

# BIOLOGICAL ASSESSMENT

## AN ASSESSMENT OF POTENTIAL EFFECTS TO FEDERALLY LISTED SPECIES

For



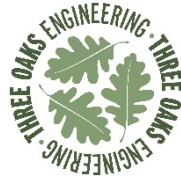
### Complete 540 – Triangle Expressway Southeast Extension Wake, Johnston, & Harnett Counties

STIP Project Nos. R-2721, R-2828, and R-2829  
State Project Nos. 6.401078, 6.401079, and 6.401080  
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Federal Highway Administration & North Carolina Department of Transportation



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## Table of Contents

<b>1.0</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	<i>Statutory Authority of Action.....</i>	<i>1</i>
1.2	<i>Summary of Consultation History.....</i>	<i>2</i>
<b>2.0</b>	<b>PROJECT AND ACTION AREA DESCRIPTION.....</b>	<b>2</b>
2.1	<i>Project Description.....</i>	<i>2</i>
2.2	<i>Avoidance and Minimization During Alternative Development.....</i>	<i>3</i>
2.3	<i>Description of Action Area.....</i>	<i>3</i>
2.4	<i>Federally Listed Species: Wake, Johnston, and Harnett Counties, NC.....</i>	<i>3</i>
2.5	<i>Habitat Conservation Plans In Action Area.....</i>	<i>5</i>
2.6	<i>Potential Effects of the Action.....</i>	<i>5</i>
2.7	<i>Conservation Measures.....</i>	<i>6</i>
2.8	<i>Other Consultations in Action Area.....</i>	<i>6</i>
<b>3.0</b>	<b>ENVIRONMENTAL BASELINE FOR DWM AND YELLOW LANCE.....</b>	<b>7</b>
3.1	<i>Watershed Conditions Baseline.....</i>	<i>7</i>
3.1.1	<i>Best Usage Classification.....</i>	<i>7</i>
3.1.2	<i>Impaired 303(d) Listing.....</i>	<i>8</i>
3.1.3	<i>Point Source Pollution.....</i>	<i>10</i>
3.1.4	<i>Non-point Source Pollution.....</i>	<i>12</i>
3.1.5	<i>Ecological Significance.....</i>	<i>13</i>
3.2	<i>Dwarf Wedgemussel (Alasmidonta heterodon) Species Baseline.....</i>	<i>15</i>
3.2.1	<i>Species Characteristics.....</i>	<i>15</i>
3.2.2	<i>Distribution and Habitat Requirements.....</i>	<i>16</i>
3.3	<i>Yellow Lance (Elliptio lanceolata) Species Baseline.....</i>	<i>18</i>
3.3.1	<i>Species Characteristics.....</i>	<i>19</i>
3.3.2	<i>Distribution and Habitat Requirements.....</i>	<i>19</i>
3.4	<i>Summary of DWM and Yellow Lance within Action Area.....</i>	<i>20</i>
3.4.1	<i>Distributions in Swift Creek.....</i>	<i>21</i>
3.4.2	<i>Distributions in Middle Creek.....</i>	<i>22</i>
3.5	<i>General Threats to DWM and Yellow Lance.....</i>	<i>22</i>
3.5.1	<i>Sedimentation.....</i>	<i>23</i>
3.5.2	<i>Habitat Alteration.....</i>	<i>23</i>
3.5.3	<i>Toxic Contaminants.....</i>	<i>23</i>
3.5.4	<i>Hydrologic Changes Due to Changes in Land Use.....</i>	<i>27</i>
3.5.4.1	<i>Peak Discharge.....</i>	<i>28</i>
3.5.4.2	<i>Runoff Volume.....</i>	<i>28</i>
3.5.4.3	<i>Base Flow.....</i>	<i>29</i>
3.5.5	<i>Thermal Pollution.....</i>	<i>30</i>
3.5.6	<i>Invasive Species.....</i>	<i>31</i>
3.5.7	<i>Loss of Riparian Buffers.....</i>	<i>31</i>
3.5.8	<i>Degradation Caused by All-Terrain Vehicle Use.....</i>	<i>32</i>

3.6	<b>Potential Effects of Roadway Projects on Freshwater Mussels and Habitat.....</b>	<b>32</b>
3.6.1	Physical Effects.....	32
3.6.2	Water Quality Effects.....	33
3.6.3	Water Quantity Effects.....	33
4.0	<b>EVALUATED EFFECTS OF PROPOSED ACTION ON DWM AND YELLOW LANCE.....</b>	<b>33</b>
4.1	<b>Construction Effects.....</b>	<b>34</b>
4.1.1	Stream Fill (Substrate (Habitat) Disturbance/Loss) .....	36
4.1.2	Fish Host Effects .....	37
4.1.3	Erosion/Sedimentation from Construction .....	38
4.1.4	Alteration of Flows/Channel Stability .....	38
4.1.5	Effects Associated with Borrow/Fill, Staging and Storage.....	39
4.2	<b>Operational Effects .....</b>	<b>39</b>
4.2.1	Alteration of Flows/Channel Stability .....	39
4.2.2	Roadway Runoff.....	40
4.2.3	Toxic Spills.....	40
4.3	<b>Induced Land Development .....</b>	<b>42</b>
4.3.1	Induced Impervious Surface Effects.....	44
4.3.2	Induced TSS Effects.....	44
4.3.3	Induced Copper Effects.....	44
4.3.4	Induced Roadway Runoff Effects .....	45
4.4	<b>Conclusions of Effects – DWM and Yellow Lance .....</b>	<b>46</b>
4.4.1	Construction Effects.....	46
4.4.1.1	Habitat Loss/Disturbance .....	46
4.4.1.2	Fish Host Effects .....	47
4.4.1.3	Sedimentation/Erosion From Stream Crossing Construction .....	47
4.4.1.4	Alteration of Flows/Channel Stability.....	47
4.4.1.5	Effects Associated with Borrow/Fill, Staging, and Storage Sites .....	48
4.4.2	Operational Effects .....	48
4.4.2.1	Alteration of Flow/Channel Stability .....	48
4.4.2.2	Roadway Runoff .....	49
4.4.2.3	Toxic Spills .....	49
4.4.3	Induced Land Development Effects .....	49
4.4.4	Cumulative Effects .....	50
4.4.5	Biological Conclusion.....	51
4.5	<b>Project Conservation Measures .....</b>	<b>52</b>
4.5.1	Conservation Measures to Avoid/Minimize Effects to DWM and Yellow Lance....	52
4.5.1.1	Erosion Control Measures.....	52
4.5.1.2	Bridge Deck Drainage.....	53
4.5.1.3	Agency Coordination .....	53
4.5.1.4	Construction Practices.....	53
4.5.1.5	Stream Crossing Review .....	53

4.5.1.6	Bridging of Swift Creek .....	54
4.5.1.7	Hazardous Spill Basins (HSBs).....	54
4.5.2	<i>Conservation Measures to Offset Effects to DWM and Yellow Lance</i> .....	54
4.5.2.1	Preconstruction Survey and Potential Mussel Relocation.....	54
4.5.2.2	Propagation Facility .....	55
4.5.3	<i>DWM Viability Study</i> .....	57
<b>5.0</b>	<b>ENVIRONMENTAL BASELINE FOR MICHAUX’S SUMAC .....</b>	<b>57</b>
<b>5.1</b>	<b><i>Michaux’s Sumac (Rhus michauxii)</i>.....</b>	<b>57</b>
5.1.1	<i>Species Characteristics</i> .....	57
5.1.2	<i>Distribution and Habitat Requirements</i> .....	58
5.1.3	<i>Presence in Action Area</i> .....	59
5.1.4	<i>General Threats to Michaux’s Sumac</i> .....	60
5.1.5	<i>Roadway-Related Threats to Michaux’s Sumac</i> .....	61
5.1.5.1	Construction Effects .....	61
5.1.5.2	Operational Effects.....	61
5.1.5.3	Induced Land Use Effects .....	61
5.1.5.4	Potential Cumulative Effects.....	61
<b>6.0</b>	<b>EVALUATED EFFECTS OF PROPOSED ACTION ON MICHAUX’S SUMAC..</b>	<b>62</b>
<b>6.1</b>	<b><i>Construction Effects</i>.....</b>	<b>62</b>
<b>6.2</b>	<b><i>Operational Effects</i> .....</b>	<b>62</b>
<b>6.3</b>	<b><i>Induced Land Development Effects</i>.....</b>	<b>62</b>
<b>6.4</b>	<b><i>Conclusion of Effects – Michaux’s Sumac</i> .....</b>	<b>64</b>
6.4.1	<i>Construction Effects</i> .....	64
6.4.2	<i>Operational Effects</i> .....	64
6.4.3	<i>Induced Land Development Effects</i> .....	64
6.4.4	<i>Biological Conclusion</i> .....	65
<b>7.0</b>	<b>ENVIRONMENTAL BASELINE FOR CAPE FEAR SHINER .....</b>	<b>65</b>
<b>7.1</b>	<b><i>Watershed Conditions Baseline</i> .....</b>	<b>65</b>
7.1.1	<i>Best Usage Classification</i> .....	65
7.1.2	<i>Impaired 303(d) Listing</i> .....	65
7.1.3	<i>Point Source Pollution</i> .....	66
7.1.4	<i>Non-Point Source Pollution</i> .....	66
7.1.5	<i>Ecological Significance</i> .....	67
<b>7.2</b>	<b><i>Cape Fear Shiner (Notropis mekistocholas)</i>.....</b>	<b>67</b>
7.2.1	<i>Species Characteristics</i> .....	67
7.2.2	<i>Distribution and Habitat Requirements</i> .....	68
7.2.3	<i>General Threats to Species</i> .....	69
7.2.4	<i>Roadway Related Threats to Cape Fear Shiner</i> .....	70
7.2.5	<i>Designated Critical Habitat</i> .....	70
7.2.6	<i>Presence in Action Area</i> .....	71
<b>8.0</b>	<b>EVALUATED EFFECTS OF PROPOSED ACTION ON CAPE FEAR SHINER..</b>	<b>71</b>
<b>8.1</b>	<b><i>Induced Land Development</i> .....</b>	<b>71</b>

8.1.1	<i>Conclusion of Effects – Cape Fear Shiner</i> .....	72
<b>9.0</b>	<b>FEDERALLY LISTED SPECIES NOT WITHIN ACTION AREA</b> .....	<b>72</b>
9.1	<i>Bald Eagle (Haliaeetus leucocephalus)</i> .....	72
9.2	<i>Rough-leaved Loosestrife (Lysimachia asperulaefolia)</i> .....	72
9.2.1	<i>Species Characteristics</i> .....	73
9.2.2	<i>Distribution and Habitat Requirements</i> .....	73
9.2.3	<i>General Threats to Species</i> .....	73
9.2.4	<i>Presence in Action Area</i> .....	73
9.2.5	<i>Conclusion of Effects – Rough-leaved Loosestrife</i> .....	73
9.3	<i>Tar River Spiny mussel (Parvaspina steinstansana)</i> .....	74
9.3.1	<i>Species Characteristics</i> .....	74
9.3.2	<i>Distribution and Habitat Requirements</i> .....	74
9.3.3	<i>General Threats to Species</i> .....	75
9.3.4	<i>Presence in Action Area</i> .....	75
9.3.5	<i>Conclusion of Effects – Tar Spiny mussel</i> .....	75
9.4	<i>Red-cockaded Woodpecker (Picoides borealis)</i> .....	75
9.4.1	<i>Species Characteristics</i> .....	75
9.4.2	<i>Distribution and Habitat</i> .....	75
9.4.3	<i>General Threats to Species</i> .....	76
9.4.4	<i>Presence in Action Area</i> .....	76
9.4.5	<i>Conclusion of Effects - Red-cockaded Woodpecker</i> .....	77
<b>10.0</b>	<b>DETERMINATION OF EFFECTS</b> .....	<b>77</b>
<b>11.0</b>	<b>LITERATURE CITED</b> .....	<b>78</b>

### Table of Tables

Table 1.	Federally Listed Species; Wake, Johnston, and Harnett Counties, North Carolina .....	4
Table 2.	Action Area Streams within Middle and Swift Creek Subbasins .....	8
Table 3.	Impaired (Category 5) Streams 2014 in Middle and Swift Creek Subbasins .....	9
Table 4.	NPDES Individual Permitted Discharges within Middle and Swift Creek Subbasins ...	11
Table 5.	NPDES General Permitted Discharges within Middle and Swift Creek Subbasins.....	12
Table 6.	Land cover in the Neuse River subbasins of the FLUSA .....	13
Table 7.	Natural Heritage Natural Areas in the Neuse River subbasins of the FLUSA (NCNHP 2017) .....	14
Table 8.	Non- Federally Protected Rare Aquatic Species in Swift and Middle Creek Subbasins	14
Table 9.	DWM Population Densities at Study Streams 1996 and Follow-up Survey Data* .....	18
Table 10.	Distances to Occupied Habitat from Verified Jurisdictional Streams .....	34
Table 11.	Percent Increases from 2010 Baseline to 2040 No-Build and from 2040 No-Build to 2040 Build.....	43
Table 12.	Stream and Wetland Crossings within the Swift Creek Watershed with Larger Proposed Structures Than Hydraulically Required.....	54

Table 13. Projected FLUSA Land Use in Build and No-Build Scenarios (Baker Engineering 2017a-d) .....	63
Table 14. FLUSA Streams within the Buies Creek-Cape Fear River Subwatershed .....	65
Table 15. Buies Creek-Cape Fear River Subwatershed Impaired (Category 5) Streams 2014. ...	66
Table 16. NPDES General Permitted Discharges within Buies Creek-Cape Fear River Subwatershed .....	66
Table 17. Land Cover in the Buies Creek-Cape Fear Subwatershed.....	66
Table 18. Cape Fear Shiner Relative Abundance* by River Segment .....	69
Table 19. Determination of Effects On Federally Listed Species .....	77

## Appendix A. Figures

- Figure 1. Future Land Use Study Area/Action Area and Preferred Alternative
- Figure 2. Preferred Alternative
- Figure 3. Future Land Use Study Area Streams and 12-digit Subwatersheds
- Figure 4. North Carolina Department of Environmental Quality 303(d) Impaired Streams
- Figure 5. National Pollutant Discharge Elimination System Discharges
- Figure 6. Land Cover, National Land Cover Data
- Figure 7. Natural Heritage Natural Areas
- Figure 8. Dwarf Wedgemussel Element Occurrences
- Figure 9. Yellow Lance Element Occurrences
- Figure 10. Distance to Occupied Habitat
- Figure 11. Streams within 0.25 RM of Occupied Habitat within Swift Creek Watershed
- Figure 12. Stream and Wetland Crossings with Larger Proposed Structures within Swift Creek Watershed
- Figure 13. Michaux's Sumac Element Occurrences
- Figure 14. Cape Fear Shiner Element Occurrences
- Figure 15. Rough-Leaved Loosestrife Element Occurrences
- Figure 16. Tar Spinemussel Element Occurrences
- Figure 17. Red-Cockaded Woodpecker Element Occurrences

## Appendix B. Dwarf Wedgemussel and Yellow Lance Records in Future Land Use Study Area

## Appendix C. Lower Swift Creek Water Quality Report

## Appendix D. Dwarf Wedgemussel Viability Study Report

## Appendix E. Aquatic Species Survey Report 2017

## **Glossary of Endangered Species Act Definitions:**

Action Area – All areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. [50 CFR §402.02].

Cumulative effects - those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation. [50 CFR §402.02] This definition applies only to section 7 analyses and should not be confused with the broader use of this term in the National Environmental Policy Act or other environmental laws.

Discountable – extremely unlikely to occur.

Effects of the action - the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. These effects are considered along with the environmental baseline and the predicted cumulative effects to determine the overall effects to the species for purposes of preparing a biological opinion on the proposed action. [50 CFR §402.02] The environmental baseline covers past and present impacts of all Federal actions within the action area. This includes the effects of existing Federal projects that have not yet come in for their section 7 consultation.

Insignificant - relate to the size of the impact and should never reach the scale where take occurs.

Interdependent action- An action that has no independent utility apart from the proposed action that is subject to consultation [50 CFR §402.02].

Interrelated action - An action that is part of a larger action, and that depends on the larger action for its justification [50 CFR §402.02].

## **Glossary of Freshwater Mussel Definitions:**

Anterior – front or forward

Cardinal teeth – teeth located between the lateral teeth in Corbiculidae and Sphaeriidae

Dorsal – the top or back; in mussels, the hinge area

Gill – a thin plate-like paired structure within the mantel cavity, which serves as a respiratory organ in aquatic mollusks and in female unionids all of the gills or certain portion of the gills serve as the marsupium.

Glochidia – the bivalve larva of unionids which are generally parasitic on the gills of fish

Gravid – a female that has embryos in the marsupium

Hinge ligament – an elastic, elongate, corneous structure that unites the two valves dorsally along the hinge plate.

Marsupium – in unionids, a brood pouch for eggs and developing glochidia, formed by a restricted portion of the outer gill, the complete outer gill, or all four gills

Mantle – soft tissue enclosing the body of a mussel, the principal function of which is to secrete the shell. In some species of the Subfamily Lampsilinae, the posterior portion of the female mantle serves to attract host fish by mimicking the shape and movement of fish or crayfish.

Nacre – the interior iridescent, thin layer of a mussel shell.

Naiad – formerly a tribe of Mollusca nearly equivalent taxonomically to the family Unionidae, often used as a synonym of unionid.

Periostracum – exterior or outside layer of the shell.

Posterior – hind or rear

Pseudocardinal teeth – triangular-shaped hinge teeth near the anterior -dorsal margin of the shell

Salvage area – the construction footprint plus an up- and down-stream buffer from which freshwater mussels will be removed prior to construction

Tachytitic – mussels which are short-term breeders; i.e., glochidia are found in the gills of the female only during the summer.

Valve – the right or left half of a mussel (or unionid) shell.

Ventral – the underside or bottom.

## 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 (Figure 1). The proposed roadway is a controlled-access toll road, approximately 27 miles in length.

The purpose of this Biological Assessment (BA) is to evaluate the potential effects of the Complete 540 project on federally listed and proposed species and designated critical habitat in accordance with Section 7 of the Endangered Species Act (ESA) (16 U.S.C. 1536 (c)). Section 7(a)(2) of the ESA (16 USC 1531-1544 and Section 1536) requires that each Federal agency shall, in consultation with the U.S. Fish & Wildlife Service (USFWS), ensure that any action authorized, funded, or carried out by such agency, is not likely to jeopardize the continued existence of an endangered or threatened species, or result in the destruction or adverse modification of critical habitat. Since the proposed project includes both funding by FHWA and approval by the U.S. Army Corps of Engineers (USACE) pursuant to the Clean Water Act (CWA), the project is subject to consultation under Section 7 of the ESA. This BA is provided to satisfy the action agencies’ (FHWA and USACE) obligations under Section 7 of the Endangered Species Act of 1973 (ESA) (See Glossary on Page vi of this report). FHWA is the lead federal agency for NEPA and the ESA.

FHWA and NCDOT is evaluating the project under the National Environmental Policy Act, as amended (42 U.S.C. 4321, et seq.) (NEPA). This BA is primarily based upon information developed for the Complete 540 project, including the Aquatic Species Survey Report (Three Oaks Engineering [Three Oaks] 2017), Dwarf Wedgemussel (DWM) Viability Study (Three Oaks 2016), Qualitative Indirect and Cumulative Effects (ICE) report (H.W. Lochner [Lochner] 2014, planning horizon is 2035), Quantitative ICE report (Michael Baker Engineering [Baker Engineering] 2017a, 2017b, 2017c, 2017d, planning horizon is 2040), Draft Environmental Impact Statement (DEIS) (H.W. Lochner 2015), and analyses detailed in this report (Appendices C, D, and E). Note that the definitions for Indirect Effects and Cumulative Effects differs between NEPA and ESA.

### ***1.1 Statutory Authority of Action***

The proposed project is included in the NCDOT’s *2016-2025 State Transportation Improvement Project* (STIP), project numbers R-2721 (NC 55 to US 401), R-2828 (US 401 to I-40), and R-2829 (I-40 to US/64/US 264 Bypass (I-495)) (Figure 3). NCDOT derives their statutory authority via North Carolina General Statutes (NCGS) 143B-345 and 346 and FHWA derives their statutory authority via 49 US Code (USC) 104.

## ***1.2 Summary of Consultation History***

In a letter dated February 17, 2011, from USFWS to NC Turnpike Authority (NCTA), the USFWS indicated that an updated Environmental Baseline on the DWM (*Alasmidonta heterodon*) population in Swift Creek would be needed to determine if the proposed action could potentially jeopardize the continued existence of this species. The USFWS suggested a three-tiered study to develop the updated baseline. Three Oaks, at the time The Catena Group (Catena), was contracted by (NCTA, through Lochner) to conduct this DWM Viability Study. The two reports produced as part of the study provide accounting of conservation measures implemented in Swift Creek to protect DWM, assess the effectiveness of those conservation measures regarding habitat and population stability, and assess the historic trends and current viability of the DWM population and its habitat in Swift Creek. The population trends of the other freshwater mussel species that occur in Swift Creek were also evaluated, including the Yellow Lance (*Elliptio lanceolata*), a species that has been officially proposed for federal listing and is also addressed in this BA. The DWM Viability Study determined that, while the DWM population in Swift Creek is under significant stress from urbanization in the watershed, declines appear to have leveled off and there is a chance the species could persist into the future if active management plans are implemented (Catena 2014, Three Oaks 2016).

In September 2013, NCDOT published the Draft Alternatives Development and Analysis Report for the Complete 540 project, including a list of recommended Detailed Study Alternatives. NCDOT decided to study all recommended alternatives in detail in the DEIS, which was completed in October 2015. The preferred alternative was selected in April 2016 (Figure 2), and the Final Environmental Impact Statement (FEIS) is anticipated in mid-2018.

A Qualitative ICE study was prepared by Lochner and finalized in December 2014. A Quantitative ICE were prepared for the FEIS. The first two parts of the study (Baker Engineering 2017a, Baker Engineering 2017b) were used to prepare the Memorandum on Water Quality Modeling Methodology and Results (WQ ICI), and Indirect and Cumulative Effects Memorandum (Baker Engineering 2017c, Baker Engineering 2017d).

## **2.0 PROJECT AND ACTION AREA DESCRIPTION**

### ***2.1 Project Description***

The Complete 540 project is proposed to be a controlled-access toll road extending the existing Triangle Expressway from NC 55 Bypass in Apex to the US 64/US 264 Bypass (I-495) in Knightdale, a distance of approximately 27 miles. The project will occupy approximately 1,240 acres within the proposed right of way (ROW). The proposed action will improve mobility, reduce forecast traffic congestion on the existing roadway network, and improve system linkage within the project study area.

## **2.2 Avoidance and Minimization During Alternative Development**

Consideration was given to the location of endangered species throughout the alternatives development and design process, based on the best available information regarding the known locations of the protected species populations. Specific consideration was provided to the DWM. As such, the DEIS states “all [design study alternatives] DSAs except those using the Red Corridor segment (Alternatives 6 and 7) cross Swift Creek below Lake Benson and therefore have the potential to directly affect the DWM. NCDOT is working with USFWS to develop feasible strategies to offset the project’s effects on these species and will complete the Section 7 consultation process following the selection of the Preferred Alternative” (H.W. Lochner 2015). Yellow Lance had not been proposed listed at the time of alternative development.

## **2.3 Description of Action Area**

The Action Area, as defined in 50 CFR 402.02, includes all areas to be affected directly or indirectly by a federal action and not merely the immediate area involved in the action, which for this project includes the land area within the Future Land Use Study Area (FLUSA) as defined in the DEIS, and the proposed freshwater mussel propagation facility (Yates Mill Aquatic Conservation Center) in Wake County, which is being developed as a conservation measure for this project (Section 4.5.2.2). Portions of Wake, Johnston, and Harnett Counties, North Carolina occur within the Action Area (Figure 1). The FLUSA component of the Action Area extends southward into northern Harnett County, and encompasses most of southern Wake County and a large portion of northern Johnston County (H.W. Lochner 2014). The Action Area includes the entire Swift Creek Watershed (SCW) below Lake Benson to allow for evaluation of potential effects on the DWM and Yellow Lance. The Action Area totals approximately 278,000 acres.

## **2.4 Federally Listed Species: Wake, Johnston, and Harnett Counties, NC**

Based on the official USFWS species list by county (dated July 10, 2017 for Wake County, April 6, 2017 for Johnston County, and September 13, 2017 for Harnett County), the USFWS lists seven federally protected and one proposed species as occurring in Wake, Johnston, and/or Harnett Counties (Table 1). There is no designated critical habitat within the Action Area for the species listed in Table 1. However, on August 17, 2017, the National Marine Fisheries Service (NMFS) designated critical habitat for the Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the Neuse River from the confluence with the Pamlico Sound below New Bern, to the base of the Milburnie Dam, just east of Raleigh. The project alignment crosses the Neuse River within this critical habitat unit, and 16 river miles of the unit occurs within the FLUSA portion of the Action Area. This species is currently not on the official USFWS species list for either Johnston, or Wake Counties. The NMFS is the lead consultation agency for this species; thus, the Section 7 consultation with the NMFS will be handled separately from this consultation.

The USFWS is in varying stages of conducting Species Status Assessments (SSAs) on four of the aquatic species in Table 1, the Atlantic Pigtoe, Carolina Madtom, Green Floater, and Neuse River Waterdog, to determine if federal listing as endangered or threatened is warranted. These species are not addressed in this BA; however, Three Oaks has gathered baseline data for these species if they become formally listed during the development stages of this project. Additionally, there are current documented occurrences of Michaux’s Sumac in the Action Area.

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

Scientific Name	Common Name	Status	County	Present in Action Area
<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	E	W, J	Yes
<i>Elliptio lanceolate</i>	Yellow Lance	Proposed	W, J	Yes
<i>Fusconaia masoni</i>	Atlantic Pigtoe	Petitioned	W, J, H	N/A
<i>Haliaeetus leucocephalus</i>	Bald Eagle	BGPA	W, J, H	N/A
<i>Lasmigona subviridis</i>	Green Floater	Petitioned	W, J	N/A
<i>Lysimachia asperulaefolia</i>	Rough-leaved Loosestrife	E	H	No
<i>Necturus lewisi</i>	Neuse River Waterdog	Petitioned	W, J	N/A
<i>Notropis mekistocholas</i>	Cape Fear Shiner	E	H	No*
<i>Noturus furiosus</i>	Carolina Madtom	Petitioned	W, J	N/A
<i>Parvaspina steinstansana</i>	Tar River Spinymussel	E	J	No
<i>Picoides borealis</i>	Red-cockaded Woodpecker	E	W, J, H	No
<i>Rhus michauxii</i>	Michaux’s Sumac	E	W, J	Yes

Notes: BGPA – Bald and Golden Eagle Protection Act, T – Threatened, E – Endangered, W – Wake, J- Johnston, H – Harnett, N/A – Not Applicable at this time; \* No longer present in subwatershed

The official species list for this project was based on potential federally listed species in all of Wake, Johnston, and Harnett Counties. The Action Area for the project is a smaller area than the counties’ limits. Given this, the species on the official species list that are outside the Action Area and do not require ESA Section 7 consultation are noted as N/A. These species are addressed briefly in Section 9.0 with a “No Effect” determination.

The DWM, Yellow Lance, Michaux’s Sumac, and Cape Fear Shiner are known to occur within some portion of the Action Area (Table 1) and the potential project related effects to these species are considered in this BA.

In addition, Table 1 lists four species that were petitioned for listing by the Center for Biological Diversity (CBD 2010). The petitioned species (Atlantic Pigtoe, Carolina Madtom, Green Floater, and Neuse River Waterdog) are also known to occur in watersheds within the Action Area (Table 1). While these species are currently not afforded protection under the ESA, and are thus not subject to Section 7, NCDOT and FHWA recognize that they do occur in the Action Area and may become federally protected during the life of this project, in which case Section 7 Consultation will be reinitiated. Thus, NCDOT has gathered information on these species during the environmental documentation phases of this project in the event they do become listed.

## **2.5 *Habitat Conservation Plans In Action Area***

There have been no Habitat Conservation Plans developed for any listed species within the Action Area.

## **2.6 *Potential Effects of the Action***

Effects of the action refer to the direct and indirect effects on the species and/or critical habitat, together with the effects of other activities that are interrelated or interdependent with the action, that will alter the environmental baseline. Direct effects are caused by the proposed action and generally occur at the same time and place as the project. Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur [50 CFR 402.02]. These types of effects can include natural responses to the proposed action's direct effects, or can include human induced effects associated with the proposed action [50 CFR 402.02].

Interrelated actions are defined as actions that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. Interrelated/Interdependent action areas include project-associated utility relocations, as well as construction borrow pits, haul roads, staging areas, and development patterns induced by the action.

Preliminary roadway designs for the Preferred Alternative are in progress at the time of this BA submittal, therefore, the proposed roadway used for planning purposes consists of a six-travel lane facility with 70-foot median. For areas where existing roads would cross the highway, various existing two and four-lane roads (e.g. Sunset Lake Road and Holly Springs Road) would be widened to be consistent with the adopted Metropolitan Transportation Plan. The areas of construction effects will encompass:

- The Complete 540 roadway footprint, including improvements along crossing roads
- Adjacent areas impacted for permanent fixtures (noise walls, ROW fences, etc.)
- Associated utility relocations (temporary as well as permanent)
- Haul/access roads
- Staging areas
- Borrow sites
- Other ground disturbing activities directly associated with the project.

Cumulative effects are those of future state or private activities, not involving federal activities, which are reasonably certain to occur within the Action Area of the proposed federal action. In addition to highway improvements, other infrastructure projects such as water and sewer service have the potential to stimulate land development and directly or indirectly result in effects within

the Action Area. However, these other types of infrastructure will likely require some type of federal authorization, such as a CWA 404 permit, and would therefore, have their own ESA Section 7 consultation and not be considered a cumulative effect under ESA.

## ***2.7 Conservation Measures***

Conservation measures are those measures that facilitate conservation of the species and offer some level of protection by minimizing, or off-setting, project related effects. Conservation measures are included as part of the Action. These measures are discussed in Section 4.5 of this report.

## ***2.8 Other Consultations in Action Area***

Following are the relevant previous consultations under Section 7 of the ESA with USFWS for projects within the Complete 540 Action Area (as defined in Section 2.3):

- Bridge No. 72 on NC 210 over Swift Creek in Johnston County (TIP B-2647) was replaced in 2015 (Catena 2013). The findings of a Biological Evaluation were transmitted to the USFWS in a letter dated March 20, 2013.
- Bridge No. 147 on SR 1525 (Cornwallis Road) over Swift Creek in Johnston County (TIP B-4561) was replaced in 2013 (Catena 2012a). The findings of a BA were transmitted to the USFWS in a letter dated October 10, 2012.
- Clayton Bypass - the Clayton Bypass was a 10.7-mile highway connecting I-40 in Wake County and US-70 in Johnston County that opened in 2008. As a part of the Section 7 Consultation for this project, the Town of Garner, Wake County, and Johnston County separately entered into Memoranda of Understanding (MOUs) with NCDOT and USFWS. Each MOU was specific to the municipality/county, but they all were aimed at reducing the potential effects of the Clayton Bypass on the DWM. The Town of Garner agreed to limit development adjacent to Swift Creek and other important streams. Wake County and Johnston County also implemented development restrictions. Johnston County also created a Watershed Administrator position to implement watershed ordinances, which was funded by NCDOT. More details about these conservation efforts are in the DWM Viability Report (Three Oaks 2016).
- Dempsey E. Benton Water Treatment Plant (WTP) – The City of Raleigh operates the Dempsey E. Benton WTP, which opened May 12, 2010. Raleigh coordinated with the USFWS on terms and conditions for offsetting effects from the WTP to the DWM. These measures include monitoring outflows from the WTP, limiting maximum base withdrawal rate and frequency of the maximum withdrawal rate, water quality monitoring, managing Lake Benson Dam to prevent reductions in downstream flows, decommissioning two small wastewater treatment facilities, and purchasing greenway

corridors surrounding Lake Benson. More details about these conservation efforts are in the DWM Viability Report (Three Oaks 2016).

### **3.0 ENVIRONMENTAL BASELINE FOR DWM AND YELLOW LANCE**

As noted in Section 2.4, the DWM and Yellow Lance are known to occur within a portion of the Action Area, specifically Swift Creek Watershed below Lake Benson and Middle Creek Watershed (outlined in Figure 3) and have the potential to be affected by the proposed action. The area within these watersheds (88,300 acres) is approximately 32 percent of the FLUSA portion of the Action Area. Due to the similarity in threats and location of the two species, DWM and Yellow Lance are analyzed collectively in this section.

#### ***3.1 Watershed Conditions Baseline***

DWM and Yellow Lance are known to occur within two subbasins of the Upper Neuse River Basin, Middle Creek and Swift Creek, within the Action Area. The current, physical and chemical conditions of these watersheds are a primary factor that influence the population status of the respective species. The Upper Neuse River Basin (US Geological Survey hydrologic unit 03020201) covers an area of approximately 540,000 acres in Person, Orange, Durham, Granville, Franklin, Wake, Johnston, Wilson and Wayne Counties. The Upper Neuse River drains all of Raleigh, Hillsborough, Wake Forest, Garner, and portions of Durham, Cary, and many other municipalities. The headwaters of the Neuse River are the Eno, Flat, and Little Rivers in Person and Orange Counties, which flow southeast into Falls Lake in Durham and Granville Counties, a manmade reservoir covering more than 12,000 acres. Following in the southeasterly flow, the next major tributaries to the Neuse River are Crabtree Creek and Walnut Creek in Wake County and Swift Creek, Middle Creek, Black Creek, and Mill Creek in Johnston County. The Little River flows into the Neuse River in Wayne County. Downstream, the Neuse River flows through the Middle Neuse River Basin and continues toward Albemarle Pamlico Sound and the Atlantic Ocean. Baseline conditions of the Middle Creek and Swift Creek subbasins are discussed below.

##### ***3.1.1 Best Usage Classification***

The North Carolina Department of Environmental Quality (NCDEQ) assigns a best usage classification to all waters of North Carolina. These classifications, which are the responsibility of the Division of Water Resources (NCDWR), provide a level of water quality protection to ensure that the designated usage of that water body is maintained. The minimum designation of Class C waters is defined as waters that are suitable for aquatic life propagation and survival, fishing, wildlife, secondary recreation and agriculture. Class C imposes a minimum standard of protection for all waters of North Carolina; they are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture, and other uses suitable for

Class C. Class B waters provide the same protection as Class C waters, plus primary recreation. Primary recreation is the use of waters for swimming or other activities involving contact with the water. Water Supply (WS) waters are protected for Class C uses and additionally are used as a source of drinking water or other uses of consumption. WS classifications are further categorized with a suffix of -I to -V, with -I being in undeveloped areas in public ownership and having a High Quality Waters supplemental classification and -V having the least amount of protection and often used by industry. A classification of WS-III, which is found in streams within the Action Area, have fewer restrictions than WS-I and WS-II streams and are found in low to moderately developed areas. Nutrient Sensitive Waters (NSW) is a supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growth of microscopic or macroscopic vegetation. The entire Neuse River Basin is classified as NSW.

Table 2 lists the named streams in the Action Area within either the Middle Creek or Swift Creek subbasins and their Usage Classification and NCDWR Index number (#). Unnamed tributaries carry the classification of the receiving water body. Figure 3 shows the streams in the FLUSA.

### 3.1.2 Impaired 303(d) Listing

As mandated in Section 303(d) of the CWA by the US Environmental Protection Agency (EPA), states, territories, and authorized tribes are required to develop lists of impaired waters, which are defined as water bodies that do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. These water quality standards include designated uses, numeric and narrative criteria, and anti-degradation requirements as defined in 40 CFR 131. Failures to meet standards may be due to an individual pollutant, multiple pollutants, or unknown causes of impairment, originating from point and non-point sources and/or atmospheric deposition. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop Total Maximum Daily Load (TMDLs) limits of identified pollutants for these waters.

**Table 2. Action Area Streams within Middle and Swift Creek Subbasins**

Stream Name	Usage Classification	DWR Index #
<b>Middle Creek (HUC# 0302020109)</b>		
Basal Creek [(Bass Lake) (Mills Pond)]	B; NSW	27-43-15-3
Beaverdam Branch	C; NSW	27-43-15-13
Bells Lake	C; NSW	27-43-15-6
Buffalo Branch	C; NSW	27-43-15-11
Camp Branch	C; NSW	27-43-15-5
Cow Branch	C; NSW	27-43-15-14
Ditch Branch	C; NSW	27-43-15-10-2-1
Guffy Branch	C; NSW	27-43-15-10-2
Juniper Creek	C; NSW	27-43-15-10-1
Little Creek	C; NSW	27-43-15-10

**Table 2. Action Area Streams within Middle and Swift Creek Subbasins (continued)**

Stream Name	Usage Classification	DWR Index #
Middle Creek	C; NSW	27-43-15-(1)
Middle Creek (Sunset Lake)	B; NSW	27-43-15-(2)
Middle Creek	C; NSW	27-43-15-(4)
Mill Branch	C; NSW	27-43-15-12
Mills Branch	C; NSW	27-43-15-7
Rocky Branch	C; NSW	27-43-15-4.5
Shop Branch	C; NSW	27-43-15-15
Steep Hill Branch	C; NSW	27-43-15-16
Terrible Creek	C; NSW	27-43-15-8-(2)
Terrible Creek (Johnsons Pond)	B; NSW	27-43-15-8-(1)
<b>Swift Creek (HUC# 0302020110)</b>		
Buck Branch	WS-III; NSW	27-43-6-(1)
Cooper Branch	C; NSW	27-43-13
Dutchmans Creek	WS-III; NSW	27-43-4.5
Little Creek	C; NSW	27-43-12
Long Branch	WS-III; NSW	27-43-2.8
Lynn Branch [(Meadows Creek) (Lochmere Lake)]	WS-III; NSW	27-43-3
Macgregor Downs Lake	WS-III; NSW	27-43-2.2
Mahlers Creek	C; NSW	27-43-9
Neal Branch	C; NSW	27-43-10
Reedy Branch	WS-III; NSW	27-43-7-(1)
Reedy Branch (Little Branch)	C; NSW	27-43-14
Regency Park Lake	WS-III; NSW	27-43-2.5
Speight Branch	WS-III; NSW	27-43-3.5
Swift Creek (Lake Wheeler)	WS-III; NSW	27-43-(1)
Swift Creek (Lake Benson)	WS-III; NSW; CA	27-43-(5.5)
Swift Creek	C; NSW	27-43-(8)
Unnamed Tributary (UT) to Swift Creek (Yates Mill Pond)	WS-III; NSW	27-43-5-(1.5)
White Oak Creek (Austin Pond)	C; NSW	27-43-11
Woodys Lake	WS-III; NSW	27-43-4

The 303(d) Category 5 streams, which require a TMDL or TMDL alternative, in the Middle Creek and Swift Creek subbasins are listed in Table 3 along with details of the impairments. They are also shown in Figure 4. As of the writing of this report, the 2016 303(d) list has not been finalized, though a draft was submitted to the EPA. The draft 2016 303(d) list (NCDEQ 2017a), submitted by NCDEQ, did not propose changes to the streams listed below.

**Table 3. Impaired (Category 5) Streams 2014 in Middle and Swift Creek Subbasins**

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/Biological Integrity (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)

**Table 3. Impaired (Category 5) Streams 2014 in Middle and Swift Creek Subbasins (continued)**

Stream	AU Number	Length/Area	Reason for Rating	Parameter (Year)
<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	0.87 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)

Notes: FW – Freshwater Miles

### 3.1.3 Point Source Pollution

Point source discharge is defined as discharge that enters surface waters through a pipe, ditch, or other well-defined point of discharge. This includes municipal (city and county) and industrial wastewater treatment facilities, small domestic discharging treatment systems (schools, commercial offices, subdivisions and individual residents), and stormwater systems from large urban areas and industrial sites. The primary substances and compounds associated with point source discharge include nutrients, oxygen demanding wastes, and toxic substances such as chlorine, ammonia, and metals.

Under Section 301 of the CWA, discharge of pollutants into surface waters is prohibited without a permit by the EPA. Section 402 of the CWA establishes the National Pollutant Discharge Elimination System (NPDES) permitting program, which delegates permitting authority to qualifying states. In North Carolina, NCDWR is responsible for permitting and enforcement of the NPDES program. Point source dischargers located throughout North Carolina are permitted through the NPDES program. All dischargers are required to register for a permit. NPDES dischargers are divided into two categories: individual and general. General permits are issued for specific activities, including non-contact cooling water discharges, petroleum-based groundwater remediation, sand dredging, seafood packaging, and domestic discharges from single family residences. Individual permits are issued on a case-by-case basis for activities not covered under general permits. Individual permits are divided into two classes: major and minor. Major discharges are permitted to discharge one million gallons per day (MGD) or greater. Minor discharges are permitted to discharge less than 1 MGD.

The NPDES Permitting Policy includes limits on various parameters, including, but not limited to chlorine (since October 2002), ammonia, fecal coliform, biological oxygen demand (BOD), dissolved oxygen (DO), flow, and temperature, for the existing facilities.

The FLUSA has 28 NPDES individual permitted discharges and 53 NPDES general permitted discharges (Figure 5). There are 15 individual permitted discharges and 13 general permitted discharges in the Middle Creek subbasin (Tables 4 and 5). There are 5 individual permitted discharges and 19 general permitted discharges in Swift Creek subbasin (Tables 4 and 5). 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 2017b). Included in Table 5 are NPDES general permitted discharges.

**Table 4. NPDES Individual Permitted Discharges within Middle and Swift Creek Subbasins**

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	Little Creek	2,500,000	Town of Clayton

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

**Table 5. NPDES General Permitted Discharges within Middle and Swift Creek Subbasins**

<b>Middle Creek (HUC# 0302020109)</b>		<b>Swift Creek (HUC# 0302020110)</b>	
<b>Permit</b>	<b>Facility</b>	<b>Permit</b>	<b>Facility</b>
NCG070111	Johnson Concrete Co	NCG070072	Oldcastle Precast Inc
NCG110047	Town of Apex	NCG500360	Oldcastle Precast Inc
NCG070014	Potters Industries LLC	NCG551548	601 Maple Lane
NCG050092	Lufkin Division of Cooper Ind	NCG551532	815 Colonial Drive
NCG030281	Tipper Tie Inc	NCG130026	Safety - Kleen Corporation
NCG080166	Colonial Pipeline	NCS000420	Town of Garner MS4
NCG110117	Town of Cary South WWTP	NCG080688	Wade H Vester Public Works
NCG551522	9624 Fayetteville Rd	NCG140074	Ready Mixed Concrete Co
NCG140010	S.T. Wooten Corp	NCG210346	Pergo Inc
NCG070075	NC Products	NCG030111	Morris & Associates
NCG160036	Gelder & Associates Inc	NCG060235	Domino's Pizza
NCG510527	Don Lees Gas	NCG551048	Dockside Dolls Night Club
NCG140073	Southern Equipment Concrete	NCG100095	Raleigh Auto Parts Inc
<b>Swift Creek (HUC# 0302020110)</b>		NCD000024	White Oak Landing Phase III
NCG200446	Wise One Clayton Plant	NCG110080	Little Creek Water Reclamation
NCG150055	Johnston County Airport	NCG200498	Source Recycling of Raleigh
NCG160050	S.T. Wooten Corp Drug Store		

### 3.1.4 Non-point Source Pollution

Non-point source (NPS) pollution refers to runoff that enters surface waters through stormwater or snowmelt. There are many types of land use activities that contribute to NPS pollution, including land development, construction activity, animal waste disposal, mining, agriculture, and forestry operations, as well as impervious surfaces such as roadways and parking lots. Various NPS management programs have been developed by several agencies to control specific types of NPS pollution (e.g. pesticide, urban, and construction related pollution). Each of these management plans develops Best Management Practices (BMPs) to control for a specific type of NPS pollution. For example, financial incentives to reduce agricultural NPS pollution are provided through North Carolina's Agriculture Cost Share Program, administered by the North Carolina Department of Agriculture and Consumer Service's Division of Soil and Water Conservation to protect water quality by installing BMPs on agricultural lands.

Land cover for the Neuse River subbasin portion of the FLUSA is shown in Table 6 (Figure 6) (Homer et al. 2015). Deciduous forest makes up the greatest percent of land cover in this portion of the FLUSA, followed closely by developed open space (such as lawns, parks, and golf courses). The effects of non-point pollution on aquatic species associated with human development and associated impervious surface area are discussed in Section 3.5.4.

**Table 6. Land cover in the Neuse River subbasins of the FLUSA**

<b>Land Cover</b>	<b>Sum of Area (Acres)</b>	<b>Percent</b>
Barren Land	1255.6	0.53
Cultivated Crops	22641.8	9.59
Deciduous Forest	42349.6	17.94
Developed, High Intensity	1296.8	0.55
Developed, Low Intensity	16301.3	6.91
Developed, Medium Intensity	5671.2	2.40
Developed, Open Space	38613.3	16.36
Emergent Herbaceous Wetlands	840.8	0.36
Evergreen Forest	25698.5	10.89
Hay/Pasture	25471.4	10.79
Herbaceous	19795.4	8.39
Mixed Forest	12858.4	5.45
Open Water	2830.4	1.20
Shrub/Scrub	5680.6	2.41
Woody Wetlands	14751.6	6.25
<b>Total</b>	<b>236056.7</b>	<b>100.00</b>

Note: While the same National Land Cover Data raw data was used in the Memorandum on Land Use Scenario – Methodology and Results (Quantitative ICE Assessment Memo #2), the Memorandum further modified the data as required for use in various models. Therefore, this data in Table 6 and ICE Memo #2 Table 4 does not exactly match.

### 3.1.5 Ecological Significance

The North Carolina Natural Heritage Program (NCNHP) maintains a database of rare plant and animal species, as well as significant natural areas, for the state. The NCNHP compiles the North Carolina Department of Natural and Cultural Resources priority list of “Natural Heritage Areas” as required by the Nature Preserves Act (NCGS 113A-164 of Article 9). Natural areas (sites) are inventoried and evaluated on the basis of rare plant and animal species, rare or high quality natural communities, and geologic features occurring in the particular site. NCNHP has revised its process for establishing conservation priorities (NCDENR 2015) for the more than 2,400 Natural Heritage Natural Areas (NHNA) that have been identified through field investigations. Each NHNA receives two significance ratings, which measure different values and assign a rating from 1 (exceptional) to 5 (general):

1. Element Collective Value rates each NHNA based on the number and rarity of all the elements it contains.
2. Element Representational Value rates each NHNA on its importance in protecting the best occurrences of individual elements.

The following sites are natural areas within the Swift and Middle Creek subbasins of the FLUSA (Figure 7, Table 7).

**Table 7. Natural Heritage Natural Areas in the Neuse River subbasins of the FLUSA (NCNHP 2017)**

Natural Heritage Natural Area	Representational Value	Collective Value
Neuse/Swift Creek Aquatic Habitat	N/A	C3 (High)
Yates Mill Pond	R1 (Exceptional)	C4 (Moderate)
Swift Creek Bluffs	R4 (Moderate)	C5 (General)
Swift Creek Magnolia Slopes	R5 (General)	C5 (General)
Hemlock Bluffs State Natural Area	R4 (Moderate)	C4 (Moderate)
Reedy Branch Floodplain	R3 (High)	C5 (General)
Middle Creek Bluffs and Floodplain	R2 (Very High)	C4 (Moderate)
Blue Pond Salamander Site	R5 (General)	C5 (General)
Middle Creek – Barber Bridge Floodplain	R5 (General)	C4 (Moderate)
Middle Creek Floodplain Knolls	R5 (General)	C5 (General)
Middle Creek Amphibolite Slope	R5 (General)	C5 (General)
Neuse/Middle Creek Aquatic Habitat	N/A	C3 (High)

In addition to DWM and Yellow Lance, the Swift and Middle Creek subbasins also support many other rare aquatic species. They are listed in Table 8, along with their state and federal status. Additionally, the aquatic habitats of Swift Creek and Middle Creek are considered to have a “High” Collective Value Rating. This rating sums the number of elements in a natural area, and the rarity of those elements, weighted by their degree of imperilment at both the global level (G-Rank) and state level (S-Rank). The imperilment scores are assigned to each extant element occurrence on a 10-point scale, based on their combination of G-Ranks and S-Ranks. The highest scores are given to elements that are considered imperiled at both the global (G1) and state (S1) levels with successively smaller scores given to elements that are considered more secure (G5S5) at both the global and state levels (NCDENR 2015).

**Table 8. Non- Federally Protected Rare Aquatic Species in Swift and Middle Creek Subbasins**

Scientific Name	Common Name	NC Status	Federal Status	Species Type
<i>Alasmidonta undulata</i>	Triangle Floater	T	~	Mussel
<i>Cambarus davidi</i>	Carolina Ladle Crayfish	SR	~	Crustacean
<i>Elliptio fisheriana</i>	Northern Lance	SR	~	Mussel
<i>Elliptio marsupiobesa</i>	Cape Fear Spike	SC	~	Mussel
<i>Elliptio roanokensis</i>	Roanoke Slabshell	T	~	Mussel
<i>Fusconaia masoni</i>	Atlantic Pigtoe	E	FSC, Petitioned	Mussel
<i>Lampetra aepyptera</i>	Least Brook Lamprey	T	~	Fish
<i>Lampsilis radiata</i>	Eastern Lampmussel	T	~	Mussel
<i>Lasmigona subviridis</i>	Green Floater	E	FSC, Petitioned	Mussel
<i>Necturus lewisi</i>	Neuse River Waterdog	SC	FSC, Petitioned	Amphibian
<i>Notropis volucellus</i>	Mimic Shiner	SR	~	Fish
<i>Noturus furiosus</i>	Carolina Madtom	T	FSC, Petitioned	Fish
<i>Orconectes carolinensis</i>	North Carolina Spiny Crayfish	SC	~	Crustacean
<i>Strophitus undulates</i>	Creeper	T	~	Mussel
<i>Villosa constricta</i>	Notched Rainbow	SC	~	Mussel

Notes: E = Endangered, T = Threatened, FSC = Federal Species of Concern, SR = Significantly Rare, SC = Special Concern, Petitioned = Species petitioned by Center for Biological Diversity (CBD) for listing, ~ = no rating (NCNHP 2017)

### 3.2 Dwarf Wedgemussel (*Alasmidonta heterodon*) Species Baseline

Status: Endangered

Family: Unionidae

Listing: March 14, 1990

Critical Habitat: Critical Habitat has not been designated for DWM, however the CBD petitioned the USFWS in 2015 to do so (CBD 2015).

#### 3.2.1 Species Characteristics



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. DWM is generally small, with a shell length ranging between 25 mm and 38 mm. The largest specimen reported by Clarke (1981) was 56.5 mm long, taken from the Ashuelot River in New Hampshire. The periostracum is generally olive green to dark and 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. This species is considered to be a long-term brooder, with gravid females reportedly observed in the fall months. Like other freshwater mussels, this species' eggs are fertilized in the female as sperm are taken in through their siphons as they respire. The eggs develop within the female's gills into larvae (glochidia). The females later release the glochidia, which then attaches to the gills or fins of a specific host fish species. Based on anecdotal evidence, such as dates when gravid females are present or absent, it appears that release of glochidia occurs primarily in April in North Carolina (Michaelson and Neves 1995). Research has confirmed at least three potential fish host species for DWM to be the Tessellated darter (*Etheostoma olmstedi*), Johnny Darter (*E. nigrum*), and

Mottled Sculpin (*Cottus bairdii*) (Michaelson 1993). A more recent study determined that the Fantail Darter (*Etheostoma flabellare*) could also be a host for DWM in North Carolina (Levine et al. 2009). McMahon and Bogan (2001) and Pennak (1989) should be consulted for a general overview of freshwater mussel reproductive biology.

The feeding processes of freshwater mussels are specialized for the removal (filtering) of suspended microscopic food particles from the water column (Pennak 1989). Documented food sources for freshwater mussels include detritus, diatoms, phytoplankton, and zooplankton (USFWS 1996).

### 3.2.2 *Distribution and Habitat Requirements*

The historic range of DWM was confined to Atlantic slope drainages from the Peticodiac River in New Brunswick, Canada, south to the Neuse River, North Carolina. Occurrence records exist from at least 70 locations, encompassing 15 major drainages in 11 states and 1 Canadian Province (USFWS 1993a). When the recovery plan for this species was written, DWM was believed to have been extirpated from all but 36 localities, 14 of them in North Carolina (USFWS 1993a). 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 were 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, it is believed to have been extirpated from the main-stem of the Neuse River.

The most recent assessment (2013 5-Year Review) indicates that DWM is currently found in 16 major drainages, comprising approximately 75 “sites” (one site may have multiple occurrences) (USFWS 2013). At least 45 of these sites are based on less than five individuals or solely on relict shells. It appears that many of 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 the floods of 2005 are still being studied. Table 9 updates population status from Strayer et al. (1996) with data included in the 2013 5-Year Review (USFWS 2013), North Carolina Wildlife Resource Commission (NCWRC) data (NCWRC Unpublished Aquatics Species Database), Smith et al. (2015), and the DWM Viability Study (Three Oaks 2016).

The population in the Upper Tar River is not a large or dense population, but it is believed to be viable due to recent recruitment, the regular occurrence of individuals, and the connectivity to other occupied tributaries (USFWS 2013), and is considered the strongest population in North Carolina (Smith et al. 2015). DWM has been found in Cub Creek as recently as July 2015 and in

Shelton Creek as recently as July 2014. DWM was found in the main-stem of the Tar River in Granville County in July 2013 and August 2012. Also within the Tar River Basin, Fishing Creek supports a viable population of DWM, with evidence of recruitment, and connectivity of several tributaries that are known to contain DWM, including Shocco Creek, Rocky Swamp, and Maple Branch. In Shocco Creek, DWM has been found consistently in recent years, with a total of 18 live and two shells found between 2009 and 2014. One live individual and over 40 live individuals were found in Shocco Creek and Little Shocco Creek, respectively, in 2017 (Neil Medlin, RK&K, and Tyler Black, WRC, personal communication). DWM has been observed steadily in Maple Branch since 1997, with 3 live individuals observed in 2013, and one shell observed as recently as January 2014 (NCWRC Unpublished Aquatics Species Database).

There are several streams within the Neuse River Basin where DWM have been found; however, Swift Creek is the only one where recent records ( $\leq 10$  years) have been reported (Figure 8). It was found in Buffalo Creek in Johnston County in 1998 (one live, two shells), the Eno River in Orange County in 1995 (one valve), the Little River in Wake and Johnston Counties, beginning in 1989 and most recently in 2004 (five live, and two shells), Moccasin Creek in Johnston and Nash Counties, beginning in 1991 and most recently in 2004 (five live, three shells), and in Turkey Creek in Wilson and Nash Counties, beginning in 1991 and last seen in 1996 (total of 19 live, and 25 shells). It has not been found in any of these water bodies in subsequent survey efforts (NCWRC Unpublished Aquatics Species Database). The documented occurrences of DWM in Swift Creek are discussed in detail in the two-phase DWM Viability Study (Three Oaks 2016), which examined the environmental baseline of the Swift Creek DWM population by characterizing watershed conditions, summarizing conservation measures meant to protect DWM, and assessing historic trends and future viability of the DWM population and habitat conditions. The baseline status of the DWM in the Action Area is summarized in Section 3.4.

**Table 9. DWM Population Densities at Study Streams 1996 and Follow-up Survey Data\***

Stream	Number of study reaches	Density Index (no/m <sup>2</sup> ) 1996 (Strayer et al. 1996)	Post 1996 catch-per-unit-efforts and presence/absence
Connecticut River, NH/VT	9	0.03 (0.1-0.05)	Present. Additional populations found, some of which may exceed densities found in 1996. Farmington River population has been extirpated.
Ashuelot River, NH	7	0.04 (0.02-0.06)	Present. Density estimates of two locations sampled in 2004 and 2006 range from 0.31 to 1.257 (Nedeau 2006). Sample sites overlapped Strayer et al. (1996) sites. Additional subpopulation found downriver of surveyed area
Neversink River, NY	6	0.04 (0.02-0.06)	Present. Populations affected by 2005 floods. Status uncertain.
McIntosh Run, MD	5	0.03 (0.01-0.05)	Present. No change.
Aquia Creek, VA	8	0.007 (0.003-0.01)	No live individuals since 2003. Population believed to be in decline
Po River, VA	3	0.01 (0.003-0.03)	Present in very low numbers
Tar River/Shelton Creek, NC	5	0.03 (0.01-0.05)	Present. Most viable population in NC.
Crooked Creek, NC	2	0	Present? 1 shell found in 2000 survey, status unknown
Little River, NC	3	0.03 (0-0.06)	Absent. 0 found in 2004, or since.
Swift Creek, NC	2	0	Present. 3 individuals found in 2002, and 30 since 2002.
Turkey Creek, NC	3	0	Absent. 0 found in 2005.
Moccasin Creek, NC	3	0	Present? Population viability unknown, presence based only on relict shells.

Notes: \* - The survey methods are not comparable; this table merely indicates whether a perceived change in the populations has been observed since the 1994 intensive surveys were undertaken.

DWM inhabits creeks and rivers of varying sizes (down to approximately two meters [6 ft] 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 1993a). In North Carolina, DWM often occurs within submerged root mats along stable streambanks (USFWS 2007a). Two general in-stream habitat types, Shallow Fast Coarse (SFC) or Deep Stream Margin Roots (DSMR) habitats were identified as primarily supporting this species in Swift Creek (Entrix 2005). The wide range of substrate types used by this species suggests that the stability of the substrate is likely as important as the composition.

### 3.3 *Yellow Lance (Elliptio lanceolata) Species Baseline*

Status: Proposed Threatened

Family: Unionidae

Proposed for Listing: April 5, 2017

Critical Habitat: To be identified at time of formal listing

Supporting documents mentioned in Section 1.0 and included in Appendix D consider effects to the DWM only because at the time of their development Yellow Lance was not listed. Yellow Lance was subsequently listed as proposed on April 5, 2017, occurs within the FLUSA, and is vulnerable to the same threats as DWM. Therefore, discussions regarding DWM in these cited documents would pertain to Yellow Lance.

### 3.3.1 *Species Characteristics*

The Yellow Lance was described from the Tar River at Tarboro, NC, 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 Lance 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, and 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. Based on the pelagic, “net-like” glochidia the fish host species is speculated to be some type of minnow (USFWS 2017a). White Shiner and Pinewoods Shiner (*Lythrurus matuntinus*) were the most effective fish hosts for Yellow Lance in laboratory studies (Eads and Levine 2009).

### 3.3.2 *Distribution and Habitat Requirements*

The reported range of the Yellow Lance has changed several times over the years due to taxonomic uncertainty with regard to “true” Yellow Lance, and other “lanceolate Elliptio” species. The Yellow Lance is currently thought to be distributed in Atlantic Slope river basins from the Neuse River Basin in North Carolina north to the Rappahannock River in Virginia, with the exception of the Roanoke River Basin, as well as the Patuxent River Basin in Maryland and possibly the Potomac River Basin in Virginia and Maryland (USFWS 2017a). It is in

considerable decline throughout its range; however, extant populations still occur in all historic river basins, except possibly the Potomac (USFWS 2017a). This species has been found in multiple physiographic provinces, from the foothills of the Appalachian Mountains, through the Piedmont and into the Coastal Plain, in small streams to large rivers, in substrates primarily consisting of clean sand, and occasionally gravel, with a high DO content (USFWS 2017a, Adams et al 1990). Alderman (2003) stated that no remaining populations appear below point source pollution or other nutrient-rich areas. Associate mussel species include Atlantic Pigtoe, Tar River Spiny mussel, 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, Figure 9).

Yellow Lance has been found in four management units (MUs) within the Tar River basin – Upper/Middle Tar River, Lower Tar River, Sandy-Swift Creek, and Fish Creek. First located in the Tar River in 1966, Yellow Lance has been recorded as recently as 2016 in the Sandy-Swift Creek MU. In the 1980 and 1990s, hundreds of individuals were often located during surveys, whereas surveys in 2015 and 2016 located only a few dozen individuals.

There is one MU in the Neuse River basin in which the first Yellow Lance was found in 1991. The most Yellow Lance recorded during a survey occurred in Swift Creek in 1994 when 18 individuals were located. Intensive surveys of Swift Creek between 2014 and 2016 have located only one individual. Population trends in each of the river basins currently or historically supporting this species were provided in detail in the SSA prepared as part of the listing package for this species (USFWS 2017a). The baseline status of the Yellow Lance in the Action Area is summarized in Section 3.4.

### **3.4 Summary of DWM and Yellow Lance within Action Area**

The Action Area (FLUSA) encompasses streams in the Neuse River Basin, including Neuse River, Swift Creek, Middle Creek, and tributaries to these streams as depicted in Figure 3. As DWM and Yellow Lance are known to occur in creeks and rivers of varying sizes (down to approximately 2 meters [6 ft] wide), perennial streams within the Action Area were evaluated for presence of these species. Existing mussel survey data within the Action Area were reviewed. Data sources consulted included the NCWRC Unpublished Aquatic Species Database, which was reviewed in November 2016, the NCNHP database (NCNHP 2017), reviewed in May 2017, Johnson (1970), and surveys conducted by Catena/Three Oaks. The 65 perennial streams crossed by the preferred alternative were evaluated for the presence of the DWM and Yellow Lance in 2010, 2011, 2012, 2015, 2016, and 2017. DWM was found in Swift Creek in 2010, 2011, 2012, 2015, and 2016 (Catena 2011, 2012b, 2012c, 2014 and Three Oaks 2016, respectively). Yellow lance was found in Lower Middle Creek in 2012, and in Swift Creek in

2010, 2011, 2012, and 2015 (Catena 2011, 2012b, 2012c, 2014 and Three Oaks 2016, respectively).

Additionally, perennial streams within the Action Area that do not directly cross the alignment were also surveyed for freshwater mussels. Neither the DWM nor the Yellow Lance was found in streams other than Swift Creek and Lower Middle Creek. The results of these surveys were provided in a report submitted to NCDOT in May 2017 (Three Oaks 2017).

The results of these evaluations indicate the DWM and Yellow Lance currently occupy portions of Swift Creek and the Yellow Lance currently occupies portions of Lower Middle Creek within the Action Area.

### *3.4.1 Distributions in Swift Creek*

The DWM was first discovered in Swift Creek in 1991 (Alderman 1991). Between 1991 and 2016, a total of 54 live individuals and 12 relict shells have been found at 34 distinct sites over 21 stream miles, including six live individuals in 2016 (Three Oaks 2016, NCWRC Unpublished Aquatics Species Database). The lower 10 miles, however, are represented by only one individual, and the species has not been found in this 10-mile section since 1991. Additionally, two individuals have been recorded in Little Creek and one in White Oak Creek; both streams are tributaries to Swift Creek. A table listing all DWM records from the Swift/Middle Creek Watershed, including year and specific locations, is included in Appendix B. The distribution of DWM Element Occurrences (EO), as described by NCNHP, is shown in Figure 8.

The DWM Viability Study (Three Oaks 2016) provides further details on the history of mussel surveys and mussel fauna population trends in Swift Creek. The results of this study showed that there are several stressors to aquatic communities in the Swift Creek subbasin, directly and indirectly related to urbanization of the watershed. While mussel populations have declined since urbanization began, the decline appears to have leveled off, and there is some indication that mussel recruitment has increased within the past few years. So, while long-term viability is threatened, with active management and increased habitat protection, there is a chance of persistence into the future. Management recommendations that would help maintain a sustainable DWM population include in-stream habitat monitoring, population augmentation using captive propagation techniques, continued targeted water quality monitoring, and establishing a DWM focused stakeholder group in the lower SCW below Lake Benson. These management actions would also apply to the Yellow Lance population.

The Yellow Lance was first recorded in Swift Creek in 1991 (Three Oaks 2016, NCWRC Unpublished Aquatics Species Database). Population trend analysis performed for the Swift Creek DWM Viability Study demonstrates that the Yellow Lance was much more common in Swift Creek during the 1992-1996 period than in later years, and it has become extremely rare in

the stream since that time (Three Oaks 2016). The species was last identified in Swift Creek in late 2015, and was not detected during 2016 and early 2017 surveys (Tim Savidge, personal communication).

### *3.4.2 Distributions in Middle Creek*

Two DWM individuals were found in Middle Creek in 1992. Subsequent surveys, including extensive survey efforts undertaken for this project in 2010, 2011, 2012 and 2016, did not detect any live individuals; however, one relict shell was found in 2016 in the lower portion of Middle Creek below the Crantock Road crossing (Tim Savidge, Three Oaks, personal observations). This shell was found along with relict shells of other rare mussel species, including Yellow Lance, Atlantic Pigtoe and Notched Rainbow, all of which have become either extremely rare, or are no longer extant in Middle Creek. The shells were found within an area of the stream that had been recently exposed by an eroded bank, suggesting the shells may have been buried in sediments for many years (Tim Savidge, personal observations). The general consensus is that the DWM has been extirpated from Middle Creek (NC Scientific Council on Mollusks 2011).

The Yellow Lance was first reported from Middle Creek in 1992, and has been reported from three distinct locations in Lower Middle Creek (USFWS 2017a). As in Swift Creek, the Yellow Lance has become increasingly rare in Middle Creek, with the last observation of a live individual being 2012. Live individuals were not found during extensive surveys in 2016; however, as mentioned above, two relict shells were found. It appears that the shells had been recently exposed by an eroded bank, suggesting the shells may have been buried in sediments for many years (Tim Savidge, Three Oaks, personal observations).

### *3.5 General Threats to DWM and Yellow Lance*

The aggregate effects of several factors, including sedimentation, point and non-point discharge, and stream modifications (e.g., impoundments, channelization) have contributed to the decline of the DWM throughout its range. With the exception of the Neversink River population in New York, which had an estimated population of over 80,000 DWM individuals (Strayer et al. 1996), all of the 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 extirpations 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. Based on expert opinion of a North Carolina DWM (NC DWM) Work Group assembled by the USFWS Raleigh field office in 2012, the “Allee effect”, defined as a high risk of demographic extirpation due to low population abundance and lack of dispersal, was identified as the second highest threat behind “unsuitable

physical habitat” to the Swift Creek DWM population (Smith et al. 2014). These threats are likely having a similar impact on the Yellow Lance population in Swift and Middle Creeks.

### *3.5.1 Sedimentation*

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 (USFWS 1996). 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 25 mm (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).

### *3.5.2 Habitat Alteration*

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. 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 5.79 meters (19 feet) of muck (USFWS 1992b). Large portions of all river basins within the DWM range have been impounded. This is believed to be a major factor contributing to the decline of the species (Master 1986; USFWS 1993a).

### *3.5.3 Toxic Contaminants*

Pollution in waterways is known to adversely affect aquatic organisms in a variety of ways. Choudri and Baawain (2016) summarize the adverse impacts to aquatic organisms from multiple types of pollutants. With regard to freshwater mussels, the presence of toxic contaminants has been shown to contribute to widespread declines of populations (Havlik and Marking 1987; Bogan 1993; Neves et al. 1997; Richter et al. 1997; Strayer et al. 2004; Henley et al. 2016). Toxic contaminants can produce lethal or sub-lethal responses to freshwater mussels. The NC DWM Work Group identified “low water quality due to contaminants” as the third most important threat to the Swift Creek population (Smith et al. 2014). The sensitivities of freshwater mussels to toxic contaminants is variable based on species, life stage (glochidium, juvenile, or adult), and environmental conditions, as well as concentration and exposure type (water column, sediments, etc.), frequency, and duration. Several studies have indicated that early life stages of freshwater mussels are among the most sensitive aquatic organisms to various inorganic toxicants such as copper (Jacobson et al. 1993; Jacobson et al. 1997; Milam et al.

2005; Wang et al. 2007a; Wang et al. 2007b), manganese and ammonia (NH<sub>3</sub>) (Archambault et al. 2017, Wade 1992; Augspurger et al. 2003; Bartsch et al. 2003; Newton et al. 2003; Wang et al. 2007a; Wang et al. 2007b; Grabarkiewicz and Davis 2008).

Anthropogenic sources of ammonia and copper in surface waters include sewage treatment effluent, industrial wastewater effluent, and runoff and ground water contamination from agriculture, lawn/turf management, livestock operations, roadways, and faulty septic systems. 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 might not occur for up to two miles below discharges of chlorinated sewage effluent. Similarly, Gillis et al. (2014) found that mussels were absent for 7 km (4.3 miles) below a WWTP on the Grand River in Ontario, Canada. Water quality measurements taken as part of this study demonstrated that ammonia and nitrate concentrations, along with diel declines in oxygen, were associated with the extirpation of mussels in that 4.3-mile reach. Mussels returned to the river below a large tributary suggesting that the addition of the tributary improved water quality conditions to a level that supported mussels (Gillis et al. 2017).

Additionally, exposure to raw sewage can have numerous impacts on aquatic organisms, resulting in fish kills and damage to shellfish beds (USEPA 2011). On April 16, 2017, an estimated 250,000 gallons of raw sewage spilled from a ruptured pipe running adjacent to Swift Creek in Johnston County. Around 125,000 gallons made it directly to Swift Creek, while the other 100,000 gallons flowed into a wetland near the creek. The impacts to the aquatic fauna in Swift Creek have not been determined; however, numerous fish were killed in the wetland that received the raw sewage (News & Observer 2017).

Recent studies indicated that previous federal water quality criteria for many pollutants commonly found in wastewater discharges and stormwater runoff were likely not protective of freshwater mussels; nationwide regulations controlling the discharge or runoff of these pollutants are also not protective (Augspurger et al. 2003). The previous (1999) EPA-recommended 'freshwater ammonia aquatic life ambient water quality' criteria were based on the most sensitive endpoints known at the time: the acute criterion was based primarily on effects on salmonids (where present) or other fish, and the chronic criterion was based primarily on reproductive effects on the benthic invertebrate *Hyalella* or on survival and growth of fish early life stages (when present) (USEPA 2009). Research demonstrated that these standards were not protective of freshwater mussel species, which are some of the most sensitive aquatic organisms to ammonia. As a result, the EPA recently revised the freshwater ammonia aquatic life ambient water quality criteria (acute and chronic standards) to reflect freshwater mussel species sensitivity thresholds (USEPA 2013).

Ward et al. (2007) sampled for ammonia, copper and chlorine at five locations within, or draining to, the portion of Swift Creek occupied by DWM, and found that ammonia and chlorine

levels rarely exceeded ecological screening values; however, copper levels exceeded ecological screening values for both acute and chronic exposure at all sites. Further discussion of this study, and results of water quality sampling targeting these compounds that were conducted as part of the DWM Viability Study are discussed in further detail in the Lower Swift Creek Water Quality Report (Three Oaks 2015), which is included in Appendix C.

When publishing the five year review for the Carolina Heelsplitter (*Lasmigona decorata*), another federally endangered freshwater mussel species that occurs in North Carolina, the USFWS stated that there were “currently no water quality standards, or monitoring requirements for ammonia, copper and phosphorus in North Carolina” (USFWS 2012).

The Goose Creek Site Specific Management Plan (NCDENR 2009), which was developed to provide protection for the Carolina Heelsplitter, requires that any direct or indirect discharge that may cause ammonia toxicity to the Carolina Heelsplitter implement measures to reduce ammonia inputs to achieve 0.5 milligrams per liter or less of total ammonia based on chronic toxicity defined in 15A NCAC 02B .0202 (NCAC 1998). This level of total ammonia is based on ambient water temperature equal to or greater than 25 degrees Celsius (NCDENR 2009).

While there are still no adopted standards or monitoring requirements for ammonia and phosphorus in North Carolina, standards have recently been developed for copper, as updated in the Triennial Review of Standards (North Carolina Register 2014). EPA water quality criteria and North Carolina water quality standards are discussed further in the Lower Swift Creek Water Quality Report (Three Oaks 2015).

In addition, studies indicate other toxicants present in wastewater effluent such as pharmaceuticals and personal care products (fluoxetine, estrogenic compounds, opiate derivatives etc.) cause a wide array of neurotoxicological (Gagné et al 2007a), reproductive (Bringolf et al. 2007; Gagné et al 2007b) and behavioral (Hazelton et al. 2013, Heltsley et al. 2006) impacts to freshwater mussels (de Solla et al. 2016).

Other sources of toxic contaminants in surface waters arise from highway and urban runoff. Gillis (2012) demonstrated that chronic exposure to a combination of WWTP effluent and highway runoff negatively affected freshwater mussel health and life span in urbanized watersheds; although, a specific cause was not identified, the assumption is that chronic exposure to multiple contaminants negatively effects health and longevity. Numerous pollutants have been identified in highway runoff, including various metals (lead, zinc, iron, copper, cadmium, etc.), sediment, pesticides, deicing salts, nutrients (nitrogen, phosphorus), and petroleum hydrocarbons (Gupta et al. 1981; Yousef et al. 1985; Davis et al. 2001; Gillis et al. 2014). The sources of these runoff constituents range from construction and maintenance activities to daily vehicular use. Hoffman et al. (1984) concluded that highway runoff can contribute up to 80 percent of the total pollutant loadings to receiving water bodies; identifying, among others,

petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), lead, and zinc. PAH compounds are largely derived from petroleum related sources (e.g., gasoline, oil) and are of major concern from transportation-related runoff to aquatic systems due to their potential acute and chronic (e.g., mutagenic and carcinogenic) toxic properties (Humphries 2006). The toxicity of highway runoff to aquatic ecosystems is poorly understood. A major reason for this poor understanding is a lack of studies focusing solely on highway runoff. Potential effects of highway runoff have often been inferred from studies conducted on urban runoff; however, the relative loadings of pollutants are often much greater in urban runoff, because of a larger drainage area and lower receiving water dilution ratios (Dupuis et al. 1985). The negative effects of urban runoff inputs on benthic macroinvertebrate communities have been well documented (Garie and McIntosh 1986; Jones and Clark 1987; Field and Pitt 1990). Lieb (1998) found the macroinvertebrate community of a headwater stream in Pennsylvania to be highly degraded by urban runoff via a detention pond. Improvements were observed at continual distances downstream from the discharge point; however, all sites examined were still impaired compared to a reference community.

The few studies that examined actual highway runoff show that some species demonstrate little sensitivity to highway runoff exposure, while others are much more sensitive (Dupuis et al. 1985). Maltby et al. (1995) found elevated levels of hydrocarbons and metals in both stream sediments and the water column below a heavily traveled British motorway. They demonstrated that the benthic amphipod (*Gammarus pulex*) experienced a decrease in survival when exposed to sediments contaminated with roadway runoff. However, this species showed no increase in mortality when exposed to water contaminated with roadway runoff. Most of these studies only measured acute toxicity to runoff and did not examine long-term effects.

The effects of highway runoff on freshwater bivalves have not been studied extensively. Augspurger (1992) compared sediment samples and soft tissues of three Eastern Elliptio (*Elliptio complanata*), a relatively common species upstream and downstream of the I-95 crossing of Swift Creek of the Tar River Basin in Nash County, North Carolina. The sediment samples, as well as the mussels, exhibited higher levels of aliphatic hydrocarbons, arsenic, lead, zinc, and other heavy metal contaminants in the downstream samples. Because of the small sample size, the effect on the health of these mussels was not studied. In another study, contaminant analysis of stream sediments showed an increase of PAHs and some metals downstream of road crossings, although there was no direct correlation found between increasing contaminant levels and decreasing mussel abundance at these crossings (Levine et al. 2005). The Eastern Elliptio was the only mussel species that was found in large enough numbers for statistically valid comparisons. The Eastern Elliptio is generally considered more tolerant of water quality degradation than many other mussel species. However, Humphries (2006) did show that mussels from streams with higher average daily traffic counts (ADTC) exhibited greater levels of genetic damage compared to mussels from streams with lower ADTC values. Additionally, laboratory data showed increasing DNA damage relative to increasing PAH concentration. Humphries

(2006) concluded that “PAHs are not likely contributing to acute toxicity of mussels in North Carolina streams, but the chronic, long-term pervasive effect of PAHs on native freshwater mussels remains uncertain.” Further research is needed before the effects of highway runoff on sensitive mussel species such as the DWM and Yellow Lance can be determined.

While additional research is needed to document highway runoff effects on freshwater mussels generally, contamination of surface water from toxic spills along roadways is known to have significant impacts to aquatic communities. A toxic spill resulting from a tanker truck accident that was carrying Octocure 554 (a chemical liquid used in the rubber making process) killed several miles of mussel populations in the Clinch River near Cedar Bluff, Virginia (Richmond Times Dispatch 1998). The spill killed thousands of fish and mussels, including three federally protected species. The Clinch River contains one of the most diverse mussel faunas in the United States. The stretch of the river affected by the spill was one of the few remaining areas that contained a reproducing population of the endangered Tan Riffleshell (*Epioblasma florentina walkeri*), which has not been found in the river since. Presence of hazardous spill basins (HSBs) adjacent to crossings of waterways that support sensitive species provides the potential to avoid/ minimize major kills such as this.

#### 3.5.4 Hydrologic Changes Due to Changes in Land Use

The SCW has experienced urbanization in recent years, as discussed in detail in Section 3.1. The correlation of increasing development within a watershed and decreasing water quality is well documented (Lenat et al. 1979; Garie and McIntosh 1986; Crawford and Lenat 1989; Lieb 1998), and is largely associated with increases in impervious surface area. These increases in impervious surface area can affect water quality in a variety of ways, particularly with regard to changes to stream flow, water temperature, total suspended sediment, and pollutant loadings.

Multiple studies have demonstrated that water quality and stream ecosystem degradation begins to occur in watersheds that have approximately ten percent coverage by impervious surfaces (Schueler 1994; Arnold and Gibbons 1996; Stewart et al. 2000). NCWRC recommendations for management of protected aquatic species watersheds are to limit imperviousness to 6 percent of the watershed (NCWRC 2002). The amount of impervious surface has increased in the SCW, constituting about 11 percent of the land area within Wake County (the more developed of the two counties). As a result, Wake County contributes about 4.29 inches/year of runoff (CDM 2003, Table 3-5). Of the precipitation that falls onto these impervious surfaces, an estimated 95 percent becomes runoff. Johnston County is less developed than Wake County. As of 2011, the county was approximately 3.6 percent urban development, while the portion in the SCW was approximately 8.6 percent. This is based on the National Land Cover Dataset (NLCD, Homer et al. 2015), and assuming all development is captured in the Low, Medium, and High Intensity Developed categories. The 2009 North Carolina Division of Water Quality (NCDWQ, now the North Carolina Division of Water Resources) Neuse River Basinwide Plan indicates the entire

SCW is 29.5 percent urbanized, with much of the growth occurring in the last 20 years. Increases in impervious surface area within a watershed can result in extremes (either high or low) in peak discharge, runoff volume, and base flow conditions.

#### 3.5.4.1 Peak Discharge

Peak discharge is the maximum rate of stormwater flow expected from a storm event, measured in cubic feet per second (cfs). Peak discharge is often one metric used in analyzing effects from development and affects channel stability (or instability). Increases in peak discharge equates to higher velocity, which in turn increases the scouring effect (surface erodibility) of the runoff. Accordingly, sedimentation will increase as erosion rates increase. Increases of peak discharge rates, coupled with deforestation, have been shown to result in stream narrowing and incision and subsequent loss of ecosystem function (Sweeney et al. 2004). Shields et al. (1994) found that during base flows, incised streams contained fewer habitat types, particularly pool habitats, and lower fish species diversity than non-incised streams. Conversely, increases in peak discharge can also result in channel widening, as streambanks become susceptible to mass failure (Simon and Rinaldi 2006), which have been noted in a few areas in Swift Creek (Tim Savidge, Three Oaks, personal observations). As stream channels begin to become unstable, incision is typically the dominant result; however, once a critical threshold is passed, channel widening can occur rapidly (Shields et al. 1994). Harvey and Watson (1986) found that increases in channel cross-sectional area of up to 1,000% can occur within a few years. Increased peak discharges in areas of streams dominated by bedrock and boulder outcroppings intersecting the stream channel tend to widen the stream much more than deepening, as the energy gets dissipated horizontally. This appears to have occurred in a bedrock dominated area of Swift Creek adjacent to the Indian Overlook neighborhood (Tim Savidge, Three Oaks, personal observations).

#### 3.5.4.2 Runoff Volume

Runoff volume is the amount of stormwater expected from a storm event, measured in acre-feet. Like peak discharge, runoff volume is another metric often used in determining effects of development, especially on the aquatic environment. For example, increases in the amount of runoff normally equates to increased sediment. While the two indicators are related, when analyzed separately, both are useful in assessing impacts to aquatic systems.

In a stable system, an increase in the volume may have little impact if velocity does not change, provided that measures to slow the increased velocity have been implemented. However, the increased runoff volume may have enough sediment to cause detrimental effects. Regardless, it is important to consider both the rate (peak discharge) and the amount (runoff volume) when assessing effects to aquatic systems. Again, sufficient stormwater controls accompanying future development activities in any given watershed are essential for conservation of sensitive aquatic species such as DWM and Yellow Lance.

### 3.5.4.3 Base Flow

Increases of impervious surface lead to decreases in infiltration and base flow (groundwater flow) within adjacent streams. This can result in the following:

- Less water to cover the stream bottom during periods of reduced base flow.
- Increases in water evaporation and temperature in widened streams as a result of reduced overhanging tree cover and increased exposure to sunlight, especially in areas with shallower water.
- Extension of the WWTP effluent “plume” further downstream, if base flow is reduced and WWTP discharge remains constant or increases, as it takes longer for the stream to dilute the nutrients and other toxins in the effluent.

Just as the road network in a watershed affects peak discharge, it also can lead to a reduction of base flow. While the total amount of water remains relatively constant, base flows decrease because the rapid runoff (increases the timing and volume of peak discharge) reduces the total amount of water that can infiltrate and be stored in the soil (Castro 2003).

The effects of lowered base flow as a result of changes in the landscape are further exacerbated by water withdrawals. Permitted and un-permitted water withdrawals for crop and turf/lawn irrigation further exacerbate this effect. In North Carolina, permits are required for water withdrawals of one million gallons per day or greater for agricultural uses (100,000 gallons per day for non-agricultural uses). Withdrawals less than this volume are not regulated, and are often unknown. Numerous small withdrawal operations have been observed in the Lower SCW (Tim Savidge, Three Oaks, personal observations).

In general, soils in the Piedmont portion of the Neuse River Basin are highly erodible and are underlain by fractured rock formations that have limited water storage capacity resulting in the streams that flow through them being naturally susceptible to periods of very low or even interrupted flow. Streams in this area tend to have low summer flows and limited ability to assimilate oxygen-consuming wastes (NCWRC 2005). In addition, the Upper SCW is close to the transitional area between the poorly drained soils of the Triassic basin and the moderately drained soils weathered from granitic rocks underlying the Lower SCW. As such, Swift Creek is even more susceptible to periods of interrupted flow, particularly in the upper reaches, which have almost no potential for sustained 7Q10 low flow discharge; 7Q10 is defined as the minimum average discharge for a consecutive seven-day period occurring, on average, once in ten years (Weaver 1998). The natural susceptibility of these watersheds to periods of very low to interrupted flow is further compounded by anthropogenic factors such as water withdrawals and urbanization.

Prolonged periods of drought have been shown to adversely impact mussel species (Johnson et al. 2001; Golladay et al. 2005; USFWS 2012), as mussels may face increased water temperatures and reduced DO concentrations (hypoxia, or eventually anoxia), increased predation, and emersion or stranding (Johnson et al. 2001). Thin-shelled species like DWM may be inherently more prone to the consequences of drought than thicker shelled species like *Elliptio* mussels. Prolonged drought has been identified as a major threat to the endangered Carolina Heelsplitter (USFWS 2012). Similarly, based on expert opinion of the NC DWM Work Group, drought (“unsuitable flow”) was identified as one of the top three threats in all of the DWM populations in the Tar River Basin (Smith et al. 2015). Similarly, the SSA completed for the Yellow Lance identified insufficient water quantity associated with drought to be a major factor affecting the resiliency of the species in the Neuse River Basin.

While drought is recognized as a major threat for many mussel species, the actual low flow requirements of mussels is poorly understood. Johnson et al. (2001) and Golladay et al. (2005) assessed drought impacts on mussel assemblages in a number of streams in the Flint River Basin of southwestern Georgia. Flow rate, water temperature, water depth, and DO were monitored throughout the study and sites were classified as flowing or non-flowing during the drought period. Sites that ceased flowing during the drought had significant declines in the abundance of all mussel species, some of which are endangered, as well as declines in species richness. However, sites that maintained some flow during the drought had increases in stable species of mussels and no change in special concern or endangered species through the drought. Mortality of mussels at sites that ceased flowing was attributed to reductions in DO concentration, which was highly correlated with water velocity.

As part of the Section 7 Consultation for the Dempsey E. Benton WTP, a 60-year synthesized hydrologic time series was developed for Swift Creek using a ratio of the drainage area from the nearby, unregulated Middle Creek. The analysis concluded that Swift Creek historically experienced near zero and zero flow conditions (Entrix 2005). Minimum flow releases are now guaranteed as a result of conservation measures developed for that project (Section 1.3 of Entrix 2005).

### 3.5.5 *Thermal Pollution*

Concerns over effects of thermal pollution from urban runoff on aquatic systems have increased in recent years. Elevation of stream temperature can raise BOD, lower DO, and alter faunal composition (Poole et al. 2001, Roa-Espinosa et al. 2003). Typically, runoff from an impervious area will have a temperature similar to that of the impervious area. During the hot summer months, this could potentially make the stormwater runoff reach temperatures up to and above 90°F, which could be detrimental to aquatic life, such as freshwater mussels. Rising stream water temperatures have been shown to have lethal and sub-lethal effects on freshwater mussels during different life stages. Thermal stress on juvenile mussels was demonstrated to result in

reduced burrowing capacity and inhibited byssal thread production, which may hamper their ability to escape predation or extreme high or low flows, as well as limit their attachment and dispersal capabilities (Archambault et al. 2013). The thermal tolerance of freshwater mussels “is controlled by multiple interacting and complex factors” (Pandolof et al. 2012). For example, mussels are not only limited by their own thermal tolerances, but also by those of their host fish (Pandolof et al. 2012). Pandolof et al. (2010) suggested that freshwater mussels “already might be living close to their upper thermal tolerances in some systems”.

Traditional structural stormwater controls, such as open storm-water detention ponds/basins that do not allow for infiltration, do not protect receiving water bodies against adverse temperature effects. Various stormwater BMPs have been shown to be effective in ameliorating temperature effects (NC State Cooperative Extension 2006a). For example, bioretention devices were shown to reduce runoff temperature by 5-10°F in Greensboro, NC (NC State Cooperative Extension 2006b). The loss of riparian buffers as well as peak discharge related channel widening can also contribute to stream temperature increases, by increasing sunlight exposure and decreasing water depth. Increases in the level of imperviousness within a watershed can result in unnatural widening of stream channels. This is due to increasing stormwater flows, that erode and widen stream channels, which in turn decreases the vegetative shading and leads to increases in water temperatures.

### 3.5.6 *Invasive Species*

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 and Yellow Lance. 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 or Yellow Lance populations.

### 3.5.7 *Loss of Riparian Buffers*

Loss of riparian buffers can lead to degradation of adjacent aquatic habitats. The role of forested riparian buffers in protecting aquatic habitats is well documented (NCWRC 2002). Riparian

buffers provide many functions including pollutant reduction and filtration, a primary source of carbon for aquatic food webs, stream channel stability, and maintenance of water and air temperatures. Numerous studies have recommended a range of buffer widths needed to maintain these functions. Recommended widths vary greatly depending on the parameter or function evaluated. Wide contiguous buffers of 100-300 feet are recommended to adequately perform all functions (NCWRC 2002). The NCWRC recommends a minimum 200-foot native, forested buffer on perennial streams and a 100-foot forested buffer on intermittent streams in watersheds that support federally endangered and threatened aquatic species (NCWRC 2002). The USFWS often takes these NCWRC recommendations into consideration when addressing federally protected aquatic species in North Carolina.

### *3.5.8 Degradation Caused by All-Terrain Vehicle Use*

Another human-related factor adversely impacting habitat of the DWM and Yellow Lance is recreational all-terrain vehicle (ATV) use. ATV tracks have been noted crossing streams as well as traveling stream channels throughout the SCW. In addition to directly running over mussels, ATVs destabilize stream banks and floodplains, causing sedimentation and buffer degradation. While there is no quantitative data available on ATV use, locally, this can have significant impacts. This was identified as a threat to the DWM population in Swift Creek (Smith et al. 2015).

## ***3.6 Potential Effects of Roadway Projects on Freshwater Mussels and Habitat***

Roadways have the potential to cause adverse effects to freshwater mussels and their habitat. In addition to direct impacts that occur during roadway construction, the roadway project can have indirect effects associated with the roadway post construction (operational effects, as well as indirect effects associated with project-induced development. While several threats are recognized (Section 3.5), potential roadway-related effects on freshwater mussels and habitat fall into three main categories, which are evaluated in detail in Section 4.0:

1. Physical effects (habitat degradation, direct mortality of individuals),
2. Water quality effects (chemical, temperature, and biological pollutants), and
3. Water quantity effects (changes in peak and base flows).

### *3.6.1 Physical Effects*

Roadway construction can result in physical impacts to individual freshwater mussels as well as to their habitat. Physical effects associated with road construction include, but are not limited to, riparian land-clearing, physical loss of habitat (substrate fill), stream re-channelization, hydrologic modification, erosion associated with construction in the project corridor as well as within fill/borrow areas, and construction staging/access areas outside of the project corridor. The potential effects of these activities on aquatic species, especially freshwater mussels, include

physical injury to individual mussels from substrate disturbance and/ or sediment deposition. Potential physical effects to mussel habitat include channel and stream bank scouring, channel erosion, and sedimentation, all of which reduces habitat suitability.

### *3.6.2 Water Quality Effects*

Roadway construction can result in a variety of chemical and thermal water quality effects during construction as well as from induced land use changes post-construction. These effects include the addition of various chemical and thermal pollutants to waterways originating from the project construction and facility footprint, as well as and those pollutants originating from induced land use changes, particularly pollutants from commercial and/or residential developments (e.g., urban runoff, fertilizers, pesticides). Various parameters that serve as proxies for chemical and thermal water quality effects were modeled for a build vs. no-build scenario, including Impervious Surface, Total Suspended Solids (TSS) and Copper (Section 4.3).

### *3.6.3 Water Quantity Effects*

Water quantity effects are temporary and permanent alteration of flows. These include construction impacts (temporary dewatering, causeway construction, channel restriction, etc.), which were qualitatively assessed in Section 4.1, as well as impacts from induced land use changes (increased runoff and storm flows, decreased infiltration and associated base flow). The amount of impervious surface levels in the subject watersheds was modeled as a proxy for water quantity effects associated with induced land use changes (Section 4.3.1).

## **4.0 EVALUATED EFFECTS OF PROPOSED ACTION ON DWM AND YELLOW LANCE**

This section evaluates the direct and indirect effects of the project, together with the effects of other activities that are the interrelated and interdependent with the action on DWM and Yellow lance. We used the potential effects to the freshwater mussels and mussel habitat discussed above to frame the evaluated effects from the Complete 540 project. The project related impacts are presented in three categories:

- 1) Construction Effects
- 2) Operation Effects
- 3) Induced Land Use Effects

The modeled effects with and without the proposed project, more specifically Build vs. No-Build scenarios as presented in the ICE (Baker Engineering 2017 a-d), were used in the induced land use effects portion of this BA. The measures incorporated into this project to avoid or minimize effects to the DWM and Yellow Lance are included in this evaluation. The induced land use

effect is considered a subset of the overall interrelated and interdependent activities associated with this action.

#### 4.1 Construction Effects

Based on mussel survey data and habitat evaluations, DWM and/or Yellow Lance have been reported in portions of the following watersheds within the Action Area of the proposed project; Swift Creek, White Oak Creek, Little Creek and Middle Creek (Appendix B). The remaining portion of the Action Area outside of these watersheds does not contain DWM or Yellow Lance; Therefore, those watersheds are not included as a part of the effects analysis of these two species. The project alignment traverses a section of Swift Creek that is occupied by both species, as well as waterbodies that drain to habitat occupied by either, or both; therefore, there is the potential for roadway construction to affect the species. While there is the potential for construction related effects from any jurisdictional crossing within the watershed, the likelihood of such impacts generally declines the further the action is from occupied habitat. As such, the distance from each jurisdictional stream crossing to occupied habitat have been placed in four categories:

- 0.0 – 0.25 river miles (RM)
- >0.25 – 1.0 RM
- >1.0 – 2.0 RM
- >2.0 RM

Potential effects are even further reduced if the stream drains into an impoundment, prior to reaching occupied habitat, such as Austin Pond on White Oak Creek. The specific streams are noted in Table 10, and depicted in Figure 10. However, in certain instances sediment effects from construction sites can extend long distances. In 1997, a large plume of sediment in the Neuse River near New Bern was traced to a construction site along Crabtree Creek in Raleigh, over 180 miles upstream (Kays 2002). While this is an extreme example, it demonstrates the potential for project related sedimentation to have far reaching effects on the aquatic habitats downstream.

**Table 10. Distances to Occupied Habitat from Verified Jurisdictional Streams**

Stream Name	JD map ID	RM to occupied habitat	Stream Name	JD map ID	RM to occupied habitat
Buffalo Branch	SCT	4.181	UT to Swift Creek	SEW	1.902
Swift Creek	SDG	0.000	UT to Swift Creek	SEY	1.882
UT to Buffalo Branch	SCR	4.571	UT to Swift Creek	SFA	3.253
UT to Buffalo Branch	SCS	4.296	UT to Swift Creek	SFB	2.964
UT to Buffalo Branch	SCU	4.181	UT to Swift Creek	SFE	2.693
UT to Buffalo Branch	SCV	4.206	UT to Swift Creek	SFF	2.788
UT to Buffalo Branch	SCW	4.353	UT to Swift Creek	SFG	2.978

**Table 10. Distances to Occupied Habitat from Verified Jurisdictional Streams (continued)**

Stream Name	JD map ID	RM to occupied habitat	Stream Name	JD map ID	RM to occupied habitat
UT to Swift Creek	SCX	1.357	UT to Swift Creek	SFH	2.736
UT to Swift Creek	SCY	0.232	UT to Swift Creek	SFI	1.434
UT to Swift Creek	SCZ	1.382	UT to Swift Creek	SFJ	3.856
UT to Swift Creek	SDA	0.983	UT to Swift Creek	SFK	3.721
UT to Swift Creek	SDB	1.164	UT to Swift Creek	SFL	1.511
UT to Swift Creek	SDC	1.172	UT to White Oak Creek	SED	2.860
UT to Swift Creek	SDD (1)	0.742	UT to White Oak Creek	SFC	5.963
UT to Swift Creek	SDD (2)	0.792	UT to White Oak Creek	SFD	6.059
UT to Swift Creek	SDE	0.742	UT to White Oak Creek	SFN	6.991
UT to Swift Creek	SDF	0.252	UT to White Oak Creek	SFP	6.834
UT to Swift Creek	SDH	0.000	UT to White Oak Creek	SFQ	6.989
UT to Swift Creek	SDI	0.294	UT to White Oak Creek	SFR	6.676
UT to Swift Creek	SDJ	0.071	UT to White Oak Creek	SFS	7.195
UT to Swift Creek	SDK	0.228	UT to White Oak Creek	SFT	7.185
UT to Swift Creek	SDL	0.275	UT to White Oak Creek	SFU	6.032
UT to Swift Creek	SDM	0.381	UT to White Oak Creek	SFX	5.750
UT to Swift Creek	SDO	0.603	UT to White Oak Creek	SFY	7.174
UT to Swift Creek	SDP	1.516	UT to White Oak Creek	SFZ (1)	7.247
UT to Swift Creek	SDQ	1.076	UT to White Oak Creek	SFZ (2)	7.141
UT to Swift Creek	SDT	1.006	UT to White Oak Creek	SGA	7.117
UT to Swift Creek	SDV	0.276	UT to White Oak Creek	SGC	7.698
UT to Swift Creek	SDW	0.684	UT to White Oak Creek	SGD	7.724
UT to Swift Creek	SDX	1.278	UT to White Oak Creek	SGE	7.854
UT to Swift Creek	SDY	1.173	UT to White Oak Creek	SGF	7.854
UT to Swift Creek	SDZ	1.173	UT to White Oak Creek	SGG	7.930
UT to Swift Creek	SEB	1.187	UT to White Oak Creek	SGH	8.342
UT to Swift Creek	SEC	1.381	UT to White Oak Creek	SGI	7.306
UT to Swift Creek	SEF	1.243	UT to White Oak Creek	SHT	5.616
UT to Swift Creek	SEG	1.014	UT to White Oak Creek	SRQ	7.477
UT to Swift Creek	SEH	1.116	UT to White Oak Creek	SRR	7.623
UT to Swift Creek	SEJ	1.131	White Oak Creek	SFV	5.872
UT to Swift Creek	SET	0.358			

Effects to the listed waterbodies will occur under three TIPs as shown on Figure 10. The projected construction duration of each TIP is approximately:

- R-2721 - 3.0 years
- R-2828 - 3.5 years
- R-2829 - 2.5 years

TIPs R-2721 and R-2828 are scheduled to be constructed first and concurrently such that they open to traffic at about the same time. TIP R-2829 is currently scheduled to follow the completion of R-2828 by about 3 to 4 years.

#### *4.1.1 Stream Fill (Substrate (Habitat) Disturbance/Loss)*

Highway construction within and around water bodies often results in the placement of fill into streams and adjacent floodplains. Two types of fill may occur, permanent and temporary. Permanent fills consist of bridge piers and abutments, culvert and pipe construction or extensions, and roadway fill slopes. Construction causeways and work bridges used for equipment access are examples of temporary fill. The specific effects to the streams within 0.25 RM of occupied habitat are as follows (Figure 11):

- Swift Creek (SDG) & SDH - As noted in Section 4.5.1, NCDOT has committed to avoiding any in-stream fill related impacts, be it permanent or temporary, at the crossing of Swift Creek
- Stream SDF & SCY – Based upon the preliminary design, the second bridge in the Swift Creek floodplain avoids the placement of permanent fill in the majority of (potentially the entire) stream channel, pending the final design. In a “worse-case scenario”, total permanent impacts are not expected to exceed 180 feet. Temporary causeways may be required to construct this bridge and roadway; however, the extent of these temporary impacts will not be known until the final design. Efforts will be made to minimize impacts to the amount practicable; however, assuming a single work bridge in between the dual bridges, temporary impacts are not expected to exceed 70 feet.
- Stream SDJ – Stream SDJ is a roughly perpendicular crossing that will be placed in a box culvert. This is expected to result in permanent fill of 443 linear feet of stream channel.
- Stream SDK – Stream SDK is an intermittent stream that begins near the edge of a fill slope based on preliminary design. Impacts will be determined in final design, but are anticipated to be relatively minor.

The crossing of Swift Creek will not involve any permanent, or temporary fill into the channel; thus, there will be no anticipated habitat loss/disturbance associated with this crossing. However, given the close proximity of the bridge footprint to the stream channel, there is always a remote possibility that small amounts of fill (rip rap, bridge materials, etc.) could inadvertently fall into the channel. These unforeseen events are unlikely to occur, and if they do occur would result in minimal amounts of fill related effects; nevertheless, this potential is factored into the effect assessment and conservation measures to offset effects.

While none of the streams within 0.25 mile aside from Swift Creek are considered to be currently occupied by either DWM or Yellow Lance, there is a slight possibility that these species could expand their respective range into the lower sections of these tributaries in the

future. Additionally, fish hosts of the two mussel species could potentially be present in these streams during construction and adverse effects to the fish hosts related to stream fill would in turn result in adverse effects to the mussels.

#### *4.1.2 Fish Host Effects*

There is the potential for fish infested with DWM or Yellow Lance glochidia to be present in streams while the crossing structures are being constructed. Lethal and sub-lethal effects to these fish resulting from construction, would in turn effect the attached mussel glochidia.

Mortality of individual fish can occur during construction in a variety of ways. Individuals can be crushed during pile driving, or causeway placement. Demersal species like darters are more inherently susceptible to this type of injury than pelagic species like shiners, as they have an affinity to occur near the stream bottom, and seek cover within the substrate when threatened, as opposed to shiners, which occur more in the water column and would swim away from the impact area.

Causeway construction may also strand individuals in areas that are dewatered, or congregate them into ponded areas where temperature and DO levels may impact their health and/or survival. Dispersal of host fish from the areas being affected by construction may increase their susceptibility to predation while they seek alternate habitats.

Acoustic, or noise impacts, can also occur to fish during pile driving and causeway placement. Underwater sound waves emitting from these actions can cause tissue damage to fish that can be lethal. There are several factors which affect the level of impact, including, frequency, sound pressure, acoustic impulse and distance from source (Caltrans Office of Environmental Engineering 2001). Anatomical and physiological traits of the fish species may also influence their susceptibility to sound impacts. For example, shiners and other ostariophysan fishes contain a series of small bones called Weberian Ossicles that connect the auditory system to the swim bladder, whereas, darters and other species in the Neotelostei clade do not have a close swim bladder-auditory system connection. Studies have shown that the level of inflation of the swim bladder greatly influenced hearing sensitivity of species with Weberian Ossicles, and had no significant effect on species without this structure (Moyle and Cech, 1988). The size of the fish also influences sensitivity to sound effects, as larger fish appear to be able to withstand a larger sound impulse than small sized fish (Caltrans Office of Environmental Engineering 2001, Yelverton et al. 1975). A further summary of the effects of acoustics on fish, including, bridge construction related effects, are provided in Caltrans Office of Environmental Engineering (2001) and references contained within.

Sub-lethal effects on host fish from construction activities can range from physiological stress (lower DO) associated with causeway de-watering, non-lethal tissue damage related to acoustic

effects, and non-lethal effects to the fish sensory system, which may impact their ability to detect predators. All of these could in turn affect the ability of attached glochidia to successfully transform into juveniles.

Furthermore, in-stream fill of these tributaries may cause downstream impacts to the species by affecting stream stability and thus resulting in erosion/sedimentation, which could then impact occupied habitat.

#### *4.1.3 Erosion/Sedimentation from Construction*

The detrimental effects of erosion/sedimentation on freshwater mussels are discussed in Section 3.5.1. Excessive suspended solids in the water column, sedimentation, and turbidity result in reduced biodiversity as well as a decline in productivity at all trophic levels (Gilbert 1989). As discussed in Section 4.5.1, NCDOT is committing to using the Design Standards in Sensitive Watersheds [15A NCAC 04B .0124 (b) – (e)] throughout the project. These measures will minimize the potential for sedimentation/erosion related adverse effects to the DWM and Yellow Lance; however, they will not completely eliminate the potential. The amount of sedimentation/erosion that will result from project construction and the level to which it adversely effects the two species is difficult to predict and is dependent on several factors, such as the frequency and duration of rainfall events during construction that exceed the erosion control design devices, construction duration and adherence to proper maintenance of erosion control devices, and the promptness to respond and remediate erosion control failures.

#### *4.1.4 Alteration of Flows/Channel Stability*

Geomorphically stable stream channels and banks are essential for the survival and conservation of many freshwater mussel species, including DWM and Yellow Lance. Stream channel instability can result from bridge construction and culvert/pipe crossings. Natural stream stability is achieved when the stream exhibits a stable dimension, pattern, and profile such that over time, the channel features are maintained, and the channel neither aggrades, nor degrades. Channel instability occurs when scour results in degradation, or when sediment deposition leads to aggradation (Rosgen 1996). The placement of fill, such as bridge piers, culverts, pipes, and causeways, into streams can alter the normal flow pattern of a water body by reducing flow velocities upstream, increasing sedimentation and flow velocities downstream, and resulting in scour and erosion. Such effects are not anticipated in the mainstem of Swift Creek, as no permanent or temporary structures will be allowed within the channel or within 10 feet of the top of the banks. There are no other streams with the Action Area that are currently considered to be occupied by the DWM or Yellow Lance, and based upon the preliminary design and NCDOT stormwater design flow standards, little to no direct alteration of flows and/or channel stability associated with these structures are expected to occur within the occupied portion of Swift Creek.

#### *4.1.5 Effects Associated with Borrow/Fill, Staging and Storage*

The contractor may use areas within the Swift and Middle Creek watersheds for staging, storage, refueling, borrow pit, or spoil areas. Any of these areas that occur within the watershed of occupied habitat have the potential to result in direct effects to the DWM and Yellow Lance. In general, the locations of borrow pits and spoil areas will be excluded from stream buffer areas per existing buffer regulations and local ordinances (Section 4.3). However, areas outside of the buffers still have the potential to affect water quality, and in turn freshwater mussels, through sedimentation, erosion, and introduction of toxic compounds into streams via stormwater channels, ditches, and overland runoff or through losses during the hauling process. The extent and magnitude of these effects is dependent upon distance to occupied habitat, as well as soils and topography which influence transport of sediment and toxicants to occupied habitat. The potential for these effects to occur can be minimized by developing measures to control sedimentation, erosion, and introduction of toxic compounds from entering streams in these areas.

#### **4.2 Operational Effects**

Operational effects include effects that arise from maintenance and daily vehicular use of the facility once it is in operation, as well as natural responses over time to the proposed action's construction effects that occur post-construction.

##### *4.2.1 Alteration of Flows/Channel Stability*

As noted in Section 4.1.4, geomorphically stable stream channels and banks are essential for the survival and conservation of many freshwater mussel species, including DWM and Yellow Lance. Once construction is completed, stream channel instability can occur as over time streams adjust to the channel alterations from construction, which could eventually impact occupied habitat and/or host fish species. The constructed project road network within a watershed can be a factor affecting channel stability as it contributes to changing of the timing and volume of peak flows, intercepting subsurface water, and decreasing the time for overland runoff to reach the stream channel. The specific factors that influence the potential for the crossing structures outside of the defined area of construction related effects to adversely affect occupied habitats as a result of destabilization of the stream channel include, but are not limited to:

- design of the structure
- distance of crossing structure to occupied habitat
- watershed size
- stream gradient and characteristics (i.e. presence of natural grade control (bedrock outcropping, etc.)

- low gradient pools, or beaver dams and other structures that may attenuate flow velocity, as well as conditions and changes to the watershed including development and road network.

As a result, even though a watershed receives the same amount of precipitation, water is transported through the system much more quickly, thus resulting in higher peak discharges and resultant increases in stream power.

This increased stream power can more effectively erode the streambed and banks (Castro 2003). While any crossing structure (bridges, culverts, pipes, etc.) can lead to channel instability, in the past, culverts have been particularly problematic. Culverts have often lead to channel instability by constricting the flow, which increases the erosional forces. Historically, the design of culverts only accounted for the passing of water, and not bed materials, sediment, and woody debris. As such, significant problems at culverts have occurred including “(1) plugging due to large wood transport, (2) sediment deposition at the inlet due to the backwater effect, and (3) high velocity flows exiting the culvert resulting in channel scour” (Castro 2003). Channel instability associated with a culvert crossing is not static, rather they can be far reaching and effect the channel, and in turn the aquatic community, for considerable distances both upstream and downstream, as “streams are linear systems that move mass and energy along the channel primarily in upstream/downstream directions and through the floodplain in all directions” (Castro 2003).

#### *4.2.2 Roadway Runoff*

Numerous pollutants have been identified in highway runoff, including various metals (e.g., lead, zinc, iron), sediment, pesticides, deicing salts, nutrients (nitrogen, phosphorus), and petroleum hydrocarbons (see Section 3.5.3 for details on how these pollutants effect freshwater mussels). In addition, thermal effects to DWM and Yellow Lance can also occur from highway runoff. The respective populations are expected to experience localized increased exposure to roadway runoff originating from the 77 crossings draining to occupied habitat along the 540 alignment, as well as increased roadway runoff originating from the existing roadway network due to induced increases in traffic volumes (Section 4.3.1). In some areas there may actually be a reduced exposure to roadway runoff from induced decreases of traffic volumes (Section 4.3.1). NCDOT has committed to eliminating deck drainage directly into any waterbody within the Action Area, as well as a commitment to match the post-discharge to the pre-construction conditions. These actions will reduce the potential for adverse effects from roadway runoff.

#### *4.2.3 Toxic Spills*

Roadway construction can also affect the aquatic environment by increasing the potential for toxic spills from vehicular accidents once the facility is in operation. As evidenced from the

Clinch River in Virginia (Section 3.5.3), toxic spills resulting from traffic accidents can be devastating to mussel populations. The type (i.e. commercial truck, etc.) and volume of traffic affect the potential for toxic spills to occur. The locations where there is the highest potential for hazardous spills to impact the DWM and Yellow Lance are at the crossing of Swift Creek and tributaries within 0.25 mile, though any spill within the watershed has the potential to affect these species. There is no way to accurately predict when and where toxic spills will occur. The Texas Department of Transportation and the FHWA commissioned a study that evaluated roadway hazardous material spill incidents associated with transportation on Texas highways. The study found that between 2002–2006, more than 900 hazardous material spills of varying volumes were recorded in the state, and it was speculated that rainy/wet roadway conditions may be a factor in the frequency of spills. The results were used to develop design guidelines and parameters to reduce the risk of exposure to travelers and individuals responsible for spill cleanup (Thompson et al. 2011).

One way to lessen the adverse effects of toxic spills to water resources is the construction of HSB(s) along roadway stream crossings, which are designed to contain hazardous materials in the event of an accidental spill. During “normal operation, stormwater runoff flows unimpeded through the basin. In the event of a spill, the outlet control structure is can be closed, preventing discharge from the basin. HSBs may be shaped like a pond or a channel. Sluice gates or sand bags are typically used to block the basin outlet. Some HSBs are marked by a sign with instructions to personnel on how to contain a spill. The HSB outlet control structure may be designed to provide detention in some applications. One measure of a successful HSB application is the ease with which someone could locate and close the outlet device during an emergency. In addition, the HSB should allow access for appropriate maintenance equipment.

The NCDOT guidelines require HSBs to be provided at stream crossings on highways functionally classified as a rural or urban arterial, and;

- The stream (1) is identified as an Outstanding Resource Water (ORW) or a WS-I water supply, or
- The stream (1) crossing is within 1/2 mile of the critical area (2) of a water supply source classified as WS-II, WS-III and WS-IV.
  - For the purpose of these guidelines, Stream (1) is defined as those depicted as blue lines on 7-1/2 minute (1:24000 scale) United States Geological Survey (USGS) quadrangles.
  - Critical area (2) is defined as extending 1/2 mile from the normal pool elevation of a reservoir; or 1/2 mile upstream of, and draining to an intake.

While none of these situations apply, NCDOT can also require basins be built for other circumstances, such as the presence of sensitive aquatic species. As mentioned in Section 4.5.1, to minimize the potential for adverse effects to the DWM and Yellow Lance from toxic spills,

NCDOT is committing to installing one to two HSB(s) within the immediate vicinity/floodplain of the crossing of Swift Creek, the ultimate location(s) to be determined during final design.

### ***4.3 Induced Land Development***

Roadway construction can influence land use and result in development that would not occur without the road (induced development). While land development itself does not affect freshwater mussels and their habitat, increases in sediment loads and various pollutants, alterations in flow regime (base flow and peak discharge), and loss of riparian buffers are consequences of development that lead to water quality degradation. How these consequences of land development affect water quality and ultimately freshwater mussels is discussed in Section 3.5.4 of this report.

Baker Engineering (2017) completed a Quantitative Indirect and Cumulative Effects (ICE) Report of the Complete 540 Project using a methodology to forecast land use changes between the base year of 2011 and design year 2040. This Quantitative ICE report utilized much of the information in the Qualitative ICE Report (H.W. Lochner 2014). As was projected in the Qualitative ICE Report and confirmed and quantified in the Quantitative ICE Report, the introduction of a high-speed, controlled-access roadway into the FLUSA would provide a faster and more direct route to employment and commercial centers in the region. Further, the primary changes in land development from the No-Build to Build are higher land use densities, more commercial and industrial development, and a greater mix of uses in the areas surrounding the interchanges. Though this pattern is captured in the model results, it is noted: “Without the project, there would be both less development overall and lower densities of development in the FLUSA. However, there does not appear to be a more sprawled development pattern in the FLUSA in the Build scenario, and the relative increase in development in the Swift Creek water supply watershed is miniscule,” (Baker Engineering 2017d).

The predictive watershed model utilized in the analysis and documented in the Quantitative ICE Report (Baker Engineering 2017c) was run twice for each land use scenario to estimate a range of potential induced and cumulative effects to the water quality study area. For both model runs, the process described in Quantitative ICE Memo #2 (Baker Engineering, 2017b) was used to calculate land cover in the water quality study area. The first, more-conservative model run, produced an “upper limit” of percent impervious coverage for each HUC in the study area. The second model run used the observed percent impervious coverage by land cover type in the Baseline condition to estimate the “lower limit” of impervious coverage for the 2010, 2040 No-Build, and 2040 Build scenarios. This approach could produce some under-estimation of impervious surface percentages; therefore, Model Run 2 provides a low-end-of-range estimate, and Model Run 1 provides a high-end-of-range estimate. These results are provided as ranges in Table 11.

**Table 11. Percent Increases from 2010 Baseline to 2040 No-Build and from 2040 No-Build to 2040 Build**

Watershed	Impervious Surface (%)			TSS (MT/yr/ac)			Copper (g/yr/ac)		
	Baseline	Baseline to No-Build % increase	No-Build to Build % increase	Baseline	Baseline to No-Build % increase	No-Build to Build % increase	Baseline	Baseline to No-Build % increase	No-Build to Build % increase
White Oak Creek	4-10	5-18	≤1	0.08	26-38	≤1	0.69-0.70	26-38	1
Piney Grove Cemetery-Swift Creek	4-7	5-12	≤1	0.20	18-20	3-4	1.36-1.40	18-20	3-4
Little Creek (Lower)	4-9	7-22	≤1	0.11	21-27	≤1	0.74	21-27	≤1
Mahlers-Swift Creek	5-14	10-29	≤1-6	0.26	88-94	≤1	2.27-2.29	88-94	≤1
Reed Branch	4-12	7-22	≤1	0.17	18-20	2	1.17	34-38	2
Middle Creek (Lower)	3-8	5-14	≤1	0.33-0.34	34-38	3	2.26-2.34	29-30	3

The Quantitative ICE Assessment Memo #4 (Baker Engineering 2017d) addressed a more detailed NEPA-based analysis of induced effects to the six subwatersheds in which DWM and Yellow Lance are currently extent; White Oak Creek (Lower), Piney Grove Cemetery-Swift Creek, Mahlers-Swift Creek, Reed Branch, Little Creek (Lower), and Middle Creek (Lower) (Figures 8 and 9). Three factors were chosen to quantify induced land use effects for this BA; impervious surface, total suspended solids (TSS), and copper. These factors were chosen as they either directly or indirectly can be correlated with, or serve as surrogates for, threats to mussel species discussed in Section 3.5.3.

Stream flow and nitrogen were also evaluated in the Quantitative ICE memos (Baker Engineering 2017a, 2017b, 2017c, and 2017d). For stream flow, any changes will be a direct correlation to impervious surface effects. As there are opportunities to temper this correlation via various stormwater control measures, it was decided that impervious surface effects would be the most appropriate parameter to consider. Nitrogen was not included directly in this evaluation because of the difficulty of using this parameter as an indicator of stream health. Nitrogen toxicity on mussels is related to a multitude of factors, and the amount of nitrogen in and of itself does not necessarily equate to an effect.

As discussed in the DWM Viability Study (Three Oaks 2016) and the ICE Memoranda and Water Quality Assessment (Baker Engineering 2017a, 2017b, 2017c, and 2017d), there are a number of development restrictions in place within the Action Area, such as Neuse Buffer Rules and designated Environmentally Sensitive Areas (ESAs), that would lessen some of the potential for project induced development. However, the DWM Viability Study (Three Oaks 2016) notes there are several areas that drain into Swift Creek that are exempt from the current ESA, such as some properties in the I-40/NC-42 interchange area. For example, the Golden Corral property was exempt as it was approved prior to the adoption of the ESA regulations. However, the Wal-

Mart property was not exempt, and various stormwater BMPs were incorporated into site development.

#### *4.3.1 Induced Impervious Surface Effects*

Impervious surface was chosen as one of the three factors since it directly relates to loss of pervious surfaces and indirectly to water flow in receiving surface waters, and is used as a proxy to represent anticipated indirect physical habitat effects (channel instability, channel scour, etc.), indirect water quality effects (thermal pollution) and indirect water quantity effects (changes in peak and base flows). The percentage increase in five of the six watersheds from the 2040 No-Build to Build is less than or equal to 1 percent, with the exception being the Mahlers-Swift Creek watershed, where the range is less than or equal to 1 to 6 percent. In the least impactful scenario, there would be a 10 percent increase from the Baseline to the No-Build. In accordance with this scenario, then the percent increase from No-Build to Build would also be the least impactful scenario, with an increase of less than or equal to 1 percent over the Baseline to No-Build total. Accordingly, in the most impactful scenario, construction of the Complete 540 project (2040 Build Scenario) would increase the percent impervious by up to 6 percent above the 29 percent increase (No-Build) that would be expected without the project. In all the other watersheds, similar scenarios are forecast with regard to increasing amounts of imperviousness from the baseline conditions to 2040; however, in those instances, the increases in impervious surface attributable to Complete 540 would be less than or equal to 1 percent.

#### *4.3.2 Induced TSS Effects*

TSS was chosen as one of the three factors as a proxy to represent anticipated indirect water quality and physical habitat effects since it directly relates to sedimentation, which degrades water quality and habitat suitability. As shown in Table 11, the percentage increase in three of the six watersheds from the 2040 No-Build to Build is less than or equal to 1 percent. In the other three, the highest potential increase is the Piney Grove Cemetery-Swift Creek watershed, where there is a 3 to 4 percent increase attributable to Complete 540, followed by 3 percent in Middle Creek and 2 percent in Reed Branch. However, Piney Grove Cemetery-Swift Creek watershed, along with the Reed Branch watershed, is where the least amount of percent increase from Baseline to No-Build (18-20% for each) is anticipated.

#### *4.3.3 Induced Copper Effects*

Copper was chosen as one of the three factors as a proxy to represent anticipated indirect water quality effects since it is generally considered to be the most toxic of the contaminants to freshwater mussels, is found in runoff directly relatable to increased development, and has been addressed in the Lower Swift Creek Water Quality Report (Three Oaks 2015). Because the transport method for copper is directly related to TSS, the same percent increases in the six watersheds that were noted for TSS are also reflected for copper. The percentage increase in

three of the six watersheds from the 2040 No-Build to Build is less than or equal to 1 percent, with the highest potential increase being the Piney Grove Cemetery-Swift Creek watershed. In this watershed, there is a 3 to 4 percent increase attributable to Complete 540, followed by 3 percent in Middle Creek and 2 percent in Reed Branch.

#### *4.3.4 Induced Roadway Runoff Effects*

Induced changes in land use also has the potential to affect traffic patterns on the existing road network within the action area of roadway construction projects, which in turn result in changes of pollutant concentration of roadway runoff exposure within occupied habitats. Increased traffic volumes on the road networks traversing the watersheds could potentially affect the associated aquatic communities, including freshwater mussels, by causing water quality degradation via an increase in runoff contaminants attributable to the additional traffic. Increased traffic volumes may also result in the need for widening and improvements to existing roads that occur within the Swift and Lower Middle Creek watersheds, further increasing runoff from both construction and increased stormwater flows from the additional impervious surface. Widening of existing roadways could also result in increased exposure to thermal pollutants due to a larger impervious footprint of the respective roadways. Decreases in traffic volume could have a potential localized beneficial effect by decreasing concentrations of toxicants originating from roadway runoff, and/or toxic spills along roadways.

Induced effects from roadway runoff fall into two categories; 1) increases/decreases in roadway runoff due to changes in traffic patterns on the existing roadway network within occupied watersheds, and 2) roadway runoff originating from project crossings of waters within occupied watersheds.

The forecasted traffic levels indicate that the induced growth effects of the proposed project will likely add to the total volume of traffic in Wake and Johnston Counties and to the total vehicle miles traveled and vehicle hours traveled. Roads that connect to Complete 540 will likely see some increases in traffic, mostly in the immediate vicinity of interchanges. The traffic analysis (HNTB 2017) of FLUSA-Level traffic conditions showed that while total Daily and PM Peak Vehicle Miles Traveled (VMT)/Vehicle Hours Traveled (VHT) slightly increased with Complete 540 in place, the congested Daily and PM Peak VMT/VHT, average Daily and PM Peak speeds, and Daily and PM Peak congested roadway mileage all improved in the Build condition. Additionally, the volume-to-capacity comparisons showed that all areas with a Level of Service of “E” or worse had Triangle Regional Model daily volume-to-capacity ratios within the same threshold in the model runs both Future-Year Build conditions (No-Build and Build). This indicates that these issues would exist with or without the project.

There are multiple crossings of water bodies within the Swift and Middle Creek watersheds all of which eventually drain to habitat occupied by DWM and/or Yellow Lance; thus, there is

potential for occupied habitat to be exposed to various toxicants originating from these crossings. Numerous factors influence the potential for these toxicants to reach occupied habitats:

- traffic volumes
- distance of crossing structure to occupied habitat
- watershed size
- stream gradient and characteristics (i.e. presence of natural low gradient pools, or beaver dams and other structures that may attenuate transport of toxins, etc.)
- toxin attributes that affect exposure pathways (i.e. bound to sediment).

The magnitude of the effects associated with roadway runoff originating from a specific crossing is dependent on the transport mechanisms described above, coupled with the amounts of toxicants entering occupied habitat via other pathways (other tributaries, atmospheric deposition, run off from adjacent land use, ground water inputs, etc.).

#### ***4.4 Conclusions of Effects – DWM and Yellow Lance***

The project will incorporate measures to avoid and minimize potential adverse effects. However, the project is still likely to have unavoidable direct and indirect effects to DWM and Yellow lance mussel populations in the action area.

##### ***4.4.1 Construction Effects***

The construction of Complete 540 has the potential to have the following construction related effects on the DWM and Yellow Lance.

###### ***4.4.1.1 Habitat Loss/Disturbance***

As discussed in Section 4.5.1, the crossing of Swift Creek will not involve any permanent, or temporary fill into the channel; thus, there will be no anticipated habitat loss/disturbance associated with this crossing. However, as stated in Section 4.2.1, unforeseen events may result in minimal amounts of fill entering Swift Creek and are factored into the assessment of effects and conservation measures to offset effects (See Preconstruction Survey and Potential Mussel Relocation Section 4.5.2.1).

There will be multiple crossings of streams within Swift Creek and Lower Middle watersheds that will result in the both the permanent and temporary loss (fill and realignment) of stream channel. Impacts to the tributaries that are within 0.25 mile of occupied habitat of Swift Creek could result in a maximum of 180 and 433 linear feet, respectively, of permanent stream channel fill. Additionally, temporary habitat disturbance/losses in Stream SDF is anticipated as a result of fill associated with the use of temporary causeways during construction, the final amount of which will be determined during final design, but will not exceed 70 linear feet.

The permanent and temporary stream impacts associated with the construction of Complete 540 may have long-lived effects on the DWM and Yellow Lance's ability to colonize these areas in the future.

#### 4.4.1.2 Fish Host Effects

As discussed in Section 4.1.2, project construction has the potential to result in lethal and non-lethal effects to fish hosts, including being crushed by construction materials, stranding in dewatered areas, physiological stress, and increased susceptibility to predation from dispersal, as well as acoustic related impacts. The completion of Complete 540 will result in some of the longest water conveyances (culvert and pipe) throughout the Swift Creek and Middle Creek watersheds. Such lengthy structures have proven to be an impediment to fish migration and passage. Further, it is not unusual for step pools to form at the outlet of these structures, further inhibiting passage. So while neither DWM or Yellow Lance occupied habitat is extent outside of the mainstems of Swift and Middle Creeks, construction of Complete 540 could prevent or adversely affect the passage of fish hosts into unoccupied portions of the watershed.

Determining if fish carrying DWM or Yellow Lance glochidia are present in streams that will be impacted would be very difficult, and require intensive fish sampling and examination. If host fish were determined to occur within these streams, such an analysis may also have more of an adverse impact on DWM and Yellow Lance glochidia than the actual effects associated with construction. Therefore, these effects are not readily quantifiable.

#### 4.4.1.3 Sedimentation/Erosion From Stream Crossing Construction

As discussed in Section 4.5.1, NCDOT is committing to using the Design Standards in Sensitive Watersheds [15A NCAC 04B .0124 (b) – (e)] throughout the project, which will reduce the potential for adverse effects; however, these effects cannot be entirely eliminated. Numerous factors influence the extent and magnitude of these types of impacts, making it difficult to quantifiably predict (See Section 4.1.3). As such, some level of direct sedimentation/erosion related adverse effects to the DWM and Yellow Lance are anticipated to occur as a result of project construction.

#### 4.4.1.4 Alteration of Flows/Channel Stability

As stated in Section 4.1.4, the crossing of Swift Creek will span the channel and not involve any fill (permanent, or temporary) in the stream; thus, alterations of flow and channel stability are not expected to occur in this location. In addition, based upon the preliminary design and NCDOT stormwater design flow standards, direct alteration of flows and/or channel stability associated with constructing the other crossings are anticipated to be minimal and are not expected to extend into the occupied portion of Swift Creek.

#### 4.4.1.5 Effects Associated with Borrow/Fill, Staging, and Storage Sites

Other potential direct effects associated with project construction are sedimentation/erosion and introduction of toxic compounds originating from borrow/spoil, staging, equipment storage, and refueling areas, entering Swift Creek or Lower Middle Creek via unregulated stormwater channels, ditches, and overland runoff. At this time, the locations of potential borrow/spoil sites, staging areas, equipment storage areas, and refueling areas have not been chosen. As noted in the Conservation Measures (Section 4.5.1), NCDOT will strongly discourage the contractor from choosing borrow/waste site locations, staging areas, equipment storage areas, and refueling areas within 0.25 mile of Swift Creek. However, if the contractor opts to pursue borrow or waste sites in these locations, the NCDOT Division Environmental Officer will coordinate with the NCTA and the USFWS during the approval process of any borrow or waste sites. In addition, NCDOT standard guidance for borrow/fill sites provide another layer of environmental protection for waterbodies. These sites will also be reviewed prior to project permitting through interagency merger meetings.

Staging sites are required to be identified by the Contractor and discussed with NCDOT and USFWS (as well as all the regulatory agencies in the merger process) prior to permitting, and as such will be subject to the same regulations and guidance as the rest of the project.

As such, if any borrow/fill sites are within Swift Creek or Middle Creek watersheds, existing regulations and the commitment of NCDOT to adopt measures to avoid/minimize the potential for adverse effects in non-regulated areas within the respective watersheds, make it extremely unlikely (discountable) that these types of project-related direct effects will occur.

#### 4.4.2 *Operational Effects*

Operational effects as described in Section 4.2 may occur in the waterbodies listed in Table 10. These effects generally diminish the further they occur from occupied habitat.

##### 4.4.2.1 Alteration of Flow/Channel Stability

Once the project has been constructed, it is anticipated some streams will continue to alter their existing flow/channel stability as they seek equilibrium from construction impacts. In addition, the road network that evolves due to Complete 540 will affect flow/channel stability as it contributes to the change of the timing and volume of peak flows, intercepting subsurface water, and decreasing overland flow. However, given the predicted growth in the area regardless of the project (No Build), the extent and magnitude of this type of effect is difficult to predict, and can be minimized with adequate design and proper installation and maintenance. It is also possible that building Complete 540 will actually result in fewer roadways that would have otherwise been constructed. As such, indirect effects to DWM and Yellow Lance from the alteration of flow/channel stability are likely immeasurable.

#### 4.4.2.2 Roadway Runoff

There are multiple streams that will be impacted due to the project that drain to occupied portions of Swift Creek and/or Lower Middle Creek. These new sources of roadway runoff coupled with increased traffic volumes on some of the existing roads within the respective watersheds may result in a localized increase of the respective DWM and Yellow Lance population's exposure to roadway derived pollutants. However, there may also be localized reductions in exposure to toxicants in other areas within the respective populations as a result of decreased traffic volumes along other roads within the Action Area that drain to occupied habitat. As such, while it is likely that construction of the Complete 540 will likely lead to slightly more exposure of freshwater mussels to roadway runoff than the No-Build scenario, there isn't existing data to determine if this potential increase would pass a threshold to which would adversely impact the mussels.

#### 4.4.2.3 Toxic Spills

As discussed in Section 4.2.3 there is the potential for adverse effects to occur to the DWM and Yellow Lance as a result of toxic spills once the facility is in operation, with the potential for impacts increasing the closer they occur to Swift Creek. There is no way to accurately predict where and when toxic spills associated with the facility will occur; however, such an event is likely to occur during the lifetime of the facility. According to the US Department of Transportation (USDOT), there were 639 reported transportation related incidents involving hazardous materials in North Carolina in 1996 (USDOT 1996). It is even harder to predict the magnitude of the impacts to DWM and Yellow Lance if such a spill were to occur along the facility. The construction of a HSB(s) at the crossing of Swift Creek will help to minimize the potential for this type of adverse impact to occur in the future.

#### 4.4.3 *Induced Land Development Effects*

As discussed in Section 4.3, both the ICE Memoranda and Water Quality Assessment (Baker Engineering 2017a, 2017b, 2017c, and 2017d) analyses, as well as the Qualitative ICE Report (H.W. Lochner 2014), forecast continued increases in developed land and associated water quality degradation in the Swift Creek and Middle Creek watersheds in both the 2040 No-Build and Build scenarios. Except for the Mahlers-Swift Creek subwatershed, all the subwatersheds occupied by or draining to habitat occupied by DWM and Yellow Lance increased in percentage of imperviousness, which is attributable to the 2040 Build Scenario, by less than or equal to 1 percent. In the Mahlers-Swift Creek subwatershed, the percent increase of imperviousness may be as high as 6 percent. Additionally, increases of 3 to 4 percent of TSS and copper associated with the 2040 Build Scenario are projected in the Piney Grove Cemetery-Swift Creek subwatershed; followed by 3 percent in the Lower Middle Creek; 2 percent in Reedy Creek; and

less than or equal to 1 percent in White Oak Creek, Little Creek Lower and Mahlers-Swift Creek subwatersheds, respectively.

Induced changes in land use may also result in changes of roadway runoff exposure within occupied habitats. Increased traffic volumes on the road networks traversing the watersheds could potentially affect the associated aquatic communities, including freshwater mussels, by causing water quality degradation via an increase in runoff contaminants attributable to the additional traffic. Decreases in traffic volume could have a potential localized beneficial effect by decreasing concentrations of toxicants originating from roadway runoff, and/or toxic spills along roadways.

#### *4.4.4 Cumulative Effects*

As detailed above, the proposed Complete 540 is expected to directly and indirectly result in adverse effects to the DWM and Yellow Lance through the construction and operation of the proposed facility, as well as through induced land use effects. Cumulative effects under the ESA are those effects of future state or private activities not involving federal activities that are reasonably certain to occur within the action area of an action subject to consultation. Under NEPA, cumulative effects are the incremental environmental impact or effect of the proposed action, together with impacts of past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. As noted, the cumulative analysis for the DEIS was performed using the NEPA definition. We used the broader, more conservative, NEPA cumulative assessment as the biases for this ESA cumulative analysis. The reasoning for this is due to the difficulty predicting which of the future development will require federal authorization, such as a CWA 404 permit, and would not be considered a cumulative effect under the ESA for this action. Therefore, the potential cumulative effects discussed in this BA, as defined per ESA, are overestimated since the ICE Report (Baker Engineering 2017a-d) included the effects of future federal actions as well as non-federal actions. We are making the assumption that some of the future activities discussed would have a Federal nexus and/or are already considered as induced development for the project (interrelated/interdependent activities).

Future state and private activities, including federal actions, are reasonably certain to occur within the Swift Creek and Middle Creek watersheds (Baker Engineering 2017d) and will continue to impact the DWM and Yellow Lance. However, as indicated above, most all of which are expected to occur with or without (Build vs. No-Build) the proposed action. The projected growth in the project Action Area is anticipated to result in additional (cumulative) effects to the DWM and Yellow Lance.

State and local regulations in the Swift and Middle Creek watersheds aim to reduce the cumulative effect of development on water quality in these sensitive watersheds. These

regulations include the *Swift Creek Land Management Plan*, the Neuse River Riparian Buffer Rules, the Neuse River Basin Stormwater Rules, protections agreed on during the consultation process for the Clayton Bypass project, and protections agreed on during the development of the Dempsey E. Benton WTP. These regulations and protections are discussed in detail in the DWM Viability Study (Three Oaks 2016). While the effectiveness of these plans has not been fully evaluated due to the short period of time in which they have been in effect, these plans provide more stringent restrictions to development than what would otherwise have been enforced by other state and federal regulations.

Other adverse effects to the DWM and Yellow Lance populations in the Action Area have occurred in the past and will continue to occur. These types of effects are difficult to identify or quantify, but may include sedimentation/erosion impacts from agricultural and residential land use; water quality effects from agricultural and residential sources (e.g., fertilizers, pesticides); small-scale littering into the river; and impacts from recreational uses of the river (e.g., fisherman stepping on individual mussels, using mussels as bait, and the riding of ATVs in occupied areas of the streams). These activities could adversely affect individual mussels or habitat. Potential effects are expected to be localized and small.

Table 11 reports the potential range of effects to the three indicator factors analyzed, however, further quantifying the ultimate effect the changes to the factors may have on the DWM and Yellow Lance is not plausible. Given the projected growth in the watershed with or without the Complete 540 project, the viability of both the DWM and Yellow Lance in these watersheds is uncertain. As detailed in the DWM Viability Study (Three Oaks 2016), aggressive management of the remaining populations, particularly through captive propagation and thereby providing the potential to augment the existing populations if conditions so warrant in the future, is considered to be the best practice to allow these populations to survive.

The combined effect of past and future actions addressed above may lead to adverse effects to the DWM and Yellow Lance. Improved land-use practices, development controls, and protection of habitat could provide beneficial effects that would help offset adverse cumulative effects. The proposed conservation measures, particularly the propagation facility, will help to alleviate some of the cumulative effects affecting these two species (See Section 4.5 – Project Conservation Measures).

#### *4.4.5 Biological Conclusion*

As summarized in Section 4.0, construction of the Complete 540 Project is expected to result in unavoidable adverse effects to both the DWM and the Yellow Lance. Therefore, the proposed action **“May Affect, Likely to Adversely Affect”** the DWM and Yellow Lance. Incorporation of conservation measures into the project will offset some of those effects (Section 4.5).

## **4.5 Project Conservation Measures**

The following measures are being implemented by NCDOT to avoid/minimize and offset potential effects from construction activities to DWM and Yellow Lance. These conservation measures fall into two general categories:

- 1) measures to avoid/minimize effects
- 2) measures to help offset anticipated effects

### *4.5.1 Conservation Measures to Avoid/Minimize Effects to DWM and Yellow Lance*

Various measures have been incorporated into the project to avoid and minimize adverse effects to the DWM and Yellow Lance.

#### 4.5.1.1 Erosion Control Measures

For projects that occur in watersheds that contain protected aquatic species, NCDOT develops erosion control measures that exceed the standard BMPs, incorporating the Design Standards in Sensitive Watersheds [15A NCAC 04B .0124 (b) – (e)], regardless of the NCDWR stream classification. For this project, NCDOT will require Design Standards in Sensitive Watersheds throughout the entire project.

The areas within the SCW and Lower Middle Creek will be identified as “Environmentally Sensitive Areas” on the Sedimentation and Erosion Control Plans. By definition, the Environmentally Sensitive Areas will be identified as a 50-foot (15.2-meter) buffer zone on both sides of the stream measured from top of streambank. Within the identified 50-foot (15.2-meter) Environmentally Sensitive Areas, the following shall apply:

1. The Contractor may perform clearing operations, but not grubbing operations until immediately prior to beginning grading operations.
2. Once grading operations begin in identified Environmentally Sensitive Areas, work shall progress in a continuous manner until complete.
3. Erosion control devices shall be installed immediately following the clearing operation.
4. “Seeding and Mulching” shall be performed on the areas disturbed by construction immediately following final grade establishment.
5. Seeding and mulching shall be done in stages on cut and fill slopes that are greater than 20 feet (6.1 meters) in height measured along the slope, or greater than 2 acres (0.81 hectare) in area, whichever is less.

All sedimentation and erosion control measures will be appropriately maintained following NCDOT standards, to ensure proper function of the measures

#### 4.5.1.2 Bridge Deck Drainage

The design for all bridges within the SCW and Middle Creek will eliminate deck drains into the water bodies they cross.

#### 4.5.1.3 Agency Coordination

NCDOT will invite representatives from USFWS and NCWRC (as well as other agency personnel) to the preconstruction meeting for the Complete 540 project, as well as to preconstruction meetings associated with installation of structures within 0.25 mile of the Swift Creek crossing to ensure compliance with special project commitments.

#### 4.5.1.4 Construction Practices

NCDOT will strongly discourage the contractor from choosing borrow/waste site locations, staging areas, equipment storage areas, and refueling areas within 0.25 mile of Swift Creek by putting such language in the project commitments. However, if the contractor opts to pursue borrow or waste sites in these locations, the NCDOT Division Environmental Officer will coordinate with the NCTA and the USFWS during the approval process of any borrow or waste sites. Note that the contractor must follow provisions in the Standard Specifications for Roads and Structures (January 2012) for borrow excavation (Section 230) and disposal of waste and debris (Section 802).

#### 4.5.1.5 Stream Crossing Review

During the development of the alternatives for the project, an interagency field review was held to review stream crossings and determine if the minimum required structure type should be altered to avoid/minimize environmental effects. Within SCW, three crossings (Figure 12) were identified as particularly high-value that warranted larger structures (Table 12) to minimize direct effects.

**Table 12. Stream and Wetland Crossings within the Swift Creek Watershed with Larger Proposed Structures Than Hydraulically Required.**

Stream ID (as noted in NRTR)	Stream Crossing	Meeting Result	Reduction of Impacts
SDF, SCY, WDV	UT to Swift Creek	3@7x5 reinforced concrete box culvert (RCBC) replaced with bridges	Streams 1,495 lf Wetlands 4.39 ac *Buffers 2.95 ac
SDV, SDW, WEC	UT to Swift Creek	3@9x5 RCBC replaced with bridges	Streams 1,619 lf Wetlands 8.62 ac Buffers 4.49 ac
SEW, WFN	UT to Swift Creek	Quad bridges extended	Streams 39 lf Wetlands 5.56 ac Buffers 0.12 ac

Notes: \* - 50 ft buffers measured from top of bank on either side of stream (Neuse Riparian Buffers)

#### 4.5.1.6 Bridging of Swift Creek

The bridge that crosses Swift Creek will not have any part of the structure in the stream channel or within 10 feet of the top of either bank. Further, no permanent structures or temporary structures required to build the bridge will be placed within Swift Creek. All permanent and temporary structures will be designed and installed such that they should not result in bank instability or cause significant sediment to runoff into Swift Creek.

#### 4.5.1.7 Hazardous Spill Basins (HSBs)

NCDOT will require construction of permanent HSB(s) on the crossing of Swift Creek. NCDOT will also require that final design attempt to direct road runoff through a HSB before being discharged to the Swift Creek tributaries (SCY, SDF, SDH, SDJ and SDK as labeled in NRTR) that are within 0.25 mile of Swift Creek. The basin(s) will be designed to contain a spill from a typical tanker truck that may have otherwise flowed directly into these water bodies. NCDOT will implement their standard protocols for upkeep and use of these basin(s).

#### 4.5.2 Conservation Measures to Offset Effects to DWM and Yellow Lance

The following conservation measures will be undertaken by NCDOT to partially offset unavoidable project related effects to the DWM and Yellow Lance.

##### 4.5.2.1 Preconstruction Survey and Potential Mussel Relocation

NCDOT will conduct preconstruction surveys (just prior to construction) at the Swift Creek crossing (Stream SDG) and remove mussels from a defined area (salvage area) and relocate them to appropriate habitat within Swift Creek outside of the salvage area (relocation site), or if deemed appropriate after coordination with the USFWS and NCWRC, DWM and Yellow Lance individuals may be taken into captivity to use as brood stock for propagation efforts (See Section 4.5.2.2). The pre-construction survey will be incorporated into a relocation plan that will be

developed in coordination with USFWS. NCDOT and Three Oaks have successfully relocated other federally protected freshwater mussel species from other project footprints. Preconstruction survey will be incorporated into a Mussel Relocation Plan, which will identify the salvage area and be developed in coordination with USFWS and NCWRC.

#### 4.5.2.2 Propagation Facility

Captive propagation of freshwater mussels is becoming an increasingly useful tool in the management and restoration of freshwater mussel populations. The Allee effect (high risk of demographic extirpation due to low population abundance and lack of dispersal) has been recognized as one of the major limiting factors of DWM and Yellow Lance population viability in Swift Creek. Whether the cause for the Allee effect in Swift Creek is due to past or ongoing anthropogenic factors is unclear. If the Allee effect is operating in Swift Creek causing unsustainable recruitment for the DWM and Yellow Lance populations, the release of propagated individuals might increase population viability given the apparent leveling off in population declines for some of the other mussel species.

As concluded in Smith et al. (2015) and discussed in detail in the DWM Viability Study (Three Oaks 2016), population augmentation through captive propagation is an essential component of management strategies to ensure DWM persistence in North Carolina, including the Swift and Middle Creek populations. Numerous imperiled freshwater mussel species have been successfully propagated and released into the wild for various projects in the United States, such as the Aquatic Fauna Restoration Project in the Cheoah River in Western North Carolina. This is an on-going cooperative effort between NCWRC, USFWS, and other private entities that has successfully propagated and released several freshwater mussels, including Appalachian Elktoe (*Alasmidonta ravenelaina*), which is federally listed, Slippershell Mussel (*Alasmidonta viridis*), Wavy-rayed Lampmussel (*Lampsilis fasciola*) and Rainbow (*Villosa iris*), as well as several native fish species and a federally threatened fish species, the Spotfin Chub (*Erimonax monachus*), into a nine-mile reach of the river (Fraleley et al. 2017). The Appalachian Elktoe and Slippershell Mussel are closely related to the DWM. To date there have not been any DWM population augmentation or re-introduction efforts using captive propagation. However, the species has successfully been propagated from two different source populations, the Po River of the York River Basin in Virginia and Moccasin Creek of the Neuse River Basin in North Carolina (Beck and Neves 2001). There were 1,191 juveniles produced from two gravid females collected from Moccasin Creek; however, they were not released back into the creek due to logistical reasons regarding the State's species augmentation/re-introduction policy at that time (Beck and Neves 2001). A number of the partners involved in the Cheoah River project will be an integral part of the proposed propagation facility.

Lastly, as stated in the DWM Viability report, the Dwarf Wedgemussel Workgroup for North Carolina concluded that propagation/augmentation was the highest priority management action for the Swift Creek population.

The long-term maintenance of captive held “ark” populations is a vital conservation strategy for critically imperiled mussels (Rachael Hoch, personal communication). Thus, in addition to augmenting the Swift Creek DWM population, developing the propagation facility will allow for the establishment of an “ark” population of the DWM for the Neuse River Basin, and in the future one for the Tar/Pamlico River Basin, to maintain the genetic stock.

An ongoing commitment by several entities in developing the Yates Mill Aquatic Conservation Center (YMACC) has been underway simultaneous to the development of the Complete 540 project. USFWS and NCDOT have been in coordination regarding the logistics (e.g., location, costs, maintenance) of developing a propagation facility in the Raleigh area as part of a conservation measure to help offset anticipated effects to the Swift Creek DWM and Yellow Lance population resulting from the construction of the Complete 540 project.

NCDOT has agreed to provide funding to be utilized for the retrofit and upgrade of the existing research facility in the A.E. Finley Center, at the Historic Yates Mill County Park, owned by Wake County and leased and operated by North Carolina State University (NCSU), for the purpose of research and propagation of DWM, Yellow Lance, and other aquatic species. The goal of the YMACC is to promote the long-term survival of rare aquatic species in streams throughout North Carolina by producing juveniles for reintroduction. Wake County will be provided with approximately \$2 million in funding for the construction of the retrofit and upgrade to the existing research facility in the A.E. Finley Center. Wake County will oversee and manage the construction of the new YMACC. In addition, approximately \$3 million in funding will be provided to NCWRC to support the North Carolina Non-Game Aquatic Species Program. These funds will be earmarked for NCSU to provide a facility manager and an assistant at the YMACC to oversee the propagation research, outreach, and other expenses needed to operate and maintain the facility for 5 years.

The responsibility of NCDOT for the propagation facility project is strictly to provide the initial funding. NCDOT is not responsible for the construction, management, or success of the facility or its propagation goals. NCDOT has committed to provide funding and will be entering into a funding agreement with Wake County for construction of the YMACC. NCDOT will enter into a separate funding agreement with NCWRC for operation of the North Carolina Non-Game Aquatic Species Program. These funding agreements are being prepared and will be in place prior to permitting for Complete 540 project.

### 4.5.3 DWM Viability Study

NCDOT in cooperation with the USFWS commissioned the DWM Viability Study to update the baseline conditions for the DWM. The specific purpose of the DWM Viability Study was threefold:

- Characterize existing conditions of the SCW
- Summarize conservation measures that have been implemented to protect DWM in the SCW
- Assess historic trends and future viability of the DWM population and habitat conditions

The results of this study provide critical information to assist in making decisions on how to best manage and conserve the SCW DWM population.

## 5.0 ENVIRONMENTAL BASELINE FOR MICHAUX'S SUMAC

As noted in Section 2.4, the Michaux's Sumac is known from the Action Area and has the potential to be impacted by the proposed action.

### 5.1 Michaux's Sumac (*Rhus michauxii*)

Status: Endangered

Family: Anacardiaceae

Listed: September 28, 1989

Critical Habitat: Not designated

#### 5.1.1 Species Characteristics



Michaux's Sumac is a rhizomatous shrub that grows 0.2 to 1.0 meter (7.9 to 39 inches [in]) in height. Although it is usually dioecious, monoecious individuals have been reported in some populations (USFWS 1993b). The entire plant is densely pubescent. The narrowly winged or wingless rachis supports 9 to 13 sessile, oblong to oblong-lanceolate leaflets that are each 4 to 9 centimeters (1.5 to 3.5 in) long, 2 to 5 centimeters wide, and acute to acuminate (USFWS 1993b, NatureServe 2016). The bases of the leaflets are rounded, and their edges are simply or doubly serrate. Flowering occurs in June and the small flowers are borne in a terminal, erect, dense cluster, with each one being four- to five-parted and greenish-yellow to white (USFWS 1993b). The fruit is a red, densely short-pubescent drupe, 5 to 6 millimeters

broad, and is visible on female plants from August to October (USFWS 1993b). Michaux's Sumac can generally be distinguished from other species in the genus due to its small stature, dense pubescence, and evenly serrate leaflets. Michaux's Sumac, also called false poison sumac, is quite harmless compared to poison sumacs of superficial resemblance.

Little information is available on the population biology and reproductive requirements of Michaux's Sumac. Most of the surviving populations appear to contain plants of only one sex and therefore reproduce only vegetatively, if at all (USFWS 1993b). Due to the rhizomatous nature of the species, this may mean that the single-sex populations may be clones of one or a few individuals. Limited genetic variation within populations may also contribute to the observed low rates of seed production; seed viability has also been shown to be extremely low (USFWS 2014).

### 5.1.2 *Distribution and Habitat Requirements*

Michaux's Sumac was originally described from "Mecklenburg County, North Carolina" as *Rhus pumula* by André Michaux in 1803, but later changed to *R. michauxii* by Sargent in 1895, to correct Michaux's use of a homonym (pullus) and to honor its discoverer (Barden and Matthews 2004). Historically, Michaux's Sumac has been documented in Davie, Durham, Franklin, Hoke, Johnston, Lincoln, Mecklenburg, Moore, Orange, Richmond, Robeson, Scotland, Wake, and Wilson Counties in North Carolina; Florence, Kershaw, and Oconee Counties in South Carolina; Columbia, Elbert, Gwinnett, Muscogee, Newton, and Rabun Counties in Georgia; and Alachua County, Florida (USFWS 1993b). Many of these populations have been extirpated. As of 2014, there are 43 populations range-wide (USFWS 2014). The NCNHP currently lists 33 extant populations in NC known from Cumberland, Davie, Durham, Franklin, Hoke, Mecklenburg, Moore, Nash, Richmond, Robeson, Scotland, and Wake Counties (NCNHP 2017). Four extant occurrences are known in Georgia (from Newton, Elbert, Henry, and Fulton Counties) and six in Virginia (from Brunswick, Dinwiddie, and Nottoway Counties, none of which were known at the time of listing). All previously known populations in South Carolina and Florida are currently considered extinct (USFWS 2014).

Michaux's Sumac grows in sandy or rocky open woods on sandy or sandy loam soils with low cation exchange capacities and appears to depend upon some form of disturbance to maintain the open quality of its habitat (USFWS 1993b, Dale Suiter, personal communication.). Michaux's Sumac can occur on circumneutral soils, loamy swales, or on clayey soils derived from mafic rocks, depending on the physiographic province where it occurs (NatureServe 2016). Most extant populations can be found on open disturbed areas, such as railroad, road, and utility rights-of-way that are periodically maintained and/or managed for the species.

Not much is known about the population dynamics of Michaux's Sumac. Fire or some other forms of disturbance, such as mowing or hand clearing (outside the normal flowering and

fruiting time), appears to be essential for maintaining the open habitat preferred by Michaux's Sumac (USFWS 1993b). Without periodic disturbance, this type of habitat is overgrown by woody vegetation. As this overgrowth occurs, Michaux's Sumac begins to decline due to its intolerance of shade. The current distribution of Michaux's Sumac demonstrates its dependence on disturbance. Of the remaining populations, most are located in areas that receive significant disturbance through periodic clearing or maintenance by fire.

### 5.1.3 Presence in Action Area

The NCNHP records indicated two known occurrences of Michaux's Sumac within the FLUSA and one historical occurrence just outside of the FLUSA (Figure 13).

1. Element Occurrence (EO) # 16/ EO ID: 8079

This approximately 0.41 acre site is in Wake County along Barwell Road in the northeast corner of the FLUSA. The City of Raleigh owns approximately 12.9 acres on the south side of Walnut Creek off of Barwell Road, which is managed by the Public Utilities Department. The City's Public Utilities Department and the City's Parks, Recreation and Cultural Resources Department have been working with the USFWS to conduct periodic monitoring and develop management recommendations since 2008 (Dale Suiter, personal communication). The site was monitored in 2014 and 115 stems were reported, an increase from previous monitoring years where 40-50 stems were reported (Dale Suiter USFWS, personal communication). In addition, a protective covenant was developed for this population as a requirement for a 2007 CWA Section 404 permit authorization issued by the U.S. Army Corps of Engineers, Wilmington District, Action ID SAW 200620349, associated with the development of an apartment complex (Legacy Oaks), that prohibits activities in this area without coordination with the USFWS Raleigh Field Office (US Army Corps of Engineers 2007).

2. EO# 53/ EO ID: 3172

This site is part of the Longleaf Restoration Area of the Harris Research Tract in the Cape Fear River Basin. This EO was an experimental planting that began in 2001 (Blank et al. 2002). The site has not been burned regularly, and the plants observed in 2009 were on the decline. The site is 3.86 acres.

3. EO# 70/ EO ID: 25384

This 0.48-acre site is in Wake County along Turnipseed Road and is just outside of the northeast FLUSA boundary, but is included in this assessment as the FLUSA boundary was set with some fluctuation and due to the proximity to this population, it was deemed prudent to consider it. This EO was first observed in 2007, last observed in 2011, and last surveyed in 2012. This EO is listed as historical, but this seems to be in error, as it was last observed in 2011. As this population is near a powerline

corridor, it may have been negatively impacted by maintenance or downed powerlines.

Species surveys were conducted within the project alignment and vicinity in 2013 by Mulkey Engineers and Consultants (NCDOT 2014) and 2017 by HDR Engineering (NCDOT 2017). At the time of the surveys in 2013, the Project Study Area (PSA) included several detailed study alternatives and was therefore much larger than the final selected alternative, but much smaller than the FLUSA. Surveys were performed again in 2017 in the selected alternative corridor; methodologies and results are included in the report (NCDOT 2017). These surveys followed established USFWS protocol. The surveys did not locate any Michaux's Sumac within the project alignment.

During the alternative selection process, there were 17 alternatives detailed in the Draft EIS (H.W. Lochner 2015) that totaled 9,327 acres when excluding the selected corridor. Surveys of these alternatives did not locate any Michaux's Sumac.

Additionally, there have been ten NCDOT projects, seven bridge replacements and three roadway improvements, just in the past five years within the Complete 540 project FLUSA that have required Michaux's Sumac surveys, none of which found any individuals.

Based on the results of these surveys and the NCNHP natural heritage database search, there are no known documented occurrences of Michaux's Sumac within the proposed project alignment.

#### *5.1.4 General Threats to Michaux's Sumac*

Michaux's Sumac is threatened by fire suppression and ecological succession (competition/shading by woody species) that occurs in areas not managed on a regular basis, either through periodic burns, or mechanically managed, to mimic historic land usage. Additionally, forested populations are threatened by timber; and utility rights of way populations are threatened by herbicide use, ground disturbing activities, and mowing during critical growth periods. Multiple observations also suggest that limited seed production continues to be a problem for most populations (Dale Suiter, personal communication).

The greatest threat to Michaux's Sumac comes from the loss/degradation or modification of habitat from activities such as development (residential, commercial, or industrial), highway construction and improvement, and intensive and/or untimely maintenance of existing utility and roadside rights of way (USFWS 1993b). Other threats include low genetic diversity within the existing populations and hybridization with other species of *Rhus*.

### 5.1.5 *Roadway-Related Threats to Michaux's Sumac*

Roadway projects can result in direct and indirect effects. These potential effects are discussed within their respective sections below.

#### 5.1.5.1 Construction Effects

Construction related effects associated with roadway projects include, but are not limited to, land clearing and loss, degradation, and/or modification of habitat in the project corridor, in fill/borrow/spoil areas, and in construction staging/access areas outside of the project corridor. These effects can also occur from utility relocation and intensive maintenance of roadside and utility ROWs. Intensive maintenance includes herbicidal treatments, mowing, and ground disturbing activities, particularly during critical growth periods of the species.

#### 5.1.5.2 Operational Effects

Operation effects are associated with maintenance and daily vehicular use of the facility post construction.

#### 5.1.5.3 Induced Land Use Effects

Induced land use change as a result of roadway construction have the potential to indirectly effect Michaux's Sumac. This induced growth and development with limited or no proper planning programs along with unchecked development controls, has the potential to degrade suitable habitat for endangered plant species as a result of a proposed action.

#### 5.1.5.4 Potential Cumulative Effects

Cumulative effects are those effects of future state or private activities, not involving federal activities, which are reasonably certain to occur within the Action Area of the proposed federal action [50 CFR 402.02]. Cumulative effects within an action area may include foreseeable infrastructure projects independent of the federal action, such as water and sewer service expansion, which have the potential to stimulate land development and associated roadway improvements. Other small-scale adverse effects to plant species may also occur within the project Action Area. Though difficult to predict or quantify, other potential cumulative effects may also include mismanagement of the species or its habitat by private landowners (i.e. poor conservation maintenance or herbicide use); habitat degradation caused by traffic accidents occurring within roadside populations; private harvesting of the species for medicinal or otherwise personal use; or habitat impairment caused by emergency repair efforts within utility ROW.

## **6.0 EVALUATED EFFECTS OF PROPOSED ACTION ON MICHAUX’S SUMAC**

Potential effects to the Michaux’s Sumac and Michaux’s Sumac habitat discussed in Section 5.0 were evaluated with regard to this project. To determine the project effects on Michaux’s Sumac, effects with and without the proposed project (2040 Build vs. No-Build scenarios) were evaluated. The types of direct, indirect, and cumulative effects that were specifically evaluated for this project are discussed below.

### ***6.1 Construction Effects***

Based upon plant surveys completed in 2017, Michaux’s Sumac does not occur in the project footprint. Therefore, no effects are anticipated as a result of the construction aspects of the project.

### ***6.2 Operational Effects***

As stated in Section 5.1.3, Michaux’s Sumac does not occur in the project alignment. Highly maintained interstate facilities such as the Complete 540 project generally do not contain habitat that is suitable for Michaux’s Sumac; thus it is very unlikely that populations of this species would become established in the project ROW after construction is completed. As such maintenance activities associated with the operation of the facility are not expected to impact this species.

### ***6.3 Induced Land Development Effects***

The ICE Quantitative Memoranda (Baker Engineering 2017a-d) divided the 287,658-acre FLUSA into 16 land use categories and modeled the change in each category between the 2040 No-Build to Build scenarios (Table 13).

**Table 13. Projected FLUSA Land Use in Build and No-Build Scenarios (Baker Engineering 2017a-d)**

<b>Land Use Category</b>	<b>Build (ac)</b>	<b>No Build (ac)</b>	<b>Acreage Change</b>
Low Density Mixed Urban	12,248	11,518	-730
Medium Density Mixed Urban	5,293	5,251	-42
High Density Mixed Urban	11,009	10,706	-303
Low Density Residential	52,287	59,989	7,702
Medium Density Residential	100,494	92,431	-8,063
High Density Residential	2,028	2,014	-14
Turf/Golf	816	833	17
Hay/Pasture	2,336	2,434	98
Cropland	22,027	22,627	600
Forest	57,287	57,620	333
Mixed Forest	530	577	47
Deciduous Forest	139	151	12
Wetland	9,782	10,134	352
Emergent Wetland	7	6	-1
Bare Rock	50	51	1
Water	2,324	2,317	-7

As noted in Section 5.1.2, habitat for Michaux sumac is open sections of forests or lightly-maintained areas such as roadside shoulders or utility corridors. As such, there are no land use categories that well represent Michaux sumac habitat. Further, while there may be loss of habitat from the Forested land use categories, there may be an increase in habitat through creation of roadside margins and utility corridors associated with development land use categories.

For existing populations, there is currently no active management plan providing protection for EO# 16/ EO ID: 8079. However, it is along and within a NCDOT right-of-way. There is no plan to widen and/or improve this roadway. In the event that the road requires widening in the future, avoidance, minimization and protective measures will need to be considered during the project development and agency coordination phases. Therefore, induced land use effects resulting from the Complete 540 project to this population are not anticipated.

EO# 53/ EO ID: 3172 is part of the Longleaf Restoration Area of the Harris Research Tract in the Cape Fear River Basin. This tract is in private ownership and within an easement. Therefore, induced land use effects from the Complete 540 project to this population are not anticipated.

While changes in land use associated with the proposed project have the potential to affect the amount of suitable habitat for this species within the FLUSA portion of the Action Area (losses, or gains), the likelihood of adverse effects to unknown populations of this species are very low. Considering the overall change in land use, the Build Scenario results in just over 1,400 more acres of development than the No-Build. The 1,400 acres is approximately 0.5% of the 278,000 acre FLUSA portion of the Action Area. A very small percentage of the 1,400 acres is likely to contain potentially suitable habitat for this species, as the habitat requirements are very specific.

Further, while there is small percentage of hypothetically suitable habitat for this species, it is very unlikely that these areas currently support the species for the following reasons:

- 1) As detailed in Section 5.1.3, there have been numerous surveys within the FLUSA portion of the Action Area and there are only three known populations. The three known populations total approximately 4.75 acres of the 278,000 acre FLUSA.
- 2) The species is rare with a fragmented distribution; thus, there are few populations to serve as seed sources to colonize these areas.
- 3) The majority of suitable habitat that remains on the landscape is generally associated with periodically maintained roadside and utility corridors and thus more likely to have been detected in targeted surveys. Further, by occurring in more visible areas that are subject to higher human traffic, they are very likely to have been identified by random observation.
- 4) Given that this species has been federally protected since 1989 and the relatively large amount of growth within the FLUSA portion of the Action Area, infrastructure projects associated with this growth will have required Michaux's Sumac surveys which reduces the likelihood there are unknown populations.
- 5) Given the number of individuals familiar with Michaux's Sumac who work and live within the Action Area, it is a reasonable assumption that any unknown populations would have been identified.

#### **6.4 Conclusion of Effects – Michaux's Sumac**

##### *6.4.1 Construction Effects*

Based on NCNHP (2017) Natural Heritage EO data, as well as project study area surveys (NCDOT 2017), Michaux's Sumac does not occur within the proposed project alignment, ROW, or clearing limits. As such, construction effects to Michaux's Sumac are not anticipated.

##### *6.4.2 Operational Effects*

Based on this analysis, operational effects to the Michaux's Sumac are not anticipated.

##### *6.4.3 Induced Land Development Effects*

Based on this analysis, induced land development effects to the Michaux's Sumac are extremely unlikely to occur (discountable).

#### 6.4.4 Biological Conclusion

The project is not anticipated to have direct or indirect effects to Michaux's Sumac. Therefore, we concluded that the project **“May Affect, Not Likely to Adversely Affect”** this species based on discountable effects.

### 7.0 ENVIRONMENTAL BASELINE FOR CAPE FEAR SHINER

A portion of the southern extent of the FLUSA component of the Action Area encompasses the Neills Creek (also shown as Neals Creek) subwatershed of the Cape Fear River Basin. The Cape Fear Shiner is known from Neills Creek downstream of the FLUSA boundary; thus potential effects to this species were evaluated.

#### 7.1 Watershed Conditions Baseline

Neills Creek is referred to here as the Buies Creek-Cape Fear River subwatershed (HUC# 0303000405). This subwatershed starts in southeast Wake County and flows south into northeastern Harnett County. The baseline conditions of this subwatershed are presented in the following sections.

##### 7.1.1 Best Usage Classification

Table 14 lists the streams in the Action Area within the Upper Cape Fear River subbasin along with their Usage Classification and NCDWR Index number. These streams are depicted in Figure 3.

**Table 14. FLUSA Streams within the Buies Creek-Cape Fear River Subwatershed**

Stream Name	Usage Classification	DWR Index #
<b>Buies Creek-Cape Fear River (HUC# 0303000405)</b>		
Kenneth Creek	C	18-16-1-(1)
Neills Creek (Neals Creek)	C	18-16-(0.3)

##### 7.1.2 Impaired 303(d) Listing

The 303(d) Category 5 streams in the Buies Creek-Cape Fear River subwatershed portion of the FLUSA are listed in Table 15 along with details of the impairments, as shown in Figure 4.

**Table 15. Buies Creek-Cape Fear River Subwatershed Impaired (Category 5) Streams 2014.**

Stream	AU Number	Length/Area	Reason for Rating	Parameter (Year)
<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)

### 7.1.3 Point Source Pollution

There are no individual permitted discharges and three general permitted discharges in Buies Creek subwatershed (Table 16, Figure 5).

**Table 16. NPDES General Permitted Discharges within Buies Creek-Cape Fear River Subwatershed**

Stream	Permit	Facility
<b>Buies Creek-Cape Fear River (HUC# 0303000405)</b>		
Neills Creek (Neals Creek)	NCS000504	Town of Fuquay Varina MS4
Neills Creek (Neals Creek)	NCG050003	Tyco Electronics Corp
Neills Creek (Neals Creek)	NCG050340	National Foam Inc

### 7.1.4 Non-Point Source Pollution

Land cover for the Buies Creek-Cape Fear River subwatershed portions of the FLUSA is in Table 17 (Figure 6). Cultivated crops make up the greatest percent (18.63%) of land cover in this portion of the FLUSA, followed by herbaceous (13.62%), and evergreen forest (12.05%), with development area making up approximately 24.84% of the subwatershed (when high, medium, and low intensity and open space categories are combined). The effects of non-point pollution on aquatic species associated with human development and associated impervious surface area are discussed in Section 3.5.4

**Table 17. Land Cover in the Buies Creek-Cape Fear Subwatershed**

Land Cover	Sum of Area (Acres)	Percentage
Barren Land	16.1	0.11
Cultivated Crops	2681.1	18.63
Deciduous Forest	1597.0	11.10
Developed, High Intensity	66.6	0.46
Developed, Low Intensity	1408.8	9.79
Developed, Medium Intensity	381.6	2.65
Developed, Open Space	1717.5	11.94
Emergent Herbaceous Wetlands	73.3	0.51
Evergreen Forest	1734.1	12.05

**Table 17. Land Cover in the Buies Creek-Cape Fear Subwatershed (continued)**

Land Cover	Sum of Area (Acres)	Percentage
Hay/Pasture	750.2	5.21
Herbaceous	1959.8	13.62
Mixed Forest	891.9	6.20
Open Water	83.1	0.58
Shrub/Scrub	620.6	4.31
Woody Wetlands	406.5	2.83
<b>Grand Total</b>	<b>14388.0</b>	<b>100.00</b>

### 7.1.5 Ecological Significance

See Section 3.1.5 for more detail about the Natural Heritage Natural Areas. Within the Buies Creek-Cape Fear River Subwatershed, there are no designated NHNAs.

## 7.2 Cape Fear Shiner (*Notropis mekistocholas*)

Status: Endangered

Family: Cyprinidae

Listed: September 26, 1987

Critical Habitat: Designated, see Section 7.2.5

### 7.2.1 Species Characteristics



The Cape Fear Shiner is a small, moderately stocky Cyprinid described by Snelson (1971). The fish's body is flushed pale silvery yellow, with a black band running along the side. The fins are yellowish and somewhat pointed. The upper lip is black, and the lower lip bears a thin black bar along its margin.

The Cape Fear Shiner is distinguished from other *Notropis* by having an elongated alimentary tract with two convolutions crossing the intestinal bulb. This is believed to be an adaptation for herbivorous feeding, although the species is known to be omnivorous based on gut content analysis (Snelson 1971, USFWS 1988). This adaptation is believed to be useful in that when insectivorous fish populations are high and animal material is correspondingly low, the Cape Fear Shiner is able to thrive by shifting to herbivorous feeding habits (USFWS 2011).

The Cape Fear Shiner is usually found in low numbers in schools with other shiner species such as Highfin Shiner (*Notropis altipinnis*), Swallowtail Shiner (*Notropis procne*), White Shiner (*Luxilus albeolus*), Sandbar Shiner (*Notropis szepticus*), Spottail Shiner (*Notropis hudsonius*), Comely Shiner (*Notropis amoenus*), Satinfish Shiner (*Cyprinella analostana*), and Whitefin Shiner (*Cyprinella nivea*) (Pottern 2009).

### 7.2.2 Distribution and Habitat Requirements

The Cape Fear Shiner is most often found in rocky pools, runs, and riffles with substrates containing gravel, cobble, and/or boulder components. These areas are typical of streams in the Carolina Slatebelt and Raleigh Belt with wide, shallow sections, an open forest canopy, and abundant American Water Willow (*Justicia americana*), Riverweed (*Podostemum* sp.), stream mosses (*Fontinalis* sp.), and filamentous algae. The species may be found in lower-gradient sections of rivers with sand dominated substrate, but usually only in low numbers, presumably as they move between more rocky sections (Pottern 2009). Gravel substrate has been shown to be important for Cape Fear Shiner in feeding and spawning (USFWS 2011). In comparing shiner density with substrate type, Howard (2003) found low shiner density in areas with less gravel availability.

Endemic to the upper Cape Fear River Basin in the Central Piedmont region of North Carolina, Cape Fear Shiner occupies the tributaries and main-stems of the Cape Fear, Deep, Haw and Rocky Rivers in Chatham, Harnett, Lee, Moore, and Randolph counties. Specifically, the current known range extends from SR 1545 (Chicken Bridge Rd) of the Haw River in Chatham County and from Coleridge Dam on the Deep River in Randolph County downstream to Erwin on the main-stem Cape Fear River. Including major tributaries such as the Rocky River, this is a range of approximately 135 river miles (Pottern 2009). The lower five miles of the Rocky River and the Deep River between High Falls and Coleridge area are known to have the highest densities of the minnow. The species is known to occupy tributaries to these main-stem rivers, but is typically only found within two miles of the confluence (Pottern 2009).

What is known of the historical and current distribution of the Cape Fear Shiner was reviewed and summarized by Pottern (2009), as shown in Table 18.

Additionally, NCNHP has developed a database of Cape Fear Shiner occurrences, which it used to estimate the following viability rankings (or probability of persistence) (USFWS 2011).

- Deep River, stretching from High Falls Dam (Moore County) to Lockville Dam (Lee County), and Rocky River below the hydroelectric dam (Chatham County) = Excellent. This group of Cape Fear shiners is likely to persist for at least 20-30 years.
- Deep River, above High Falls Dam (Randolph and Moore Counties) = Good/Fair. This group of shiners may or may not persist in its current condition.
- Haw River (Chatham County) = Fair/Poor. This group of Cape Fear shiners may be at risk of extirpation in the foreseeable future; however, restoration is deemed feasible/plausible.
- Upper Cape Fear River, from Buckhorn Dam (Lee County) through Harnett County = Fair/Poor. This group of Cape Fear shiners may be at risk of extirpation in the foreseeable future; however, restoration is deemed feasible/plausible.

- Upper Rocky River, south of Siler City to the hydroelectric dam (Chatham County) = Possibly Extirpated. There is evidence that this group of shiners may no longer exist.

**Table 18. Cape Fear Shiner Relative Abundance\* by River Segment**

River Segment	Miles	1949-1983	1984-1986	1987-2006	2007-present
Haw River, Saxapahaw to Bynum Dam	17.4	None	None	Rare	Rare
Haw River, Bynum Dam to Jordan Lake	4.7	Rare	None	Rare	None
Haw River/ Roberson Creek to Jordan Lake Pool	4.9	Uncommon	None	None	None
Rocky River, Siler City to Rocky River Hydro	16.0	Common	Rare	None	None
Rocky River, Rocky River Hydro to Deep River	5.5	Common	Common	Common	Common
Deep River, Randleman to Coleridge Dam	21.6	None	None	None	None
Deep River, Coleridge to Highfalls Dam	18.9	None	Rare	Uncommon	Rare
Deep River, Highfalls to Carbonton	21.9	None	Rare	Uncommon	Common
Deep River, Carbonton to Rocky River	22.0	None	Uncommon	Uncommon	Uncommon
Deep River, Rocky River to Lockville Dam	3.5	None	Common	Common	Common
Deep River, Lockville Dam to US-1	0.3	None	Uncommon	Uncommon	Common
Cape Fear-Deep Haw confluence to Buckhorn Dam	12.7	None	None	None	None
Cape Fear River, Buckhorn to Lillington	14.0	Uncommon	Rare	None	None
Cape Fear River, Lillington to Erwin	11.5	None	None	None	Rare

Notes: \* Rare= average 1-4 collected, Uncommon=average 4-16 collected, Common=average 16+ collected

### 7.2.3 General Threats to Species

General threats to the Cape Fear Shiner are similar to those described for the DWM and Yellow Lance (Section 3.5). More specifically, three main conservation threats for the Cape Fear Shiner have been identified: (1) alteration of flow regimes; (2) pollution from anthropogenic sources; and (3) introduction of non-native predators (USFWS 2011). Additionally, the restricted range and small population sizes make this species vulnerable to catastrophic events (USFWS 1988). 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.

Habitat alteration resulting from multiple dam construction projects in the Cape Fear system is likely the most significant factor that contributed to the species decline (USFWS 1988). Upper Cape Fear River Basin dams alter flows and sediment transport and impound key habitat elements critical to the Cape Fear Shiner. These impoundments fragment the species' population and limit genetic exchange, which can increase vulnerability to catastrophic events (USFWS 2011).

Water quality has been identified by Howard (2003) to be a limiting factor for Cape Fear Shiner. Caged shiners in the Haw River saw significant reduction in survival and growth, which was associated with higher concentrations of metals (cadmium, copper, zinc, mercury, lead) and organic contaminants (PAH, PCB, DDT, chlordane) in tested tissues as well as in Haw River

water and sediments. Sedimentation resulting from poor agricultural practices or construction projects threatens habitat by smothering key rocky substrates or submerged aquatic vegetation areas.

New predator species introductions could negatively affect the Cape Fear Shiner. Hewitt et al. (2009) noted introductions of Roanoke Bass (*Ambloplites cavifrons*) and Flathead Catfish (*Pylodictis olivaris*) into the upper Cape Fear River Basin could result in a decline of the Cape Fear Shiner within its range.

#### 7.2.4 Roadway Related Threats to Cape Fear Shiner

Roadway related threats on the Cape Fear Shiner are similar to those described for the DWM and Yellow Lance (Section 3.6).

#### 7.2.5 Designated Critical Habitat

In accordance with Section 4 of the ESA, Critical Habitat for listed species consists of:

- (1) The specific areas within the geographical area occupied by the species at the time it is listed, in which are found those physical or biological features (constituent elements) that are:
  - a. essential to the conservation of the species, and
  - b. which may require special management considerations or protection
- (2) Specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of Section 4 of the Act, upon a determination by the Secretary that such areas are “essential for the conservation of the species.”

On 25 September 1987, USFWS listed the Cape Fear Shiner as an endangered species under the Endangered Species Act. Critical habitat designation provided at that time (CFR Vol. 52 No. 186) consists of the following:

- Approximately 4.1 miles of the Rocky River, from NC State Highway 902 Bridge downstream to Chatham County Road 1010 Bridge (Chatham County).
- Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River in Chatham County. From there the critical habitat area flows downstream approximately 4.2 river miles along the Rocky River (Chatham County). At the confluence of the Rocky and Deep Rivers, the critical habitat area extends downstream approximately 2.6 river miles on the Deep River. It ends at a location 0.3 river mile below the U.S. Geological Survey Gauging Station in Moncure, NC in Chatham County.
- Approximately 1.5 river miles of Fork Creek, flowing from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge and downstream to where the creek meets the Deep River (Randolph County). From there, the critical habitat area extends

downstream approximately 4.1 river miles along the Deep River in Randolph and Moore Counties to a point 2.5 river miles below Moore County Road 1456 Bridge.

Since the listing of the species, the area of known occupied habitat for the Cape Fear Shiner has significantly expanded through restoration activities such as the removal of the Carbonton Dam on the Deep River and updated survey efforts (Catena 2006a, 2006b, 2007, 2009, 2010).

#### *7.2.6 Presence in Action Area*

The NCNHP database was searched for known populations, or EOs, within the Action Area. The NCNHP records indicated one historical occurrence of Cape Fear Shiner (EO ID# 23981) within the extreme southern portion of the FLUSA within the Neills Creek subwatershed (Figure 14).

### **8.0 EVALUATED EFFECTS OF PROPOSED ACTION ON CAPE FEAR SHINER**

As detailed in Section 7.2.2, the Cape Fear Shiner occurs only within the Cape Fear River Basin. Given that the Complete 540 alignment occurs within the Neuse River Basin, there will be no Construction related, or Operation related effects to this species. Therefore, it was determined that the only potential effects would be indirect in the form of water quality and habitat effects associated with induced land development.

#### ***8.1 Induced Land Development***

As discussed in Section 4.3, roadway construction can influence land use and result in development that would not occur without the road (induced development). While land development itself does not affect aquatic species like the Cape Fear Shiner and its habitat, increases in sediment loads and various pollutants, alterations in flow regime (base flow and peak discharge), and loss of riparian buffers are consequences of development that lead to water quality degradation. How these consequences of land development affect water quality and ultimately freshwater mussels, as well as fish species like the Cape Fear Shiner, is discussed in Section 3.5.4 of this report.

Baker Engineering (2017a-d) completed a Quantitative Indirect and Cumulative Effects (ICE) Report of the Complete 540 Project using a methodology to forecast land use changes between the base year of 2011 and design year 2040. This Quantitative ICE report utilized much of the information in the Qualitative ICE Report (H.W. Lochner 2014). As was projected in the Qualitative ICE Report and confirmed and quantified in the Quantitative ICE Report, the introduction of a high-speed, controlled-access roadway into the FLUSA would provide a faster and more direct route to employment and commercial centers in the region. Further, the primary changes in land development from the No-Build to Build are higher land use densities, more commercial and industrial development, and a greater mix of uses in the areas surrounding the

interchanges. Though this pattern is captured in the model results, it is noted: “Without the project, there would be both less development overall and lower densities of development in the FLUSA”.

However, for all parameters modeled in the ICE in the Cape Fear watershed, the change from No-Build to Build is equal to or less than 1%, except for total phosphorous in Hector Creek Watershed, which is 2%. As such, induced land development attributable to the construction of Complete 540 is insignificant.

### *8.1.1 Conclusion of Effects – Cape Fear Shiner*

The project will have no construction or operation related effects in the Cape Fear Watershed. Induced land development effects will be insignificant. While a portion of the Neills Creek subwatershed occur within the FLUSA, the species has not been found in Neills Creek since it was first observed in December 1986 despite numerous targeted surveys (USFWS 2017b, NCWRC Unpublished Aquatics Species Database) and is considered to no longer occur in the subwatershed. Therefore, it is concluded that the project “**May Affect, Not Likely to Adversely Affect**” the Cape Fear Shiner. Furthermore, since project induced land development effects in the Cape Fear Watershed are anticipated to be insignificant, the project will not prohibit the watershed to become occupied in the future through natural recolonization, or active reintroduction.

## **9.0 FEDERALLY LISTED SPECIES NOT WITHIN ACTION AREA**

The official species list for this project was based on federally listed species potential in all of Wake, Johnston, and Harnett Counties. The Action Area for the project is a smaller area than those counties’ limits. Given this, some of the species on the official species list are outside the Action Area and the project will have no effect on those species. This section discusses the characteristics and current status of the other six federally protected species (Table 1) throughout their ranges.

### **9.1 *Bald Eagle (Haliaeetus leucocephalus)***

Bald Eagle is no longer federally listed under the ESA. While Bald Eagle is still afforded protection under the Bald and Golden Eagle Protection Act, Section 7 consultation is not required.

### **9.2 *Rough-leaved Loosestrife (Lysimachia asperulaefolia)***

Status: Endangered  
Family: Primulaceae  
Listed: June 12, 1987

Critical Habitat: Not designated

### 9.2.1 *Species Characteristics*

This perennial herb, which has slender stems, grows from a rhizome to a height of 12 to 24 inches. The whorled leaves encircle the stem at intervals below the showy yellow flowers, and usually occur in threes or fours. Flowers are borne in terminal racemes of five petaled flowers. Flowering occurs between late May and early June. Fruits are present from July through October.

### 9.2.2 *Distribution and Habitat Requirements*

Rough-leaved Loosestrife, endemic to the Coastal Plain and Sandhills of North and South Carolina, occurs in the ecotones or edges between longleaf pine uplands and pond pine pocosins (areas of dense shrub and vine growth usually on a wet, peaty, poorly drained soil), on moist to seasonally saturated sands and on shallow organic soils overlaying sand. It has also been found to occur on deep peat in the low shrub community of large Carolina bays (shallow, elliptical, poorly drained depressions of unknown origins). It occurs in fire maintained areas and is rarely associated with hardwood stands; acidic soils are preferred (USFWS 1995). In North Carolina, Rough-leaved Loosestrife is known to occur in Beaufort, Bladen, Brunswick, Carteret, Cumberland, Harnett, Hoke, New Hanover, Onslow, Pamlico, Pender, Richmond and Scotland counties. The Richmond County population is thought to be extirpated.

### 9.2.3 *General Threats to Species*

Threats to this species include urban development, conversion of land to agriculture and silviculture, associated drainage, and fire suppression, which reduce this species' habitat.

### 9.2.4 *Presence in Action Area*

The southern limits of the FLUSA extend into northern Harnett County, where this species is known to occur. This portion of Harnett County is within the Piedmont Physiographic Province. The NCNHP database was searched for known populations, or EOs, within the Action Area and none were found. Occurrences of this species within Harnett County are in the very southern portion of the county in the Sandhills region (Figure 15).

### 9.2.5 *Conclusion of Effects – Rough-leaved Loosestrife*

Since there will be no direct or indirect effects in any areas known to support Rough-leaved Loosestrife and the lack of EO records within or near the FLUSA, the project will have **“No Effect”** on this species.

### 9.3 *Tar River Spiny mussel (Parvaspina steinstansana)*

Status: Endangered

Family: Unionidae

Listed: July 29, 1985

Critical Habitat: Not designated

#### 9.3.1 *Species Characteristics*



The TSM grows to a maximum length of 60 millimeters. Short spines are arranged in a radial row anterior to the posterior ridge on one valve and symmetrical to the other valve. The shell is generally smooth in texture with as many as 12 spines that project perpendicularly from the surface and curve slightly ventrally. However, adult specimens tend to lose their spines as they mature (USFWS 1992a). The smooth, orange-brown to dark brown periostracum may be rayed in younger individuals. The shell is significantly thicker toward the anterior end, and the nacre is usually pink in this area. The posterior end of the shell is thinner with an iridescent bluish white color. Two or more linear ridges, originating within the beak cavity and extending to the ventral margin, can be found on the interior surface of the shell. The distance between these ridges widens toward the ventral margin. Johnson and Clarke (1983) provide additional descriptive material.

#### 9.3.2 *Distribution and Habitat Requirements*

Previously this mussel was believed to be endemic to the Tar River system and probably ranged throughout most of the Tar River Drainage Basin before the area was settled during the 1700s (NC Scientific Council on Mollusks 2011). Historically, the TSM was collected in the Tar River from near Louisburg in Franklin County to Falkland in Pitt County (approximately 78 river miles). By the mid-1960s, its known range had been reduced to the main channel of the Tar River from Spring Hope in Nash County to Falkland in Pitt County (Shelley 1972, Clarke 1983). By the early 1980s, its range in the Tar River was restricted to only 12 miles of the river in Edgecombe County (Clarke 1983). The species was last observed (two individuals) in the river in 2001 within an extensive sandbar habitat in Edgecombe County (NCWRC Unpublished Aquatics Species Database). It is currently found in three streams, Shocco, Sandy/Swift and Fishing/Little Fishing creeks in the Tar River Basin (NCWRC Unpublished Aquatics Species Database). In 1998, the species was found in Johnston County in the Little River, a tributary to the Neuse River. Only a few individuals have been found in the Little River in subsequent years (unpublished data, NCWRC Aquatics Database). This species was last observed September 2011 in the Little River site (NCNHP 2017).

### 9.3.3 *General Threats to Species*

Threats to TSM are similar to those described in Section 3.5 for the DWM and Yellow Lance.

### 9.3.4 *Presence in Action Area*

TSM has not been found in the Action Area (Figure 16).

### 9.3.5 *Conclusion of Effects – Tar Spinymussel*

TSM has not been found in the Action Area (Figure 16); therefore, it can be concluded that project construction will have “**No Effect**” on this species.

## 9.4 *Red-cockaded Woodpecker (Picoides borealis)*

Status: Endangered

Family: Picidae

Listed: October 13, 1970

Critical Habitat: Not designated

### 9.4.1 *Species Characteristics*

The Red-cockaded Woodpecker (RCW) is a small bird measuring about 7 inches in length. Identifiable by its white cheek patch and black and white barred back, the males have a few red feathers, or "cockade." These red feathers usually remain hidden underneath black feathers between the black crown and white cheek patch unless the male is disturbed or excited. Female RCWs lack the red cockade. Juvenile males have a red 'patch' in the center of their black crown. This patch disappears during the fall of their first year at which time their 'red-cockades' appear (USFWS 2003).

### 9.4.2 *Distribution and Habitat*

RCWs were once considered common throughout the longleaf pine ecosystem, which covered approximately 90 million acres before European settlement. Historical population estimates are 1 to 1.6 million "groups," the family unit of RCWs. The birds inhabited the open pine forests of the southeast from New Jersey, Maryland, and Virginia to Florida, west to Texas and north to portions of Oklahoma, Missouri, Tennessee and Kentucky. The longleaf pine ecosystem initially disappeared from much of its original range because of early (1700's) European settlement, widespread commercial timber harvesting and the naval stores/turpentine industry (1800's). Early to mid-1900 commercial tree farming, urbanization and agriculture contributed to further declines. Much of the current habitat is also very different in quality from historical pine forests in which RCWs evolved. Today, many southern pine forests are young and an absence of fire has created a dense pine/hardwood forest (USFWS 2003).

For nesting and roosting habitat, RCWs need open stands of pine containing trees 60 years old and older, depending on species of pine. RCWs need live, large older pines in which to excavate their cavities. Longleaf pines (*Pinus palustris*) are preferred, but other species of southern pine are also acceptable. Dense stands (stands that are primarily hardwoods, or that have a dense hardwood understory) are avoided. Foraging habitat is provided in pine and pine hardwood stands 30 years old or older with foraging preference for pine trees 10 inches or larger in diameter. In good, moderately-stocked, pine habitat, sufficient foraging substrate can be provided on 80 to 125 acres (USFWS 2003).

Roosting cavities are excavated in living pines, and usually in those that are infected with a fungus known as red-heart disease. The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Completed cavities that are being actively used have numerous, small resin wells which exude sap. The birds keep the sap flowing as a cavity defense mechanism against rat snakes and other tree climbing predators (USFWS 2003).

Hardwood mid-story encroachment results in cluster abandonment; therefore, it is critical that hardwood mid-story be controlled. Prescribed burning is the most efficient and ecologically beneficial method to accomplish hardwood mid-story control. (USFWS 2003)

#### 9.4.3 *General Threats to Species*

The loss of suitable habitat has caused the number of RCWs to decline by approximately 99 percent since the time of European settlement. The primary habitat of the RCW, the longleaf pine ecosystem, has been reduced to 3 percent of its original expanse. Many RCW populations were stabilized during the 1990s due to management based on new understanding of RCW biology and population dynamics. However, there are still populations in decline and small populations throughout the species' current range are still in danger of extirpation (USFWS 2003).

#### 9.4.4 *Presence in Action Area*

To determine presence of the species within the Action Area, the NCNHP database was searched for EOs, suitable habitat was evaluated, and presence/absence surveys were conducted. Species surveys were conducted within the project alignment and vicinity by Mulkey Engineers and Consultants in May 2014 (Mark Mickley, personal communication).

The NCNHP records indicate one known occurrence (EO ID: 15047) of RCW within the Action Area (Figure 17). The record was first and last observed in 1977 in the Lake Myra area and is considered historic. There are several other historical EOs in the vicinity. The closest current EOs are approximately 12 miles outside of the FLUSA: one west in Chatham County on Jordan

Lake (John Hammond, personal communication); and one east in Johnston County west of Smithfield (NCNHP 2017).

9.4.5 Conclusion of Effects - Red-cockaded Woodpecker

Based on the (EO ID: 15047) being considered historical, and the results of the surveys within the project alignment, it appears that the RCW no longer occurs within the Action Area. It can be concluded that the project will have “**No Effect**” on this species.

**10.0 DETERMINATION OF EFFECTS**

FHWA has made the following determinations for federally listed and proposed species under the ESA for the Complete 540 project (Table 19).

**Table 19. Determination of Effects On Federally Listed Species**

Scientific Name	Common Name	Status	County	Present in Action Area	Determination of Effect
<i>Alasmidonta heterodon</i>	Dwarf Wedgemussel	E	W, J	Yes	LAA
<i>Elliptio lanceolata</i>	Yellow Lance	Proposed	W, J	Yes	LAA
<i>Lysimachia asperulaefolia</i>	Rough-leaved Loosestrife	E	H	No	No Effect
<i>Notropis mekistocholas</i>	Cape Fear Shiner	E	H	No*	NLAA
<i>Parvaspina steinstansana</i>	Tar River Spiny mussel	E	J	No	No Effect
<i>Picoides borealis</i>	Red-cockaded Woodpecker	E	W, J, H	No	No Effect
<i>Rhus michauxii</i>	Michaux’s Sumac	E	W, J	Yes	NLAA

Notes: T – Threatened, E – Endangered, W – Wake, J- Johnston, H – Harnett, LAA –Likely to Adversely Affect; NLAA –Not Likely to Adversely Affect; \* No longer present in Neills Watershed

FHWA has determined that the project will likely adversely affect the Dwarf Wedgemussel and the Yellow Lance mussel. FHWA has determined the project may affect but is not likely to adversely affect the Cape Fear Shiner and Michaux’s Sumac based on insignificant and discountable effects.

FHWA is consulting with the National Marine Fisheries Service regarding the Atlantic Sturgeon and Atlantic Sturgeon critical habitat for the Complete 540 project. The biological assessment for the Atlantic sturgeon and designated critical is contained in a separate document.

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