

NCHRP 25-25, Task 113

ROAD PASSAGES AND BARRIERS FOR SMALL TERRESTRIAL WILDLIFE SPECIES

SUMMARY CONSIDERATIONS FOR LARGE UNDERPASS STRUCTURES

Prepared for:

AASHTO Committee on Environment and Sustainability

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September 2019

The information contained in this report was prepared as part of NCHRP Project 25-25, Task 113,
National Cooperative Highway Research Program.

SPECIAL NOTE: This report **IS NOT** an official publication of the National Cooperative Highway
Research Program, Transportation Research Board, National Research Council, or The National
Academies.

ACKNOWLEDGMENTS

This study was conducted for the American Association of State Highway and Transportation Officials (AASHTO) Committee on Environment and Sustainability, with funding provided through the National Cooperative Highway Research Program (NCHRP) Project 25-25, Task 113, *Road Passages and Barriers for Small Terrestrial Wildlife: Summary and Repository of Design Examples*. NCHRP is supported by annual voluntary contributions from the state departments of transportation (DOTs). Project 25-25 is intended to fund quick response studies on behalf of the Committee on Environment and Sustainability. The report was prepared by Marcel P. Huijser of the Western Transportation Institute - Montana State University and Kari E. Gunson of Eco-Kare International under contract to Louis Berger U.S. Inc., A WSP company (contract manager Edward Samanns). The work was guided by a technical working group that included:

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The project was managed by Ann Hartell, NCHRP senior program officer.

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LARGE UNDERPASS STRUCTURES

This document summarizes the considerations for large underpasses originally designed for wildlife (designated large underpasses for large mammals, small animal species, or both) and large underpasses originally designed for non-wildlife purposes. This summary is based on the literature review, survey report, and the knowledge and experience of the authors. The literature review and survey report are available as separate documents produced for this project (NCHRP 25-25, Task 113).

A. GENERAL CONSIDERATIONS

Characteristics

This summary considers large underpass structures (larger than 10 feet [3 meters]) in diameter, width, or height) that are either designated or not designated for wildlife. Designated wildlife crossing structures are “primarily designed for wildlife,” while non-designated structures are “originally designed for other purposes than wildlife,” but these structures may still allow for wildlife use, with or without modifications, depending on the species, surrounding habitat, and characteristics of the underpass and the conditions inside the underpass. Therefore, the summary for both designated and non-designated large structures for small animals is combined into one document.

Some designated large underpass structures for wildlife explicitly list small animal species among the target species, while others do not. Nonetheless, in many cases, when both small and large animal species are specifically listed as a target species, the design is often guided by the requirements of large mammal species, and provisions for small animal species (e.g., cover) are often lacking.

Location: Designated wildlife crossing structures are (or should be) located where improved connectivity for the target species is expected to have the greatest benefit to the population survival probability (Figures 1 and 2). On the other hand, the location of non-designated crossing structures is not based on connectivity needs for (small) animal species, but it is based on other primary functions, which may include hydrology (e.g., stream or river crossing), non-motorized or motorized transportation (e.g., trail or road crossings), or livestock crossings. However, in some situations, the location of a non-designated wildlife structure can be the same as that of a designated wildlife structure. For example, riparian or aquatic target species are associated with water, and the location of a stream crossing (non-designated structure) can be the same as that for a designated structure for riparian or aquatic wildlife species (Figure 3). Note that the distance between large structures is typically much larger than the home range of small animal species; smaller suitable structures are typically required at much shorter intervals (e.g., several dozens of meters up to perhaps hundreds of meters) (Bissonette & Adair 2008).



Figure 1: Large underpass designated for wildlife with piles of branches (cover) for small animal species in the right-of-way at the entrance of the structure. While the primary purpose of this structure is wildlife (including small animal species), provisions for small animal species such as cover were not provided. The cover for small animal species shown in this image was added much later for research purposes (Connolly-Newman 2013; Huijser et al. 2016). Montana.



Figure 2: Large underpass designated for wildlife with row of branches (cover) for small animal species inside the structure. While the primary purpose of this structure is wildlife (including small animal species), provisions for small animal species such as cover were not provided. The cover for small animal species shown in this image was added much later for research purposes (Connolly-Newman 2013; Huijser et al. 2016). Montana.



Figure 3: Tall and wide viaducts or underpasses allow for light and moisture to come in from the sides. Especially for structures that have no artificial bottom, this allows the vegetation, soil, and hydrology to be similar to that of the surroundings. This allows small animal species to move unimpeded. Split structures for the two travel directions (such as the one in the image) allow for more light and moisture to come in from the sides than one larger structure for the two travel directions. This bridge spans a gully associated with a small river (primary purpose), but it also allows for safe crossing by wildlife, especially those that live and move in low-lying and wet areas (secondary purpose). Yunnan, China.

Structure Type: Typically, large underpass structures for wildlife are open-span bridges or viaducts or elliptical culverts. Because of the topography, these structures are often located in a valley, gully, or riparian corridor; however, they can also be built in higher and dryer terrain but may require more elaborate recontouring of the surroundings. For structures for which the primary function is not wildlife, but for which wildlife is a secondary purpose, modifications during the design process can make the structures better suited for wildlife. For example, widening the structure beyond what is needed for its primary purpose (e.g., a stream) can also allow for dry passage for terrestrial species (Figure 4).

Modifications to structures that already exist may include creating a pathway for animals through traditional riprap (large rocks) that are often used to stabilize the embankments (Figures 5, 6, and 7). Structures that are much wider than strictly needed for hydrology or another primary purpose, structures that have natural substrate rather than an artificial concrete or metal bottom, and structures that have an opening in the median (i.e., two structures, one for each travel direction; e.g., Chambers & Bencini 2015), result in abiotic conditions (light, water, soil) and habitat (vegetation, cover) that more closely resemble the natural conditions on either side of a structure (Figures 3 and 8). Note that small and confined structures may be used more readily by certain small mammal species than larger structures that have no or limited cover (Foresman 2004; McDonald & Cassady St. Clair 2004). This illustrates just how important cover is to many small animal species.



Figure 4: An underpass for a stream (primary purpose) and wildlife (secondary purpose). During the design process, the structure was made wider than strictly needed for hydrology to allow riparian and terrestrial species to cross. Montana.



Figure 5: Pathway for large mammals in an underpass (bridge) primarily designed for water (stream). The design specifies a path that is at least 3-feet (90 centimeters) wide. Minnesota. Photo Credit: Peter Leete, DNR – MnDOT liaison.



Figure 6: Pathway for large mammals in an underpass (bridge) primarily designed for water (a stream). For more details on wildlife use, see Cramer & Hamlin 2017. Montana.



Figure 7: Pathway for large mammals in an underpass (bridge) primarily designed for water (stream). However, the water has eroded the substrate under the concrete path, and the path is collapsing. It would have been better to make the structure wider, have natural substrate for the path, and have the path sit above the high water (provided there would still be sufficient clearance or “head space” for the target species). For more details on wildlife use, see Cramer & Hamlin, 2017. Montana.



Figure 8: *Opening in the median to allow light and moisture in the wildlife underpass, Florida.*

Large enclosed box culverts (greater than 9.8 feet or 3 meters) are seldom primarily designated for small animal species. However, there are a few examples from the literature. In Ontario, three large box culverts (11-feet [3.4-meters] wide, 8-feet [2.4-meters] high, and 79-feet [24.1-meters] long) were integrated into a new highway twinning project with a 43-foot (13-meters) wide fenced median (Figure 9). The primary purpose of these box culverts is to provide safe crossing opportunities for freshwater turtles. The design allows for wetland habitat and vegetation in the median and at entrances to the structures. The structures have shown successful turtle passages (Gunson 2019).



Figure 9: *Large box culvert designed for turtles. Left: situation in the median. Right: under construction with the adjacent wetland habitat. Photo Credit: Kari Gunson.*

Structure Dimensions: Structures that are not designated for small animal species, but whose primary function is for livestock, large wild mammals, or stream crossing, typically have dimensions that are sufficient for small animal species. However, adaptations may be required (e.g., dry shelves for animals to walk on in culverts that are fully inundated).

Species-specific Habitat Requirements: Because small animal species move slowly, the width of a road (i.e., the length of a crossing structure), may be too great of a distance for small animal species to cross if cover, food, and water, and other resources cannot be accessed along the way.

Cover may be provided through root wads, branches, rocks, or artificial materials (e.g., concrete blocks) (Figures 1, 2, 4, 10, and 11) (D'Amico et al. 2015). Food may be provided through vegetation (including fruit-bearing plant species) and habitat that is suitable for prey species for small animal species (e.g., invertebrates). The presence of water may depend on the topography and the presence of streams or wetlands, which are typically critical for most amphibian and turtle species. Snakes and lizards may benefit from dry, warm areas with a combination of sunny spots (e.g., sandy or open grass-herb vegetation) as well as cover (e.g., root wads, tree branches, rocks, and thorny shrubs). Relatively small changes or additions to existing structures can make such structures more suitable for small animal species. Care must be taken that cover material does not block the water flow in a structure, including during periods with higher water volume.



Figure 10: An underpass for a two-lane road under a motorway (original purpose). The structure was originally designed for a wider road, but instead the available space was retrofitted for amphibians, small mammals, large mammals, and non-motorized use by humans. Note the root wads, shrubs, and trees growing in the foreground in between the two bridges (in the median), and the wildlife fence designed for amphibians, (plastic sheets), medium-sized mammals (fine mesh), and large ungulates (tall larger mesh). The Netherlands.



Figure 11: An underpass for a one-lane road under a motorway (original purpose). The original purpose of the structure was for motorized and non-motorized human use. However, there was sufficient space to allow for retrofitting with root wads and some soil to be put along the sides for small animal species. The Netherlands.

While certain “small” mammal species (e.g., small canids and felids) may use large box culverts, the availability of cover and vegetation is expected to greatly enhance use by most small animal species (Figures 12, 13, and 14).



Figure 12: Large box culvert with bare concrete bottom (not preferred for small animal passage). For more details on the research, see González-Gallina et al. (2018). Quintana Roo, Mexico.



Figure 13: Box culvert with soil from the surroundings placed on the bottom (preferred). This allows for some vegetation to grow at the edges of the structure, and woody debris and small rocks can accumulate over the entire length of the structure. For more details on the research, see González-Gallina et al. (2018). Quintana Roo, Mexico.



Figure 14: Box culvert with local substrate placed on the bottom. Rocks of various sizes have been placed on the approaches and inside the culvert to provide cover for small animal species and to block access to unauthorized vehicles. Idaho.

Supplementary Repository Materials:

- ME-5-Technical Drawings (Dry area next to stream in underpass)
- CO-8 Technical Drawings (Boreal toad crossing in arch culvert)
- CO-6 Technical Drawings (Cover in culvert)

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