrurus matutinus</i>	Pinewoods Shiner
<i>Percina roanoka</i>	Roanoke Darter

#### 5.2.3.6 Black Creek 170413.3tws

This survey in Black Creek was conducted for 2.0 person hours above the Raleigh Road (SR 1330) crossing (Figure 5). Habitat consisted of run and pool with substrate dominated by coarse sand and gravel. Water clarity was light tannic. The stream channel ranged from 13 to 16 feet wide with stable banks up to 2 feet high. A wide, mature forested buffer surrounded the site.

**Table 50. Freshwater Fish Observed at Black Creek 170413.3tws**

Scientific Name	Common Name
<i>Aphredoderus sayanus</i>	Pirate Perch
<i>Elassoma zonatum</i>	Banded Pygmy Sunfish
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish
<i>Esox niger</i>	Chain Pickerel
<i>Etheostoma olmstedii</i>	Tessellated Darter
<i>Gambusia holbrooki</i>	Eastern Mosquitofish
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Lepomis microlophus</i>	Redear Sunfish
<i>Noturus gyrinus</i>	Tadpole Madtom

#### 5.2.3.7 Black Creek 170414.1tws

This survey in Black Creek was conducted for 2.0 person hours above the Federal Road (SR 1331) crossing (Figure 5). Habitat consisted of run and pool with substrate dominated by sand and pebble. Water clarity was light tannic. The stream channel was approximately 13 feet wide with banks up to 2 feet high. Some erosion and undercutting was present along the banks. A moderate forested buffer surrounded the site.

**Table 51. Freshwater Fish Observed at Black Creek 170414.1tws**

Scientific Name	Common Name
<i>Aphredoderus sayanus</i>	Pirate Perch
<i>Cyprinella analostana</i>	Satinfin Shiner
<i>Esox niger</i>	Chain Pickerel
<i>Gambusia holbrooki</i>	Eastern Mosquitofish
<i>Noturus gyrinus</i>	Tadpole Madtom



### 5.2.3.8 Middle Creek 170413.1tws

This survey in Middle Creek was conducted for 2.5 person hours in a reach downstream from Crantock Road (SR 1504, Figure 5). Habitat consisted of riffle, run, and pool with a gravel and sand substrate. The stream channel was approximately 42 feet wide with banks approximately 5 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A moderately wide forested/shrub-brush buffer was present at the survey reach.

**Table 52. Freshwater Fish Observed at Middle Creek 170413.1tws**

Scientific Name	Common Name
<i>Anguilla rostrata</i>	American Eel
<i>Cyprinella analostana</i>	Satinfin Shiner
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish
<i>Etheostoma olmstedii</i>	Tessellated Darter
<i>Ictalurus punctatus</i>	Channel Catfish
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Percina roanoka</i>	Roanoke Darter

### 5.2.3.9 Middle Creek 170413.2tws

This survey of Middle Creek was conducted upstream of Crantock Road (SR 1504) for 2.03 person hours (Figure 5). Habitat consisted of riffle, run, and pool with a cobble and gravel substrate. The stream channel was approximately 39 feet wide and the banks were approximately 5 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal and clear. A narrow to moderately wide forest buffer was present at the site.

**Table 53. Freshwater Fish Observed at Middle Creek 170413.2tws**

Scientific Name	Common Name
<i>Anguilla rostrata</i>	American Eel
<i>Etheostoma olmstedii</i>	Tessellated Darter
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Percina roanoka</i>	Roanoke Darter
<i>Pylodictis olivaris</i>	Flathead Catfish

### 5.2.3.10 Neuse River 170414.2tws

This survey was conducted for 2.0 person hours downstream of the Poole Road (SR 1007) crossing (Figure 5). Habitat consisted primarily of riffle and run with substrate dominated by gravel and cobble in higher velocity runs. Water conditions were slightly turbid during the survey. The stream channel was approximately 100 feet wide with stream banks approximately 8 feet high. Some erosion and undercutting was present along the banks. A moderate forested floodplain buffer surrounded the site.

**Table 54. Freshwater Fish Observed at Neuse River 170414.2tws**

<b>Scientific Name</b>	<b>Common Name</b>
<i>Anguilla rostrata</i>	American Eel
<i>Etheostoma olmstedii</i>	Tessellated Darter
<i>Ictalurus punctatus</i>	Channel Catfish
<i>Lepomis auritus</i>	Redbreast Sunfish
<i>Lepomis macrochirus</i>	Bluegill
<i>Noturus gyrinus</i>	Tadpole Madtom
<i>Noturus insignis</i>	Margined Madtom
<i>Percina nevisense</i>	Chainback Darter
<i>Percina roanoka</i>	Roanoke Darter

#### 5.2.3.11 White Oak Creek

A visual survey of this site was not conducted using the methods described in this section. The site conditions were not conducive to a visual survey, as the stream was small and the water was turbid. Instead, the methods described in the following section were used. See section 5.2.4.4 for survey results.

#### 5.2.4. Electrofishing Surveys

Surveys were conducted using electroshockers at select sites with the highest quality Carolina Madtom habitat observed during other efforts. The following discussion focuses on these additional surveys and the results of these surveys.

##### 5.2.4.1 Swift Creek 170511.1ted

This survey in Swift Creek was from Swift Creek Nursery off Cleveland Road (Figure 5). Habitat consisted of run and riffle with substrate dominated by gravel, sand, and cobble. Water clarity was clear. The stream channel was approximately 50 feet wide with banks up to 12 feet high. A wide forested buffer surrounded the site.

In addition to a visual survey at this location (Section 5.2.3.1), a more comprehensive survey was performed using the electroshocking methodology. The protocol for measuring an Index of Biotic Integrity (IBI) was used at this site to determine the quality of the fish community. The survey was conducted using two electroshocking units, two people using dip nets, and three seine net blocks for a total of 6,543 electroshocking seconds. The IBI score was 52, which represents a “Good” rating.

**Table 55. Freshwater Fish Observed at Swift Creek 170511.1ted**

<b>Scientific Name</b>	<b>Common Name</b>	<b>Number Observed</b>
<i>Anguilla rostrata</i>	American Eel	13
<i>Aphredoderus sayanus</i>	Pirate Perch	4
<i>Cyprinella analostana</i>	Satinfin Shiner	24
<i>Enneacanthus gloriosus</i>	Bluspotted Sunfish	4
<i>Erymizon oblongus</i>	Creek Chubsucker	1
<i>Esox niger</i>	Chain Pickerel	2
<i>Etheostoma flabellare</i>	Fantail Darter	16
<i>Etheostoma nigrum</i>	Johnny Darter	10
<i>Etheostoma olmstedi</i>	Tessellated Darter	11
<i>Etheostoma vitrium</i>	Glassy Darter	8
<i>Gambusia holbrooki</i>	Eastern Mosquitofish	1
<i>Hypentelium nigricans</i>	Northern Hogsucker	3
<i>Ictalurus punctatus</i>	Channel Catfish	5
<i>Lepomis auritus</i>	Redbreast Sunfish	39
<i>Lepomis cyanellus</i>	Green Sunfish	4
<i>Lepomis gibbosus</i>	Pumpkinseed	1
<i>Lepomis gulosus</i>	Warmouth	6
<i>Lepomis machochirus</i>	Bluegill	50
<i>Luxilus albeolus</i>	White Shiner	4
<i>Lythrurus matutinus</i>	Pinewoods Shiner	6
<i>Micropterus salmoides</i>	Largemouth Bass	3
<i>Nocomis raineyi</i>	Bull Chub	1
<i>Notropis amoenus</i>	Comely Shiner	9
<i>Notropis cummingsae</i>	Dusky Shiner	9
<i>Notropis hudsonius</i>	Spottail Shiner	6
<i>Notropis procne</i>	Swallowtail Shiner	9
<i>Noturus insignis</i>	Margined Madtom	1
<i>Percina nevisense</i>	Chainback Darter	2
<i>Percina roanoka</i>	Roanoke Darter	48
<i>Pomoxis nigromaculatus</i>	Black Crappie	6
<i>Pylodictis olivaris</i>	Flathead Catfish	3
<i>Scartomyzon cervinus</i>	Black Jumprock	2
<i>Semotilus atromaculatus</i>	Creek Chub	1

#### 5.2.4.2 Middle Creek 170517.1tws

This survey of Middle Creek was conducted upstream of Crantock Road (SR 1504) for 673 electroshocking seconds (Figure 5). A visual survey had been performed previously at this site 170413.2tws (Table 53 in Section 5.2.2.9). More species were recorded using the electrofishing methods; no species detected using visual surveys were also not found electrofishing (Table 56). No madtom species were detected using either method (Tables 53 and 56).

**Table 56. Freshwater Fish Observed at Middle Creek 170517.1tws**

Scientific Name	Common Name	Number Observed
<i>Anguilla rostrata</i>	American Eel	6
<i>Cyprinella analostana</i>	Satinfin Shiner	8
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	5
<i>Esox niger</i>	Chain Pickerel	1
<i>Etheostoma olmstedii</i>	Tessellated Darter	11
<i>Gambusia holbrooki</i>	Eastern Mosquitofish	10
<i>Lepomis auritus</i>	Redbreast Sunfish	18
<i>Lepomis macrochirus</i>	Bluegill	11
<i>Lepomis microlophus</i>	Redear Sunfish	2
<i>Luxilus albeolus</i>	White Shiner	15
<i>Notropis procne</i>	Swallowtail Shiner	7
<i>Percina nevisense</i>	Chainback Darter	6
<i>Percina roanoka</i>	Roanoke Darter	15
<i>Pylodictis olivaris</i>	Flathead Catfish	1

#### 5.2.4.3 Little Creek 170518.2tws

The survey of Little Creek, above Steel Bridge Road (SR 1562), was conducted for 587 electroshocking seconds (Figure 5). A visual survey had been performed previously at this site 170518.1tws (Table 49 in Section 5.2.2.5). More species were recorded using the electrofishing methods; no species were detected using visual surveys that were also not found electrofishing (Table 57). However, the visual surveys did not detect the Margined Madtom (Table 49), yet it was easily detected (n=7) using electrofishing (Table 57).

**Table 57. Freshwater Fish Observed at Little Creek 170518.2tws**

Scientific Name	Common Name	Number Observed
<i>Ameiurus brunneus</i>	Snail Bullhead	1
<i>Ameiurus natalis</i>	Yellow Bullhead	1
<i>Anguilla rostrata</i>	American Eel	8
<i>Aphredoderus sayanus</i>	Pirate Perch	2
<i>Cyprinella analostana</i>	Satinfin Shiner	6
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	3
<i>Esox niger</i>	Chain Pickerel	1
<i>Etheostoma flabellare</i>	Fantail Darter	2
<i>Etheostoma olmstedii</i>	Tessellated Darter	12
<i>Gambusia holbrooki</i>	Eastern Mosquitofish	Present*
<i>Ictalurus punctatus</i>	Channel Catfish	1
<i>Lepomis auritus</i>	Redbreast Sunfish	7
<i>Lepomis macrochirus</i>	Bluegill	4
<i>Lepomis microlophus</i>	Redear Sunfish	2
<i>Luxilus albeolus</i>	White Shiner	4
<i>Lythrurus matutinus</i>	Pinewoods Shiner	11
<i>Moxostoma pappillosum</i>	V-Lip Redhorse	1
<i>Nocomis leptcephalus</i>	Bluehead Chub	8
<i>Nocomis raneyi</i>	Bull Chub	2
<i>Notropis cummingsae</i>	Dusky Shiner	6

**Table 57. Freshwater Fish Observed at Little Creek 170518.2tws (continued)**

Scientific Name	Common Name	Number Observed
<i>Notropis hudsonius</i>	Spottail Shiner	1
<i>Notropis procne</i>	Swallowtail Shiner	8
<i>Noturus insignis</i>	Margined Madtom	7
<i>Percina roanoka</i>	Roanoke Darter	6
<i>Scartomyzon cervinus</i>	Black Jumprock	1

\* Many individuals captured, total number not recorded

#### 5.2.4.4 White Oak Creek 170518.3tws

The survey of White Oak Creek, located at NC 42 below Austin Pond, was conducted for 489 electroshocking seconds (Figure 5). Habitat consisted of riffle, run, and pool with substrate dominated by sand and cobble. White Creek was approximately 6 to 11 feet wide in the riffle run section, and widened to 50 feet in the pool within the tailrace of Austin Pond. The unstable banks were approximately 5 feet high. During the survey, the water was slightly turbid. There was a moderate forested buffer surrounding the survey site.

**Table 58. Freshwater Fish Observed at White Oak Creek 170518.3tws**

Scientific Name	Common Name	Number Observed
<i>Ameiurus brunneus</i>	Snail Bullhead	3
<i>Ameiurus platycephalus</i>	Flat Bullhead	1
<i>Anguilla rostrata</i>	American Eel	8
<i>Cyprinella analostana</i>	Satinfin Shiner	12
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	2
<i>Etheostoma olmstedii</i>	Tessellated Darter	7
<i>Gambusia holbrooki</i>	Eastern Mosquitofish	Present*
<i>Lepomis auritus</i>	Redbreast Sunfish	21
<i>Lepomis cyanellus</i>	Green Sunfish	6
<i>Lepomis gulosus</i>	Warmouth	2
<i>Lepomis macrochirus</i>	Bluegill	14
<i>Lepomis microlophus</i>	Redear Sunfish	2
<i>Luxilus albeolus</i>	White Shiner	3
<i>Notropis procne</i>	Swallowtail Shiner	1
<i>Noturus insignis</i>	Margined Madtom	2
<i>Percina nevisense</i>	Chainback Darter	1
<i>Percina roanoka</i>	Roanoke Darter	3

\* Many individuals captured, total number not recorded

#### 5.2.4.5 Middle Creek 170519.1tws

This survey of Middle Creek was conducted downstream of Smith Road (SR 2553) for 572 electroshocking seconds (Figure 5). Habitat consisted of riffle, run, and pool with a sand and gravel substrate. The stream channel was approximately 30 feet wide and the banks were approximately 7 feet high. The stream banks were unstable. Stream conditions were normal and clear. A narrow to moderately wide forest buffer was present. In addition to the following fish species found during the survey, an individual Neuse River Waterdog was located (see Section 5.3.3.3 for details on Waterdog surveys).

**Table 59. Freshwater Fish Observed at Middle Creek 170519.1tws**

Scientific Name	Common Name	Number Observed
<i>Anguilla rostrata</i>	American Eel	8
<i>Cyprinella analostana</i>	Satinfin Shiner	5
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	1
<i>Esox niger</i>	Chain Pickerel	1
<i>Etheostoma olmstedii</i>	Tessellated Darter	11
<i>Gambusia holbrooki</i>	Eastern Mosquitofish	Present*
<i>Lepomis auritus</i>	Redbreast Sunfish	21
<i>Lepomis cyanellus</i>	Green Sunfish	2
<i>Lepomis macrochirus</i>	Bluegill	7
<i>Luxilus albeolus</i>	White Shiner	5
<i>Nocomis leptocephalus</i>	Bluehead Chub	7
<i>Notropis cummingsae</i>	Dusky Shiner	4
<i>Notropis procne</i>	Swallowtail Shiner	8
<i>Percina nevisense</i>	Chainback Darter	1
<i>Percina roanoka</i>	Roanoke Darter	11
<i>Pylodictis olivaris</i>	Flathead Catfish	3

\* Many individuals captured, total number not recorded

#### 5.2.4.6 Middle Creek 170519.2tws

This survey in Middle Creek downstream of NC 50 was conducted for 537 electroshocking seconds (Figure 5). Habitat consisted of run, riffle, and pool with sand and gravel substrate dominant. The stream channel in the surveyed reach was approximately 40 feet wide with banks 6 feet high. Some erosion and undercutting was present along the banks. Stream conditions were low and clear. A moderately wide forested buffer was present surrounding the survey reach.

**Table 60. Freshwater Fish Observed at Middle Creek 170519.2tws**

Scientific Name	Common Name	Number Observed
<i>Anguilla rostrata</i>	American Eel	5
<i>Aphredoderus sayanus</i>	Pirate Perch	1
<i>Cyprinella analostana</i>	Satinfin Shiner	10
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	4
<i>Etheostoma olmstedii</i>	Tessellated Darter	10
<i>Lepisosteus osseus</i>	Longnose Gar	1
<i>Lepomis auritus</i>	Redbreast Sunfish	19
<i>Lepomis macrochirus</i>	Bluegill	11
<i>Luxilus albeolus</i>	White Shiner	8
<i>Nocomis leptocephalus</i>	Bluehead Chub	6
<i>Nocomis raneyi</i>	Bull Chub	1
<i>Notropis cummingsae</i>	Dusky Shiner	4
<i>Notropis hudsonius</i>	Spottail Shiner	1
<i>Notropis procne</i>	Swallowtail Shiner	6
<i>Percina roanoka</i>	Roanoke Darter	9
<i>Pylodictis olivaris</i>	Flathead Catfish	1

### 5.2.4.7 Middle Creek 170519.3tws

This survey in Middle Creek was conducted upstream of Barber Bridge Road (SR 2739) for 389 electroshocking seconds (Figure 5). Habitat consisted of riffle, run, and pool with a sand and cobble substrate. The stream channel was approximately 20 feet wide with banks ranging from 2.5 to 3 feet high. Some erosion and undercutting was present along the banks. Stream conditions were normal flow and slightly turbid. A moderate forested buffer was present surrounding the survey reach.

**Table 61. Freshwater Fish Observed at Middle Creek 170519.3tws**

Scientific Name	Common Name	Number Observed
<i>Ameiurus brunneus</i>	Snail Bullhead	1
<i>Anguilla rostrata</i>	American Eel	5
<i>Cyprinella analostana</i>	Satinfin Shiner	13
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	6
<i>Etheostoma olmstedii</i>	Tessellated Darter	11
<i>Lepomis auritus</i>	Redbreast Sunfish	15
<i>Lepomis macrochirus</i>	Bluegill	6
<i>Lepomis microlophus</i>	Redear Sunfish	1
<i>Luxilus albeolus</i>	White Shiner	5
<i>Notropis procne</i>	Swallowtail Shiner	4
<i>Noturus gyrinus</i>	Tadpole Madtom	1
<i>Percina roanoka</i>	Roanoke Darter	6

### 5.3 Neuse River Waterdog Surveys

Surveys were conducted by Three Oaks personnel on the following dates:

Personnel	12/20/16	12/21/16	12/22/16	12/23/16	2/7/17	2/8/17	2/9/17	2/10/17
Kate Sevick (Permit #16-ES00485)	X	X			X	X	X	
Tom Dickinson (Permit # 16/17-ES00343)			X					
Tim Savidge (Permit # 16-ES0034)				X				
Nancy Scott		X					X	
Chris Sheats	X							
Nathan Howell	X			X				X
Mary Frazer	X		X		X	X		X

#### 5.3.1. Survey Locations

Survey locations were selected based on location within the FLUSA, previous NCWRC survey data, and Three Oaks' staff knowledge of appropriate habitat and previous sightings. Surveys were conducted in December 2016, in Middle Creek (at three locations: Susan Road, Smith Road, and Crantock Road), Black Creek, Neuse River (Milburnie Dam), White Oak Creek, and Little Creek based on previous negative survey results or no available survey information. In February 2017, four additional sites were surveyed in Middle Creek (Barber Bridge Road), Swift

Creek (NC 42 and Barber Mill Road) and Neuse River (Poole Road) along with repeat sampling of two sites in Middle Creek (Susan Road and Crantock Road).

### 5.3.2. *Methodology*

Three Oaks developed methods in consultation with the USFWS and NCWRC that were designed to replicate winter trapping efforts conducted as part of the species status assessment undertaken by these agencies and collaborators. Ten baited traps were set for four soak nights at each of the survey locations. Trap sites were selected based on habitat conditions and accessibility. Undercut banks, with some accumulation of leaf pack, as well as back eddy areas within runs were the primary microhabitats selected. Traps were baited with a combination of chicken liver and hot dogs, and allowed to soak overnight. The traps were checked daily, all species found within the traps were recorded, and the traps were re-baited. If the targeted Neuse River Waterdog was found at a site, trapping efforts were discontinued.

Prior to the 2017 surveys, Three Oaks was invited to assist in a NCWRC study, in cooperation with researchers at Nash County Community College, examining the genetics of the Neuse River Waterdog. Tissue samples were collected in the field from the tail of any captured Neuse River Waterdogs and sent to NCWRC staff. In addition to new sites, Three Oaks resurveyed a few locations that had positive captures from 2016 in an effort to contribute additional data to this study.

### 5.3.3. *Neuse River Waterdog Survey Results*

The Neuse River Waterdog was found at three of the Middle Creek Sites (Susan Road, Smith Road, and Crantock Road) and in Swift Creek (Barber Mill Road). In addition, 14 fish species along with multiple crayfish were found during trapping efforts. The results for each survey location are shown below.

#### 5.3.3.1 Middle Creek at Barber Bridge Road (170203.4kms)

This Middle Creek survey location is at Barber Bridge Road (SR 2739) in Johnston County (Figure 6). All ten traps were placed downstream of the bridge crossing. At this survey location, Middle Creek ranged from 20 to 35 feet wide with water depths of 1 to 6 feet with a sandy substrate interspersed with gravel and cobble sections. Water flow was slightly turbid and at a moderate to fast velocity. The buffer was wide, forested, and intact within the survey vicinity.



**Table 62. Middle Creek at Barber Bridge Road (170203.4kms)– February 2017**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	~	~	~
2	~	~	~	Catfish
3	~	Blue Spotted Sunfish (1)	Blue Spotted Sunfish (1), Bluegill (1), and Crayfish (1)	~
4	~	~	~	~
5	~	~	~	~
6	~	~	~	~
7	~	~	~	White Shiner (1)
8	~	~	~	~
9	~	Crayfish (1)	~	Crayfish (2)
10	~	~	~	~

### 5.3.3.2 Middle Creek near Susan Road (161220.1kms and 170203.2kms)

This Middle Creek survey location is west/upstream of NC 50 and south of Susan Drive in Johnston County (Figure 6). At this survey location, Middle Creek ranged from 15 to 30 feet wide with water depths of 1 to 3 feet. The site was surveyed twice. Water flow was clear and at a moderate to fast velocity. The buffer was wide, forested, and intact within the survey vicinity which contained multiple wetlands.

**Table 63. Middle Creek near Susan Road (161220.1kms)– December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	Crayfish (1)		
2	~	~		
3	~	~		
4	~	Crayfish (1)		
5	~	~		
6	Crayfish (2)	Neuse River Waterdog (1)		
7	~	Crayfish (1)		
8	~	Crayfish (1)		
9	~	Crayfish (1)		
10	~	~		

\*Grey cells indicate target species presence was confirmed and additional survey days were not necessary

**Table 64. Middle Creek near Susan Road (170203.2kms) – February 2017**

Trap #	Day 1	Day 2	Day 3	Day 4
1	Crayfish (1)			
2	Neuse River Waterdog (1)			
3	~			
4	~			
5	~			
6	~			
7	Crayfish (1)			
8	~			
9	~			
10	~			

\*Grey cells indicate target species presence was confirmed and additional survey days were not necessary

#### 5.3.3.3 Middle Creek at Smith Road (161220.2kms)

This Middle Creek survey location is upstream of the Smith Road (SR 1507) crossing in Johnston County (Figure 6). The banks are quite steep and eroding within this survey location. Middle Creek ranged from 15 to 20 feet wide with water depths of at least 6 feet. The survey location was surrounded by a forested, intact, toe-of-slope floodplain, which contained multiple wetlands. During the survey, the water was clear with a fast velocity.

**Table 65. Middle Creek at Smith Road (161220.2kms) – December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~			
2	Neuse River Waterdog (2)			
3	~			
4	Neuse River Waterdog (1)			
5	~			
6	~			
7	~			
8	~			
9	Crayfish (1)			
10	Crayfish (3)			

\*Grey cells indicate target species presence was confirmed and additional survey days were not necessary

#### 5.3.3.4 Middle Creek at Crantock Road (161220.3kms and 170203.3kms)

This Middle Creek survey location is downstream of the Crantock Road (SR 1504) crossing in Johnston County (Figure 6). It was surveyed twice. Upstream of the crossing is a breached concrete dam structure. Downstream, Middle Creek ranges from 15 to 20 feet wide with depths between 2 to 4 feet. During the survey, the water velocity was fast and clear. The site is surrounded by a forested buffer that has been logged east of the stream.

**Table 66. Middle Creek at Crantock Road (161220.3kms) – December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	Neuse River Waterdog (1), Crayfish (1)			
2	~			
3	~			
4	~			
5	Neuse River Waterdog (1)			
6	~			
7	Crayfish (1)			
8	~			
9	Pirate Perch (1), Crayfish (1)			
10	Neuse River Waterdog (1), Crayfish (1)			

\*Grey cells indicate target species presence was confirmed and additional survey days were not necessary

**Table 67. Middle Creek at Crantock Road (170203.3kms) – February 2017**

Trap #	Day 1	Day 2	Day 3	Day 4
1	Crayfish (1)	~		
2	~	Spottail Shiner (1)		
3	~	~		
4	~	~		
5	~	White Shiner (1)		
6	~	Neuse River Waterdog (1)		
7	~	Bluegill (1) and Crayfish (1)		
8	~	Pirate Perch (1) and Warmouth (1)		
9	~	~		
10	~	~		

\*Grey cells indicate target species presence was confirmed and additional survey days were not necessary

### 5.3.3.5 Black Creek (161220.4kms)

The Black Creek Survey location is approximately 0.2 river mile east/downstream of Raleigh Road (SR 1330) in Johnston County (Figure 6). Unlike the other survey locations, the Black Creek location is surrounded by a large wetland complex. Water was slightly tannic to tannic with a moderate velocity. The creek ranged from 10 to 20 feet wide with water depths from 1 to 4 feet. The survey location was surrounded by a large intact forested wetland buffer.

**Table 68. Black Creek near Raleigh Rd (161220.4kms)– December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	~	~	~
2	~	~	~	~
3	~	~	~	~
4	~	~	~	~
5	~	~	~	~
6	~	~	~	~
7	~	~	~	Pirate Perch
8	~	~	~	~
9	~	~	~	~
10	~	~	~	~

### 5.3.3.6 Neuse River near Milburnie Dam (161220.5kms)

This Neuse River survey location is downstream of Milburnie Dam and upstream of New Bern Avenue (US 64) in Wake County (Figure 6). Eleven traps were placed at this site on both sides of the river based on the larger size of the system. The river ranged from 140 to 200 feet wide with depths greater than 6 feet. The water flow was clear with a fast velocity during the trapping effort. This portion of the Neuse River has a relatively intact forested buffer approximately 200 feet on either side of the river.

**Table 69. Neuse River near Milburnie Dam (161220.5kms)– December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	Bluegill (1)	~	~	~
2	~	~	~	~
3	~	Sunfish (1)	Bluegill (1)	~
4	White Shiner (2)	Satinfin Shiner (1)	Satinfin Shiner (1)	~
5	~	Crayfish (1)	~	~
6	~	~	~	~
7	~	~	~	~
8	~	~	Redbreast Sunfish (1)	~
9	~	Channel Catfish (1)	~	~
10	~	~	~	~
11	~	~	Spottail Shiner (1)	~

### 5.3.3.7 Neuse at Poole Road (170203.6kms)

This Neuse River survey location is upstream of Poole Road (SR 1007) in Wake County (Figure 6). The river ranged from 100 to 120 feet wide with depths greater than 6 feet. The water flow was clear with a fast velocity during the trapping effort. This portion of the Neuse River has a relatively intact forested buffer approximately 200 feet on either side of the river.

**Table 70. Neuse River at Poole Road (170203.6kms)– February 2017**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	~	Satinfin Shiner (5)	~
2	~	American Eel (1)	~	~
3	~	~	~	~
4	~	~	~	~
5	~	~	~	~
6	~	~	~	~
7	~	~	~	~
8	~	Spottail Shiner (1)	~	Catfish (1)
9	~	~	~	~
10	~	~	~	~

### 5.3.3.8 White Oak Creek (161220.6kms)

The White Oak Creek survey location is south/downstream of NC 42 and west of Anna Drive in Johnston County (Figure 6). Only nine traps were placed at this location because of equipment limitations. The creek ranged from 4 to 8 feet wide with water depths of approximately 2 to 6 feet. The water flow was clear with moderate velocity during the trapping effort. The buffer in this area is forested and intact.

**Table 71. White Oak Creek at NS 42 (161220.6kms)– December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	~	~	~
2	~	~	~	~
3	Crayfish (1)	~	~	~
4	~	~	~	~
5	White Shiner (1)	Flyer (1)	~	~
6	~	~	~	~
7	~	~	~	White Shiner (2)
8	White Shiner (2)	~	~	~
9	~	~	Bluegill (2)	~

### 5.3.3.9 Little Creek (161220.7kms)

The Little Creek survey location is at Steel Bridge Road (SR 1562) with traps both upstream and downstream of the bridge (Figure 6). Little Creek ranged from 6 to 20 feet wide with water depths of approximately 2 to 6 feet. During the survey, the water was clear with moderate velocity. The buffer in the area is relatively intact and forested.

**Table 72. Little Creek at Steel Bridge Road (161220.7kms)– December 2016**

Trap #	Day 1	Day 2	Day 3	Day 4
1	Snail Bullhead (1), Creek Chub (1), Crayfish (1)	Crayfish (1)	~	~
2	~	~	Crayfish (1)	Crayfish (3)
3	Bluegill (1)	Pirate Perch (1)	~	~
4	~	~	~	~
5	~	~	~	~
6	~	~	~	Snail Bullhead (1)
7	Tessellated Darter (1), Margined Madtom (2)	Margined Madtom (1), Crayfish (1)	Margined Madtom (1)	~
8	White Shiner (2)	Snail Bullhead (3)	~	Snail Bullhead (1), Crayfish (2)
9	~	Pirate Perch (2)	Pirate Perch (1), Crayfish (1)	Crayfish (2)
10	Pirate Perch (1)	~	~	Crayfish (1)

#### 5.3.3.10 Swift Creek at NC 42 (170203.5kms)

This Swift Creek survey location is south/downstream of NC 42 in Johnston County (Figure 6). The creek ranged from 25 to 45 feet wide with water depths of approximately 2 to 6 feet. The water flow was slightly turbid and with a moderate velocity during the trapping effort. The buffer in this area is cleared on the left descending bank and forested on the right descending bank.

**Table 73. Swift Creek at NC 42 (170203.5kms)– February 2017**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	~	~	~
2	~	~	~	~
3	~	~	~	~
4	~	~	~	~
5	~	~	~	Crayfish
6	Crayfish (1)	~	~	~
7	~	~	American Eel (1)	NC Spiny Crayfish (1)
8	~	~	~	NC Spiny Crayfish (1)
9	~	~	Crayfish (1)	~
10	~	~	~	~

#### 5.3.3.11 Swift Creek at Barber Mill Road (170203.4km)

This Swift Creek survey location is downstream of Barber Mill Road in Johnston County (Figure 6). The creek ranged from 15 to 25 feet wide with water depths of approximately 1 to 6 feet. The water flow was slightly turbid and with a moderate velocity during the trapping effort. The buffer in this area is poor with the right descending bank being a cutover.

**Table 74. Swift Creek at Barber Mill Road (170203.4km) – February 2017**

Trap #	Day 1	Day 2	Day 3	Day 4
1	~	~	Neuse River Waterdog (2)	
2	~	~	~	
3	~	~	~	
4	~	~	~	
5	~	~	~	
6	~	~	~	
7	~	~	~	
8	~	~	~	
9	~	~	~	
10	~	Crayfish (1)	American Eel (1)	

\*Grey cells indicate target species presence was confirmed and additional survey days were not necessary

## 6.0 DISCUSSION/CONCLUSIONS

The results indicate that several streams in the study area continue to support diverse freshwater mussel and fish faunas. As discussed in Section 1.0, all target species have been reported within some of the study area streams at some point in time. The survey efforts detailed in this report serve to update and/or supplement species occurrence information within the study area streams. The information was gathered to support the development of a BA for this project, which will address direct, indirect, and cumulative effects of the proposed project on the DWM and Yellow Lance. A full analysis of the environmental baseline, discussion of species, and effects of the project on individual species will help determine the Biological Conclusions of federally protected species. The other target species, the Atlantic Pigtoe, Carolina Madtom, and Neuse River Waterdog will be included in the BA should they become proposed before the beginning of project construction.

### 6.1 Freshwater Mussel Surveys

Extensive mussel surveys conducted for this project in Swift Creek have documented that the DWM, Yellow Lance and Atlantic Pigtoe are still present. The data generated from these efforts have been presented in many other reports for this project. The mussel survey component of the aquatic species surveys presented in this report focused on other water bodies within the study area, as recent survey data was not available.

#### 6.1.1 DWM

Other than one relict shell at site 161102.2tws in Middle Creek, the DWM was not found during these efforts. In addition to Swift Creek, the DWM has been found in Middle Creek, White Oak Creek (Swift Creek Tributary) and Little Creek within the study area. The last records of this species from these streams are from 1992, 1994, and 2003, respectively. Based on these and other survey efforts since 1992, it is unlikely that the DWM still occurs in Middle Creek; however, it cannot be ruled out entirely. Although it was not found in Little Creek during this survey effort, based on habitat conditions, and minimal survey efforts since 2003, the DWM could still be present in Little Creek.

While the DWM was reported from the Neuse River in the 1950's there are no recent records of occurrence. Although a diverse mussel fauna is still present in this portion of the Neuse River, the DWM was not found during this, or other recent surveys efforts; thus, it is likely extirpated from the Neuse River. Additionally, it was not found in any of the other streams surveyed during this effort, and is unlikely to occur in any of them.

### *6.1.2 Yellow Lance*

In addition to Swift Creek, the Yellow Lance has also been recorded in Middle Creek, most recently in 2011. Other than the relicts found at site 161102.2tws, it was not found in Middle Creek during this effort. However, given the recent (2011) record, it should still be considered present in the stream. It was not found in any of the other streams surveyed during this effort, and is unlikely to occur in any of them.

### *6.1.3 Atlantic Pigtoe*

In addition to Swift Creek, Atlantic Pigtoe has been recorded in Middle Creek and Black Creek within the study area. These survey efforts confirmed its continued presence in Middle Creek. It was not detected in Black Creek and based on the survey results, it is unlikely to still occur in the stream. Additionally, it was not found in any of the other streams surveyed during this effort, and is unlikely to occur in any of them.

## **6.2 Carolina Madtom Surveys**

Two survey methodologies were used to determine if this species occurred in any of the study area streams. The NCWRC visual survey protocol was primarily used, and for the most part was effective in detecting other species of madtoms (i.e. tadpole madtom, margined madtom). The one exception to this was in Little Creek, where the margined madtom was found using electrofishing, but was not observed using the visual techniques. This may be a result of a limited amount of large cover (e.g. cobble, logs, etc.) in the middle of the channel, with the majority of cover consisting of submerged rootmats, which are difficult to survey visually. The Carolina Madtom was not detected during this effort and has not been confirmed from any of the study area streams for 30 years, and thus is unlikely to still occur.

The results of these survey efforts also demonstrate that multiple methodologies may be needed to obtain a complete inventory of all fish species present in a stream reach. The visual method was fairly effective at detecting benthic (stream bottom) species like darters and madtoms; however, it was not effective for many of the more pelagic (water column) species. While the electrofishing methods detected more species than the visual methods, they still did not provide a complete inventory of all species present at a site. This is evidenced by the Warmouth detected in Middle Creek at the Crantock Road site during Neuse River Waterdog trapping efforts, but not found during the visual or electrofishing efforts.



### **6.3 Neuse River Waterdog Surveys**

The results of this survey effort confirmed the continued presence of the Neuse River Waterdog in Swift Creek and Middle Creek. Given that the species has not been reported from the Neuse River since 1987, and was not observed during this effort, it is unlikely to still occur in the Neuse River. Additionally, it was not found in any of the other streams surveyed during this effort, and is unlikely to occur in any of them.

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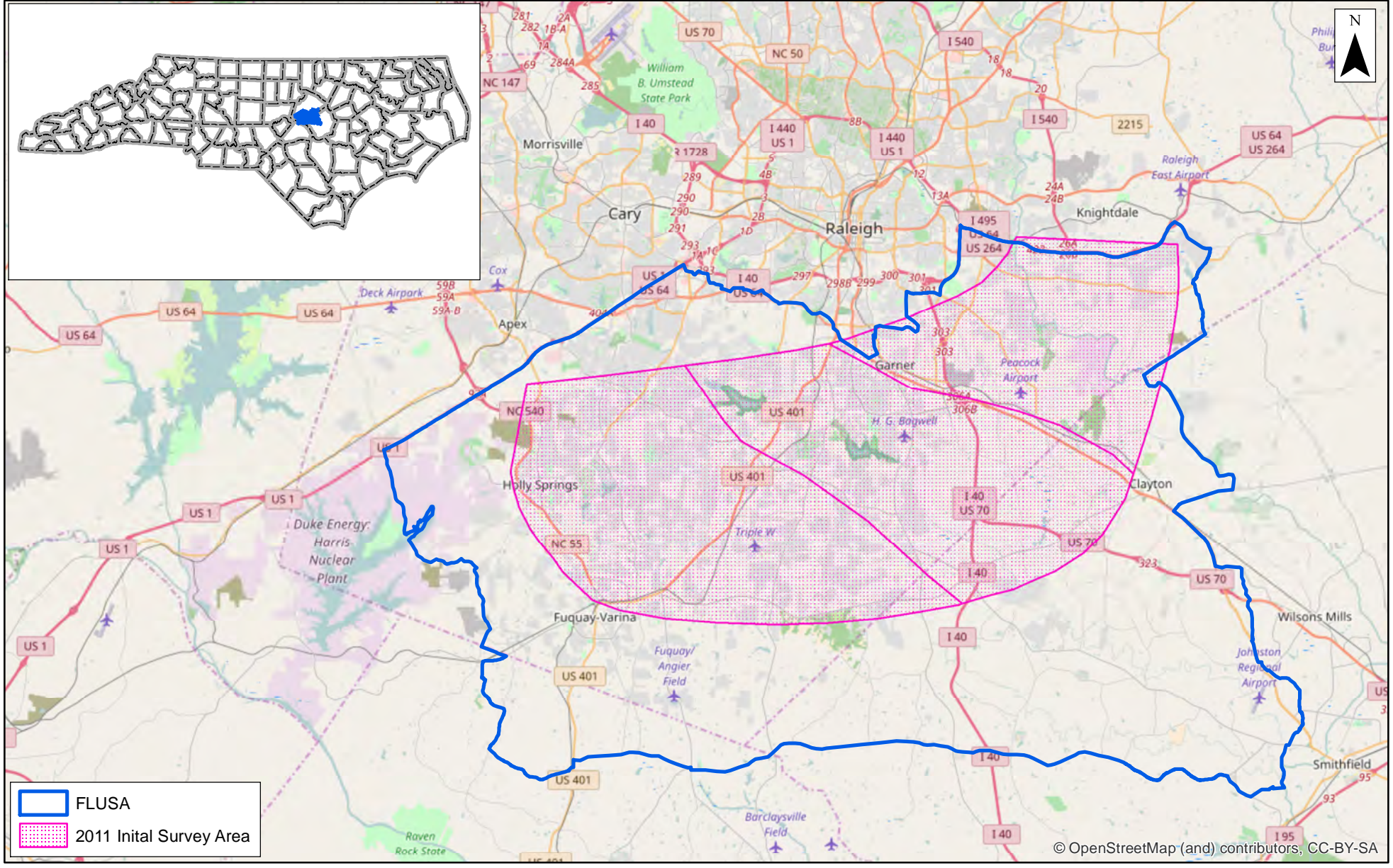
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# **APPENDIX A**

## Figures





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FLUSA  
 2011 Initial Survey Area



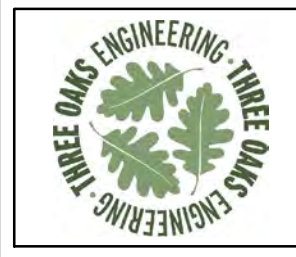
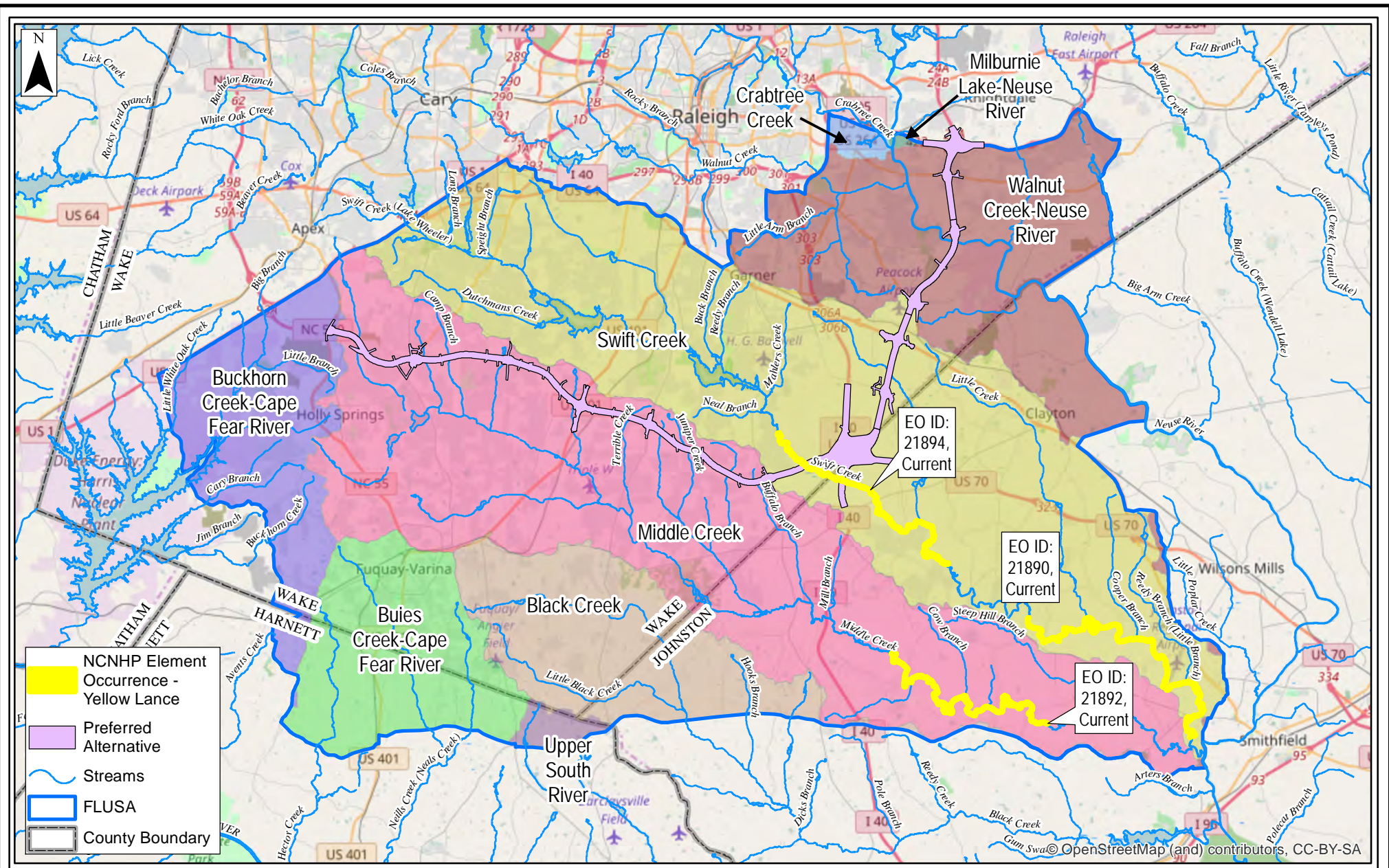
Prepared For:

**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**  
 Future Land Use Study Area (FLUSA)  
 Wake, Johnston, & Harnett Counties, North Carolina

Date:	June 2017
Scale:	0 1 2 Miles 
Job No.:	16-318
Drawn By:	NMS
Checked By:	KMS

Figure  
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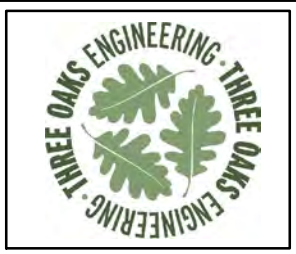
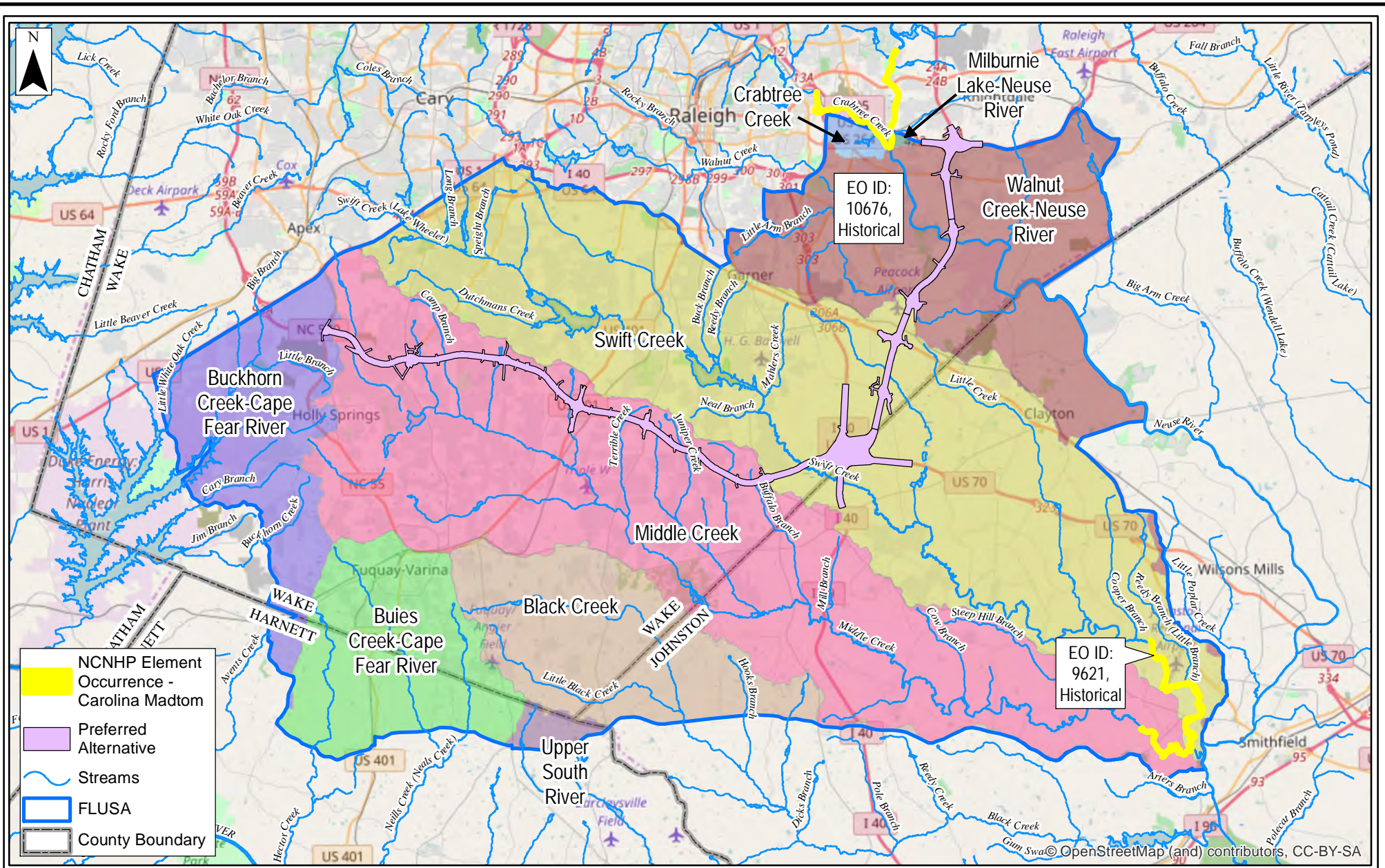


**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**  
 North Carolina Natural Heritage Program  
 Element Occurrence: Yellow Lance  
 Wake, Johnston, & Harnett Counties, North Carolina

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Job No.:	16-318
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Checked By:	KMS

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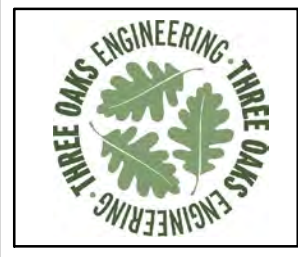
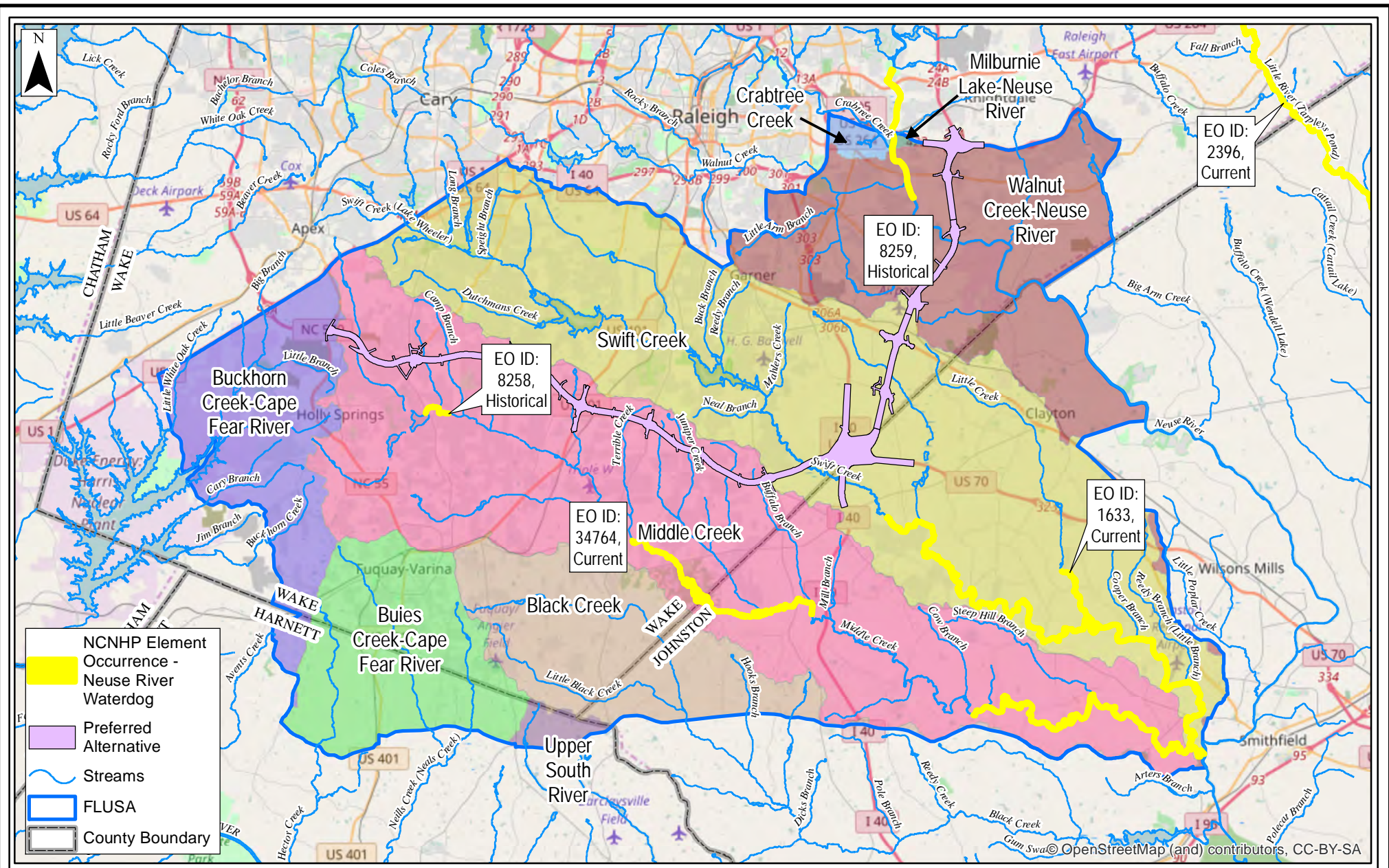




**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**  
 North Carolina Natural Heritage Program  
 Element Occurrence: Carolina Madtom  
 Wake, Johnston, & Harnett Counties, North Carolina

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Checked By:	KMS

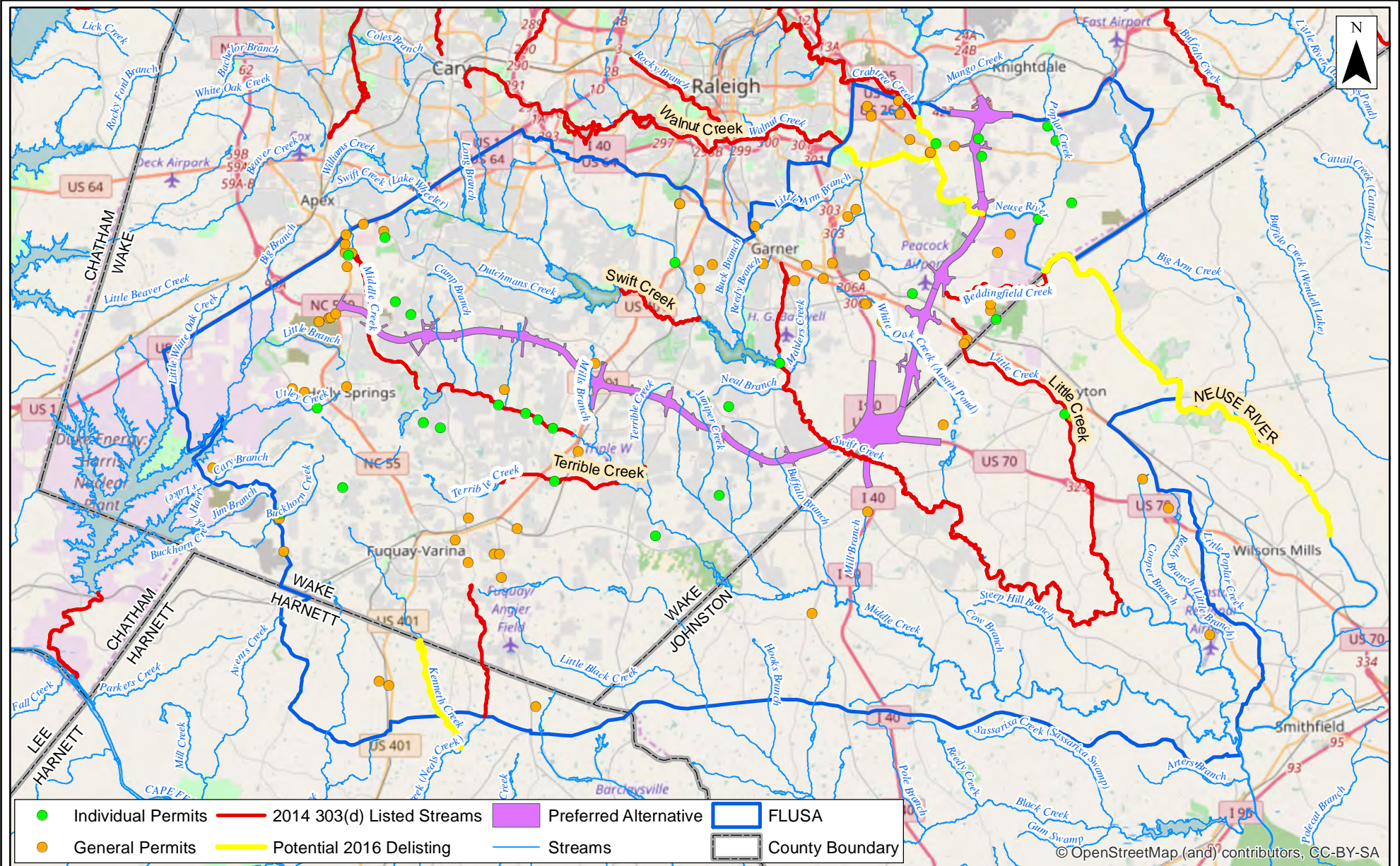
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**2-4**



**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**  
 North Carolina Natural Heritage Program  
 Element Occurrence: Neuse River Waterdog  
 Wake, Johnston, & Harnett Counties, North Carolina

Date:	June 2017
Scale:	0 1 2 Miles
Job No.:	16-318
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Checked By:	KMS

Figure  
**2-5**



Prepared For:



## Aquatic Species Survey Report Complete 540 Triangle Expressway Southeast Extension

303(d) Listed Streams & National Pollutant  
Discharge Elimination System Discharges  
Wake, Johnston, & Harnett Counties, North Carolina

Date: June 2017

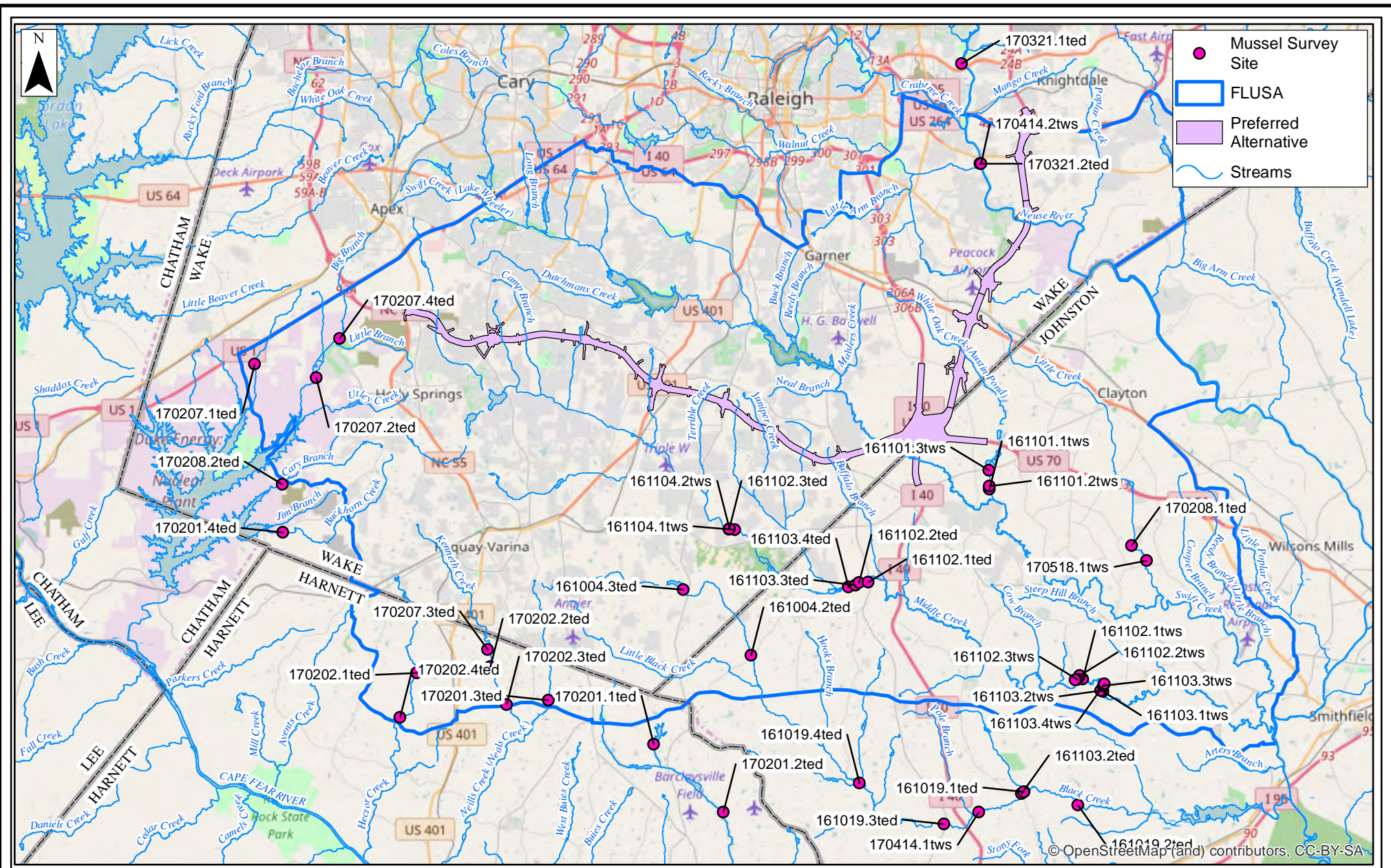
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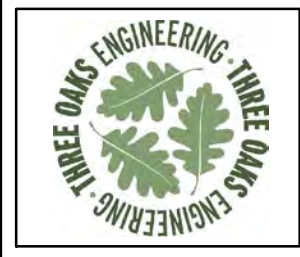
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Figure

3



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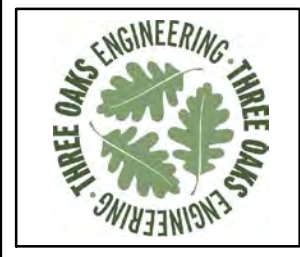
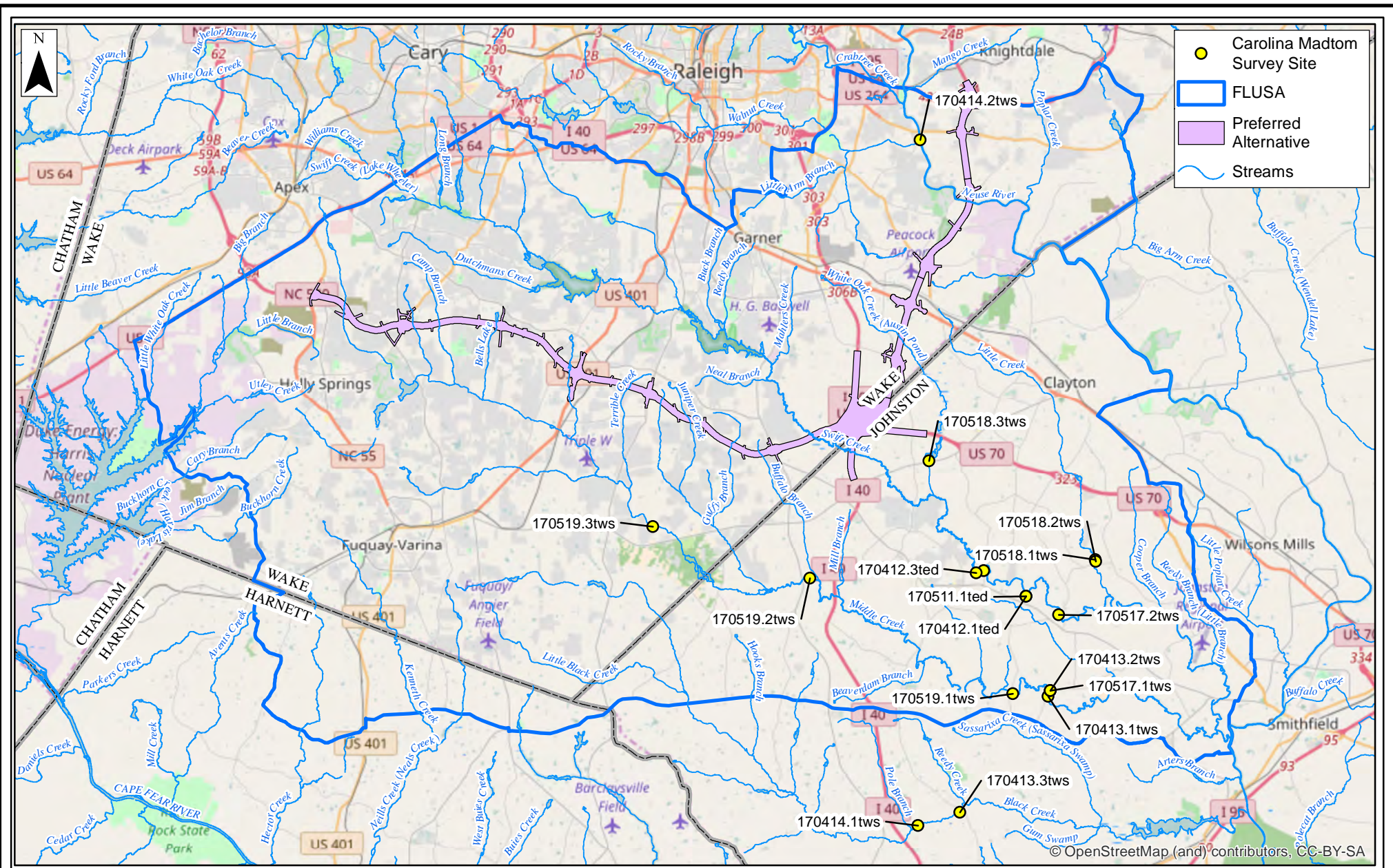


**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**  
  
**Mussel Survey Locations**  
 Wake, Johnston, & Harnett Counties, North Carolina

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Job No.:	16-318
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Checked By:	KMS

Figure  
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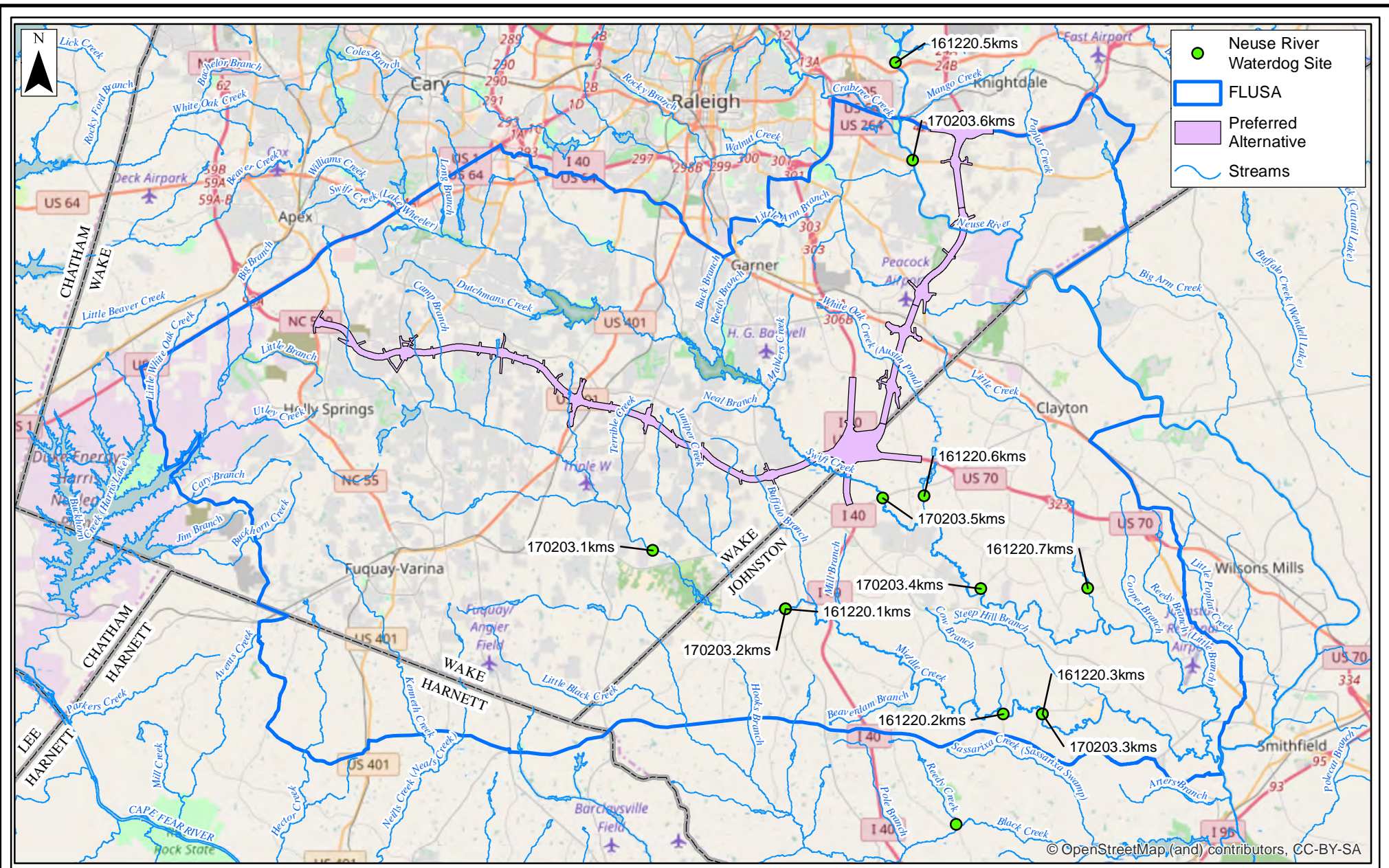


**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**

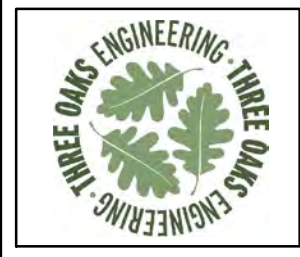
Carolina Madtom Survey Locations  
 Wake, Johnston, & Harnett Counties, North Carolina

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Figure  
5



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**Aquatic Species Survey Report**  
**Complete 540 Triangle Expressway**  
**Southeast Extension**

Neuse River Waterdog Survey Locations  
 Wake, Johnston, & Harnett Counties, North Carolina

Date:	June 2017
Scale:	0 1 2 Miles
Job No.:	16-318
Drawn By:	NMS
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Figure  
6