Large Animal Crash Countermeasures in Virginia

TECHNICAL GUIDANCE AND BEST MANAGEMENT PRACTICES

Virginia Department of Transportation
PREPARED BY BRIDGET DONALDSON | VIRGINIA TRANSPORTATION RESEARCH COUNCIL
APRIL 2022
# Table of Contents

CHAPTER 1 Introduction ............................................................................................................................... 2

CHAPTER 2 Determining If an Area Has a High Risk of Deer Crashes ........................................................... 3

CHAPTER 3 Selecting the Appropriate Large Animal Crash Countermeasure ................................................. 4

CHAPTER 4 Bridges and Culverts: Underpass Designs and Enhancements to Accommodate Deer/Bear Passage.......................................................................................................................................................... 6

4.1 Structures That Are Suitable for Deer/Bear Passage ........................................................................ 7

Structure Sizing and Features to Encourage Use .................................................................................. 7

The Number and Spacing of Wildlife Crossing Structures ................................................................. 9

4.2 Measures to Enhance Structures to Increase Suitability for Large Animal Passage ......................... 10

The Addition of Fencing to New or Existing Underpasses .................................................................. 10

Other Enhancements to Structures to Encourage Wildlife Use.......................................................... 16

CHAPTER 5 Seasonal Wildlife Advisories on Changeable Message Signs ................................................... 19

CHAPTER 6 Animal Detection Driver Warning Systems .............................................................................. 22

Test Installations in Virginia .................................................................................................................... 23

Site and Installation Considerations ....................................................................................................... 24

Training and Maintenance Requirements .............................................................................................. 25
CHAPTER 1 Introduction

These guidelines provide information to the Virginia Department of Transportation (VDOT) on measures to reduce collisions with large animals, namely, white-tailed deer and black bear. Wildlife crash countermeasures are useful to consider not only in the project scoping process for new road projects but also for existing roads in areas with frequent wildlife crashes.

The measures in the guidelines have been shown to be effective at reducing wildlife crashes and associated costs from property damage and animal carcass disposal. These measures include (1) wildlife crossings with fencing (including enhancing existing underpasses with fencing and other features), (2) wildlife advisory messages on changeable message signs (CMSs), and (3) animal detection driver warning systems. Other methods to reduce wildlife crashes are not discussed in these guidelines because robust evaluations of their effectiveness are unavailable or inconclusive or the measures have been found to be ineffective. Because of the limited effectiveness of static large animal warning signs, these signs should be used only in accordance with VDOT’s memorandum IIM-TE-369 where the implementation of another recommended countermeasure is not feasible.

Virginia is considered a high-risk state with regard to deer-vehicle collisions, with more than 60,000 incidents per year according to insurance claims estimates. Although insurance claim data provide an indication of the scale of the deer crash problem, the locations of these crashes are unavailable to agencies and the public. VDOT predominantly uses police crash report data for project planning and safety evaluations. Although police crash reports have precise location information, deer-related crashes are substantially underreported and represent less than 10% of insurance claim estimates. Chapter 2 of these guidelines provides information on how to calculate a more accurate estimate of the number of deer crashes for interstates.

Vehicle collisions with black bears are also frequent in some areas of Virginia and can have adverse effects on driver safety and bear populations. In general, the countermeasures described in these guidelines are intended for reducing crashes with deer and black bear, but they can also be effective at reducing crashes with a variety of other wildlife species.

Elk inhabit portions of Southwest Virginia. Two of the deer and bear crash countermeasures discussed in these guidelines can also apply to elk (i.e., wildlife advisories on CMSs and animal detection driver warning systems). Wildlife crossing designs for elk, however, can have different size requirements than those for deer and black bear, and elk-specific designs are not included in these guidelines. Any consideration of wildlife crossing placement and sizing for elk should include site-specific factors (such as the mountainous terrain) and should be conducted in consultation with the Virginia Department of Wildlife Resources, which has information on elk movement relative to roadways.
As with any safety improvement project, evaluating the effectiveness of measures to reduce wildlife crashes helps justify costs and determine whether similar improvements should be conducted on other road segments. Accurate animal carcass removal information provides the most useful dataset. If carcass removals are not currently documented along the targeted road section, collecting these data from road maintenance staff as soon as possible will be useful for assessing the effectiveness of enhancements and mitigation measures once they are implemented. Post-project monitoring should be conducted for several years (no fewer than 2 years) to evaluate efficacy and make adaptive management decisions if necessary. The Virginia Transportation Research Council can also be contacted to assist with or conduct any evaluations, including the selection and implementation of the countermeasures discussed in these guidelines.

CHAPTER 2 Determining If an Area Has a High Risk of Deer Crashes

For VDOT safety evaluations, police crash report data are used to evaluate high-risk crash types, including those that involve deer. According to comparisons of police-reported deer crashes and deer carcass removal records in various areas of Virginia, the number of carcass removals can be up to 9 times greater than the number of deer crashes documented in police crash reports. Although the crashes documented in police crash reports are likely more severe than undocumented crashes with wildlife, areas with a large number of carcass removals represent an increased risk to driver safety. Deer crashes, in particular, have also been found to be among the costliest reported collision types because of their high volume.

Prior evaluations of deer crash data from I-64 and I-81 in several Virginia counties found that deer carcass removals were 4 to 9 times greater than the number of police-reported deer crashes. Data for other road types likely fall within the same range (4 to 9), but data are currently not available to verify this. To improve the accuracy of deer crash estimates, a correction factor of 5 should be applied to police-reported deer crashes on interstates to account for non-reported crashes.

Applying a correction factor of 5 will typically result in a conservative estimate of deer crashes, as this factor does not account for the proportion of deer that are injured or die away from the road. Other research found the number of unaccounted deer to be more than twice the number of deer carcasses removed from the road. Nevertheless, the use of this correction factor will result in a more accurate representation of the actual number of deer crashes and will provide a better indication of whether deer crash countermeasures are needed. VDOT’s Instructional and Informational Memorandum on Large Animal Crash Countermeasures (IIM-LD-262/IIM-TE-396) refers to this correction factor and provides information on determining whether an area is appropriate for the implementation of a wildlife crash countermeasure.
CHAPTER 3 Selecting the Appropriate Large Animal Crash Countermeasure

Measures to reduce wildlife crash risk can be incorporated relatively inexpensively when designed into a new road project, such as a new road or alignment, a lane addition, or a culvert or bridge replacement. Whether selecting the best countermeasure to implement as part of a new road project or to reduce crashes along an existing road, selection of the most appropriate measure depends on location and site features, among other factors.

Figure 1 provides guidance to help identify the appropriate countermeasure for an existing or proposed road segment that has been identified as being suitable for a large animal crash countermeasure. Figure 1 distinguishes between (1) new road projects that may result in a high risk of large animal crashes and (2) existing roads with a high frequency of large animal crashes.
Figure 1. Identifying appropriate countermeasures for detailed consideration in VDOT projects.

Note: Although static wildlife warning signs are not included in the diagram, they remain an option for VDOT when other countermeasures are not feasible and when they meet the requirements listed in the Traffic Engineering Division’s Instructional and Informational Memorandum IIM-TE-369 Deer and Other Large Animal Crossing Warning Signs.
CHAPTER 4 Bridges and Culverts: Underpass Designs and Enhancements to Accommodate Deer/Bear Passage

Wildlife crossings are overpasses or underpasses used by wildlife to cross above or beneath a road. These structures are the most effective method of reducing wildlife crashes while also providing a means for wildlife to access habitat on the other side of a road. When combined with fencing, which restricts wildlife access to the road and helps guide them toward the crossings, these structures have been found to reduce wildlife crashes by more than 90% throughout the United States and other countries.

Wildlife crossings can be implemented relatively inexpensively by incorporating them into certain maintenance projects, road improvement or widening projects, and culvert or bridge replacements or by adding wildlife fencing to existing structures that are suitable for wildlife. When evaluating the potential for new wildlife crossing construction (or substantial enhancements to existing underpasses), the land uses of the surrounding area must be considered. For example, areas where development is expected in the near future should not be considered candidate locations for wildlife crossings unless there are protected areas of habitat that enable wildlife access to the structures.

Although there are few structures designed specifically for wildlife in Virginia, there are many structures designed for other purposes that wildlife use as part of their daily and seasonal movements. According to the National Bridge Inventory, for example, there are nearly 11,000 structures over waterways in Virginia. Many of these structures provide room for wildlife movement adjacent to the waterway. For many existing bridges and large culverts, and for new wildlife crossings, the addition of wildlife fencing has a significant effect on increasing structure use by wildlife and decreasing crashes along the fenced section. The addition of wildlife fencing to a bridge underpass and a large box culvert beneath I-64 in Virginia resulted in an average crash reduction of 92% and up to a 410% increase in use of the structures by wildlife.

There are significant economic benefits from these large animal crash reductions, predominantly in the form of property damage savings to drivers. Savings from deer crash reductions at the fenced underpass sites on I-64 began exceeding fencing costs in an average of 1.8 years, and there was an average estimated savings of more than $2 million at each site over the lifetime of the fencing.

The addition of wildlife fencing to existing large underpasses in Virginia has resulted in deer crash reductions of more than 90%.
4.1 Structures That Are Suitable for Deer/Bear Passage

Structure Sizing and Features to Encourage Use

In general, larger and more open structures receive more use by large animals in Virginia than smaller structures. Figure 2 illustrates structures used by deer and black bear in Virginia, and Figure 3 provides the size dimensions and features of underpasses recommended for deer and black bear use. Wildlife overpasses can also provide a seamless habitat connection above the road and substantially reduce wildlife crashes. Although overpass structures can be more suitable in certain terrain than underpasses, these guidelines are limited to underpasses, which are typically less costly and can be as effective as overpasses for white-tailed deer and black bear.

Figure 2. Underpass structures used by deer and other wildlife in Virginia. Top left: a box culvert with 20-ft by 15-ft openings beneath Fairfax County Parkway. Top center: a box culvert with 10-ft by 12-ft openings beneath Interstate 64. The addition of wildlife fencing to this structure increased deer use by 410%. Top right: a bridge spanning a creek beneath Interstate 81. Lower left: a bridge spanning a river along Interstate 64. Lower right: a bridge spanning a wetland on Route 17 near the Great Dismal Swamp National Wildlife Refuge, constructed with a dry path to provide a crossing for black bears.
Figure 3. Criteria for new and existing wildlife crossings / underpass structures suitable for large animal passage.

<table>
<thead>
<tr>
<th>Features</th>
<th>Optimal</th>
<th>Adequate</th>
<th>Low to none</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>Bridges: 8 ft min height</td>
<td>Culverts: If less than 125-ft barrel length:</td>
<td>Less than 8 ft high</td>
</tr>
<tr>
<td></td>
<td>Culverts: If less than 125-ft barrel length:</td>
<td>Openings should be 8 ft min height, 10 ft min width.</td>
<td>Less than 8 ft wide</td>
</tr>
<tr>
<td></td>
<td>打开</td>
<td>If greater than 125-ft barrel length:</td>
<td>打开</td>
</tr>
<tr>
<td><strong>Visibility</strong></td>
<td>Clear line of sight; habitat visible on other side of structure. Can add artificial lighting or grate in ceiling of culvert for natural light.</td>
<td></td>
<td>Exposed concrete or metal bottom (with no soil backfill).</td>
</tr>
<tr>
<td><strong>Substrate</strong></td>
<td>Natural substrate, backfill several inches of topsoil to cover exposed culvert floor.</td>
<td></td>
<td>No dry path for wildlife movement.</td>
</tr>
<tr>
<td><strong>Access/path</strong></td>
<td>Unobstructed path leading to entrances. Min 3-ft wide dry path for wildlife movement (or 1.2x bankfull width) though the underpass.</td>
<td></td>
<td>No dry path for wildlife movement.</td>
</tr>
<tr>
<td><strong>Fencing</strong></td>
<td>Up to 1 mile of wildlife fencing with underpass at the center. Fencing should continue across medians of bridge underpasses.</td>
<td></td>
<td>No dry path for wildlife movement.</td>
</tr>
</tbody>
</table>

Notes

- Culverts can be open bottom, box, elliptical, or circular.
- Culverts should have level or minimum grading and be situated perpendicular to road.
- Two shorter culverts separated by the road median is recommended over one long continuous culvert, where possible.
- The addition of wildlife fencing will improve the effectiveness of any new or existing structure that meets the above criteria.
Many underpasses are designed to facilitate the movement of streams and rivers, either throughout the year or seasonally, to accommodate storm events. These structures can be designed or modified to serve a dual role of facilitating the passage of both water and wildlife. Large countersunk culverts or bottomless culverts are particularly useful for accommodating both water and wildlife movement (Figure 4).

![Figure 4. A bottomless box culvert with 20-foot by 15-foot openings beneath Fairfax County Parkway. The underpass facilitates stream passage and includes a dry path for wildlife.](image)

Underpasses designed for livestock and farm vehicle passage beneath a road are often suitable for large wildlife. These underpasses are often tied to livestock fencing that corrals livestock into the underpass. This fencing can prevent access or discourage wildlife from using the underpass. If livestock fencing is present, the best method to encourage wildlife use is to create an opening in the livestock fencing. If this is not feasible, wildlife-friendly livestock fencing that consists of a 3-wire design with minimal use of barbed wire is recommended. The bottom wire should be high enough (16 to 18 in) to allow young animals to travel under the fence.

**The Number and Spacing of Wildlife Crossing Structures**

Decisions regarding the number and spacing of wildlife crossing structures depend on the length of the identified high-wildlife-crash area, site-specific factors, and project budget. A single wildlife crossing with 1 mile of wildlife fencing can be expected to reduce crashes significantly along the length of the fenced segment. To reduce crashes along a high-crash road segment that is longer than 1 mile, more than one structure is recommended. Structures
should be situated approximately 0.5 mile apart or less from one another and connected with fencing.

Existing road segments that have been identified as having a high risk for wildlife crashes can be scanned for the presence of existing suitable underpasses or underpasses that can be enhanced to provide wildlife passage (as described in the subsequent section). Multiple existing structures or opportunities for structure replacements may exist in proximity. Extending fencing between multiple suitable structures can be expected to result in a significant wildlife crash reduction (more than 90%) along the entire length of the mitigated road segment.

4.2 Measures to Enhance Structures to Increase Suitability for Large Animal Passage

The Addition of Fencing to New or Existing Underpasses

Wildlife will not exclusively use a suitable underpass structure to cross the road unless fencing prevents them from crossing at-grade. Although deer and other wildlife will use a suitable unfenced structure to some extent, they will also cross the highway immediately adjacent to a suitable structure unless they are prevented from doing so. Fencing not only prevents at-grade crossing attempts but also serves to guide wildlife to the structure so it becomes a habitual means of travel for adults and their young. As mentioned previously, the addition of 1 mile of wildlife fencing at two existing underpasses along Virginia’s I-64 resulted in a 92% average crash reduction and up to a 410% increase in underpass use by deer and bear. Costs ranged from $12 to $29 per linear foot, for a total average cost per fenced site (including site preparation, traffic control, and maintenance) of approximately $265,000.

To determine whether the addition of wildlife fencing to an existing underpass structure is likely to be effective, the following three conditions must be met:

1. The underpass meets the minimum size dimensions listed in Figure 3.
2. There is some degree of evidence of underpass use by deer or black bear (such as deer or bear trails, tracks, or scat).
3. Fencing can extend continuously along the roadside that is not interrupted by driveways or intersecting roads for a distance greater than 0.25 miles (or less than 0.25 miles) as long as the fencing extends beyond the segment with high wildlife crashes.

Fencing Construction and Placement

Wildlife fencing is typically easier to accommodate on limited access highways because of the longer segments of highway that are not intersected by roads or driveways. Wildlife fencing is not currently addressed in the VDOT Road & Bridge Standards or Road & Bridge Specifications,
but a sample special provision can be provided by VDOT’s Central Office Construction Division and a sample special design drawing can be provided by the Central Office Location and Design Division’s Special Design Section upon request.

Fencing length is an important factor in ensuring that a structure is as effective as possible at facilitating wildlife passage and reducing crashes. Fencing should extend up to 1 mile, or 0.5 mile on each side of the culvert. The underpass should ideally be situated at the center of the 1-mile length of fencing. This is based on the distance that deer and smaller wildlife can be expected to travel to the underpass. Depending on where animals encounter the fence relative to the crossing structure, they will be more motivated to circumvent the fence end if the distance to the structure is greater than they are willing to travel. If a wildlife crash hotspot is slightly greater than 0.5 miles from an underpass, fencing can be longer to cover the entire length of the crash hotspot, but in general, the fencing should not extend more than 0.75 miles from the underpass. The next section provides details on fence end designs.

Fencing should be constructed on both sides of the roadway, and sections across the road from one another should be constructed as close to the same time as possible. Leaving only one side of the road unfenced for a long period increases the risk of collisions by trapping wildlife on the roadway side of the fenced section.

The wildlife fence should typically run parallel with the roadway between the shoulder and the tree line (Figure 5). Fencing constructed closer to the tree line allows maintenance staff access to mowable areas and roadside equipment. Fencing placed beyond the tree line into wooded areas is more likely to be damaged from fallen trees or limbs and is more difficult to access and maintain. Further, areas in need of repair will be difficult to detect because of the lower visibility from the roadside.
Figure 5. Illustrations of 8-foot-high woven wire wildlife fencing along Interstate 64. Placement should be at least several feet from the edge of the pavement (bottom left), several feet behind paved ditches, and behind areas that need to be accessed for mowing or equipment (bottom right).

Fencing should be placed as follows:

- Outside the established deflection zone of guardrails;
- Outside the flowable area of ditches (5-foot minimum offset);
- Outside the canopy of large trees and other tall vegetation where possible;
- Behind sign structures;
- Behind areas of mowable grass; and
- Behind roadside equipment or devices (weather stations, solar panels, etc.).

The bottom of the fence should be no higher than 3 inches from the ground. In areas of uneven terrain or drainages where gaps are greater than 3 inches, additional wires can be strung between the posts and a dead-man or additional post.

Fence End Designs and Tying Fence Into Underpass Openings

Fence ends should be designed to minimize “end runs” whereby an animal circumvents the fence end and can access the highway. The best option for reducing ends runs (and providing
an additional connection between habitats across the highway) is to connect fencing from one suitable underpass to another suitable underpass (Figure 6, Option 1). This option can include bridges that span a low volume road, railroad tracks, or other options that allow wildlife to share safely the use of the underpass with slow-moving vehicles or farm animals/equipment. Another highly effective option is to tie the fence into a landscape feature such as steep topography or another barrier (Figure 6, Option 2). With this design, care should be taken to ensure that the final fence post is situated close enough to the barrier to prevent large animals from squeezing between the barrier and the fence end. Incorporating the use of the existing topography can also help limit the amount of fencing needed. When steep slopes and rock cuts are not present at the site, a third option has been found to be effective at minimizing fence end runs. With this design option, the fence end should angle away from the road (at an approximate 45 degree angle) and tie in to the existing right-of-way fencing (Figure 6, Option 3). Although adult deer can scale 4-foot-high right-of-way fencing, the intersection of the wildlife fence with the right-of-way fence creates enough of an obstacle that it reduces end runs. Finally, the fourth and last option is to angle the end of the fence away from the road; extend it as far as possible away from the road; and end the fence in an area where the habitat type changes (i.e., between forest/field/wetland, etc.) (Figure 6, Option 4).

Figure 6. Illustration of wildlife fencing placement, length, and options for fence ends for bridge underpasses (top) and culverts (bottom). Fence end design options are numbered in order of effectiveness (1 to 4). Option 1 = tie fence in to another underpass suitable for wildlife use (low volume road, culvert, etc.). Option 2 = tie fence into area of steep topography. Option 3 = tie fence into right-of-way fence. Option 4 = end fence in an area of habitat transition. Hash marks along wildlife fence signify jumpout locations (discussed in a subsequent section).
Fencing should be designed to lead wildlife to the openings of the underpass. For large culverts, fencing should either continue behind the culvert or tie directly into the wing-wall / head-wall of the structure. For bridge underpasses that include a median between the lanes of travel, the fence should extend just below the bridge abutments, continue downhill and beneath the bridge, and tie into the abutment on the other side of the highway (Figure 7). This will prevent wildlife from traveling uphill from beneath the bridge toward the median above. For bridge underpasses that do not include a median, fencing should end at the top of the bridge abutment.

**Figure 7.** For a bridge underpass with a median, wildlife fence should extend from the roadside and continue beneath the bridge to prevent wildlife from accessing the median from the underpass.

**Jumpouts**

Animals may occasionally get caught on the wrong side of the fencing barrier and become a driver safety risk. Jumpouts are features designed into the wildlife fence that allow a means of escape for any wildlife trapped on the road-side of the fence. They are designed to prevent animals from entering the roadway from the habitat side of the fence. Jumpouts should be incorporated along each 0.25-mile extent of fencing and should ideally be situated approximately halfway between the underpass and each fence end (see Appendix A for design details).

Successful jumpouts constructed in Virginia consist of 8-foot-wide sections of fencing that are cut out to a height of 3.5 feet (approximately 40 to 42 inches). Fencing leading to a jumpout should angle away from the road, functioning as a short funnel and thereby increasing the likelihood that wildlife will notice the jumpout (Figure 8). For fencing and jumpouts situated on flat areas, jumpouts should have a top-mounted angled attachment (Figure 8 and Appendix B). These attachments are angled away from the road toward the habitat side of the fence, making it unlikely for deer on the habitat side of the fence to jump over them. The attachments are unnecessary for jumpouts located on a downhill grade (Figure 8 and Appendix B). On downhill grades, the height required to scale the jumpout from the downslope habitat side of the fence is typically too great for deer.
Figure 8. Jumpouts should be constructed at the end of a funneled section of fencing set back from the road with an attachment angled away from the road if the jumpout is on flat ground (left) or with no angled attachment if the jumpout is on a downslope (right).

Another location to create a jumpout is toward the top of some underpasses, where the fence can lead to a 4- to 5-foot-high section of a culvert wingwall or bridge abutment. This would allow wildlife that are trapped on the roadway side of the fence to escape the road and access the underpass. As Figure 9 illustrates, the fence can be designed to lead to the top of a bridge abutment and leave a 3-foot opening to serve as a jumpout. Deer are likely to jump down an abutment or wingwall that is 4 to 5 feet high but are unlikely to jump up that distance.

Figure 9. To create an additional means of escape for any wildlife trapped on the road-side of the fence, the fencing adjacent to the underpass can be designed to leave a 3-foot gap above a 4- to 5-foot-high section of a bridge abutment or a culvert wing wall, allowing wildlife to jump down toward the underpass. The photographs show the view from above the underpass (left) and from below the underpass (right).

Wildlife Underpass and Fencing Maintenance

Maintenance staff should be involved in the planning for any underpass or fencing projects, as maintaining these features is critical to long-term effectiveness. Maintenance staff should
provide input on the best fencing placement to ensure the fencing is visible to assess for damage but that its placement will not hinder vegetation management or access to roadside devices or equipment.

Thick vegetative growth that hinders access to underpasses used by wildlife should be cleared to provide a path up to and through the underpass. For wildlife fencing, vegetation should be prevented from growing up the fence. Vegetative growth should be controlled and managed in a manner similar to that used for any other roadside infrastructure or equipment (i.e., hand tools or spray).

Maintenance staff should visually assess the fence for damage as part of their routine maintenance activities. Fencing maintenance should be expected one or more times per year, depending on the frequency of damage. Damage that results in any openings in the fence that are large enough for large animals to pass through should be repaired as quickly as possible.

Other Enhancements to Structures to Encourage Wildlife Use

There are several other ways to encourage use of a structure by wildlife. As with adding wildlife fencing to an existing structure, enhancing an underpass for wildlife use is often more cost-effective than constructing a new structure, particularly when it can be done as part of a highway project. The following illustrates some of the measures that can be applied to new or existing underpass structures to encourage use by large animals (also illustrated in Figure 10):

- **Trail/passage bench and selective use of riprap.** Riprap can be a significant movement barrier to wildlife, particularly deer, and should be used sparingly (if at all) in bridge underpasses where wildlife can be expected to travel. If it must be used to stabilize slopes, a level trail should be built across the riprap for use by deer and other wildlife. Chapter 8 of the VDOT Manual of the Structure and Bridge Division (8.03-12 through 8.03-14) provides details on creating a passage bench (or trail) for wildlife, which should be level, have a minimum width of 3 feet, and be set above drainage outlets/outfalls to prevent washout from crossflows. Trails should be constructed on both sides of a creek/river or low volume road.

- **Topsoil or other natural substrate on culvert floor.** For dry culverts that are potentially suitable for large animals, covering the bottom with topsoil typical of or from the adjacent habitat will encourage use.

- **Vegetation leading to underpass entrances.** If not already present, adding vegetation that is typical of the adjacent habitat will serve as a means of cover and thereby encourage use by wildlife.

- **Increased ease of access to and through an underpass.** This includes contouring/modifying the approaches to an underpass and the slope beneath bridge underpasses to allow easier wildlife movement. Approaches should be clear of material and equipment that may be barriers to movement (such as large foreign material and thick/impassable vegetation, riprap, and other material that is difficult for wildlife to
traverse). For underpasses that serve as a crossing for livestock, openings should be created in any existing fencing used to corral livestock into the structure.

- **Natural or artificial light.** For many wildlife species, including deer, more open and well-lit structures will be used more readily than dark tunnel-like culverts. The addition of grating at the top of the underpass will fill the culvert with natural light and will encourage wildlife use (Figure 11). Artificial light sources can be installed in dark culverts when grating is not an option.

![Figure 10. Illustrations of a large culvert (left) and a bridge underpass (right) with unimpeded access, space for wildlife movement, a natural bottom, vegetation at the structure entrances, and fencing either above the structure (left) or through an underpass that includes a median (right).](image)

![Figure 11. Grating constructed in the median of Fairfax County Parkway in Virginia. The grating allows natural light into a box culvert to encourage use by deer and other wildlife.](image)
Key References


Chapter 5 Seasonal Wildlife Advisories on Changeable Message Signs

The purpose of CMSs, also known as dynamic message signs, is to increase driver safety by calling attention to unexpected conditions. The aim is to increase driver alertness and often to reduce driver speed. Studies have suggested that drivers can reduce the chance of a collision...
with wildlife by reducing speed and remaining alert in areas with abundant wildlife. In general, reducing speed has been found to decrease the number of crashes and the severity of injuries regardless of the type of collision. Several studies have found lower numbers of animal crashes in areas with lower speeds.

Although studies show mixed results with regard to their effectiveness at deer crash reduction, a study along a 17-mile segment of Virginia’s Interstate 64 showed a 51% reduction in the number of deer crashes on days that deer advisories were posted on the segment’s three CMSs compared to days the messages were not posted. In addition, there were significant reductions in vehicle speeds during periods that deer advisories were posted. The advisories were posted every other day that other safety or advisory messages were not prioritized and only in October and November when the risk of deer crashes are greatest. This posting schedule was intended to reduce the likelihood of driver habituation to the messages.

As a result of the study’s conclusion that deer advisories on CMSs can be an effective deer crash countermeasure, VDOT’s Operations Division added a Wildlife Warning Campaign section (chapter 2.1.17) to VDOT’s Changeable Message Signs Policy (IIM-OD-13.03) that states the following:

2.1.17 Wildlife Warning Campaigns

Many roadways in Virginia experience high rates of animal crossings at certain times of the year and times of the day. These messages are general warnings to be displayed on CMS and/or PCMS near known areas with high rates of vehicle-animal crashes involving large animals. A “large” animal is one that is taller than a typical car’s bumper and large enough that there is significant potential that the vehicle will be significantly damaged if that animal is struck. Neither CMS nor PCMS shall be used to warn of the presence of small animals. These messages are similar to general safety campaigns, except they are targeted to certain areas at certain times.

Messages should be displayed only during those times of year and times of day when the risk of animal-related crash is most significant. For deer, messages should be displayed only in October through December between the hours of 5:00 PM and 9:00 AM, provided there are no higher priority messages to be displayed. Locations and time periods for wildlife warning messages must be approved by the ROD, in coordination with the Traffic Engineering Division. If there is no congestion, wildlife warning campaigns should be displayed in place of travel time messages. Messages should follow the example message shown in Appendix A [see
Figure 12 for example messages. Messages should refer to the specific animal (e.g., “deer”) rather than to more generic terms such as “animal” or “wildlife.”

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Permanent CMS</strong></td>
<td><strong>Watch for deer</strong></td>
</tr>
<tr>
<td><strong>DEER CROSSING</strong></td>
<td><strong>Next XX miles</strong></td>
</tr>
<tr>
<td><strong>NEXT XX MILES</strong></td>
<td><strong>Call 511 for info</strong></td>
</tr>
<tr>
<td><strong>Portable CMS</strong></td>
<td><strong>Watch for deer</strong></td>
</tr>
<tr>
<td><strong>Next XX miles</strong></td>
<td><strong>Call 511 for info</strong></td>
</tr>
</tbody>
</table>

Figure 12. Example wildlife warning messages, which should refer to the specific animal and the length of the high-risk road segment. Further, they should be displayed seasonally (when crashes are highest) on days when no higher priority messages are to be displayed.

Key References


CHAPTER 6 Animal Detection Driver Warning Systems

Animal detection warning systems are designed to sense large animals as they approach the roadway and are intended to warn drivers about their presence. Most animal detection systems contain either above-ground area-cover sensors or break-the-beam sensors. The system is activated once an animal’s body blocks or reduces the signal received by the receiver. Once detection is verified, a warning system (such as a flashing warning sign or a CMS that wirelessly communicates with the detection cable) can be used to alert drivers to the danger, resulting in a reduction in vehicle speed and stopping distance. Some studies have found more than a 90% reduction in deer crashes following the installation of a system. Buried cable detection systems offer several advantages over above-ground detection technologies when environmental variables such as precipitation and vegetation and site-specific characteristics such as topology, subsidence, and road curvature are considered.

Unlike wildlife crossings (overpass or underpass structures), these systems do not provide a means of connecting wildlife habitat across a roadway. They can, however, be used in combination with wildlife crossing structures, particularly at fence ends or in an extensive gap along a fence.

Buried cable animal detection systems generally consist of two buried cables that distribute radio frequency signals along the cable path. The two cables are approximately 12 inches apart, with the cable nearest the road approximately 15 feet from the pavement edge. The two cables are connected to a processor box. The system generates an invisible electromagnetic detection field around the cables; when an animal interrupts the radio frequency sensors, the processor
box activates the flashing beacons attached to a W11-series large animal sign (e.g. deer, bear, or elk).

Note: Installations of buried cable animal detection systems in Virginia have been conducted for research purposes, but the system is not yet approved for use outside of pilot applications. Any VDOT installation of an animal detection system must be coordinated among the following:

1. The project team;
2. The applicable VDOT Regional Operations Director or designee; and
3. VDOT’s Traffic Engineering Division.

Test Installations in Virginia

In studies of a buried cable animal detection system (an area-cover system) installed in Blacksburg and Christiansburg, Virginia, the system detected large animals with more than 95% reliability, even when the cable was covered with 2 feet of snow (a factor that can block the sensors of other detection systems). The system was tested under various vehicle traffic conditions, and rare instances of relatively minor interferences were observed. Vehicle speed and brake light application data collected during warning sign activation showed that approximately 80% of drivers either braked or slowed in response. The system is still operational several years after installation. However, to determine the system’s effectiveness at reducing collisions with wildlife, a longer study with a robust wildlife crash dataset is needed.
Although the data on the effectiveness of animal detection driver warning systems in Virginia and elsewhere are very encouraging, the studies in Virginia were limited to an evaluation of the system’s reliability at detecting wildlife on the roadside and an analysis of driver speed reduction when the lighted signs were activated. The system has not been tested in Virginia with regard to its effectiveness at reducing wildlife crashes. Further, systems have not been fully evaluated for holistic, sustainable maintenance and operations and compliance with security standards.

The following sections provide initial considerations for teams considering this system. Full details on these topics will be evaluated and determined by the project team, VDOT district/region staff, and VDOT’s Traffic Engineering Division during the planning stage of any pilot installation.

Site and Installation Considerations

The installation site should allow for solar power or a connection to a power source. The optimal site would also have access to a fiber optic or other communication system with which the cable
detection system can be physically connected. Cellular modems can be used, but they can be unreliable and are unlikely to be worth the effort required to manage an additional piece of equipment. If the installation site happens to be in an area with existing VDOT traffic cameras, the cameras can provide a simple means of monitoring the system to ensure that the cable is reliably detecting wildlife.

The selected site should have at least 15 feet of available right of way from the pavement edge. For effective installation and operation of an animal detection system, the roadside terrain should be relatively flat, without ridges, gullies, or rock outcrops. Adequate sites should include 12 to 18 feet of flat terrain off the shoulder with suitable drainage. Sites with depressed areas (ditches) where water can accumulate or flow, a high volume of oversized/overweight vehicles, metal structures (e.g., fences and guardrails), and communication cables including buried and overhead power lines lower than 12 feet should be avoided.

Access roads should also be avoided because vehicles turning off the road can trigger the system. If a break-the-beam system is used, vegetation should be managed to ensure that grass, bushes, or branches do not trigger the system. There has not yet been any testing with break-the-beam above-ground animal detection systems in Virginia.

The warning beacon assembly should consist of a Large animal warning sign (e.g. deer, bear, or elk), and flashing beacons per Chapter 4L of the MUTCD. VDOT’s Traffic Engineering Division should consider whether such assemblies should be equipped with a “When Flashing” or similar supplemental sign message.

Training and Maintenance Requirements

Animal detection system vendors provide training on equipment, which can be conducted in a 1-to 2-day timeframe. Companies that provide driver warning devices such as flashing signs or CMSs also provide training on pairing the sign with the detection system. Information on equipment, costs, and operational procedures are also available in Druta and Alden (2015 and 2019), referenced below.

Initial setup of the detection system, which can be conducted during the training period, includes calibrating the equipment so the device detects only large wildlife. The system can be recalibrated at any time if needed.

For the animal detection system tested in VDOT’s Christiansburg Residency, maintenance was not needed in its 4 years of operation. The system should be monitored occasionally to ensure that it is reliably detecting wildlife and that the warning systems are functioning properly. If a
traffic camera is not at the site, a video camera or motion-activated trail camera can be temporarily placed for monitoring detection reliability.

Key References


