PronghornXing

WILDLIFE CROSSING STRUCTURE DESIGN:

Pronghorn and Grassland Species Guidance

The Pronghorn Xing project is a collaborative initiative aimed at enhancing ecological connectivity across the Northern Sagebrush Steppe (NSS) in Alberta and Saskatchewan to protect pronghorn and other grassland species and enhance motorist safety.

Grasslands are among Canada's most threatened ecosystems due to conversion to agriculture, residential, and industrial development.

Grassland species, such as pronghorn, are particularly affected by barriers such as highways, railways, and fences. Pronghorn Xing addresses these challenges by informing decisions related to linear infrastructure, with a specific focus on the creation of a road mitigation system for the Trans-Canada Highway.

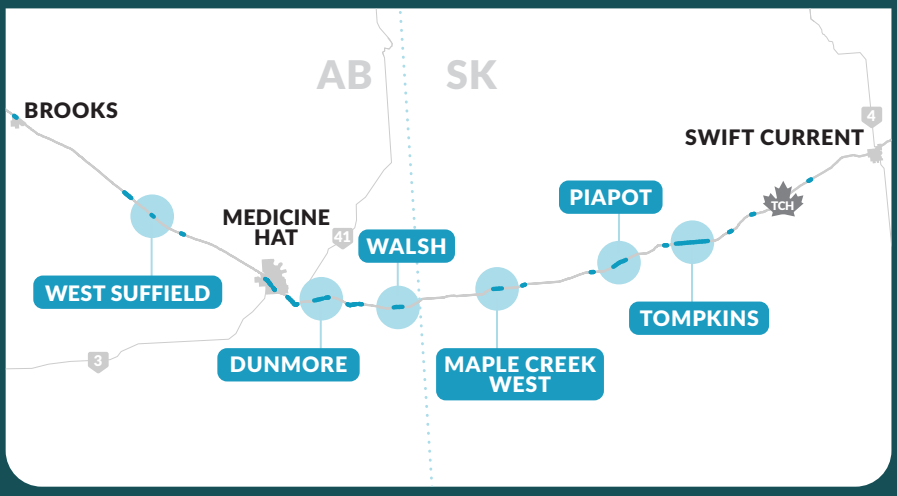
Based on rigorous scientific assessment, the Pronghorn Xing team prioritized six locations where road mitigation, such as wildlife overpasses and underpasses, could best accommodate pronghorn and other prairie wildlife movement across the Trans-Canada Highway.

Biodiversity monitoring that we conducted across the six priority sites documented a diverse range of grassland taxa including several species at risk, including badger, Great Plains toad, bullsnake, and multiple grassland bird species. Additional species at risk likely to occur in the area include swift fox, prairie rattlesnake, and burrowing owl.

This document provides practical, species- and taxa-specific design considerations for wildlife crossing structures. Drawing on a targeted literature review and structured expert input, it links species ecology and movement behaviour to actionable design solutions for transportation planning.

Not all considerations for one species may be compatible with the others. We attempt to provide the most current knowledge for all species, irrespective of contradictions with others so that readers can identify design characteristics appropriate for their target species.

Beyond wildlife benefits, these structures support the integrity of working landscapes by providing potential opportunities for seasonal cattle movement.



HOOFED WILDLIFE

Several hoofed wildlife species occur within the study area, with mule and white-tailed deer and pronghorn among the most common species on the landscape. This guidance focuses on moose, mule-deer, pronghorn, and white-tailed deer as they were observed during biodiversity monitoring and/or are likely to occur based on habitat connectivity and seasonal movement patterns. We give particular attention to pronghorn, which are highly sensitive to roads, and have particular crossing design considerations.

Design considerations that are broadly applicable to these hoofed wildlife are listed directly below, with species-specific features highlighted in each individual section.

Crossing structure preference	Key Design Features	References *(for detailed references please contact the project team)*
All Hoofed Wildlife	**Physical Passage Design** • Install wildlife-impermeable fencing along roadways to guide animals toward crossing structures. **Substrate and Microhabitat:** • Dry natural pathways. • Avoid the use of rip rap near structures. • Avoid erosion netting that could catch hooves. • Maintain natural vegetation with low growing shrubs and grasses. • Trees should be avoided on narrow structures as predators could use them as cover. **Disturbances** • Noise level may decrease use. Reduce traffic-related disturbance where possible by creating "quiet zones" around crossings (e.g., noise barriers, vegetation, recessed roadways, or quieter pavement treatments).	Alberta Transportation and Economic Corridors, 2023 Central Federal Lands Highway Division, 2011 Clevenger & Huijser, 2011 Dodd et al., 2011 Jones et al., 2020 Kintsch & Cramer, 2011 Kintsch et al., 2021 Sawyer et al., 2016 Yoakum et al., 2014
Moose **Overpass, underpass**	**Physical Passage Design** • Will use multiple sizes but prefer structures that feel open. • Minimum overpass dimensions: 40–50 m in width with a recommendation of 50–70 m. • Minimum large span underpass dimensions: 10 m high × 70 m wide. Structure length is an important consideration. If the crossing is > 100 m long, consider design elements that enable light (e.g., openings) to encourage use. • Minimum underpass dimensions: 5 m high (although they have been seen crossing through as low as 4 m) × 11.5 m wide. Structure length is an important consideration. If the crossing is > 40 m long, consider design elements that enable light (e.g., openings) to encourage use. • Corrugated steel culverts or box of 4 m high × 7 m wide, will support movement. Structure length is an important consideration. If the crossing is > 20 m long, consider design elements that enable light (e.g., openings) to encourage use. • Minimum fence or berm height of 2.4 m.	Bhardwaj et al., 2020 Central Federal Lands Highway Division, 2011 Elfstrom et al., 2026 Sawyer et al., 2011

Mule Deer
Overpass, underpass
	Physical Passage Design
	• Will use multiple sizes but prefers structures that feel open.
	  ◦ Minimum overpass dimensions: 30 m wide.
	  ◦ Minimum underpass dimensions: 2.4–3.0 m high × 6 m wide. Structure length is an important consideration. If the crossing is > 40 m long, consider design elements that enable light (e.g., openings) to encourage use.
	• Minimum fence height of 2.4 m.
	Disturbances
	• Human activity around structures decreases use.
	• Lighting near structures can deter use.
		Alberta Transportation and Economic Corridors, 2023
		Central Federal Lands Highway Division, 2011
		Clevenger, A.P. and Huijser M.P., 2011
		Kintsch and Cramer. 2011
		Kintsch, J., et al., 2025
		Newmark and Rickart, 2012

Crossing structure preference	Key Design Features	References *(for detailed references please contact the project team)*
Pronghorn **Preference for overpass but may use an underpass**	**Physical Passage Design** • Overpasses are generally preferred, particularly for width-sensitive species like pronghorn; widths of ~30–50 m perform well. • Underpasses can function if sufficiently large; recommended minimum dimensions are approximately 20 m wide and 4.5 m high. • Maximize openness and width of crossing structures; maintain clear line-of-sight through the structure with no visual obstructions. • Avoid fences or gates across crossing openings. If livestock fencing is necessary, ensure it is pronghorn-permeable. **Substrate and microhabitat** • flat and gently undulating, expansive terrain is preferred. • plant natural species with low vegetation height (25–46 cm) **Disturbances** • Incorporate visual screening from traffic, such as earthen berms or vegetation, to reduce disturbance. • Locate crossings in areas with minimal human activity and limit recreational or hunting access near structures. **Behavioural Considerations** • Visibility is critical: pronghorn require clear sightlines when approaching and moving through crossings.	Alberta Transportation and Economic Corridors, 2023 Brennan et al., 2022 Caldwell et al., 2020 Clevenger & Huijser, 2011 Dodd et al., 2011 Gavin, 2006 Jones et al., 2020 Robb et al., 2022 Sawyer et al., 2016 Seidler et al., 2018

White-tailed Deer
Overpass, underpass
	Physical Passage Design
	• Will use multiple sizes but prefers structures that feel open.
	• Line of sight is important.
	  ◦ Minimum overpass dimensions: 40–50 m wide with a recommendation of 50–70 m.
	  ◦ Minimum underpass dimensions: 4 m high × 7 m wide.
	  ◦ Minimum fence height of 2.4 m.
	Disturbances
	• Nearby human activity may decrease use.
	Behavioural Considerations
	• Takes time for animals to use structures successfully and with less hesitation.
		Central Federal Lands Highway Division, 2011
		Kintsch and Cramer, 2011
		Sawyer et al., 2011

SMALL TO MEDIUM SIZED PREDATORS

A range of small to medium sized predator species may occur within the study area; however, this guidance focuses on red fox, American badger, and swift fox, as they were either observed during biodiversity monitoring, included in road mortality data, or are likely to occur based on habitat suitability and connectivity. We give particular attention to swift fox and American badger that are species at risk within the region.

Crossing structure preference	Key Design Features	References (for detailed references please contact the project team)

Badger
Prefer underpass or culvert, but will use an overpass
	Physical Passage Design
	• Underpass (culvert) size: minimum diameter 450–600 mm, but larger underpasses (e.g., ≥2 m) are also used. Size should be slightly larger than body size (badgers 0.6–0.9 m) to provide cover and protection.
	• Fencing to direct animals toward crossing structures.
	  ◦ Use buried fencing to prevent digging under (e.g., 1–1.2 m buried chain-link, page wire, etc. at 45°).
	  ◦ Swing gates should have concrete bases to deter digging.
	• Materials: tunnel material (concrete vs. corrugated steel), length, or light penetration are less critical, but entrances should remain visible.
	• Maintenance: maintain existing underpasses, including culverts, to maximize cost-effective use.
	Substrate and Microhabitat
	• Cover and vegetation: provide brush, root wads, or small culverts along sides of crossing especially near entrances.
	• Culvert openings: keep mostly open to increase visibility, free of standing water, rocks, or dense vegetation, with 1–5 m buffer of cleared shrubs. Some vegetation cover at the entrance has shown increased use in Europe.
	• Edge management: Mow right-of-way edges below road grade; plant low-growing, low-palatable species (<30 cm) to reduce prey abundance near road.
	• Dry ledges are not used by badgers in culverts with water.
	Disturbances
	• Nighttime lighting: reduce artificial light near culverts; light decreases crossing probability and speed.
	• Human activity: badgers are tolerant at some scales, but crossing success improves >2 km from urban centers.
	Behavioural Considerations
	• Preference for cover: badgers favour enclosed, vegetated structures over exposed or wide-open ones.
		Brieger et al., 2025
		Clevenger et al., 2011
		Cserkész et al., 2013
		Eldridge & Wynn, 2011
		Grilo et al., 2008
		Grilo et al., 2009
		Iglesias et al., 2012
		Jensen et al., 2022
		Klafki, 2001
		Mata et al., 2005
		Mata et al., 2008
		Ministry of Water, Land and Resource Stewardship, 2025
		Mysłajek et al., 2020
		Sordello et al., 2025
		Sunga et al., 2017
		Villalva et al., 2013
		Wang et al., 2018

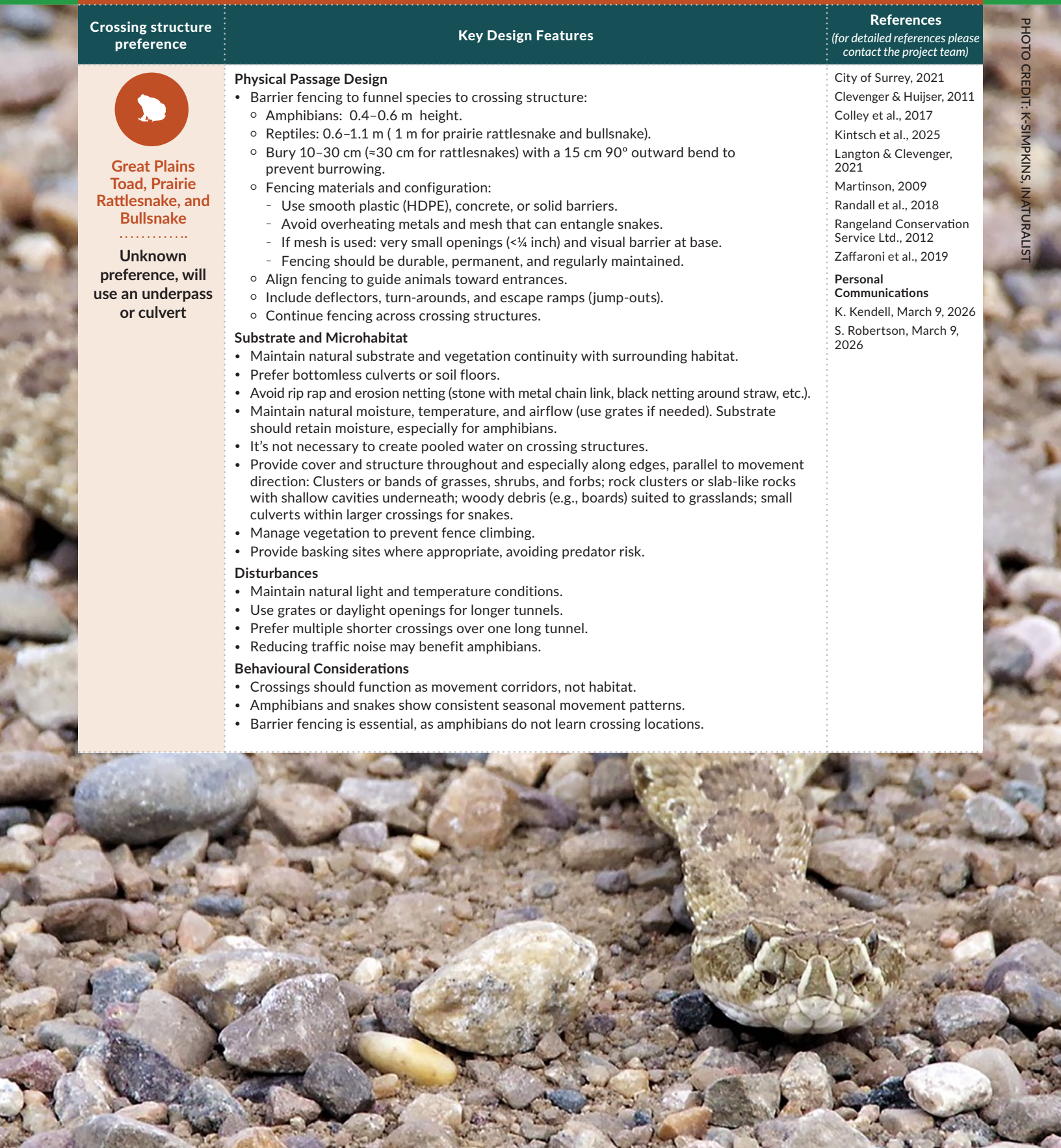
Crossing structure preference	Key Design Features	References *(for detailed references please contact the project team)*
Red Fox **Overpass, underpass, culvert**	**Physical Passage Design** • Red foxes use a wide range of crossing structure type and sizes (culverts, underpasses, overpasses). They may avoid enclosed box culverts with poor visibility. • Maintain clear sightlines through structures; openness is important for use. • Use chain-link or welded mesh fencing (avoid knot braid mesh). • Include dig-prevention measures (e.g., buried mesh, synthetic plates, or concrete footings). • One-way escape gates for larger mammals may be used in the opposite direction by foxes. **Substrate and Microhabitat** • Dry footing is important—avoid wet or flooded conditions, ensure there is good drainage. • Include wide walkways/benches in culverts to maintain dry passage. • Vegetation near entrances is beneficial, particularly moderate cover (>0.5 m). • Dry ledges are not used by red foxes in culverts with water. **Disturbances** • Minimize artificial nighttime lighting, which can reduce crossing probability. • Focus on overall disturbance reduction rather than site-specific noise mitigation. • Foxes show moderate tolerance to human activity, but heavy disturbance (e.g., traffic) can reduce crossing success.	Brieger & Strein, 2025 Clevenger & Huijser, 2011 Grilo et al., 2008 Healy & Gunson, 2014 Horton, 2025 Iglesias et al., 2012 Jensen et al., 2022 Kintsch et al., 2025 Mata et al., 2008 Mysłajek et al., 2020 Sordello et al., 2025 Villalva et al., 2013 Warnock-Juteau et al., 2022 Ważna et al., 2020 Young et al., 2023 **Personal Communications** S. Jordan-McLachlan, March 5, 2026
Swift Fox **Limited research however they may use an overpass, underpass, or culvert**	**Physical Passage Design** • Structure type: swift foxes use a variety of crossing structures but may avoid low-visibility underpasses. They may also prefer to cross at grade. • Visibility: maintain good line-of-sight through structures; avoid confined or visually obstructed designs. • Minimum culvert diameter: ≥0.6 m (24 in). • Structures should be scaled to fox body size to reduce use by larger predators. • Use grates or gates (e.g., ~15 × 15 cm mesh) to allow fox passage while limiting larger predators. • Use wildlife fencing to funnel movement where appropriate, especially where road mortality risk is high. **Substrate and Microhabitat** • Include escape cover within structures and near entrances (e.g., small-diameter pipes with restricted openings). 3 m length × 20 cm diameter pipe, anchored in the structure, entrance constricted to 10–15 cm to exclude red foxes. • Maintain natural ground conditions and ensure structures conform to local topography. • Ensure adequate drainage to prevent flooding within crossings. • Manage vegetation to maintain low-growing cover; avoid dense or tall vegetation that limits visibility and could conceal predators. **Disturbances** • Minimize artificial nighttime lighting, as it can reduce crossing use. **Behavioural Considerations** • Predation risk is a key factor influencing structure use: foxes may avoid crossings used by larger predators (e.g., coyotes). • May travel along roads or rights-of-way, so fencing and structure placement should account for this behaviour. • In some cases, foxes may avoid crossing structures altogether and attempt at-grade crossings, reinforcing the importance of effective guidance fencing.	Bremner-Harrison et al., 2007 Buxbaum, 2025 Clevenger & Huijser 2011 Clevenger et al., 2010 Kintsch et al., 2025 Ray, 2015 Sordello et al., 2025

REPTILES AND AMPHIBIANS

In our study area, many species of reptiles and amphibians could occur. However, we choose to focus on Great Plains toad, prairie rattlesnake, and bullsnake as they were either observed during biodiversity monitoring or models showed a high likelihood of connected habitat at our sites. Design considerations are very similar for this group, with some differences as indicated below.

Crossing structure preference	Key Design Features	References (for detailed references please contact the project team)

Great Plains Toad, Prairie Rattlesnake, and Bullsnake
 	
Unknown preference, will use an underpass or culvert
	Physical Passage Design
	• Barrier fencing to funnel species to crossing structure:
	  ◦ Amphibians: 0.4–0.6 m height.
	  ◦ Reptiles: 0.6–1.1 m (1 m for prairie rattlesnake and bullsnake).
	  ◦ Bury 10–30 cm (≈30 cm for rattlesnakes) with a 15 cm 90° outward bend to prevent burrowing.
	  ◦ Fencing materials and configuration:
	  – Use smooth plastic (HDPE), concrete, or solid barriers.
	  – Avoid overheating metals and mesh that can entangle snakes.
	  – If mesh is used: very small openings (<¼ inch) and visual barrier at base.
	  – Fencing should be durable, permanent, and regularly maintained.
	  ◦ Align fencing to guide animals toward entrances.
	  ◦ Include deflectors, turn-arounds, and escape ramps (jump-outs).
	  ◦ Continue fencing across crossing structures.
	Substrate and Microhabitat
	• Maintain natural substrate and vegetation continuity with surrounding habitat.
	• Prefer bottomless culverts or soil floors.
	• Avoid rip rap and erosion netting (stone with metal chain link, black netting around straw, etc.).
	• Maintain natural moisture, temperature, and airflow (use grates if needed). Substrate should retain moisture, especially for amphibians.
	• It's not necessary to create pooled water on crossing structures.
	• Provide cover and structure throughout and especially along edges, parallel to movement direction: Clusters or bands of grasses, shrubs, and forbs; rock clusters or slab-like rocks with shallow cavities underneath; woody debris (e.g., boards) suited to grasslands; small culverts within larger crossings for snakes.
	• Manage vegetation to prevent fence climbing.
	• Provide basking sites where appropriate, avoiding predator risk.
	Disturbances
	• Maintain natural light and temperature conditions.
	• Use grates or daylight openings for longer tunnels.
	• Prefer multiple shorter crossings over one long tunnel.
	• Reducing traffic noise may benefit amphibians.
	Behavioural Considerations
	• Crossings should function as movement corridors, not habitat.
	• Amphibians and snakes show consistent seasonal movement patterns.
	• Barrier fencing is essential, as amphibians do not learn crossing locations.
		City of Surrey, 2021
		Clevenger & Huijser, 2011
		Colley et al., 2017
		Kintsch et al., 2025
		Langton & Clevenger, 2021
		Martinson, 2009
		Randall et al., 2018
		Rangeland Conservation Service Ltd., 2012
		Zaffaroni et al., 2019
		Personal Communications
		K. Kendell, March 9, 2026
		S. Robertson, March 9, 2026



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BIRDS

A wide range of bird species may occur within the study area; however, this guidance focuses on key functional groups: grassland obligates, aerial insectivores, raptors, waterfowl, shorebirds and cranes, and generalist/edge species. Particular attention is given to species at risk that were observed during monitoring or are likely to occur, including Long-billed Curlew, Chestnut-collared Longspur, and Ferruginous Hawk.

While many design considerations are broadly applicable across bird groups, key differences are highlighted below where relevant. It should be noted, however, that research on the design of wildlife crossing structures for birds is currently limited, and recommendations are therefore based on the best available evidence and expert input.

Crossing structure preference	Key Design Features	References *(for detailed references please contact the project team)*

Grassland Obligates, Aerial Insectivores, Raptors, Waterfowl, Shorebirds and Cranes, Generalists and Edge species
 	
Overpass, underpass
	Physical Passage Design
	• Encourage birds to fly above traffic by incorporating:
	  ◦ Visual barriers such as aluminum or PVC diversion poles set back from the roadside to discourage birds from going towards the road and divert them to an over- or underpass.
	  ◦ Soil berms (also reduce noise).
	  ◦ Wire mesh fencing that is impermeable to songbird-sized birds. Height used for large mammals (2.4 m) is recommended to encourage birds to fly above traffic.
	• Design structures to minimize wind downdrafts, as grassland obligate species and larger waterfowl (e.g., pelicans, geese, swans) are more susceptible to collisions when bridges are oriented perpendicular to prevailing winds.
	• Discourage raptors from using fence posts as hunting perches along the highway by using deterrents (e.g., bird spikes, pole toppers, and closely spaced, frangible reflective markers).
	  ◦ Use of fence posts or vertical structures along the overpass itself is beneficial to encourage raptors to use overpass. However, it may be detrimental to prey species such as snakes and small mammals. Therefore placement away from cover objects is recommended.
	• Provide nesting habitat for cliff and barn swallows, which commonly nest under bridges and overpasses, by using rough construction materials that are suitable for adhesion on underpass walls and ceiling, especially at locations close to waterbodies or streams.
	• Avoid inadvertently creating nesting habitat for bank swallows, which may nest in exposed, unconsolidated substrates such as aggregate pits, road cuts, or soil stockpiles. These features are temporary during the construction period, and their removal could destroy nests.
		Central Federal Lands Highway Division, 2011
		Colwell & Oring, 1988
		Dodd et al., 2011
		Fellows and Jones, 2012
		Forman, et al., 2014
		Freitag, 2024
		Howard, 1975
		Jacobson, 2005
		Kintsch and Cramer, 2011
		Kovinka et al., 2023
		Medrano-Vizcaino et al., 2023
		Nordell et al., 2017
		Pell, 2015
		Pelletier et al., 2022
		Scobie et al., 2014
		Schmutz et al., 2008
		Somershoe, et al., 2018
		Slater & Smith, 2010
		Sliwinski & Koper, 2012
		Sutter et al., 2001
		Tarr et al., 2010
		Todd et al., 2003
		Van der Ree, et al., 2015
		Watson, 2020
		Wellicome, et al., 2014

Crossing structure preference	Key Design Features	References *(for detailed references please contact the project team)*

	Substrate and Microhabitat
	• Ensure adequate soil depth (~1 m) to support native plants.
	• Design for proper drainage (2–3% slope).
	• Maintain native vegetation consistent with surrounding habitat.
	• To encourage use of the crossing by a variety of birds, plant a diversity of native vegetation types, height, and density including short and tall grass, forbs, and low shrubs.
	  ◦ Sprague's Pipit, Baird's, Vesper and Savannah Sparrow require denser vegetation patches.
	  ◦ Clay-coloured Sparrows prefer tall grass and shrubs.
	  ◦ Long-billed Curlew avoid sagebrush/bunchgrass habitat.
	• Incorporate areas of sparse vegetation and bare/loose soil (mud) for foraging, which supports species like Long-billed Curlew and Chestnut-collared Longspur.
	Disturbances
	• Avoid the use of artificial light near crossing structure.
	• Reduce road noise by creating "quiet zones" around crossings (e.g., noise barriers, vegetation, recessed roadways, or quieter pavement treatments), particularly important for burrowing owls and birds who communicate primarily through vocalizations (i.e. songbirds).
	• Avoid mowing as this may disturb birds and impact ground-nesting species.
	• Limit human use (e.g., off-highway vehicle use) near crossing structures.
		Personal Communications
		I. Cook, February 20, 2026
		R. Fisher, February 10, 2026
		K. Kendell, March 11, 2026
		J. Ng, February 25, 2026
		B. Robinson, March 11, 2026

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