NCHRP 25-25, Task 113

ROAD PASSAGES AND BARRIERS FOR SMALL TERRESTRIAL WILDLIFE SPECIES

CASE STUDIES 3 & 4, DRAINAGE CULVERTS

Prepared for:

AASHTO Committee on Environment and Sustainability

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DISCLAIMER

CASE STUDY 3: USE OF SHELVING IN DRAINAGE CULVERTS FOR SMALL MAMMALS

In Quebec, Canada, culverts were installed for drainage and wildlife passage during a road upgrade project that bisected the Laurentides Wildlife Reserve. Two modifications were made to the drainage culverts to facilitate passage by small mammals. First, when there was adequate road clearance/allowance, a ledge was installed for small terrestrial animal passage (Martinig & Bélanger-Smith 2016). In some cases, when ledges could not be installed, small dry pipes were installed on higher ground adjacent to the drainage culverts. Second, a barrier/guide-wall fence was installed at each drainage culvert (Plante et al. 2019). In this case study, research conducted at these structures from 2012–2018 is highlighted.

Name Highway: Highway 17

Project Type: Widening from two to four lanes; tripling width of road from 30 to 90 m

Partners: Ministère des Transports - Gouvernement du Québec, Concordia University, Ontario Ministry of Natural Resources and Trent University, and other independent researchers

Construction Year: 2006–2011

Costs: Unknown

Location and Habitat: Between Québec City and Saguenay, km 60 to km 144; Highway bisects the Réserve Faunique des Laurentides. Large parts of the road are directly adjacent to the Parc National de la Jacques-Cartier. The area is dominated by Boreal forest, e.g., balsam fir (*Abies balsamea*) and black spruce (*Picea mariana*).

Target Species: Small-medium mammals under 30 kilograms

Structure Type and Dimensions: 33 culvert structures designed for both drainage and wildlife passage; 18 monitored

- Diameter of adjacent pipe culvert without shelving: 60 centimeters (cm) and 90 cm (Figure 3a)
- Minimum width and height of box culverts: 1.2 m (Figures 3a-3d)
- Maximum width and height of box culverts: 1.5 m (Figures 3a-3d)
- Range of length of all box and pipe culvert: 46 to 91 m (Figures 3a-3d)
- Concrete ledge width: 0.49 m (Figure 3c); wood ledge width: 0.54 m (Figure 3b); 0.69 m distance of ledge from ceiling

Barrier Type and Dimensions (Figure 3e): Each fence was about 100 m long in each direction from the small animal underpass.

- Chain link
- 90 cm high with a 6 cm mesh size.

Figure 3: *The four types of wildlife underpasses designed for small and medium-sized mammals and the two types of fences along Highway 175: (a) pipe culvert or round concrete culvert (on the left next to the water culvert; n = 6), (b) box culvert with a wooden ledge (n = 4), (c) box culvert with a concrete ledge (n = 7), (d) box culvert with a concrete walkway (n = 1), (e) fence for medium-sized mammals, and (f) combined fencing for large mammals (upper half) and medium-sized mammals (lower half). Photo Credit: Concordia University Montreal, J. Jaeger.*

Modifications to Structures for Target Species:

- Added wood and concrete shelves to the sides of the structures with the exception of the pipe culverts.

- Exclusion fences for medium-sized mammals were placed on both sides of each passage entrance. The fences were approximately 100 m long on either side, 90 cm high with a 6 cm × 6 cm mesh size.

Effectiveness in Providing Connectivity: There were 1,851 complete crossings (13%), 28% explorations (animals entered and exited), and 59% unknown at the 18 passages from May to October 2012 to 2015 (Jaeger et al. 2017). Passage preferences are outlined below:

- American marten, fisher, Canada lynx, and northern flying squirrels were not detected at the culverts
- Used by more than17 species, primarily marmots (*Marmota monax*)
- Most mammal species used concrete pipe culverts (Figure 3a)
- Wooden ledge culverts were preferred over concrete ledge culverts
- Pipe culverts (Figure 3a) were discovered more by micromammals, e.g., shrews and voles
- Wooden ledge box culverts were used more by red squirrels
- Mammals prefered single segment structures with no open medians

Effectiveness in Reducing Road-kill: Road-kill was significantly greater at fence-ends than within fenced and unfenced sections. Road-kill was less in fenced road sections (and around the associated fence-ends) where wildlife passages were more frequently used.

Conclusions: This study showed that shelving is an important component for small mammal use of existing wet or for newly designed culverts in wet locations that are also intended for wildlife passage. When shelving cannot be implemented, adjacent higher dry pipe culverts may be suitable to enhance wildlife passage (CO-6, Repository).

Another consideration is to use dry pipe culverts not only adjacent to drainage culverts but interspersed between drainage culverts if spacing is not adequate for the target species, to improve connectivity.

Limited research has been conducted on adequate fence lengths and fence-end treatments for small mammals. Fences should be long enough and designed to reduce fence-end road-kill to a desired level.

There may be some maintenance concerns about using bolt-on metal brackets for metal shelving due to shelves becoming dislodged. Some transportation agencies prefer moulded concrete shelving, which would require construction prior to installation of drainage culverts in roads. Pipe culverts installed in higher ground is also an option.

Alternate Designs: Other research has studied the use of ledges in drainage culverts for small to medium-sized mammals. These include catwalks in drainage culverts for bobcats (Cain et al. 2003). Another study documented successful use of custom-built wood ledges that were added to various box and round drainage culverts, some with and some without entrance ramps, for the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) (Meaney et al. 2007; CO-7, Repository). Foresman (2004) added flat galvanized expanded metal mesh (6-millimeter [mm]) shelving to round drainage culverts in Montana and studies use when waters rose. In addition, tubes made from plastic rain gutters were also used by voles (Figures 4 and 5).

Figure 4: *Metal shelving installed in drainage culvert in Montana.*

Figure 5: *Ramp extending at right angle from metal shelving installed in a drainage culvert in Montana.*

Supporting Repository Materials:

- ME-1 to ME-5 (Images and technical drawings of creek pathways and shelving in culverts for turtles)
- CO-6 and C0-7 (Report and subsequent drawings for road project that used adjacent dry crossings with cover for small animals because maintenance issues with bolted ledges were a concern)
- VT-8 (Technical drawings of raised shelf made from crushed stone fill to allow dry wildlife crossing)

CASE STUDY 4: USE OF EXISTING DRAINAGE CULVERTS BY FRESHWATER TURTLES IN ONTARIO, CANADA

In the County of Haliburton, in central Ontario, Canada, an existing drainage culvert was converted into a turtle crossing structure by installing a custom-made wildlife exclusion fence (Heaven et al. 2019). This project is unique because of the sheer numbers of turtles captured using the existing drainage culvert and the significant reduction in turtle road-kills at the site using a Before-After-Control-Impact design that also evaluated turtle road-kill as a result of the “fence-end” effect.

Name Road: Gelert Road is a paved, two-lane road with gravel shoulders and a traffic volume of approximately 66 vehicles per hour

Project Type: Existing road

Partners: Glenside Ecological Services and Haliburton Highlands Land Trust with funding from the Ministry of Natural Resources, Species at Risk Stewardship Fund

Construction Year: Fall 2014

Cost:

- **$**43.00 per meter for materials
- $34.00 per meter for installation: retained excavator; used a team of community volunteers to reduce cost
- Total cost = $34,000

Location and Habitat: Rural road between the towns of Haliburton and Minden; Canadian Shield landscape dominated by natural conifer/deciduous forests, lakes, and wetlands, and exposed Precambrian bedrock. Wetlands comprised of marshes with a mix of open water and vegetation consisting of sedges (*Carex stricta)*, grasses (*Calamagrostis canadensis)*, and floating aquatic vegetation.

Target Species: Freshwater turtles, including Common snapping turtle (*Chelydra serpentina*), Blanding’s turtle (*Emydodiea blandingii*), and Painted turtle (*Chrysemys picta*)

Drainage Structure Type and Dimensions:

- Pre-existing, semi-aquatic HDPE culvert, situated in the center of the site
- 1.22-m diameter, 21-m long, and an openness ratio (width x height / length) of 0.07

- High water levels; in spring, the culvert was 66% submerged, which dropped to 35% submerged in summer

Modifications to Existing Drainage Structures for Target Species:

- Addition of barrier wall to funnel animals to one drainage structure

Barrier Type and Dimensions (Figure 6):

- Used readily available and inexpensive materials to construct the barrier wall; BOSS 2000 HDPE culvert pipe cut in half lengthwise, 75 cm diameter
- Held upright with 1.9 cm steel rod of 150 cm and 200 cm lengths
- Buried to a depth of 15 cm
- Height aboveground 60 cm
- Backfill from buried excavation used on-top of the backside of the fence and seeded so vegetation would hold the soil in place

Figure 6: *Boss HDPE materials used for barrier wall with back-fill and supported with steel rods. Photo Credit: Paul Heaven.*

Fence-end Treatment (Figure 7):

- Curved ends that ran back at an angle of 135 degrees for 6 m then ran parallel to the wall for another 6 m

Figure 7: *Curved back barrier ends that redirected at least 23% of the turtles back towards the drainage culvert; turtle shown in red circle. Photo Credit: Paul Heaven.*

Effectiveness in Providing Connectivity: Monitoring occurred over a 3-year period: 2014 (Before); and 2015 and 2016 (After). Cameras were used at each end of the culvert and at the four fence-ends. Cameras were set to capture animals at 1-minute intervals between5:00 am and 9:00 pm daily from May to June in 2015 and 2016. There were 371 observations of turtles near the culverts—4 Blanding's turtles (Figure 8), 42 snapping turtles, and 14 painted turtles were observed completely crossing the culvert.

Figure 8: *Blanding's Turtle entering the 1.2-m drainage culvert shown in red circle. Photo Credit: Paul Heaven.*

Effectiveness in Reducing Road-kill: Researchers surveyed a 500-m-long section of road at three sites: Gelert Road (mitigated site), County Road 21, and Glamorgan Road (unmitigated sites). Road-kill was significantly reduced at the mitigated site compared to the control site as a result of mitigation. In addition, road-kill did not significantly increase at the fence-ends (approximately 280 m) compared to the control sites. This can be partially attributed to the success of the barrier walls that redirected 23% of the turtles. Another47% of the turtles that exited around the barrier fence-end may not have gone on the road and may have traveled into adjacent habitat.

Conclusions: This study showed a remarkably high number of turtles using one drainage culvert in two years of monitoring using time lapse photos set for 1 minute. It is interesting Blanding's turtles had the lowest number of complete crossing and snapping turtles had the highest, showing species-specific differences in drainage culvert use. Other concurrent research on Highway 69 has shown similar results. On Highway 69 in Ontario, there are taxa-specific differences in drainage culvert use between snakes and turtles, and turtles cross through drainage culverts more often than snakes (Gunson 2019). In addition, only one Blanding's turtle was documented using three reptile tunnels (2.8 m x 3.3 m) in four years of monitoring in 2018. On the other hand, painted and snapping turtles were regularly captured using the same reptile tunnels in the first three years of monitoring from 2015–2017 (Eco-Kare International 2017).

This study also showed a significant reduction in road mortality along the length of the barrier when road-mortality at the barrier ends was included contrary to other studies that have shown increased road-kill at barrier ends (e.g., Markle et al. 2017; Plante et al. 2019). This reduction was likely a result of partially effective barrier end treatments that entailed a 6-m turnaround (Figure 7). The reduction could also be attributed to the fact that the barrier was continuous and extended along the majority of the natural wetland habitat where turtles crossed the road. A study by Caverhill et al. (2011) also showed that short sections of barrier fencing were effective in reducing road-kill at a similar site. Turtles used an existing drainage culvert to cross under the highway when the fence extended along the majority of wetland habitat that was surrounded by agricultural land.

Alternative Designs:

- Additional studies for fence-end designs such as an additional piece that turns back toward the linear barrier or a longer extension away from the road into the adjacent habitat.
- Alternate nesting sites strategically placed at fence-ends or within habitat as supplementary features; however, these sites require routine maintenance to ensure vegetation overgrowth does not occur.
- Using a stronger post such as an angle iron and 2-m-long posts to ensure enough support and deter slumping. Backfill should be a less heavy more porous material (e.g., pebble stones) to allow for drainage.

Supporting Repository Materials:

ON-42 (collection of images and .pdf for case study above);

ON-1 through to ON-9 (images, technical drawings, and other documents from Outer Road existing drainage culvert with exclusion fencing modification) from Ausable Bayfield Conservation Authority.

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