Management of Protected Freshwater Mussels With Regard to North Carolina Department of Transportation Highway Projects

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Abstract

No other faunal group in North America is as critically imperiled as the freshwater mussels (Unionacea). Five federally protected mussel species occur in North Carolina. These mussels have accounted for 35% of the Section 7 Consultations that the North Carolina Department of Transportation (NCDOT) has been involved with. The NCDOT has developed a management strategy to ensure that concerns with protected mussels are resolved early in the planning process, so that project schedules are met, and the mussel resource is not compromised. Protective and conservation measures that were taken on four NCDOT projects that have involved protected mussels are are highlighted.

Introduction

The freshwater mussel fauna (Unionacea) of North America (the richest in the world) consists of approximately 297 species and subspecies (Turgeon et al. 1988), with much of the higher classification of taxa still unresolved. The greatest species diversity occurs in the southeastern United States, in the Ohio, Tennessee, Cumberland, and Mobile drainages, as well as other rivers to the Gulf of Mexico and South Atlantic (Neves 1993). In terms of biomass, freshwater mussels (naides) were collectively the most abundant organisms in many aquatic habitats during previous centuries (Alderman 1993). Ecologically they are significant as biofilters of contaminants, sediments and nutrients, as well as providing an important food source for numerous aquatic and terrestrial animals (Alderman 1993, Biggins et al. 1995).

Freshwater mussels have been utilized by Native Americans for centuries, as supplemental food sources (Call and Robinson 1983) and for jewelry (Biggins et al. 1995, Fassler 1997). There is a long history of economic exploitation of naides in North America, beginning with the pearl button industry of the late 19th and early 20th century and more recently with the cultured-pearl industry. In 1916, the peak year in button production, the product value was estimated at $12.5 million dollars (Fassler 1997). With the advent of the plastic button in the 1940s, along with Japanese competition, demand for American pearl-buttons gradually diminished, and fortunately for the resource so did the harvesting pressures. More recently, mussel shells from North America have been processed into beads and used as nuclei in the Japanese cultured pearl industry. The annual value of the North American shells has been between $40 to $50 million dollars (Biggins et al. 1995).

The cumulative effects of the modification of aquatic habitats through impoundments, channelization and dredging, along with sedimentation and water pollution has resulted in dramatic declines of the North American naiad fauna in this century (Neves 1993). Williams et al. (1992) considers 72 % of the fauna to be extinct, endangered, threatened, or of special concern and only 24 % as stable. The US Fish and Wildlife Service (FWS) currently categorizes this fauna as 6% extinct, 19% listed as endangered or threatened and 23% are candidates for protection (Biggins et al. 1995). The vulnerability of this faunal group to anthropogenic impacts such as these has been attributed to ecological and biological traits such as reproductive and feeding strategies (Neves 1993). "No other widespread group of animals in North America approaches this level of faunal collapse" (Biggins et al. 1995).

The introduction of exotic species such as the Asiatic clam (*Corbicula fluminea*) and zebra mussel (*Dreissena polymorpha*) has also been shown to pose significant threats to native freshwater mussels. The Asiatic clam is now established in most of the major river systems in the United States (Fuller and Powell 1973). 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 1997).

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). Zebra mussels attach to almost any solid substrate, including freshwater mussel shells, with a byssus or tuft of byssal threads (Mackie 1991). The adverse affects of zebra mussels on native unionids have been summarized by Schloesser and Kovalak (1991) and include interference with valve closure and opening, impairment of burrowing, competition for food resources, creation of anaerobic conditions near the mussel, and production of toxic metabolic wastes. The zebra mussel 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 1992).

Approximately 60 recognized freshwater mussel species are documented from North Carolina waters. Of these, 67% are considered to be in some degree of peril (Legrand and Hall 1997). No other faunal group in North Carolina has such a high percentage of species on the rare list (Table 1).

Table 1
Number of Animal species in North Carolina (as of March 31, 1997) Taken from Legrand and Hall 1997)

Group	Total # Species (approx. #)	# Species --State Protected (E,T,SC)	# Species -- Rare List (E,T,SC,SR,Other)	% on State Prot. List	% on Rare List
Mammals	120	20	28	17	23
Birds	200 (420)*	24	53	12	26
Reptiles	70	15	20	21	28
Amphibians	80	16	20	20	25
Freshwater Fishes	245	48	58	20	24
Freshwater Bivalves	60	33	40	55	67
Freshwater and Terrestrial Gastropods	250	36	40	14	16
Crayfishes	35	0	9	0	26
Dragonflies	135	0	39	0	29
Butterflies	160	0	38	0	24
Macro-moths	1000+	0	65	0	6.5

** The number in parentheses is the total number reported in the state; the smaller number is the estimated number of breeding species, which is used in the calculations of the percentages.*

Five freshwater mussel species found in NC currently receive federal protection under the Endangered species Act (ESA) in North Carolina. Two of these species, the Endangered little-wing pearly mussel (*Pegias fabula*) and the Threatened Appalachian elktoe (*Alasmidonta raveneliana*) occur within the Ohio River Basin drainage, while the other three, the Carolina heelsplitter (*Lasmigona decorata*), dwarf-wedge mussel (*Alasmidonta heterodon*) and the Tar River spiny-mussel (*Elliptio steinstansana*), all of which are Endangered, occur in Atlantic Slope drainages.

A total of 26 plant and 36 animal species that are protected under the Endangered Species Act of 1973, (ESA) are known to occur in North Carolina. The procedural regulations governing interagency cooperation (consultation process) under Section 7 of the ESA were established by a joint rule (50 CFR Part 402) between the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) on June 03, 1986. Since this time, NCDOT has completed, or is in the process of completing approximately 69 consultations with the FWS and 6 with NMFS. The five species of freshwater mussels have accounted for 26 or 35% of these consultations. The large number of consultations involving freshwater mussels can be equally attributed to two factors; an aggressive statewide bridge replacement program and to the fact that the distribution of two of these species, Carolina heelsplitter and dwarf-wedge mussel occur respectively within close proximites of two rapidly developing metropolitan areas of the state, Charlotte and the Triangle (Raleigh/Durham/Chapel Hill). Twenty four other NCDOT consultations have also involved aquatic species, mainly the Cape Fear shiner (*Notropis mekistocholas*) and shortnose sturgeon (*Acipenser brvirostrum*). This large number of consultations involving aquatic species is also a reflection of the condition of the water resources of the state.

Since the passage of the North Carolina Highway Trust Fund in 1989 and subsequent $950 million dollar bond referendum in 1996, there has been a very high volume of transportation projects undertaken throughout the state. One of the major goals of this highway initiative provided for accelerated schedules and the addition of major economic development highways and other major projects, such as urban loops, intrastate routes and secondary road improvements (North Carolina 2001 Transportation Improvement Program 1997). Another important aspect of the NCDOT transportation initiative is the North Carolina Bridge Replacement Program, part of the Federally funded Highway Bridge Replacement and Rehabilitation Program (HBRRP). This program funds the replacement of deficient or functionally obsolete bridges throughout the state highway system. The state of North Carolina has an extensive system of state maintained roads and highways (over 77,000 miles) that include over 16,000 bridges. At current funding levels the bridge program allows the replacement of about 100 bridges per year.

Protocols for Managing Protected Mussels

With the large number of projects that involved listed mussel species, it became imperative for NCDOT to develop a management strategy to resolve mussel concerns so that project schedules are met, without compromising the resource. This involves first determining presence/abscence of a listed mussel species within a particular project area, and then if present, developing measures that avoid, minimize, or lastly, offset impacts (mitigation). Direct, secondary and cumulative impacts are considered for each project.

Establishing Presence/Absence of Listed Mussels in Project Area

During routine natural resources studies for NEPA documentation, information sources are consulted to determine if the proposed project will impact any listed species. Sources consulted include the North Carolina Natural Heritage Program (NHP) database of rare plant and animal species and the US Fish and Wildlife Service (FWS), designated Critical Habitats for those species listed by the FWS to occur in the project County. Additionally, the North Carolina Wildlife Resources Commission (WRC) has identified 25 areas in North Carolina that have formally been proposed as aquatic Critical Habitats (PCH). These habitats are considered essential for the continued survival of endangered or threatened aquatic wildlife species. Certain conservation procedures, such as high quality waters (HQW) designation and protection, are then established by the state regulatory agencies (Alderman et al. 1993). Presently the WRC is not allowed to designate areas as Critical Habitat; however NCDOT uses the areas that have been identified as PCHs for guidance in determining if a project will impact a federally listed aquatic species. NCDOT implements HQW standards in waters identified as PCHs that contain federally listed species. If projects occur within a federal Critical Habitat, known location or a PCH for a listed mussel species, the Section 7 consultation process is initiated.

If a project does not occur near a known population, and is not within a PCH for a listed mussel species, then the sequence of examining suitability of habitat, followed by stream reconnaissance for the presence of mussel fauna, and finally a particular survey for the target species by a licensed person (FWS and WRC Endangered

Species Collection Permit) is followed. If suitable habitat, mussel fauna, or the target species is not present during each of the successive steps, than a conclusion of No Effect is rendered. If the species is found to be present than the Section 7 Consultation process is initiated.

Direct Impacts

Direct impacts refer to consequences that are directly attributed to the construction of the project, such as land clearing, stream rechannelization and erosion. Potential direct impacts to mussels associated with transportation projects include; siltation, substrate disturbance and introduction of toxic compounds.

Siltation resulting from improper erosion control of various land usage, including agricultural, forestry and development activities 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 1 inch have been shown to cause high mortality in most mussel species (Ellis 1936). In Massachusetts, a bridge construction project decimated a population of dwarf-wedge mussel, because of accelerated sedimentation and erosion (Smith 1981).

Numerous pollutants have been identified in highway runoff, including various metals (lead, zinc, iron etc.), sediment, pesticides, deicing salts, nutrients (nitrogen, phosphorus) and petroleum hydrocarbons (Gupta et al. 1981). The sources of these runoff constituents range from construction and maintenance activities, to daily vehicular use. The toxicity of highway runoff to aquatic ecosystems is poorly understood. A major reason for this poor understanding, is a lack of studies on highway runoff alone. Potential impacts of highway runoff have 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 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). Unfortunately, these studies only measured acute toxicity to runoff and did not examine long-term impacts.

The effects of highway runoff on freshwater bivalves have not been studied. The North Carolina Mussel Research Program, which consists of representatives from various federal and state conservation and regulatory agencies, academia and NCDOT, identified this issue as a major research need.

Bridge construction activities such as causeway construction, bridge pilling installation and bridge removal result in disturbances to the existing substrate of the water body crossed. If mussel beds are present in the substrate where this activity is to occur, mortality to those mussels, or "take" (as defined by the ESA) will occur without some type of mitigative measures.

Secondary and Cumulative Impacts

Secondary impacts are not direct consequences of the road construction, but result from modifications in access to parcels of land and from modifications in travel time between various areas (Mulligan and Horowitz 1986). They are defined as those impacts that are "caused by an action and are later in time or farther removed in distance but are still reasonably foreseeable" (40CFR 1508.8). Secondary land use impacts have included residential, commercial and industrial developments, or urban sprawl. Cumulative impacts are those that result from "the incremental impacts of an action when added to other past and reasonable foreseeable future actions" (40CFR 1058.7).

Economic development is often used as a criterion in highway funding (Eagle and Stephanedes 1987). Historically, transportation has been viewed as a necessary precursor to economic development (Anderson et al. 1992), and transportation infrastructure is "one of the principle policy levers that state and local governments can use to increase their attractiveness to business investors" (Forkenbrock 1990). Beltway projects around metropolitan areas have been extensively studied with regard to economic impacts. Beltways have contributed to the conversion of undeveloped land to urban usage, by promoting net new growth as well as redistributing growth from already urbanized areas (USDOT and USHUD 1980, Lathrop and Cook 1990, Transportation Research Board 1995). Lathrop and Cook (1990) concluded that beltways "permit and encourage" intensified land usage in the formerly remote areas around beltways, which are attractive to development because of the gained accessibility and lower cost of property. Communities near interchanges are particularly affected by this type of development (Gamble et al. 1966). Beltways have also been shown to foster development in environmentally sensitive areas such as aquifer recharge locations (USDOT and USHUD 1980). The existing beltline facility constructed around the city of Raleigh has been a significant factor in determining the locations of residential, commercial and industrial developments, as well as contributing to increased land values (Khasnabis et al. 1975).

Mitigative Measures Implemented by NCDOT With Projects Involving Mussels

In developing management protocols for projects that have the potential to impact a listed mussel species, it became apparent that because of various conditions inherent with each individual project (topography, stream width etc.) only a few standard mitigative measures could be developed. The following measures are used on all projects involving listed mussels. The ultimate goal of these measures and additional measures that may be developed through the Section 7 process, is to avoid a resulting adverse impact, and thus avoiding formal consultation. Of the 26 projects that have involved Section 7 consultations concerning freshwater mussels, only two have required formal consultation (resulted in take).

Standard Measures

1). The use of High Quality Waters (HQW) Erosion Control standards. The NCDOT in cooperation with the North Carolina Department of Environment Health and Natural Resources (DEHNR), has developed a sedimentation control program for highway projects which adopts formal Best Management Practices (BMPs) for protection of surface waters. The Sedimentation and Erosion Control Program (SECP) established and authorized under the Sedimentation Pollution Control Act of 1973, requires prior to construction, the submission and approval of erosion control plans on all projects disturbing one or more acres. The responsibility of administration and enforcement of the act is with the Division of Land Resources (DLR) (Land Quality Section) of the DEHNR. On-site inspections by the DLR are conducted to determine compliance with the plan and to evaluate the effectiveness of the BMPs which are being used. In areas that have been designated by the DEHNR as HQWs, erosion control standards are more stringent (Design standards in Sensitive Watersheds; NCAC T15A: 04B.0000). NCDOT treats all waterbodies that contain protected aquatic species as HQW waters, regardless of the DEHNR waterbody classification. HQW erosion control devices are designed for the 25-year storm event, and as a general rule are approximately 25 % larger than standard devices.

2). Elimination of Direct Discharge from Bridge Deck Drainage into the Water Body. To minimize the potential impacts of highway runoff to mussels, NCDOT generally attempts to locate bridge drainage outlets only on approach spans and not over the waterbody. The discharge is directed through a filtering device (erosion control stone) on land before entering the stream. Safety concerns may necessitate the use of direct drainage in some instances.

3). Participation of Resource Agencies in the Pre-construction Meeting. Prior to beginning of construction NCDOT personnel meet with the contractor that is doing the particular project, to review the design and construction specifications, and also to go over any special provisions that need to be addressed. Representatives from the US Fish and Wildlife Service (FWS) and the NC Wildlife Resources Commission (WRC) are invited to attend these meetings for projects that occur in areas that contain listed species. This allows the resource agency representatives to meet with the contractor and stress the importance of special measures that were agreed to during the planning stages of a project. The resource agency representatives are also given the opportunity to make unannounced visits to the construction site, to determine if the provisions are being followed, as well as to assess the effectiveness of the measures taken.

Project Specific Measures

Aside from the three measures described above that apply to all projects with mussel concerns, it became evident that projects need to be evaluated on a case-by-case basis to determine which protective measures can be applied. Through discussions with the appropriate agencies, it may be determined that the population occurs far enough away from the proposed action that with the above mentioned standards, a Biological Conclusion of Not Likely to Adversely Affect would be warranted and Section 7 requirements satisfied. In many cases however, a site meeting and other special provisions, which are developed during the meeting, are required. These include specifications on demolition of existing structures, construction methods, and time of year certain activities can occur. The following four projects illustrate the various mitigative measures that have been taken by NCDOT with regard to protected mussels.

Bridge Replacement Over Crooked Creek; Franklin County

Project Description

This project involved a bridge replacement on SR 1001 over Crooked Creek, in Franklin County. The federally Endangered dwarf-wedge mussel (*Alasmidonta heterodon*) (DWM) is known to occur in Crooked Creek, mostly in the vicinity of the bridge. The proposed action was to replace the bridge with a new structure on existing location with road closure. Traffic was detoured on secondary roads. Crooked Creek is small, approximately 15 feet wide and 2 feet deep at the crossing. Because of the existing vertical alignment (bridge occurred at the bottom of two hills), the road grade needed to be elevated approximately 17 feet, to meet current design safety standards for secondary roads.

Potential Impacts to DWM

With such a large amount of fill material needed to raise road-bed, coupled with the small size of Crooked Creek and the proximity of DWM to the project, the potential for significant erosion and thus, an adverse impact to the population was high. Additionally, because of the close proximity of DWM to the bridge site, disturbance of the substrate may also have led to an adverse impact. In order for NCDOT to avoid a "take" to this population, measures needed to be made that would eliminate the potential impacts associated with erosion and substrate disturbance.

Special Project Commitments

Through a number of Section 7 meetings, special measures were adopted that avoided causing an adverse impact to the DWM, and thus avoided a formal Section 7 consultation. In addition to the standard provisions described earlier, NCDOT committed to the following:

The existing timber piles were cut off at stream level using a crane and bucket to lower one construction worker down to the stream level. The construction worker then used a hydraulic saw to cut off the timber piles without affecting the stream substrate.

No debris from the demolition of the existing bridge was allowed to reach the stream.

The drilled shaft method was utilized when constructing bridge piles in the stream. With this method, the drill mechanism is enclosed in a metal sheath. All of the slurry produced from the drilling is contained within the shaft and pumped out into a settling basin on land. A turbidity curtain was placed in the creek surrounding this activity. A preconstruction survey for the DWM was conducted in the exact location of the bridge piles. Fortunately no DWM were found in these locations. If any DWM had been located, relocation efforts would have had to have been made, which would require a formal consultation with the FWS.

The Roadside Environmental Unit of NCDOT monitored suspended solids, turbidity and pH above and below the construction activity using a single stage sampler (Interagency Committee 1961). The advantage to using the single-stage sampler is that the sample is taken during, or just after a rain event, the most opportune time for the designed erosion control devices to fail. The results of this monitoring indicate, with the exception of one day following a major storm event (Hurricane Daniel) turbidity levels downstream of the project were not significantly different than upstream levels.

The contractor was required to use select borrow to build the fill approaches for the new bridge. The borrow material specified was granular in nature as opposed to clay material. All fill slopes were encased with stone (rip rap) plating. A cloth fabric was placed on the slopes prior to the stone plating.

The contractor was required to construct the fill approaches using lifts not to exceed four (4) feet. Each lift was encased with stone (rip rap) plating on the slopes before a new lift was begun.

It was recommended that the construction work not take place in the winter months (highest potential for erosion). The construction sequence for the project was as follows:

December, 1996: Let date for project.

April 15, 1997: Project availability date for contractor to begin work.

October 1, 1997: Interim completion date for approach work and bridge substructure (everything except roadway paving and bridge superstructure).

November 15, 1997: Final completion date.

A cloth fabric (engineering, or drainage fabric) was used to cover the exposed fill at night, when fill was not being placed, and when a storm event was approaching the construction site. The same material was able to be used throughout the construction as it was rolled back while working.

The Environmental Unit of the Planning and Environmental Branch (Tim Savidge) conducted qualitative assessment of the stream substrate and bank stability, upstream and downstream of the project site. This monitoring was done before, during, and after construction. An inspection of the site was made prior to construction and at least monthly during construction, particularly following significant rain events. Cursory surveys of mussel beds were made during some of these visits. Living DWM were found downstream of the project while

underconstruction. A final site visit was made after the construction was completed. There did not appear to be any impacts to mussel substrates associated with the project.

Eastern Charlotte Outer Loop; Mecklenburg County

Project Description

The proposed Eastern Charlotte Outer Loop calls for the construction of a multi-lane facility on new location from US 74 to I-85 in Mecklenburg County. This project will connect with the Southern Charlotte Outer Loop at US 74, and the Charlotte Outer Loop at I-85.

The concept of a circumferential freeway (outer loop) around the city of Charlotte was first adopted in 1977 through the Charlotte-Mecklenburg Thoroughfare Plan. Local planning efforts for the Eastern Charlotte Outer Loop began in 1978. A report identifying alternative alignments, with a recommended alignment was completed in early 1980 by the Technical Coordinating Committee (TCC) and submitted to the Mecklenburg Planning Organization (MPO). In April of 1985, the MPO requested Mecklenburg County, the city of Charlotte, and the towns of Mint Hill and Matthews to adopt a set of maps showing the locally preferred alignment and incorporate measures that would reserve right-of-way (ROW) for the alignment (Final EIS 1989).

Portions of this project will impact headwater areas of the Goose Creek Subbasin. Both Goose Creek and Stevens Creek (a tributary to Goose) are proposed to be crossed with triple barrel 11"x 7" box culverts. Goose Creek is one of only seven streams currently known to have surviving populations of the federally endangered Carolina heelsplitter (CHS) (USFWS 1996).

Potential Impacts to CHS

With the use of proper sedimentation control and given the distance downstream of known occurrences of the CHS from the project crossing (approximately 9.7 km/6 mi), it was believed unlikely that project-related sedimentation would adversely affect the population in Goose Creek. Commitments were made to minimize the clearing of riparian areas.

The major concern with regards to project-related impacts to the CHS were the effects of secondary development associated with the project. Residential and commercial development is occurring rapidly in the Goose Creek watershed, as the City of Charlotte continues to grow. This development within the watershed has contributed to the decline of the CHS in Goose Creek. As mentioned earlier, a recommended alignment for this project was made in 1980, and has been depicted on road maps since this time. Examination of the development patterns in this area suggest that it is likely that a large amount of this development has taken place in anticipation of the Charlotte Outer Loop. It was determined that the proposed Eastern Charlotte Outer Loop had contributed to the degradation of Goose Creek by influencing development patterns within the watershed. It was believed that the construction of the facility would continue to result in secondary development of the watershed, resulting in an adverse impact to the CHS.

Research in North Carolina Piedmont streams has shown that water quality and biota is greatly affected by land use. Streams in urbanized settings have comparatively lower water quality and corresponding lower biotic diversity than streams in forested and agricultural areas (Crawford and Lenat 1989). It is believed that preservation of the remaining forested areas within the Goose Creek subbasin is necessary to ensure the continued survival of the CHS within Goose Creek. The idea of NCDOT purchasing and preserving riparian buffers along Goose Creek was considered. Given the fact that NCDOT was not the sole contributor to the degradation of the watershed, and considering the amount of land purchase that would be required to be effective, this mitigative idea was determined to be cost prohibitive. An alternative concept of funding a conservation position within the Goose Creek watershed was developed.

Special Project Commitments

Through the Section 7 process it was determined that the implementation of the three standard measures described earlier would eliminate the potential for direct impacts to the CHS. To offset secondary impacts associated with this project, NCDOT provided $150,000 in funding to the NC Wildlife Resources Commission's (WRC) Non-game Program to hire a conservation biologist to work with landowners and local government officials in the Goose Creek area (Mecklenburg and Union Counties). The purpose of this three-year position, which began in early 1997, is to develop, and initiate, conservation plans to protect and restore riparian areas through voluntary agreements and conservation easements (donated). Funding may also be used to develop education and informational documents.

Clayton Bypass; Johnston County

Project Description

The proposed Clayton Bypass calls for the construction of a multi-lane bypass of the town of Clayton from I-40 in Wake County to U.S. 70 Business in Johnston County. Project length is approximately 10 miles. The project study area encompasses 50 square miles, and includes much of the Swift Creek Subbasin of the Neuse River Basin, which contains the federally Endangered dwarf-wedge mussel (DWM).

The proposed action will not involve a direct crossing of Swift Creek, however, the proposed interchange of this project with I-40 involves two access ramps just north of and draining to the creek. Two moves to the south that cross Swift Creek are designed in anticipation that the Southern Wake Freeway, part of a circumferential loop around the City of Raleigh will intersect with I-40 and the Clayton bypass at this interchange. If the outer loop project does not get built, or does not intersect I-40 in this location, then the two moves designed may be studied at a future date, if traffic needs arise.

This project first appeared in the NCDOT Transportation Improvement Program (TIP) in December 1990, and is included as a major thoroughfare in the 1992 Thoroughfare Plan for Wake County. This project is not included in the Clayton Thoroughfare Plan, adopted by the town of Clayton in August 1994. There is currently no adopted thoroughfare plan for Johnston County. The Draft Environmental Impact Statement (DEIS) was completed for this project in July 1994, followed by a Corridor Public Hearing in October 1994. A preferred alternative was selected in January 1995. The Final Environmental Impact Statement (FEIS) is presently being prepared.

The stated purposes of this project are to construct a highway that will serve the growing transportation needs of Wake and Johnston counties and also provide a connection with the North Carolina Intrastate System of Highways (ISH). In July 1989, the North Carolina Legislature created the ISH to provide safe, high-speed travel throughout the state connecting major population centers both inside and outside of the state, as well as to support statewide growth and economic development (NCDOT 1996). The ISH states that the US 70 Intrastate Corridor east of Raleigh will provide a minimum of four travel lanes, and will consist predominately of freeways on new location.

Potential Impacts to DWM

Although this project will not involve a direct crossing of Swift Creek, several tributaries to the Creek will be crossed, and a large area that drains into Swift Creek will be exposed for the construction of the interchange with I-40 and the future Raleigh Outer Loop. These activities have the potential to result in significant sedimentation into Swift Creek.

The Swift Creek watershed is rapidly urbanizing. Wake and Johnston Counties experienced 40.5% and 15.2 % increases in population between 1980 and 1990, respectively, compared to the 12.7 % increase for the state of North Carolina. Two municipalities

in the Swift Creek watershed, Clayton and Garner experienced 16.3 % and 48.6 % population increases during this time period (NCDOT 1996).

The high growth rate exhibited in the project area, particularly in Johnston County, has been attributed to a variety of factors, including employment opportunities in nearby Wake County, affordable housing, private utility companies and public water and sewer. As of Mach 1989, 62% of Johnston County residents worked in Wake County (NCDOT 1996). This is linked to the economies of the Raleigh/Durham metropolitan area, (including Cary and the Research Triangle Park) and the convenient access to these areas via the I-40 and US 70 corridors. The Johnston County Planning Department stated that Johnston County is expected to continue to grow, and this growth will generally occur near the I-40 corridor and along the US 70 corridor.

The proposed Clayton Bypass is part of the transportation system linkage of US-70 to I-40 and the future Raleigh Outer Loop. This transportation system has provided easy access of formerly remote areas within Johnston County, to the Raleigh-Durham metropolitan center. This accessibility to these areas provided by the Transportation system has enhanced the attractiveness of Johnston County to residential development, and accompanying commercial development (restaurants, shopping centers, service stations etc.). The Johnston County Planning Department 1997 was consulted to determine if land-use changes were anticipated with regards to the Clayton Bypass. They noted that soon after completion of interchanges along I-40 in Johnston County (near Swift Creek) numerous re-zoning requests for uses other than one acre single family lot development were made. Based on this experience, the Johnston County Planning Department anticipated changes in land use patterns associated with the Clayton Bypass.

The extant of the DWM population in Swift Creek has experienced significant incremental declines in recent years as a result of the cumulative impacts associated with a wide variety of activities. The potential direct and secondary impacts associated with the Clayton bypass, was expected to further jeopardize the DWM in Swift Creek.

Johnston County has drafted a comprehensive land use ordinance to protect the Swift Creek watershed. This ordinance involves the development of a stormwater management plan and the establishment of forested buffers equal to a hundred year floodplain, or 100 feet, whichever is greater along perennial watercourses and 35-foot vegetative buffers along intermittent streams. Johnston County budgeted for a "Watershed Administrator" position to assist in the implementation of these ordinances.

Special Project Commitments

Additional protective measures to avoid direct impacts, will be developed through the consultation process. To offset the anticipated secondary and cumulative impacts associated with this project, NCDOT has agreed to partially fund ($125,000 over five years) the "Watershed Administrator" position budgeted in Johnston, as well as provide additional funding to the FWS to be spent on artificial propagation of juvenile DWM to augment the Swift Creek population. This work will be done by Richard J. Neves (National Biological Service) at Virginia Polytechnic Institute and State University. This will be a three year effort and is not to exceed $75,000. A biological conclusion of "Not Likely to Adversely Affect" contingent upon this measures was reached and concurred with by the FWS. With the enactment and enforcement of the Johnston County land ordinances, future NCDOT projects within the Swift Creek watershed, should not have the same concerns with secondary and cumulative impacts.

Bridge Replacement Over North Toe River; Mitchell and Yancy Counties

Project Description

This project involves the replacement of the existing 75-year old 111.9 m (367 ft) long bridge on SR1304 over the North Toe River in Mitchell and Yancey Counties. The federally threatened Appalachian elktoe (AE) (*Alasmidonta raveneliana*) is known to occur in this river at the bridge site. Because of the cost-prohibitive nature of a temporary on-site detour structure, and the excessive length of potential offsite detours, the bridge needs to be replaced on new location with traffic maintained on the existing bridge during construction. Three potential alignments were studied. The recommended alignment was chosen because it involved the least amount of environmental impacts (shorter length, less horizontal encroachment into the North Toe River).

Potential Impacts to AE

Because of the river width, it will be necessary to construct temporary stone work pad in the river to provide equipment access. This will involve significant substrate disturbance and any mussels occurring in this area will be destroyed unless relocated.

Normally when removing existing bridges in protected mussel habitats, strict provisions are made to avoid getting debris in the water. Unfortunately, because of the design of the existing structure (concrete arch) and the deteriorated condition, it is likely that removal cannot be accomplished without dropping the bridge into the river and pulling the debris out. This would result in additional substrate disturbance and loss of mussel habitat.

Although the preferred alignment involves the least amount of land disturbance activities, the potential for sedimentation impacts still exists. There are existing sediment problems in this river from a variety of sources). Additional sediment inpute could be detrimental to the AE population.

Special Project Commitments

After reviewing the proposed project it was determined that the project could not be completed without impacting the AE population in this river. NCDOT has consulted with the FWS to develop means that will minimize these impacts to the fullest extent possible. The following measures have been agreed to. Additional measures will be developed through further consultation.

High Quality Waters standards will be implemented throughout the construction of project. Mitigation measures will be in-place prior to the beginning of each construction phase of the project. Monitoring of these measures will be completed weekly and will be confirmed by the Division Construction Engineer. Turbidity and suspended solids will be monitored during construction by the NCDOT Roadside Environmental Unit as described previously.

The general contractor and all subcontractors, as well as, all appropriate NCDOT personnel (including project inspectors) will be present at the pre-construction meeting and at meetings prior to drilling of the bridge piers and roadway grading. The person(s) in charge of actually performing the work will be present at these meetings. Notes will be included on the design plans and in the project's Special Provisions ensuring that these meetings take place. All of these meetings will take place on-site and a representative from the US Fish & Wildlife law enforcement will be present to explain consequences of violations.

The bridge piers of the interior bents will be constructed using the drilled shaft method. The temporary stone work road used to provide access for the drilled shaft construction will be no more than half the width of the river and will only be installed on one side of the river at a time. Pipes will be installed in the

road to maintain normal flow rates in the river. Each temporary road will be removed in a manner not to cause significant turbidity and will be completely removed. Spoil from the drilled shaft construction will be pumped and removed from the site and will not be allowed to run-off into the river.

Demolition and removal of the old bridge will be completed from the top without any debris falling into the river, to every extent practicable. Measures to minimize debris falling into the river will be studied and implemented. Abandoning the existing bridge, without removal, will be studied. Liability concerns will likely make this idea unfeasible.

The location of interior bents will be studied in the design stage of this project. Placement of interior bents in the river will be minimized, if practicable.

It has also been determined that mussels within the project footprint (causeway, under existing bridge etc.) should be relocated to suitable substrate within the North Toe River away from the impact zone associated with this project. There have been numerous relocation efforts of mussels, with mixed success (Cope and Waller 1995). Relocations seem to be viewed as an easy solution to adverse impacts of mussels, however their is little guidance available for successful relocation and monitoring. NCDOT generally views relocation of freshwater mussels as the last option, when adverse impacts are unavoidable. NCDOT will continue to consult with the FWS to develop a relocation strategy, that involves monitoring of the relocated mussels, as well as mussels left in place downstream of the construction.

Conclusions

As development pressures in North Carolina increase, and our aquatic resources are increasingly stressed, NCDOT will continue to have to address concerns regarding protected freshwater mussels. Although a uniform method of resolving these concerns is not possible, the strategy that has been developed has allowed for project completion's, as well as provide for pro-active conservation measures to protect the critically imperiled resource. The key to the success of this management plan is the active participation of people from a variety of disciples, with different concerns. The result of this multi-disciplinary approach is the development of innovative ideas that allow for protection of the resource.

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References Cited

Alderman, J.M. 1997. Monitoring the Swift Creek freshwater mussel community. Pages 98-107 in K.S. Cummings, A.C.Buchanan, C.A. Mayer and T.J. Naimo, eds. Conservation and management of freshwater mussels II: initiatives for the future. Proc. of the UMRCC symposium, 16-18 October 1995, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island Illinois.

1993. Freshwater Mussels. Pages 67-85 in J.M. Alderman, A.L. Braswell, S.P. Hall, A.W. Kelly and C. McGrath, Biological Inventory: Swift Creek Subbasin. North Carolina Wildlife Resources Commission.

R. C. Wilson and C. McGrath. 1993. Conservation of aquatic critical habitats in North Carolina. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 47:348-352.

Anderson, S.J., R. Harrison, M.A. Euritt, H.S. Mahmassani, C.M. Walton, and R. Helaakoski. 1992. Economic Impacts of Highway Bypasses. Research report 1247-3F conducted for the Texas Dept. Trans. in cooperation with U.S. Dept. Trans. FHWA. 36 pp.

Biggens, R.G., R.J. Neves and C.K. Dohner. 1995. Draft National strategy for the conservation of native freshwater mussels, 26 pp.

Call, S. M. and K. Robinson. 1983. Mollusks from an archaeological site in Woodford County, Kentucky. Amer. Malacological Bulletin Vol. 1(1983):31-34.

Cope,G.W. and D. L. Waller. 1995. Evaluation of freshwater mussel relocation as a conservation and management strategy. Regulated Rivers: Research & Management, Vol. 11:147-155.

Crawford, J. K. and D. R. Lenat, 1989. Effects of land use on the water quality and biota of three streams in the piedmont province of North Carolina. Prepared for US Geological Survey. Water-Resources Investigations Report 89-4007.

Eagle, D., and Y.J. Stephanedes, 1987. Dynamic highway impacts on economic development. Pp. 56-62 in Transportation Research Record 1116: Transportation Economics: Issues and Impacts. TRB National Research Council Wash. D.C. 90 pp.

Ellis, M.M. 1936. Erosion silt as a factor in aquatic environments. Ecology. 17:29-42.

Embler, P.F. and M.O. Fletcher, 1981. Effects of highway construction on stream turbidity and suspended solids: A case study. Report S.C. Dept. of Highways and Public Transportation and FHWA, U.S. Dept. Of Transportation, 69 p.

Fassler, C.R. 1997. The American mussel crisis: effects on the world pearl industry. Pages 265-277 in K.S. Cummings, A.C.Buchanan, C.A. Mayer and T.J. Naimo, eds. Conservation and management of freshwater mussels II: initiatives for the future. Proc. of the UMRCC symposium, 16-18 October 1995, St. Louis, Missouri. Upper Mississippi River Conservation Committee, Rock Island Illinois.

Forkenbrock, D.J. 1990. Putting transportation and economic development into perspective. Pp. 3-11 in Transportation Research Record 1274: Transportation and economic development 1990, TRB National Research Council, Wash. DC. 290 pp.

Fuller, S.L.H., and C.E. Powell. 1973. Range extensions of *Corbicula manilensis* (Philippi) in the Atlantic drainage of the United States. Natilus. 87(2): 59.

Gamble, H.B., D.L. Raphael, and O.H. Sauerlender. 1966. Direct and indirect economic impacts of highway interchange development. Pp. 42-55 in Highway Research Record 149: Forecasting models and economic impact of highways, Highway Research Board, Wash. DC. 57 pp.

Interagency Committee on Water Resources, Subcommittee on Sedimentation. 1961. The single-stage sampler for suspended sediment. Report No. 13. US Government Printing Office. 105pp. Available from: St Anthony Falls Hydraulic Laboratory, Minneapolis, MN.

Khasnabis, S., and W. Babcock. 1975. Impact of a beltline type freeway upon a medium-sized urban area in North Carolina: A case study. Raleigh, NC: Univ. North Carolina.

Lathrop, G.T., and K.E. Cook. 1990. The effect of beltways on urban development: a discussion of U.S. experience in Orbital motorways. Proc. of the conference organized by the

Institution of civil engineers and held in Stratford. Upon-Avon on 24-26 April 1990. D. Baylis Ed. pp 143-156.

LeGrand H.E. Jr., and S.P. Hall. 1997. Natural Heritage Program List of the Rare Animals of North Carolina. Div. Parks and Recreation, Dept. Env. Health and Nat. Res. Raleigh NC. 82pp.

Mackie, G.L. 1991. Biology of the exotic zebra mussel, *Dreissena polymorpha*, in relation to native bivalves and its potential impact in Lake St. Clair. Hydrobiologia 219:251-268.

Marking, L.L., and T.D. Bills. 1979. Acute effects of silt and sand sedimentation on freshwater mussels. Pp. 204-211 in J.L. Rasmussen, ed. Proc. of the UMRCC symposium on the Upper Mississippi River bivalve mollusks. UMRCC. Rock Island IL. 270 pp.

Mulligan, P.M., and A.J. Horowitz 1986. Expert panel method of forecasting land use impacts of highway projects. Pp. 9-15 in Transportation Research Record 1079 land development simulation and traffic mitigation, TRB National Research Board, Wash. DC., 36 pp.

NCDOT 1996. Draft Environmental Impact Statement for U.S. 70 Improvements From I-40 to Intersection of U.S. 70 and U.S. 70 Business, Wake and Johnston Counties, State Project No. 8.T311001, TIP Project No. R-2552.

Neves, R.J. 1993. A state of the Unionids address. Pp. 1-10 in K.S. Cummings, A.C. Buchanan, and L.M. Kooch, eds. Proc. of the UMRCC symposium on the Conservation and Management of Freshwater Mussels. UMRCC. Rock Island IL.189 pp.

Neves, R.J., and J.C. Widlak. 1987. Habitat ecology of juvenile freshwater mussels (Bivalvia: Unionidae) in a headwater stream in Virginia. Amer. Malacol. Bull. 1(5):1-7.

O'Neill, C.R., Jr., and D.B. MacNeill. 1991. The zebra mussel (*Dreissena polymorpha*): an unwelcome North American invader. Sea Grant, Coastal Resources Fact Sheet. New York Sea Grant Extension. 12 pp.

Smith, D. 1981. Selected freshwater invertbrates proposed for special concern status in Massachussetts (Mollusca, Annelida, Arthropoda). MA Dept. of Env. Qual. Engineering, Div. of Water Pollution Control. 26 pp.

Transportation Research Board. 1995. Expanding metropolitan highways Implications for air quality and energy use: Special report 245 National Academy Press Wash. DC., Ch. 5 Land use and urban form pp. 174-209.

U.S. Department of Transportation, and U.S. Department of Housing and Urban Development. 1980. The land use and urban development impact of beltways final Report 124 pp.

U.S. Fish and Wildlife Service. 1996. Revised Technical/Agency Draft Carolina Heelsplitter Recovery Plan. Atlanta GA. 47 pp.

U.S. Fish and Wildlife Service. 1992. Special report on the status of freshwater mussels.