North Carolina Department of Transportation &

North Carolina Wildlife Resources Commission

Wildlife Passage Guidance

I-140 Brunswick County

Wildlife cross or access roadways during foraging, mating, and dispersal activities. These interactions with roadways can compromise roadway safety and traffic reliability. Roadways can also impair wildlife conservation by fragmenting habitats and causing the mortality of rare species. Wildlife crossing structures are proven to enhance habitat connectivity and facilitate wildlife movement under or over North Carolina's roads.

In 2023 the North Carolina Department of Transportation (NCDOT) and the North Carolina Wildlife Resources Commission (NCWRC) entered into a *Wildlife Stewardship Memorandum of Understanding (MOU)* that is intended to foster and enhance communication and cooperation between the two agencies.

Considerations are expected to include:

- Cooperative project planning and coordination
- Public Safety
- Maintenance and expansion of habitat connectivity and wildlife habitat conservation
- Inventory, monitoring, and biological studies
- Impacts on wildlife due to vehicles
- Habitat loss due to invasive species
- Maintenance of recreational access
- Information and education
- Conflict resolution

The MOU identified this guidance document as a necessary tool to help facilitate communication and stewardship related to terrestrial wildlife passage. It is a living document; updates will be made as new information, techniques, and technologies are developed. This guidance is based on many years of study, implementation, observational data collection, and peer-reviewed reports and literature, as cited. For further information, you may contact: NCDOT's Environmental Policy Unit or Environmental Analysis Unit's Biological Surveys Group at *epu@ncdot.gov* or *bsg@ncdot.gov* and WRC's Eastern Habitat Coordinator, Travis Wilson at *travis.wilson@ncwildlife.org* or the Western Habitat Coordinator, Dave McHenry at *david.mchenry@ncwildlife.org*. (Note, this guidance also complements and should be used in conjunction with existing guidance for aquatic organism passage included in *NCDOT Guidelines for Drainage Studies and Hydraulic Design.*)

Background

The NCDOT and NCWRC have collaborated to construct numerous wildlife crossings of highway corridors statewide. NCWRC monitoring has shown that these properly planned and implemented dedicated wildlife crossings are effective in North Carolina. Dedicated crossings are costly and thus are typically focused on priority wildlife habitats, species conservation needs, and/or identified safety concerns. However, adding dry passage and other design modifications to bridge and culvert replacement projects can also provide opportunistic wildlife habitat connectivity on a much broader scale.

Many of North Carolina's 18,000 bridges and culverts already accommodate wildlife movements. Extending dry, clear passage areas under a bridge or improving a culvert crossing during replacement is the most cost-effective and practical method to connect wildlife habitats statewide. The addition of wildlife fencing can significantly improve the effectiveness of wildlife crossing structures. NCDOT and NCWRC have developed standard design features for bridges and culverts, including some lower or no cost considerations, as described in greater detail herein. Both agencies will educate staff and partners to better integrate wildlife passage into routine bridge and roadway designs for North Carolina highways. A multi-disciplinary approach has been proven to result in our most effective wildlife passage success stories, so both agencies strive to include an array of expertise for any wildlife crossing decision-making. For example,

when NCDOT's hydraulic engineers are considering increased capacity in a culvert system, an opportunity arises for wildlife passage to also benefit from that needed floodplain capacity.

Animal-Vehicle Collision Data

NCDOT and NCWRC are continually improving the collection of wildlife-vehicle mortality data to help assess the need for warning signs, crossing structures, fencing, and other mitigative efforts (Figure 1). Reported animal-vehicle collision (AVC) data are available and may support mitigation measures for some projects[1]. North Carolina had over 20,000 reportable AVCs including four fatalities in 2022, (NCDOT 2020-2022). The estimated comprehensive crash costs for all of North Carolina's 2022 AVC is $486,000,000 (based on NC Standardized Crash Cost 2022). Carcass removal data from other states has documented actual AVC occurrences more than five times greater (in Utah study) and nine times greater (in Virginia study) than the accident-reported AVC numbers (Olson, 2013; Donaldson & Lafon, 2008). Applying the most conservative correction factor to reportable AVC suggests there are closer to 100,000 large AVC occurring annually in North Carolina.

Figure 1 Wildlife warning on I-26 West, Madison County.

Techniques for Enhancing Design for Wildlife Passage

Increasing hydraulic capacity often results in larger structures that provide better habitat connectivity. Bridges typically provide more span length and opening than culverts and thus often better accommodate movements of a broader range of wildlife species. In-kind bridge-to-bridge replacements or culvert-to-bridge replacements should be evaluated on streams with frequent wildlife usage, such as along high-quality habitats and contiguous riparian corridors. In high-quality habitats, such as large floodplain wetlands, if sloping abutments preclude the ability to provide clear floodplain or streambank benches under the structure then bridge span should be increased or vertical abutments used. For single pipe or box culvert crossings, widths that allow bedload retention and floodplain/streambank construction should be pursued while also maintaining a natural stream channel width. Maintenance of a natural stream width may require notched sills or baffles, per NCDOT *Guidelines For Drainage Studies* (Figures 2 and 3). Where practical, high-flow floodplain barrels should be added to hydraulic crossings to provide dry passage areas

[1] Reportable crashes are those that involve injury or meet the $1,000 property damage threshold.

for terrestrial wildlife; these would supplement the hydraulic design capacity and help to maintain the stream's baseflow channel dimensions for aquatic passage through the primary barrel(s) (Figures 4 and 5).

Figures 2 and 3. Wide corrugated metal pipe (Wayne County, SR 1300, Unnamed Tributary) retaining bedload (left) and aluminum box culvert (Transylvania County, #870163, North Prong Glade Creek) with notched sills and baffles buried by bedload (right, note partially exposed sill in photo right).

Benching

Floodplain or approach benches must be constructed to transition high-flow culvert barrels or dry benching in or under single pipes, boxes, or bridges, into the stream banks upstream and downstream of the structure (Figures 4 and 5). This will encourage wildlife use by creating unobstructed habitat connectivity under the roadway. Bank sloping may be required on incised stream channels to transition the floodplain or lower dry ground elevation down to the bench elevations (Figure 4).

Figures 4 and 5. Benching into box culvert (left, Transylvania County, #870012, Hogsed Creek) and benching with bank sloping (right, Mecklenburg, I-485 vicinity, unnamed tributary).

Rip Rap / Armoring

Full armoring of streambanks or sloping abutments can deter passage of wildlife that move along stream corridors, and it can encourage wildlife to attempt at grade road crossings. Widespread use of riprap creates barriers to wildlife movement; riprap should be avoided where effective soil stabilization can be achieved with vegetation. Where armoring must be used, the following guidance will enhance habitat connectivity.

1. Avoid the use of rip rap under new bridges if not needed for scour protection or slope stabilization (Figures 6-8). Unarmored stream banks under bridges often remain stable without matting or any stabilizing treatments (observations by NCWRC and NCDOT staff). Some situations such as a sharp channel meander may warrant armoring the outside of the meander while leaving the opposing bank unarmored to allow unobstructed wildlife passage.
2. Where plating is used, incorporate a rip rap-free area in the excavated slopes, or construct a path over the rip rap using aggregate, coarse stone, or floodplain material that eliminates voids and creates a flat surface (Figures 9, 10, and 11). (Note, topping treatments are not expected to be maintained post-construction due to access limitations. The fine materials will often accumulate over time naturally due to sediment deposition during floods.)
3. Where possible, rip rap should be keyed-in or embedded below grade before overfilling with native material or aggregate, as approved (Figures 12 and 13).
4. Rip rap used for floodplain benching and as backfill inside dry culvert barrels should be topped with native streambed/floodplain material to reduce roughness and rip rap voids that can deter wildlife use. (Figures 3 and 14). This is consistent with current NCDOT Guidelines for Drainage Studies and Hydraulic Design. Exceptions may include stream systems with heavy sediment loads, such as urban streams, that will fill in rip rap voids quickly during flood events. The construction engineer and environmental staff should approve all materials used.
5. The portions of lateral ditches that are armored and that cross floodplains should be topped to fill in voids similar to floodplain benching and dry culvert barrels to make it traversable for wildlife.
6. Erosion control matting with nylon mesh needs to be avoided on benches, or anywhere in riparian areas according to standard Division of Water Resources General Certification conditions, due to the entanglement hazard it poses for wildlife.

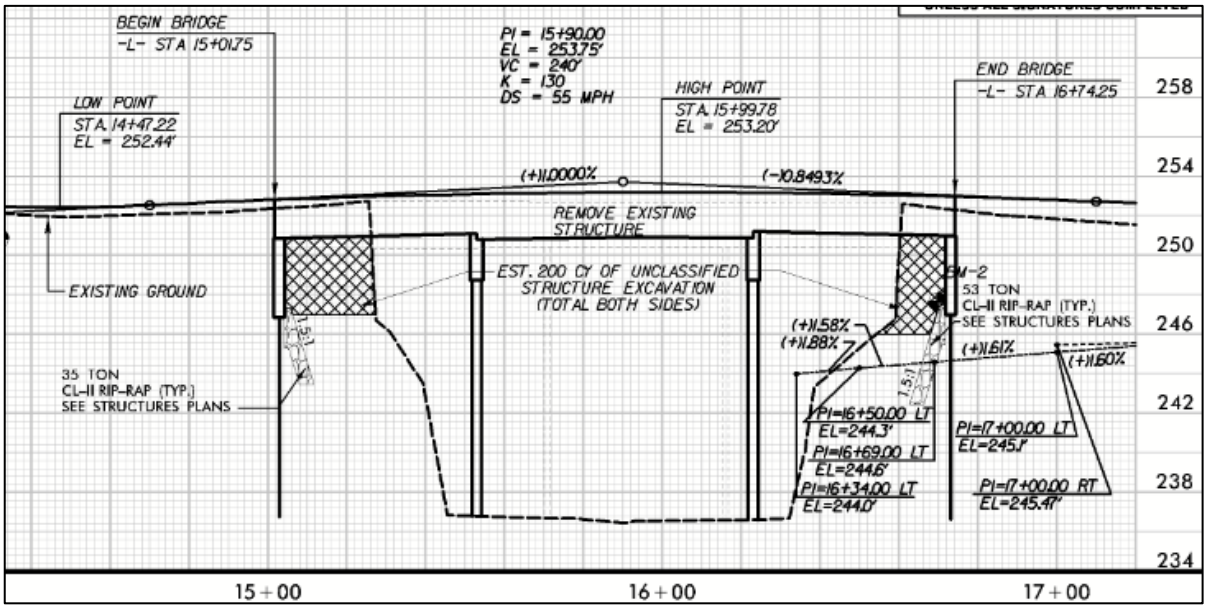


Figure 6. Unarmored slopes on proposed Anson bridge #030217 over Lanes Creek.

Figures 7 and 8. Unarmored floodplains under bridge in Iredell County (left, #480212, Patterson Creek) and large bridge in Stokes County (right, #840008, Dan River).

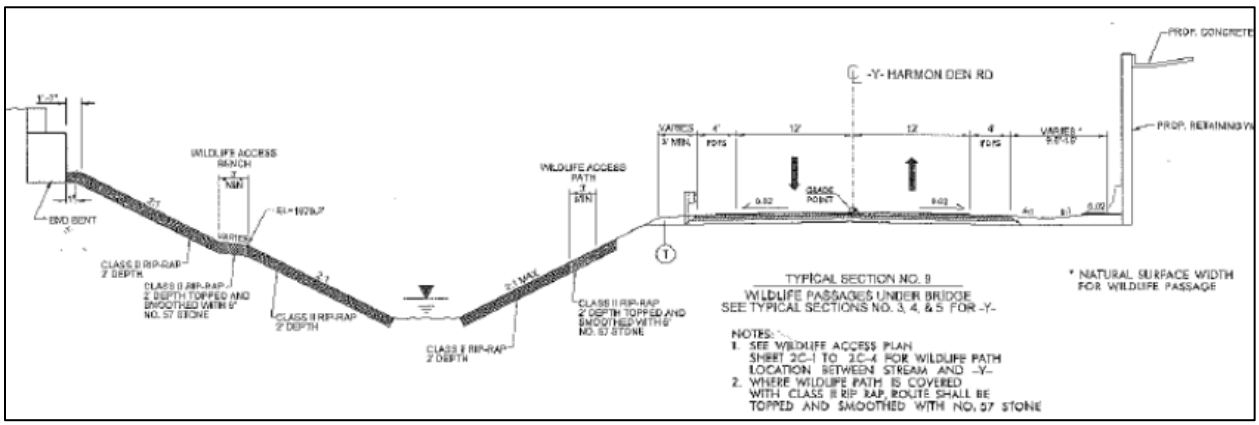


Figure 9. Wildlife pathway detail over rip rap (B-6054A, Haywood #430057)

Figure 10. Wildlife pathway or "bench" as built from Figure 9.

Figure 11 Eno River bench, Orange County, NC.

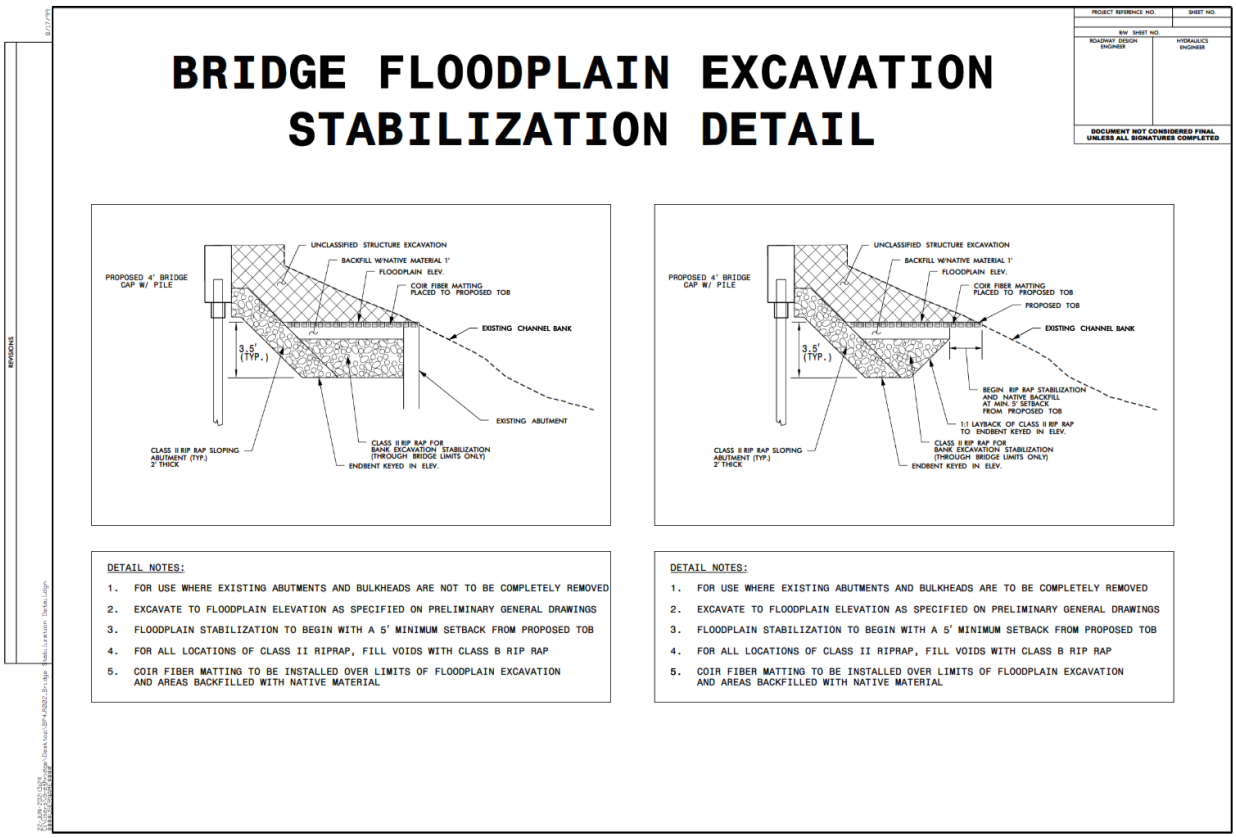


Figure 12. Rip rap embedment detail for floodplain stabilization.

Figure 13. Construction of bench over embedded rip rap (Edgecombe County, # 320113, Otter Creek).

Figure 14. Native material backfilled over rip rap in aluminum box culvert (Henderson County, #440073, Greer Creek).

Dedicated Wildlife Crossing Design

The NCDOT is responsible for managing public funds while addressing an increasing number and complexity of regulatory and planning considerations to deliver transportation projects. The NCWRC is similarly charged with ensuring public funds are used for conservation priorities and objectives. Cost-benefit analysis of safety/habitat connectivity measures must validate the extra costs associated with providing habitat connectivity/safety measures.

Projects specifically identified for conservation needs or vehicle collision reduction will be planned and developed in accordance with the 2023 Wildlife Stewardship MOU under established procedures (e.g., NEPA/SEPA scoping, NEPA/404 merger). Such projects typically involve new roadways or upgrades to existing roadways including widening, areas with legacy conservation needs, and/or roadways where AVC issues have increased or developed over time. Available wildlife population and habitat information, wildlife mortality rates, cost-benefit analyses, and other pertinent supporting information will be collectively considered where these dedicated wildlife passage accommodations are pursued for either safety and/or conservation. The NCWRC has been monitoring wildlife crossing structures to collect data to assure the effectiveness of structures and help guide future project decisions. This monitoring will continue in accordance with the MOU.

Structure Types and Objectives

There are several dedicated wildlife crossing structures in North Carolina with different designs and objectives. Large wildlife crossing structures can be overpasses or underpasses that allow wildlife to travel over/under the roadway using a grade-separated bridge or culvert (Figures 15 and 16). North Carolina has constructed several successful wildlife underpasses that provide habitat connectivity for a full range of wildlife species. By contrast, site-specific or species-specific crossings will typically cover a much smaller area and may only utilize small crossing structures (Figure 17). Structures intended to promote ecological connectivity should provide both the ability to pass large mammals as well as small mammals, reptiles, and amphibians. Connectivity projects will often include multiple structures providing better habitat connectivity and conservation value, particularly for small and/or range-limited species.

Figure 15. Wildlife underpass on US 64 in Washington County.

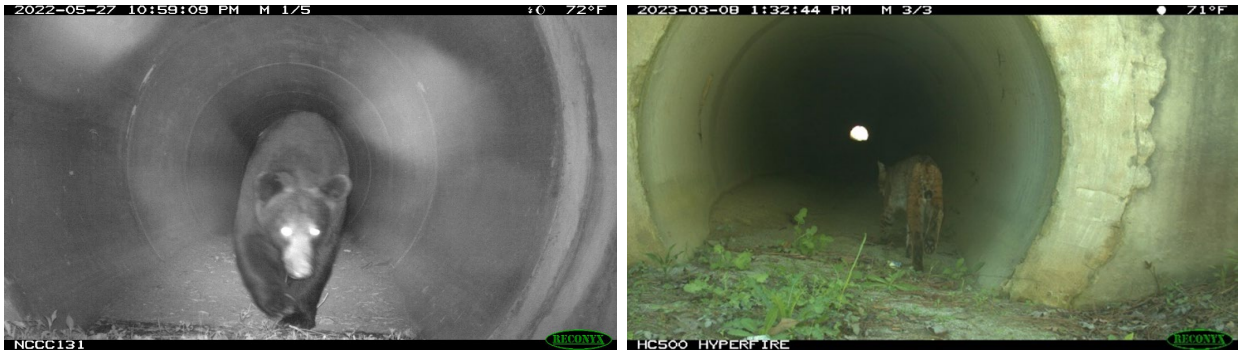
Figure 16. Wildlife underpass on US 17 in Jones County for connecting habitat for a range of species.

Figure 17. Culvert designed for small and medium animal passage on EF Middleton Blvd. Brunswick County.

Culverts

Culverts offer a wide range of designs and sizes to provide passage for small and medium species with some larger species commonly using them as well (Figure 18). When incorporating culverts for wildlife passages the following key design features are important and should be evaluated:

1. Align culverts to provide a clear line of sight through the structure (Figure 19)
2. Backfill culverts with a natural substrate.
3. Incorporate grates in the culvert to allow light and acclimatization to outside conditions (Figure 20)
4. Elevate grates and properly grade culvert approaches to prevent concentrated stormwater from entering the crossing structure. In some cases, specialized crossing structures such as full open grate structures may be necessary to effectively provide wildlife passage (Figure 21).



Figures 18 and 19. Bear in culvert, US 17 Wildlife Crossing Jones County (left), and daylight visible through culvert, US 17 Wildlife Crossing Jones County.

Figures 20 and 21. Grate in median of wildlife culvert, EF Middleton Blvd Brunswick County (left) and open grate crossing Ashe County.

Wildlife Fencing

Providing appropriate wildlife crossings with wildlife fences is a proven effective measure to reduce AVC. Fencing both provides a mechanism for excluding wildlife from the roadway corridor as well as directing wildlife toward a viable crossing location. Studies conducted within North Carolina and across North America have documented a reduction of AVC from 58% - 98.5% (NC US 64 wildlife 58% McCollister and Van Manen, 2010), (Utah I-15 deer 98.5% Bissonette and Rosa, 2012), (Trans-Canada Highway wildlife 80% Clevenger et al., 2001), (Arizonia Preacher Canyon elk Dodd and Gagnon, 2008). Although traffic levels, road characteristics, and wildlife habitat vary considerably, review of NCDOT 2020-2022's AVC data shows wildlife crossings and fencing installed for I-140 in Brunswick County have reduced AVC on I-140 by 75% compared to a nearby unfenced stretch of US 17, and 50% for stretches of US 64. NCDOT's standard wildlife fencing details (866.07 Wildlife Fence with Chain Link & 866.08 Wildlife Fence for Rocky Soils with Chain Link) are designed for large mammals and smaller species with options to accommodate various terrains and durability needs. (Figure 22), When using wildlife fencing it should always be incorporated in conjunction with a crossing structure (Figures 23 and 24). Wildlife fencing without an appropriate wildlife crossing structure will increase habitat fragmentation. The fencing intends to exclude wildlife access to a roadway while also increasing the effective area of the structure. The design of wildlife fencing should complement the structure size and target species. For large mammal crossings, taller heavy fencing extending up to a few miles would be appropriate, while a crossing for reptiles and amphibians may be only 2-3 feet in height and relatively short as determined by habitat and species range. There are multiple options suitable for reptile and amphibian fencing. Considerations such as species, habitat, and fire frequency should be considered when determining the appropriate fence. Fence options include concrete or aluminum headwalls, small mesh wire fences, as well as specialized products marketed for reptiles/amphibians.

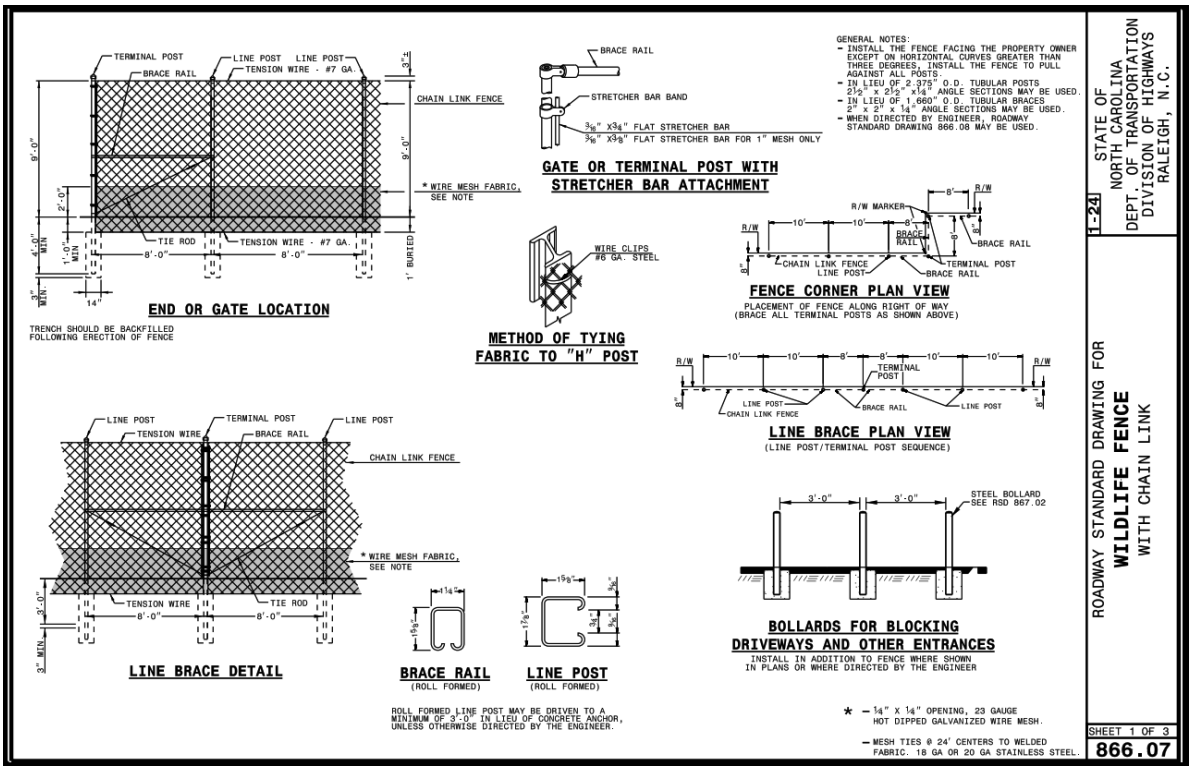


Figure 22. Wildlife fence standard detail (866.07).

Many factors must be considered with wildlife fencing such as terrain, private property, access points, ditch crossings, gates, maintenance, controlled access fence connections, etc. Gaps and openings in fences

create pathways for wildlife to access the roadside of the fencing therefore greatly reducing the effectiveness of the fence and risking AVCs. For NCDOT to properly provide maintenance, the fence should be placed within the limits of the right-of-way or permanent easement. Slope considerations should evaluate both the positive and negative effects of the slope alignment. A higher terrain on the roadside of the fence (Figures 23 and 24) that can provide a jump out for larger species such as white-tailed deer. Conversely, higher terrain outside the fence increases the possibility of wildlife jumping over the fence into the roadway.

Figures 23 and 24. Woven-wire wildlife fence run (left) and tie into crossing structure (right). US 17 Jones County

Greenway and Trail Considerations

The combined presence of greenways or trails providing wildlife passage is a common consideration. The two are not mutually exclusive; however, multiple factors need to be considered in these circumstances. Foremost is how the presence of people using the structure can shift the amount, timing, and type of usage by wildlife. How significant that shift is will vary depending on the type of trail and trail activity. For example, a high-use urban greenway will have a more significant impact on wildlife usage than a rural portion of the Mountains to Sea trail. When looking at trail type in conjunction with the wildlife passage objective, a busier more developed trail should provide physical separation from the wildlife corridor to the maximum extent practicable while also providing vegetated screening. This approach will help ensure the wildlife corridor will accommodate a broader range of wildlife species.

A designed wildlife bench or crossing may look very attractive in the future to use as part of a trail corridor. For this reason, it is important to document the original intent of the wildlife passage and consider the above factors when considering a trail addition.

Maintenance of Crossing Structures

In most cases wildlife crossing measures will not include maintenance beyond what NCDOT typically incurs for a standard structure; however, there are a couple of significant exceptions that are paramount to supporting the investment made in the crossing. These include:

1. Vegetation maintenance within a wildlife crossing should be coordinated with NCDOT environmental staff and/or NCWRC prior to cutting or spraying. Uncoordinated clearing activities have resulted in crossings being blocked or filled by brush often covering existing wildlife trails. Vegetation management is necessary for both NCDOT right-of-way maintenance and the success of the wildlife crossing. Vegetation management activities are typically more frequent in the earlier years post-construction until a suitable vegetation structure and setback are established.

2. Wildlife fence maintenance will insure both the integrity and longevity of the fence. Vegetation can easily grow through and over a fence eventually stressing the fence. Right-of-way setbacks and routine vegetation management around the fence can reduce problems, increase the life of the fence, and allow easy visual inspection from the roadway. Gaps in the fence that develop from tree falls, vehicle crashes, etc. should be repaired as soon as possible. Wildlife will quickly find new gaps in the fence and access the roadway, significantly increasing the likelihood of a wildlife-vehicle collision.

3. It is also important to coordinate with NCWRC on all projects adjacent to wildlife crossings to ensure the activities will not impact the effectiveness of the structure. Even inconspicuous projects (highway lighting, emergency management signs, utility work, access breaks, etc.) could have adverse effects on wildlife use of a crossing structure.

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