I-40 Pigeon Gorge
North Carolina
Existing NCDOT Bridges
Field Review August 28th, 2019

1.0 INTRODUCTION

This report comprises the observations and engineering considerations associated with the potential to improve wildlife connectivity arising from the field review of five existing bridges on the I-40 within Pigeon Gorge area slated for rehabilitation by North Carolina Department of Highways (NCDOT)

The observations and possibilities identified in this report are based on information gleaned from or provided by NCDOT representatives and their engineering consultant Benesch during a field visit on August 28, 2019 of the bridges planned for rehabilitation. No specific studies or in-depth research has been undertaken to verify information provided. Apart from identifying potential solutions and concepts, no work has been undertaken to verify the feasibility of ideas proposed.

2.0 BRIDGE REPLACEMENT FIELD REVIEW

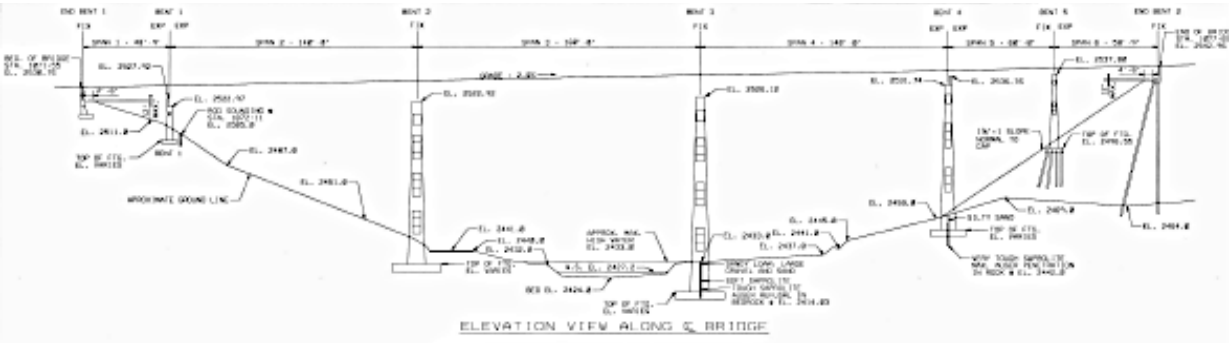
A total of five bridges have been identified by NCDOT for rehabilitation. For reference and identification purposes of this report, the five bridges in order of the field review are:

- High Bridge over White Oak Road
- Low Bridge over White Oak Road
- Harmon Den/Cold Springs Creek Interchange Bridge
- Fines Creek Road Interchange Underpass
- Pigeon River Bridge

In all cases, the rehabilitation will essentially involve the total removal of the existing structure and replacement with a new structure that will not necessarily share the same dimensions, structural make-up or materials. Work in many cases will need to occur in a staged fashion - usually two lanes at a time - over several seasons in order to minimize traffic disruption. In majority of cases, work will be undertaken during the winter season when traffic volumes on the I-40 are lower.

2.1 High Bridge over White Oak Road

Existing Bridge



The bridge is a total of 610 feet in length and sits about 90 feet above the valley floor it traverses. It comprises six spans of varying length sitting on five piers of varying height. From below the piers look in reasonable condition but the bridge girders and deck appear to be in poor condition. Given the sounds from above, the expansion joints/plates are loose and are creating loud noise when traffic passes over them that would be a deterrent to wildlife. Abutment slopes on each end are steep and essentially absent of vegetation. A low volume two lane road and small creek flow in a u-shaped valley beneath the structure. The adjacent lands and riparian area of the creek are well vegetated. Apart from the noise, the existing bridge and its configuration would appear to function well as a means for wildlife to cross beneath the I-40.

NCDOT Rehabilitation Proposal

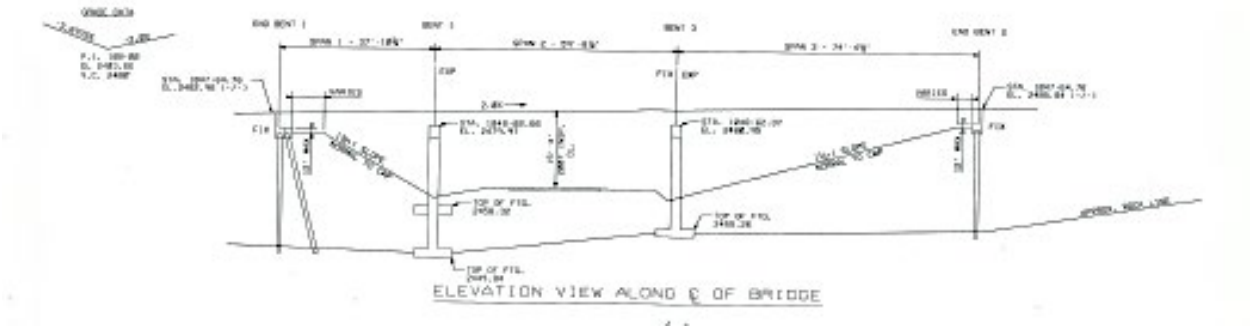
Bridge will be totally replaced with a new structure. Vertical clearance from valley floor will remain the same but the number of spans will be reduced to 3 spans with 2 piers along with new abutments. Overall bridge length would remain about the same. Creek and road will remain unaltered. Work will be accomplished over two winter seasons when traffic volume on the I-40 is at its lowest with two lanes one year and the opposing lanes the following. Work is to be undertake primarily from below. Work will be paired with the Low Bridge over White Oak Road due to proximity and ability to co-ordinate and manage traffic accommodation requirements for I-40.

Observations/Considerations

An overall replacement of the bridge with new robust expansion joints should eliminate much of the noise currently generated by the structure. It will remain very open and conducive to wildlife movement. Care will need to be taken to reduce overall footprint of disturbance and clearing to a minimum and rehabilitation and replanting should be included in the project. Thought should be given in specifying ways and means of not inhibiting wildlife movement under the structure during construction.

2.2 Low Bridge over White Oak Road

Existing Bridge



The bridge is a total of 172 feet in length and has a vertical clearance of about 15 feet above a low volume, two-lane road it traverses. It comprises three spans of varying length sitting on two piers of similar height. From below, the piers look in reasonable condition but the bridge girders and deck appear to be in poor condition. Abutment slopes on each end are moderately steep and absent of vegetation. Given the sounds from above, the expansion joints/plates are loose and are creating loud noise when traffic passes over them that would be a deterrent to wildlife. Apart from the noise, the existing bridge and its configuration is open and likely functions adequately as a means for wildlife to cross beneath the I-40. There exists a narrow 8 foot, grassed shoulder on both sides of the roadway beneath the structure that may support wildlife movement. There is certainly the possibility of a conflict between vehicles and large mammals using the roadway.

NCDOT Rehabilitation Proposal

The bridge will be total replaced with a new structure. The new structure is proposed to have a shorter overall length spanning only the two-lane road requiring no piers. Two options under consideration comprise either a standard single span bridge structure of 67 feet simply spanning the roadway sitting on vertical abutments located just inside or outside the existing piers that will be demolished; or a box culvert design that would be constructed inside where the existing piers currently are located spanning only 47 feet. The box culvert design would require the existing two-lane road to be lowered to maintain vertical clearance height.

While NCDOT representatives indicate no decision has been made, the box culvert design solution appeared to be favoured due to reduced future maintenance costs plus increased safety by minimizing potential frosting/icing of the deck surface from below.

Observations/Considerations

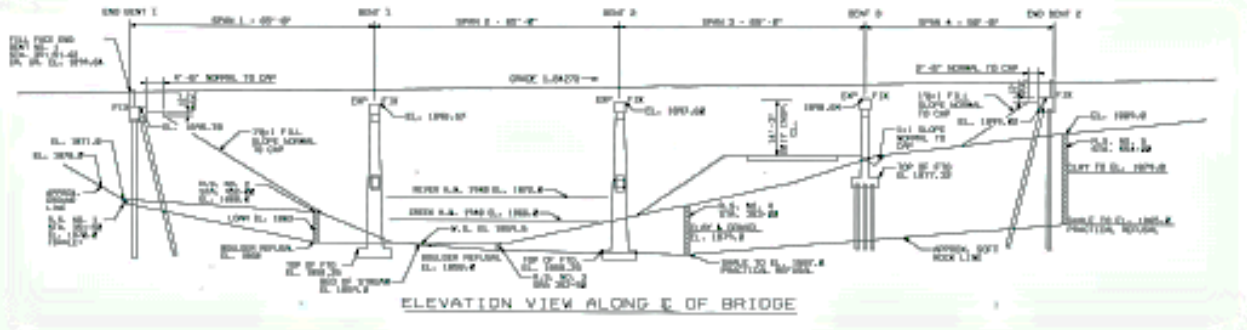
Both proposed replacement structures will significantly reduce the overall openness of the bridge from its current length of around 170 feet to a width of between 47 and 67 feet, essentially just spanning the existing two-lane road. Studies and experience have shown that elk are hesitant about passing through box culvert structures, especially when they are dual purpose i.e. functioning as a road as well as wildlife passage. Although White Oak Road appears to a relatively low volume roadway, the probability of this structure functioning as an effective wildlife crossing based on the proposed replacement designs as discussed in the field with NCDOT and its consultant Benesch is low.

Ideally from a wildlife perspective, the replacement structure should maintain the current overall width, construct vertical abutment walls thus avoiding the sloping sides and either span the distance without any piers or maintain the three span design. This would create 30 and 50 foot wide movement corridors on either side of the road for wildlife. It is acknowledged that this would be more expensive than the box culvert style design being proposed. Alternatively, the shorter 30 foot span could be eliminated and only the 50 foot corridor maintained.

A compromise might be to install 8 ft diameter corrugated steel plate culvert or equivalent sized precast concrete box culverts on one or both sides of the proposed new structures where the existing slopes are currently prior to these areas being backfilled. While these will not be used by elk, smaller animals such as deer and black bear are known to use these more confined types of crossing structure.

2.3 Harmon Den/ Cold Springs Creek Interchange Bridge

Existing Bridge



The bridge is a total of 245 feet in length and has a vertical clearance of about 14 feet above a low volume, two-lane road and a creek that it traverses. It comprises four spans of varying length sitting on three piers of varying height. From below, the piers look in poor condition as do the the bridge girders and deck. Abutment slopes on each end are steep and absent of vegetation. Given the sounds from above, the expansion joints/plates are loose and are creating loud noise when traffic passes over them that would be a deterrent to wildlife. Apart from the noise, the existing bridge and its configuration is open and likely functions as a means for wildlife to cross beneath the I-40 likely moving along the road as opposed to the rocky eroded creek drainage. There is certainly the possibility of a conflict between vehicles and large mammals using the roadway.

NCDOT Rehabilitation Proposal

The bridge is to be totally replaced with a structure consisting of two spans and a central pier. The abutments will be shifted slightly from their current location and the new pier will be constructed closer towards the creek. The abutments will be more vertical in nature. The bridge will be totally demolished and traffic detoured around the site by using the interchange's on and off ramps. Work is estimated to take one season. NCDOT indicated that this is their first priority bridge for replacement once funding confirmed

The possibility of shifting the Harmon Den road away from the center pier toward the south abutment was discussed in the field as well as reviewing the extent of guiderail currently installed along the roadway.

There was mention by NCDOT officials about the possibility of wildlife fencing and animal guards across the interchange ramps although the source of funding this work was uncertain.

Observations/Considerations

An overall replacement of the bridge with new robust expansion joints should eliminate much of the noise currently generated by the structure.

The proposed bridge replacement with large spans between abutment and center pier should leave an open feel to the structure. While a dual use structure for vehicles and wildlife is far from ideal, the road is a very low volume one, hence the number and type of vehicles should be less of a deterrent for use by wildlife. Rather than encouraging use of a pathway at road elevation between the edge of road and the center pier by shifting the existing road toward the south abutment, monies might be better spent on improving the creek and its associated riparian zone to encourage and better accommodate wildlife movement from elk all the way down to amphibians. Work should include removal of miscellaneous concrete and stone rubble that currently precludes easy wildlife movement and improved planting.

The location of this structure and its potential for use by wildlife really make it a good candidate for encouraging its use as a wildlife crossing. To be truly effective, and to encourage its use, it will be necessary to fence the highway right-of-way on both sides for a distance in each direction and subsequently tie the fence into the bridge abutments. There are steep slopes along I-40 to the north and south of the structure within reasonable distance where the fence can be terminated to avoid end of fence access into the right-of-way by animals. Animal guards (similar to cattle guards or Texas gates) or Electro Mat will need to be installed on all four on and off ramps and to install wildlife jump outs if animals find their way into the fenced right -of-way. The exact routing of the fence and animal guard along with jump outs need to be carefully planned. An example of the type of fence and animal guards used in Banff National Park Canada are available upon request.

While reducing the extent of guiderail to aid in wildlife movement, the challenge remains the steep banks created where the interchange ramps cross the creek channel and the less than ideally sized (from an elk usage perspective) dual 10 ft x 9 ft - 105 foot long concrete box culverts the creek flows through as it passes beneath these ramps. Openness ratio ((h x w)/l) greater than 0.75 is sometimes used as a simplistic means of evaluating an underpass as to its effectiveness as a crossing but other factors from type of species to be accommodated, cross-sectional shape and interior brightness must be considered.

Given the increasing intensity of storm events arising from changing weather patterns, it might be appropriate for NCDOT to verify the adequacy of these culverts to carry such flows. This, along with the ability of these culverts to easily pass fish, might make it a good time to replace these culverts with open bottom structures that are sized large enough to accommodate elk and black bear.

A dry ledge above normal stream height along one side of existing culverts to accommodate wildlife movement without entering the water is another consideration although this must be evaluated from a culvert flow/capacity perspective and able to withstand high flow events.

At minimum, in-stream riffles/weirs should be installed to back up water to ensure fish passage through the existing culverts.

Eastbound exit ramp culverts in Cold Springs - downstream view.

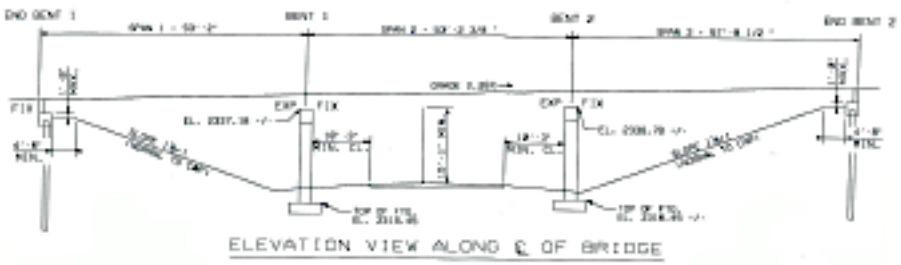
Westbound entrance ramp culverts in Cold Springs - downstream view.

Photos courtesy of David McHenry NCDOT

The installation of earth ramps or recontouring of existing steep slopes on the ramp embankments might encourage elk to use the drainage and riparian areas as a passage.

2.4 Fines Creek Interchange Bridge

Existing Bridge



The bridge is a total of 164 feet in length and has a vertical clearance of about 15 feet above a busy two-lane road that serves as access to an area landfill. It comprises three spans of varying length sitting on two piers of similar height. From below, the piers look in poor condition as do the bridge girders and deck. Abutment slopes on each end are steep and absent of vegetation. Given the sounds from above, the expansion joints/plates are loose and are creating loud noise when traffic passes over them that would be a deterrent to wildlife. There exists a narrow 10 foot, grassed shoulder on both sides of the roadway beneath the structure that may support wildlife movement. Apart from the noise from both traffic above and that passing through the structure, the existing bridge and its configuration is open and could functions as a means for wildlife to cross beneath the I-40. There is certainly the possibility of a conflict between vehicles and large mammals using the roadway. Further possibly reducing use by wildlife is the proximity of the Pigeon River and the need to traverse the river or use a narrow highway bridge.

NCDOT Rehabilitation Proposal

The bridge will be total replaced with a new structure. The new structure is proposed to have a shorter overall length spanning only the two-lane road requiring no piers. Similar to the Low Bridge over White Oak Road, two options under consideration comprise either a standard bridge structure simply spanning the roadway sitting on vertical abutments located just inside or outside the existing piers that will be demolished or a box culvert design that would be constructed inside where the existing piers currently are located. The box culvert design would require the existing two-lane road to be lowered to maintain vertical clearance height.

While NCDOT representatives indicate no decision has been made, the box culvert design solution appeared to be favoured due to reduced future maintenance costs plus increased safety by minimizing potential frosting/icing of the deck surface from below.

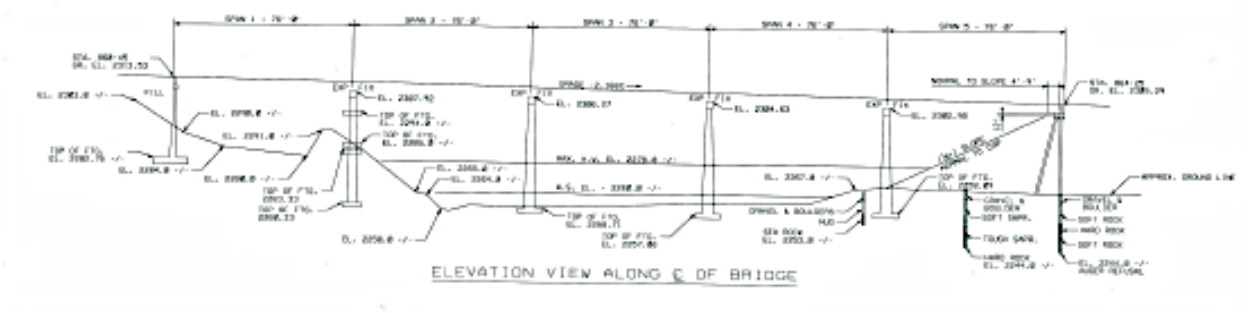
Observations/Considerations

Both proposed replacement structures will significantly reduce the overall openness of the bridge to a width of less than 40 feet essentially matching the existing two-lane road. Studies and experience have shown that elk are hesitant about passing through box culvert structures, especially when they are dual purpose i.e. functioning as a road as well as wildlife passage. The Fines Creek Road appears to carry a large number of trucks accessing the nearby landfill creating noise likely early to late in the day. The probability of this structure functioning as an effective wildlife crossing regardless of the proposed replacement designs as discussed in the field with NCDOT and its consultant Benesch is low.

The installation of 8 ft diameter corrugated steel plate culvert or equivalent sized precast concrete box culverts on one or both sides of the proposed new structures where the existing slopes are currently prior to these areas being backfilled. While these will not be used by elk, smaller animals such as deer and black bear are known to use these more confined types of crossing structure.

2.5 Pigeon River Bridge

Existing Bridge



The bridge is a total of 380 feet in length and sits about 47 feet above the Pigeon River it traverses. It comprises five spans of varying length sitting on five piers of similar height. From below the piers look in reasonable condition but the bridge girders and deck appear to be in poor condition. Given the sounds from above, the expansion joints/plates are loose and are creating loud noise when traffic passes over them that would be a deterrent to wildlife. Abutment slopes on each end are steep and essentially absent of vegetation. The north abutment slope is primarily rock that rises up steeply parallel to the abutment to within feet of the east side of the bridge.

The adjacent lands and riparian area of the river are well vegetated save for beneath the structure. Apart from the noise, the south side of the existing bridge would appear to function well as a means for wildlife to cross beneath the I-40 while the northside and the rock outcrop less so.

NCDOT Rehabilitation Proposal

Bridge will be totally replaced with a new structure of similar length. Vertical clearance from valley floor will remain the same but the number of spans will be reduced to 4 with 3 piers along with at least one new abutment. The possibility of retaining the existing high vertical concrete abutment on the north side of the bridge is under serious consideration. At least one of the piers to be located within the Pigeon River.

Observations/Considerations

An overall replacement of the bridge with new robust expansion joints should eliminate much of the noise currently generated by the structure.

The proposed replacement bridge with large spans between abutments and high piers will be very open and could be conducive to wildlife movement if large flat passageways or benches are created or maintained between abutment and river on both sides. It will be important to address the rock outcrop on the north side that is inhibiting wildlife movement higher up the slope near the abutment. This rock could easily be removed by rock hammer from the top of bridge once the deck is removed as part of the bridge demolish. A minimum clearance of 10 feet beneath the bottom of the new bridge girder and the rock surface should be created.

3.0 CONCLUSIONS

While every bridge structure that carries the I-40 over it and allows for passage beneath is a potential wildlife crossing opportunity, not all have the same potential for adoption and use. Wildlife can be fickle in terms of usage, what works for one species may not work for another. Designing for multiple species usage can be a challenge, often erring on the side of caution by creating large open crossings.

It will be important to verify where wildlife wish to cross the highway based on both predictive modelling, terrain analysis, field data from cameras and road kill and observations by local highway maintenance crews before pursing significant changes to proposed bridge replacement designs.

In reviewing the five bridge structures planned for replacement, it is obvious from a wildlife crossing perspective, even without knowing fully the propensity or desire of wildlife to cross at each location, certain structures and their locations have better characteristics than others.

In order of wildlife connectivity /usage potential, I would rank the five structures as follows:

- Pigeon River Bridge – high, large spans and no road crossing, only a river
- High Bridge over White Oak Road – high, large spans, low volume road and creek that only take up less than 20% of area beneath the structure
- Harmon Den/Cold Springs Creek – open feel, traverses a creek, low volume road although it takes up 40% of area
- Low Bridge over White Oak Road – closed feel if rehabilitation proceeds as currently planned, low volume road will take up almost 100% of area beneath the planned structure
- Fines Creek – closed feel if rehabilitation proceeds as planned, high volume road will take up almost 100% of area beneath the planned structure

Certainly, the High Bridge over White Oak Road will require little additional work on the part of NCDOT to ensure and increase usage after construction is complete. The Pigeon River Bridge will require modest rock demolition on the north side to create good potential wildlife movement corridors on both sides of the river.

I believe Harmon Den/Cold Springs Creek Interchange Bridge offers good potential and possibilities as a wildlife crossing but will require both fencing as well as attention to the stream's drainage channel for fish passage. Improvements to the riparian zones on each side of the creek will also be needed to better accommodate and encourage use by wildlife. The culverts passing beneath the off and on ramps on the north side of the interchange are likely the greatest impediment facing wildlife especially elk, from using the drainage to cross beneath the highway.

The Low Bridge over White Oak Road and Fines Creek Interchange have the least possibility/probability of adoption and use by wildlife as a means of crossing the beneath the highway if the NCDOT preference of constructing essential box culverts the width of the road proceed. Given the low volume nature of White Oak Road wildlife and in particular elk, might still utilize it. However, the less than ideal driver sight line distances as a result of the road's curvature approaching the structure from either direction may lead to animal/vehicle conflicts. Fine Creek is the least likely to see adoption by wildlife regardless of bridge design due to the traffic volumes it experiences. Certainly, replacement of the structure by a box culvert that accommodates only the road width will further diminish its potential for usage by wildlife.

Any construction results in localized disturbance to vegetation and land. Given the amount of demolition and replacement of piers and abutments planned, there will be a significant amount of disturbance that should be anticipated. At this time, the extent of this disturbance is difficult to ascertain and hence develop plans for mitigation or rehabilitation. At minimum access roads and crane platforms will need to be constructed and temporary bridge crossing of creeks. Landscaping is often one of the last activities to be undertaken and can often be neglected or minimalized especially if project budget has been depleted due to unforeseen issues arising during construction. However, from a wildlife perspective, it is important to re-establish vegetation and cover for wildlife as soon as possible.

One method to ensure sufficient funds remain and are part of the tender/bid amount is to include a provisional sum for landscaping that can be developed and undertaken once the extent of disturbance and rehabilitation is known.

There are inherent activities that can affect terrestrial, bird, amphibian, reptile and aquatic species movement that must be considered during the duration of construction. These range from noise disturbance, increased human presence, temporary disruption/interruption of movement, habituation, interference with breeding cycles and general environmental residual impacts. The following are some general tips and advice to be considered and specified once construction commences.

There must be a general recognition that construction is noisy. Some noise can be minimized by ensuring equipment is well greased, have latest mufflers and not left idling. Operations can be limited to specific hours with quiet times such as night or at least one day off per week to permit normal animal movement. There can become a fine balance between undertaking the work in as quick and efficient a fashion as possible versus extending construction duration (short term pain/long term gain).

Disruptive activities can also be specified to occur during specific seasons or periods to avoid potential effects. Work should be undertaken when birds are not likely to be nesting on rock cuts and avoided when animals that frequent the area are likely to be giving birth or in the early days of nurturing their young.

Tree clearing should be undertaken outside of not only resident bird nesting season but also those of migratory birds that may utilise the area. Another consideration is the loss or disruption of nests especially for those birds (swallows) who employ structures such as bridges or steep banks to build their nests on. Netting can be strung under bridges to prevent nest building prior to or during bridge construction as well as constructing man-made structures/roosts upon which to build their nests. Extent of clearing should be kept to a minimum, especially in the vicinity of under crossings to maintaining cover for animal movement.

Work near or in fish bearing streams should be scheduled to avoid disrupting spawning as well as being undertaken potentially during freshets or when high sediment bedload is present to minimize silt covering spawning beds. It should go without saying, that flows must be maintained in fish bearing and constantly flowing streams as well as maintained in wetlands. Care should also be exercised around water bodies and wetlands by minimizing disruption to important vegetation along stream and river banks (riparian zone) used by small wildlife, amphibians and insects as well as creating shade for fish. These areas should have silt fences erected to intercept unintended silt flowing from disturbed areas during rain or snow melt as well as to keep equipment and any refueling well away from the water body. Disturbed soils or stockpiles to be left for any intended period of time should be located away from water courses and sprayed with an emulsion/tackifier to prevent silt runoff, dust and growth of weeds from occurring. Concrete and hot mix asphalt should be disposed of well away from water table and formwork over waterbodies should be caulked to prevent cement from entering water.

Wildlife is naturally curious and can be attracted to construction areas by the noise and smells. Therefore, it is important that good housekeeping practices be observed during construction. Food, greases and garbage should be properly stored and disposed of in animal proof containers or removed daily from site. Human error is inevitable with trees removed accidentally or areas not to be disturbed that are not easily rectified. Construction staff should be required to go through a short course describing the various mitigations to be exercised and why. This often creates sense of caring and understanding amongst construction personnel about how their activities may create unintended impacts.

Fencing installed as a measure to reduce vehicle wildlife collisions should be installed in a coordinated manner and not until associated crossing structures are in place. When installed, it should progress concurrently on both sides of the transportation corridor so as to avoid creating a barrier and trapping wildlife on the wrong side of the fence. Temporary fencing preventing wildlife movement should be avoided or provisions made to permit wildlife to traverse the site in off hours.

4.0 CLOSING

Of all the bridges under consideration for replacement, the Harmon Den Bridge likely offers the best opportunity to provide improved connectivity for multiple species. This bridge should be a focus of effort to influence inclusion of connectivity measures and mitigations into the project scope. NCDOT appeared receptive to making modifications to accommodate this including mentioning fencing as part of the project although funding source for these features was uncertain. Data indicating use or desired use by wildlife at this crossing point to substantiate this investment will be important

I believe it is also important to maintain on-going dialogue with NCDOT to understand latest timelines and which bridge(s) will be the first to be rehabilitated. It will be important to push to see plans, and if possible specifications or Terms of Reference, as they are being developed and understand when decisions are made or pending if there is to be any chance of influencing the final design outcome from a wildlife connectivity perspective. Ideally, while not an equal member/influencer on the design team, a representative from the coalition sitting in on meetings would help inform and understand the rationale for decisions.

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