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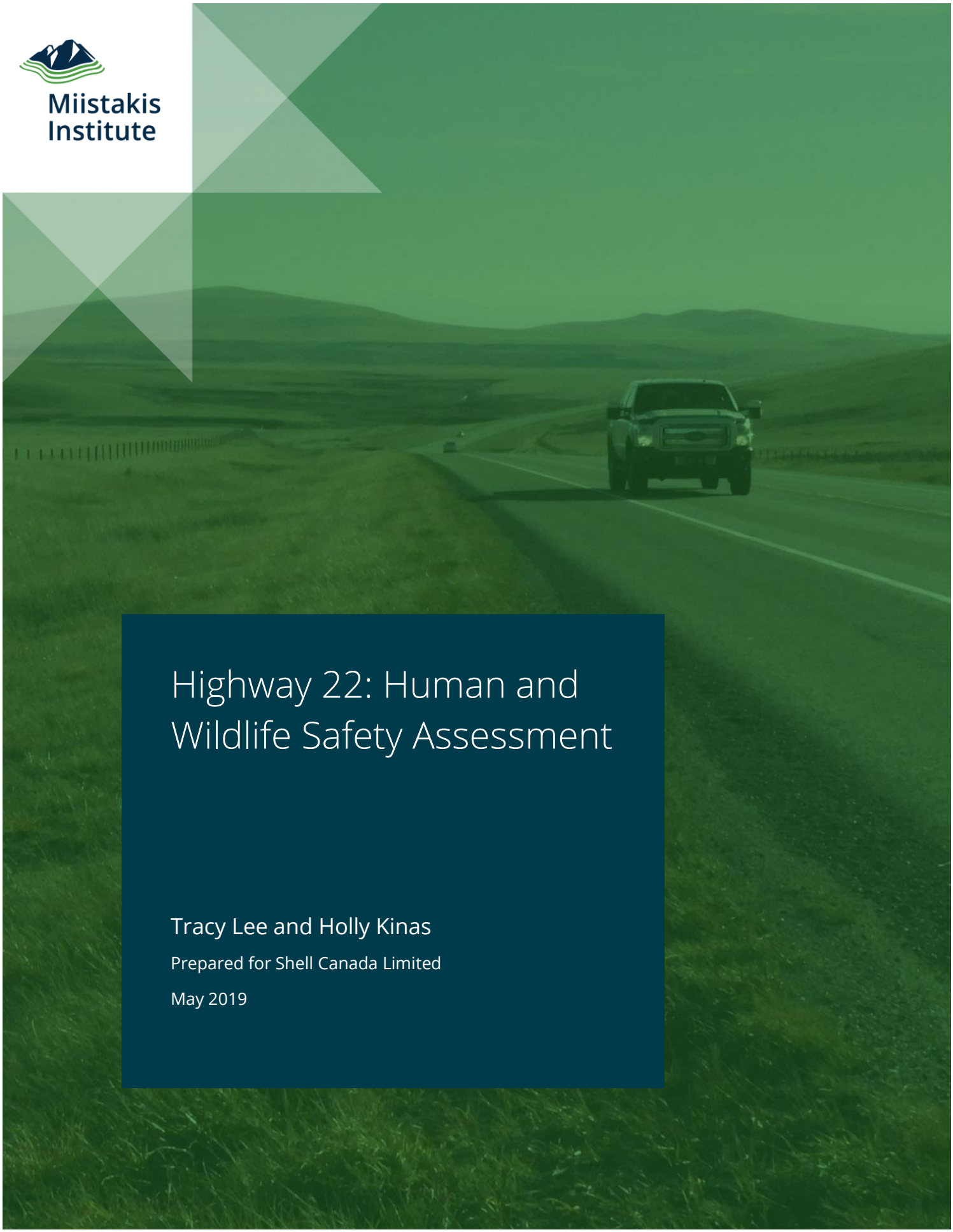

Highway 22: Human and Wildlife Safety Assessment

Tracy Lee and Holly Kinas

Prepared for Shell Canada Limited

May 2019

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Miistakis Institute
Rm U271, Mount Royal University
4825 Mount Royal Gate SW
Calgary, Alberta T3E 6K6

Phone: (403) 440-8444
Email: institute@rockies.ca
Web: www.rockies.ca

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Executive Summary

Highway 22 is situated along Alberta's Eastern Slopes which supports the full complement of large mammal species common in the Rocky Mountains. Highway 22 from the junction of Highway 3 to Caroline is a 325 km stretch of road with high variability in traffic volumes ranging from 2,000-13,000 annual average daily traffic (AADT) depending on the highway section. Wildlife species observed along Highway 22 include black and grizzly bear, elk, white tailed deer, mule deer, moose, wolf, and cougar and other medium sized mammals.

The intersection of wildlife and people on highways raises two concerns, impact of roads on the movement and mortality of wildlife; and risks to people and vehicles caused by collisions with wildlife. Highway 22 possess both human safety concerns due to increased risk of animal vehicle collisions and wildlife management and conservation concerns, though direct morality of wildlife and fragmentation of habitat.

Traffic volumes along Highway 22 predominately range between 2,000 to 10,000 AADT, from the junction of Highway 3 to Bragg Creek and from the junction of Highway 567 to Caroline. Conceptual models indicate as traffic volumes within this range increase the risk of animal vehicle collisions also increase and successful wildlife crossings decrease. Highway 22 from Bragg Creek to the junction of Highway 567 (near Cochrane) where traffic volumes exceed 10,000 AADT, wildlife may start to avoid the highway.

To better understand patterns of wildlife mortality and movement, we undertook a two-pronged research approach that included a review of existing datasets and models, and interviews with local knowledge experts. This approach resulted in the following products:

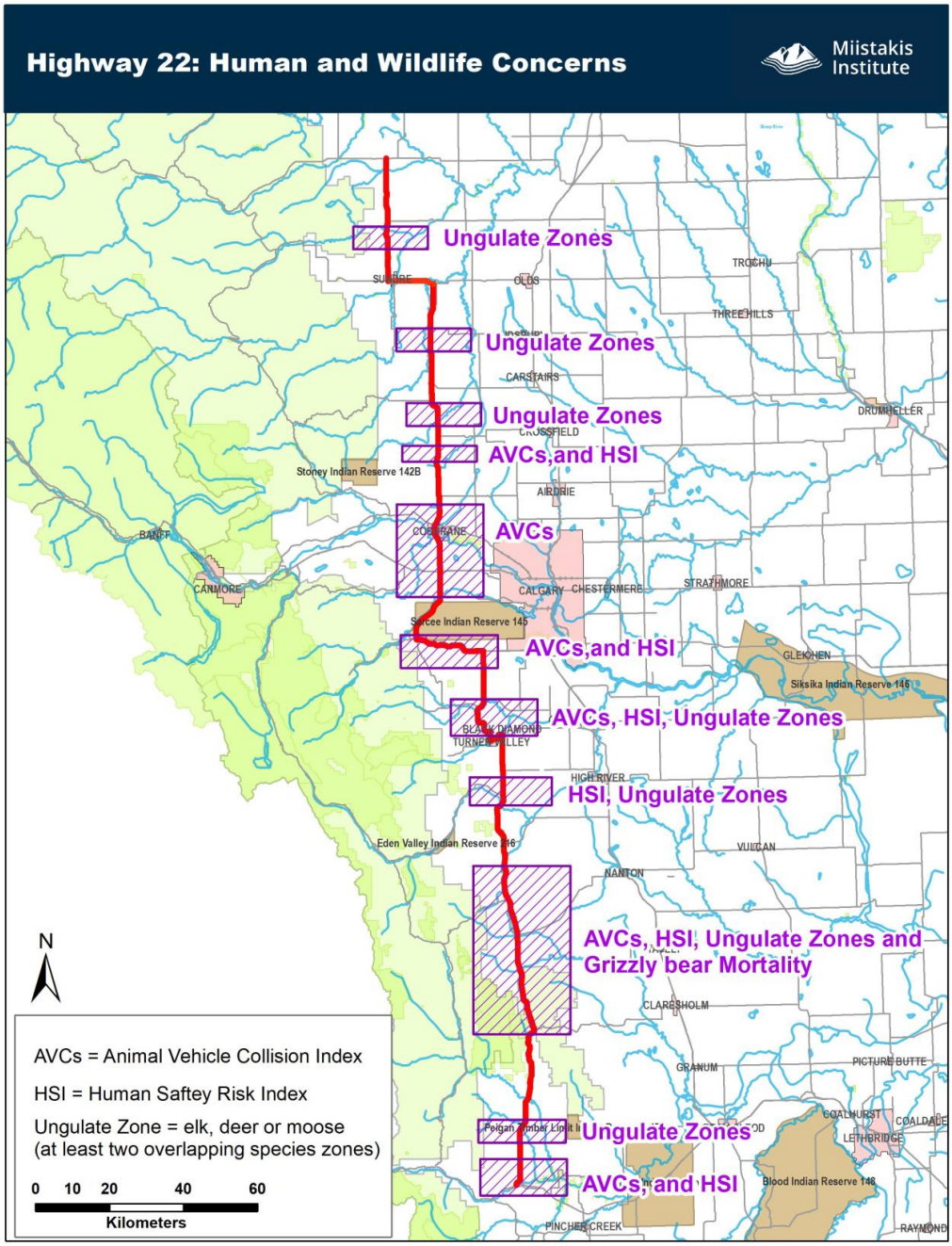
- Animal Vehicle Collision Index (**AVC**) generated from RCMP data from 2010 to 2014 identified highway sections where total number of collisions annually is highest (data was not available north of the 567 junction);
- Human Safety Index (**HSI**) generated from RCMP data from 2010 to 2014 normalized to traffic volume identified highway sections where individual motorists have the greatest risk of being involved in an animal vehicle collision (data not available north of 567 junction); and

- Local knowledge movement zones (primary and secondary) were identified for elk, moose, and deer. The ungulate data was summed to identify zones with overlap between all three species (**ungulate zones**).
- Grizzly bear connectivity modeling and mortality were reviewed and **grizzly bear zones** were identified.

Together, these datasets allow an assessment of different wildlife and transportation issues. For example, if a management goal is to reduce total animal vehicle collisions, mitigation efforts would be focused where there is the highest number of AVCs, thus improving human safety and reducing costs to society. If the concern is reducing human safety risk, then mitigation would be focused where there is the highest risk per motorist, thus reducing individual human safety risk. Where these two analysis overlap might be the most telling in terms of benefit to human safety and reducing costs to society from collisions. A wildlife manager may be most concerned with reducing mortality for a species at risk and would focus mitigation on important movement zones or mortality hotspots for specific species.

Mitigation measures are both expensive and often fixed (i.e., not portable), therefore it is critical that their installation is strategic to maximize return on investment in meeting the management priorities of both wildlife and transportation agencies. We reviewed the resulting datasets and identified **11 mitigation zones** (displayed as purple boxes on map insert below) that address one or a combination of issues relating to wildlife and/or human safety. Mitigation zones were not prioritized, partly due to inconsistency in datasets and modeling available for this assessment. The section of Highway 22 between the junction of Highway 567 and Caroline did not include AVCs or Human Safety Index for consideration. Future assessments should update this important information gap.

The section of Highway 22 between Highways 520 to 532 represents high AVC's, high human safety risk per motorist, ungulate movement zones for all three species, and experiences a high level of grizzly bear mortality from collisions with vehicles. Grizzly bears are a threatened species in Alberta, and human caused mortality is the main cause of population decline. Four recorded grizzly bear deaths over a four year period along this stretch is a significant concern. This section of Highway 22 is a high priority consideration for mitigation.



If mitigation planning focused on these eleven sites, it would improve both human and wildlife safety. The local knowledge movement zones for each species also identify important contextual information to inform mitigation planning, for example some sites are very seasonally specific and many only require temporary measures to address the issue.

Introduction

Alberta supports an extensive network of transportation infrastructure; 31,000 km of highway enables the efficient movement of people and goods. Alberta is also home to the most diverse assemblage of large mammal species in Canada, including elk, moose, bighorn sheep, deer, black bear, cougar, wolf, wolverine, lynx and the provincially-threatened grizzly bear. Most of these species require large landscapes for survival as they search for food, shelter, and mates. Inevitably, these movements bring animals into contact with roads and, too often, the vehicles driving on them.

The intersection of wildlife and people on highways raises two critical issues: impact of roads on the movement and mortality of wildlife; and risks to people and vehicles caused by collisions with wildlife (Frissell and Trombulak 2000).

Wildlife may avoid crossing roads, creating movement barriers across the landscape. These barrier effects reduce the amount of habitat available to animals, alter predator-prey interactions, and can reduce the viability of populations through genetic isolation (Frissell and Trombulak 2000). For some species like large carnivores, mortality from vehicle collisions is often the greatest cause of mortality. As such, roads can pose a major hurdle to wildlife management and conservation objectives.

Human safety is also compromised by wildlife-road interactions. Across Canada, about 6 large mammals are involved in a wildlife vehicle collision every hour (L-P Tardif and Associates Inc. 2003). Alberta Transportation reported 9 human fatalities, 498 human injuries, and a total cost of $240 million in damages in 2008 as a result of wildlife vehicle collisions. The majority of the collisions (85%) involved deer, followed by moose (11%), bears (2%), and other species (<2%) (Alberta Transporation 2016).

Highway mitigation is a widespread and highly effective means to resolve issues of road-wildlife interaction. Mitigation may involve making drivers more alert (e.g., animal detection systems, variable message signs), separating wildlife and motorists (e.g., exclusion fencing, and crossing structures -overpasses and underpasses), and modifying animal behavior near the road (large boulder fields, vegetation manipulation) (Huijser et al. 2008). However, because mitigation measures are both expensive and often fixed (i.e., not portable), it is critical that their installation is strategic to maximize return on investment in meeting the management priorities of both wildlife and transportation agencies.

Highway 22 from the junction of Highway 3 to Caroline, Alberta is a 325 km stretch of highway that supports between 2,000-13,000 annual average daily traffic (AADT). Vehicle types vary depending on the highway section, but there is a trend of decreasing passenger vehicles and increasing single unit trucks from south to north. For example in the southern portion (junction of Highway 3) passenger vehicles represent 97% with truck traffic 1.3%, near Cochrane passenger vehicles represent 90% with truck traffic increasing to 3.8%, and in northern portion passenger vehicles represent 75.6% while truck traffic represents 15% of vehicles on highway (Alberta Transporation 2019).

Wildlife observed along Highway 22 include black and grizzly bears, elk, deer and moose, wolf and cougar as well as many other medium-sized mammals, however there is little documentation on the highway sections where wildlife movement is most common. There is therefore a need to determine the current state of knowledge on known wildlife mortality zones and zones important for wildlife movement.

Methods

Our approach was two-pronged and included a review of existing data and models, and interviews with local knowledge experts to form an understanding of patterns of wildlife mortality and movement zones across Highway 22.

Existing Data and Information

We reviewed the following datasets for Highway 22:

1. Alberta Transportation Annual Average Daily Traffic (AADT) volumes extracted for Highway 22.
2. Royal Canadian Mounted Police (RCMP), AVC dataset, provided by Alberta Transportation (AT), Traffic Safety office for 2010 to 2014 from junction Highway 3 to Highway 547 (extracted from Lee *et al.*, 2019).
3. Solicitor General, Enforcement Occurrence Records (ENFOR), reported by Conservation Officers based on a search for “roadkill” observations from April 2014 to July 2017 from Highway 3 junction to Priddis.
4. Connectivity modeling for grizzly bear extracted from *Lee et al.* (2019).

The ENFOR data was used to develop a species list for discussions with local knowledge experts and included white tailed deer, mule deer, black bear, moose, grizzly bear and elk.

The RCMP AVC five-year dataset was used to create two indexes in Lee et al. (2019) and indices were extracted for Highway 22 from the junction with Highway 3 to Highway 567:

- AVC index by aggregating recorded carcasses per km section along highways; and
- Human safety risk index where animal vehicle collision data per km was normalized for traffic volume.

Local Knowledge Approach

Highway 22 from the Highway 3 junction to Caroline is a 325 km stretch. To simplify the assessment and focus interviews we separated the highway into two spatial segments:

- Segment 1: Highway 22 junction with Highway 3 to Priddis; and
- Segment 2: Highway 22 from Priddis to Caroline.

To report findings were amalgamated results.

Recognizing there is a dearth of data related to wildlife mortality and wildlife movement along Highway 22 we organized an expert opinion and local knowledge workshop with local stakeholders to compile relevant information. Key stakeholders included government biologists, highway maintenance contractors, municipal staff and council, local landowners, Shell employees and researchers.

The purpose of the workshop was to:

- Identify AVC zones based on existing datasets;
- Spatially represent, based on the best available knowledge, core habitat and wildlife corridors for terrestrial large mammal species occurring along Highway 22; and
- Develop species GIS layers for elk, deer, and grizzly bear zones as movement areas to inform conservation planning.

The workshop outcomes included consensus on the best locations for terrestrial large mammal movement and local knowledge descriptions on features of

temporal aspects of movement. In addition, for each zone, local knowledge experts were asked to identify if the zone classified as priority or secondary, where by

- A priority zone is >1 mortality per month; and
- A secondary zone < 1 mortality per month or wildlife crossing alive.

Crossing zones were only created for areas where wildlife mortality occur or where wildlife are seen crossing the highway. If wildlife were adjacent to roadway but not seen crossing, this area was not recorded as a crossing zone.

For Highway 22 segment 2 we undertook two group interview sessions with highway maintenance contractors and Shell employees. Each group was asked to identify areas where wildlife species are commonly (two or more per year) observed crossing the highway or involved in animal vehicle collisions. This approach was chosen over a workshop mainly due to time constraints of participants.

Results

Traffic Volume

Highway 22 is a two lane medium volume road, with a low of 2,000 and a high of 13,000 AADT depending on location. Two concerns for wildlife are road-related mortality and reduced wildlife movements across or near roads. The degree to which these factors depress or threaten populations depends on the level of traffic volume. A conceptual model shown in Figure 1 describes the effect traffic volume has on 1) animal avoidance of roads, 2) the likelihood of them getting killed while trying to cross, and 3) successful crossing attempts.

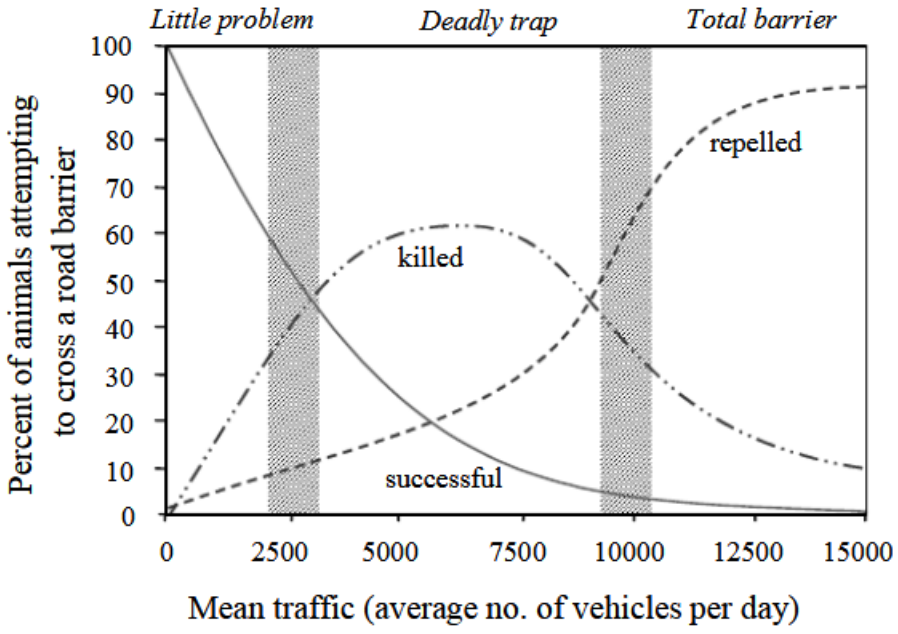


Figure 1: Conceptual model on the effects of traffic volume on the percentage of animals that successfully cross a road, are repelled by traffic noise and vehicle movement, or get killed as they attempt to cross. The model is based on empirical data indicating that most collisions occur on intermediate roads as extracted from (Seiler 2003)**.**

The conceptual model provides a general understanding that on low volume roads animals tend to cross unharmed with the potential of collisions low. With increased traffic more animals will be killed while trying to cross a road while on very busy roads animals will most likely avoid the road due to traffic noise or vehicle movement.

At most locations along Highway 22 segment 1 (from Highway 3 junction to Priddis) traffic volume is currently within the thresholds on the conceptual model for increased potential animal vehicle collisions while not meeting animal avoidance thresholds (Figure 2). Although certain species maybe more sensitive to traffic volume thresholds, such as the grizzly bear.

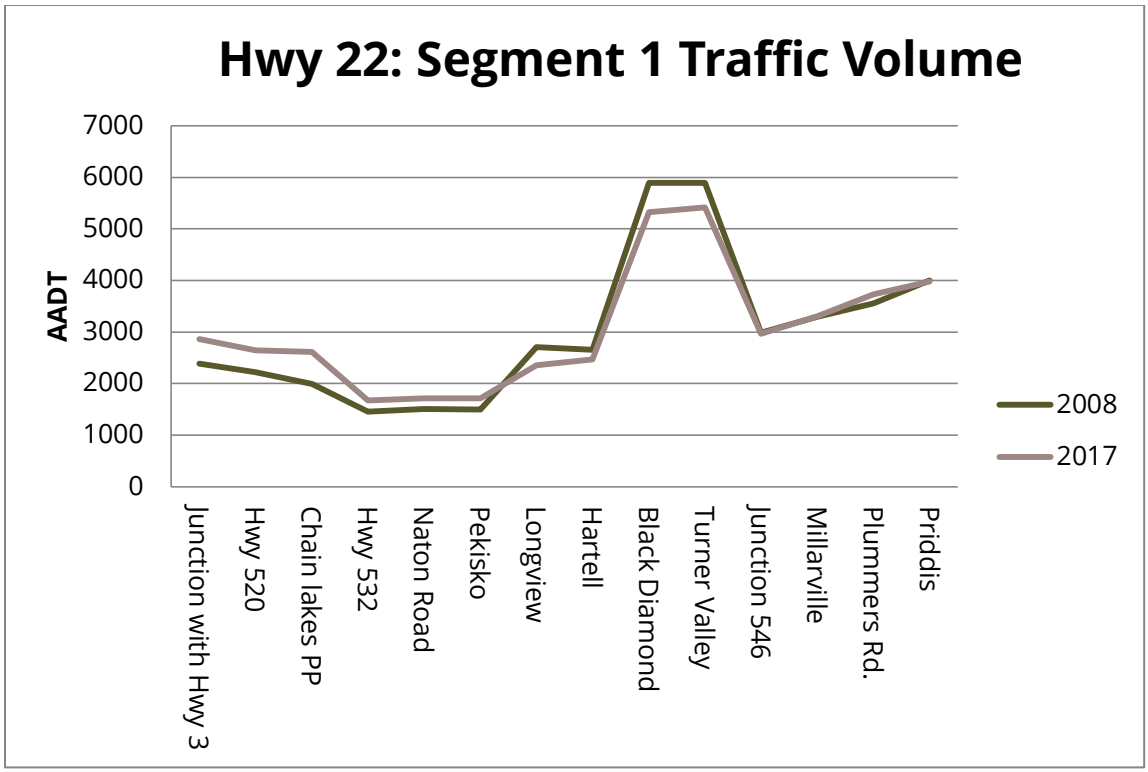


Figure 2: Segment 1 AADT (Average Annual Daily Traffic Volume) along Highway 22 in 2008 and 2017 based on local land descriptions.

Along Highway 22 segment 2 (from Priddis to Caroline), traffic volumes fluctuate greatly with highway sections between Bragg Creek and Cochran (to junction with 567) exceeding thresholds of 10,000 AADT potentially resulting in wildlife avoidance of the highway. Highway 22 from Priddis to Bragg Creek and from the junction of Highway 567 to Caroline fall within the threshold for increased risk of animal mortality due to collisions with vehicles (Figure 3).

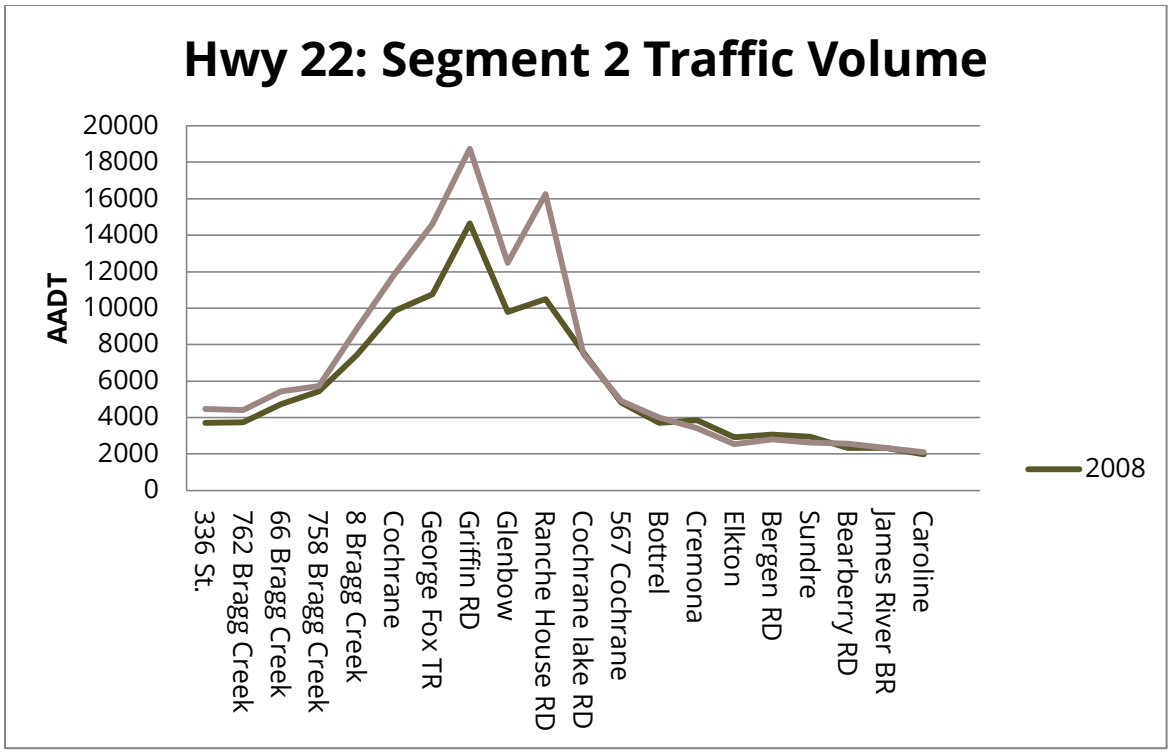


Figure 3: Segment 2 AADT (Average Annual Daily Traffic Volume) along Highway 22 in 2008 and 2017 based on local land descriptions.

Highway 22 AVC Data

Traditionally, animal carcass data is acquired from motorist reports to RCMP for accidents exceeding $2,000 dollars of damage to the vehicle. There are several analytical challenges associated with this type of information; it tends to have poor locational accuracy (typically based on public reporting to RCMP after the incident) and the magnitude of reporting tends to be lower than the actual number of AVCs occurring (Alberta Transportation 2017). These challenges reduce confidence in the RCMP dataset as a reliable indicator of high-risk AVC highway sections. Although AVCs are under-reported there is no evidence that reporting is biased spatially in representation and therefore we used RCMP data to measure relative AVC risk.

The RCMP AVC five-year dataset was used to create two indexes in Lee et al. (2019) and indices were extracted for Highway 22 from the junction with Highway 3 to Highway 567:

- AVC index by aggregating recorded carcasses per km section along highways (Figure 4); and

- Human safety risk index where animal vehicle collision data per km was normalized for traffic volume (Figure 5).

The AVCs index provides valuable information to transportation departments in identifying highway sections with the highest risk of AVCs and costs associated with AVCs. Figure 1 indicates AVCs are highest along Highway 22:

- From Priddis to Highway 567 junction (north of Cochrane);
- Highway 3 junction,
- Highway 533 junction (near Chain Lakes Provincial Park); and
- around towns of Black Diamond and Millarville.

The human safety risk index enables transportations departments to understand which km sections have the highest risk to individual motorists. Figure 2 indicates highway sections with the highest human safety risk occur in more rural areas along Highway 22. Highway sections with higher human safety risk include:

- Highway 3 junction;
- Cow Creek;
- South Willow Creek;
- Between Highway 333 to 532 junctions (Chain Lakes Provincial Park);
- Township Road 162a junction;
- Highway 540 junction;
- Between Highway 531 and 543 junctions;
- Millarville;
- Between 247 Ave West junction to Priddis;
- Highway 762 junction;
- Township Road 280a junction.

AVCs and human safety risk index overlap at key rural highway sections:

- Highway 3 junction;
- Highway 533 (Chain Lakes Provincial Park);
- around towns of Black Diamond and Millarville;
- between 247 Ave West junction to Priddis;
- Highway 762 junction; and
- Township Road 280a junction.

These highway sections therefore represent areas where both individual human safety risk and number of animal vehicle collision show agreement possibly representing the best value to society from a mitigation perspective. It is likely there are highway sections in the northern portion, but we were not able to obtain AVC data for this portion of Highway 22.

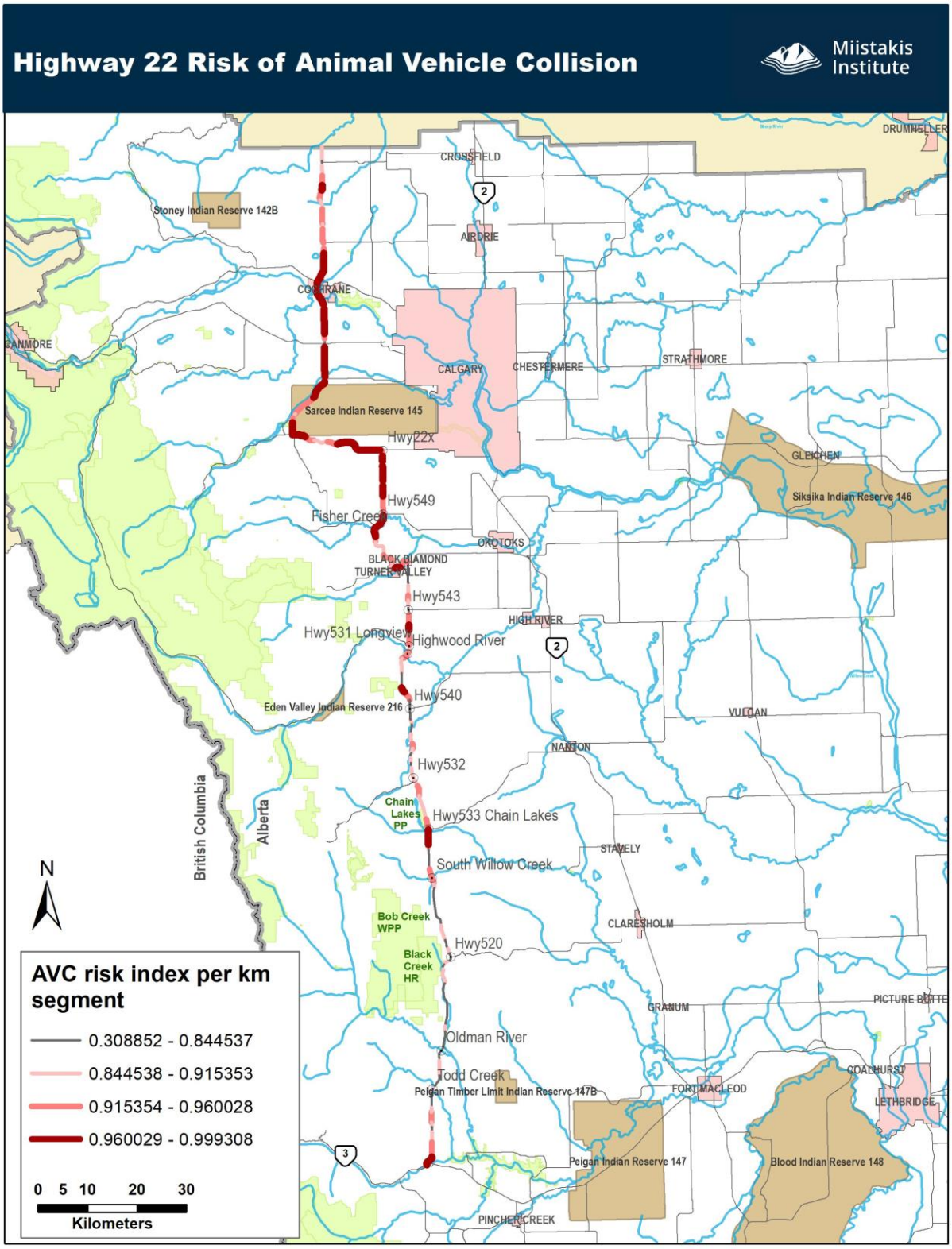


Figure 4; AVC risk metric for Hwy 22 (junction Hwy 3 to Hwy 547) based on reports to RCMP (2010 to 2014), darker red represents higher risk of an animal vehicle collision.

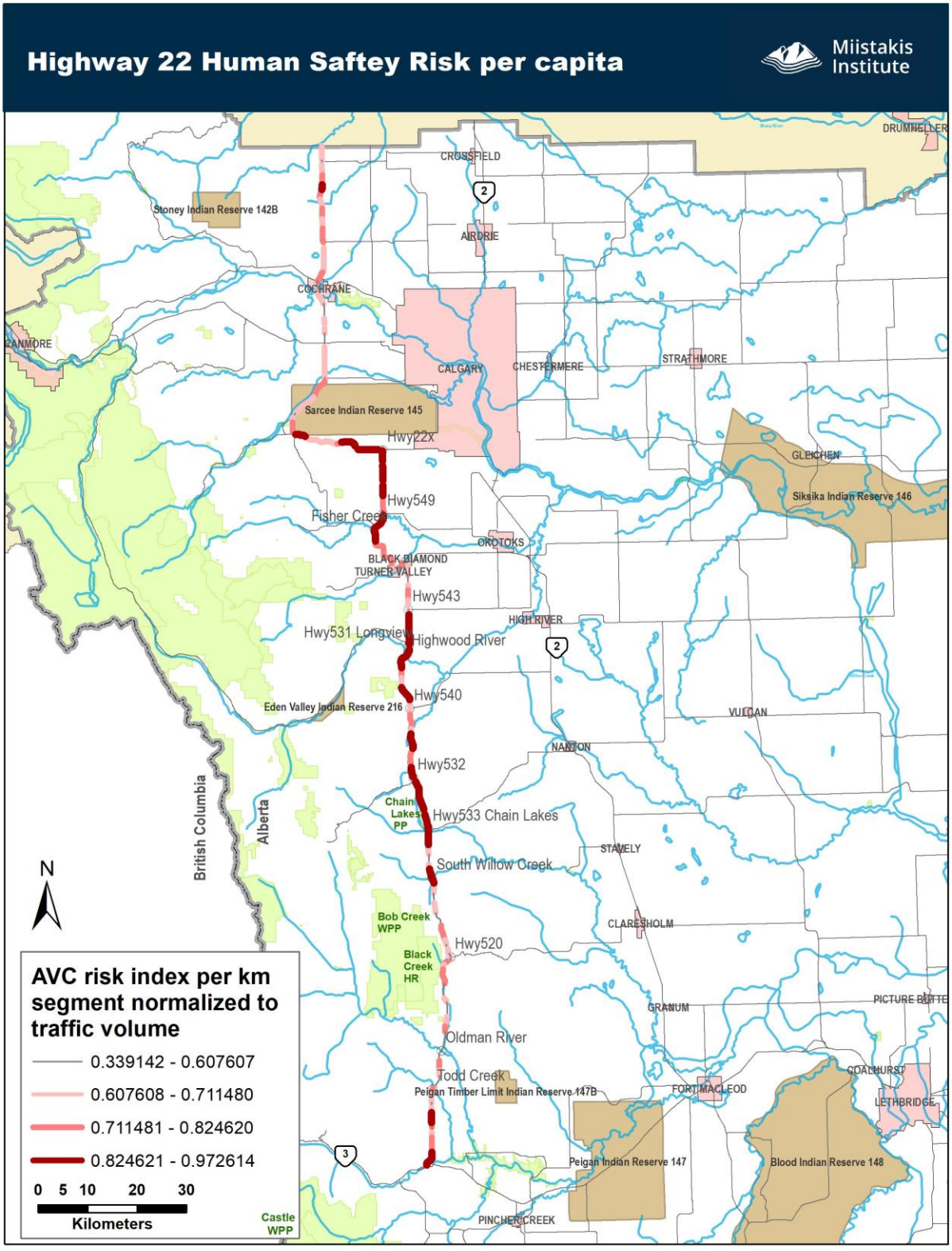


Figure 5: human safety risk metric for Hwy 22 (junction Hwy 3 to Hwy 547) based on reports to RCMP (2010 to 2014) normalized to traffic volume, darker red represents higher risk of an animal vehicle collision

Local Knowledge Movement Zones

Local knowledge experts identified zones of movement/mortality for deer sp., elk, and moose along Highway 22, and were asked to provide local knowledge contextual information associated with each zone. Participants were asked to determine if zones were primary or secondary in priority for animal movement (based on number of observations of crossings and mortality). In addition, participants were asked to identify carnivore observations along Highway 22 which were marked as point data.

DEER SPECIES

Local knowledge experts identified 36 deer zones (Figure 6, Figure 7, and Figure 8) along Highway 22, with 23 identified as priority zones (Table 1). A priority zone was identified using >1 mortality per month; while a secondary zone < 1 mortality per month or wildlife crossing alive.

Table 1: Deer Spp. Zones of movement based on expert opinion

Zone Name	Priority	Comments
DEER 1	Priority	- Home range for deer - One of the worst areas for deer south of 520. Tree cover both sides, pivot feedlot
DEER 2	Secondary	- Second worst after DEER 1south of 520 - Points by feed lot and cow creek could be localized due to hay field, grain spill, etc.
DEER 3	Secondary	None
DEER 4	Secondary	- South of south willow creek collisions where draw from hill meets highway
DEER 5	Secondary	None
DEER 6	Secondary	None
DEER 7	Priority	- 5 deer mortality in one year
DEER 8	Secondary	None
DEER 9	Priority	- 5 deer mortality in one year
DEER 10	Priority	- 13 deer mortality in one year
DEER 11	Priority	- 7 deer mortality in one year
DEER 12	Secondary	None
DEER 13	Priority	- 10 deer mortality in one year

DEER 14	Secondary	None
DEER 15	Priority	- 2 mortality per month, more in fall, 1 per month in summer
DEER 16	Secondary	- 2 mortality per year
DEER 17	Secondary	- Near school, 2-3 mortality per year
DEER 18	Priority	- 1 mortality per month
DEER 19	Priority	- 3-4 mortality per month
DEER 20	Priority	- 1-2 mortality per month
DEER 21	Priority	- 1-2 mortality per month
DEER 22	Priority	- 2-3 mortality per month, hayfields, fed/feed in area - Agreement provided
DEER 23	Priority	- 2-3 mortality per month - Agreement provided
DEER 24	Priority	- 1-2 mortality per month - Shell employees extended section northward, passing lane, see deer there 3-4 times per week
DEER 25	Priority	- 1 mortality per month - Agreement provided
DEER 26	Priority	- 1 mortality per month - Daily visual (alive), all year, lots of food
DEER 27	Priority	- 1 mortality per month - Daily visual (alive), all year, lots of food
DEER 28	Priority	- 1 mortality per month - Daily visual (alive), all year
DEER 29	Priority	- 6 mortality per month - Daily visual (alive) - Feed nearby
DEER 30	Priority	- 6 mortality per month - Daily visual (alive) - Feed nearby
DEER 31	Secondary	- Outside of town - Seen every morning (4-5 times per week) - Agreement provided
DEER 32	Secondary	- Almost daily/daily - Tank farm/mailbox, warm site - Agreement provided - 1 mortality per year between DEER 18 and 19
DEER 33	Priority	- Participants indicated this was a higher priority area than DEER 18 - Almost daily/daily

		- Tank farm/mailbox, warm site - Agreement provided - 1 mortality per year between DEER 18 and 19
DEER 34	Secondary	- Almost daily (mule deer) - Agreement provided
DEER 35	Priority	- 1 mortality per month, all year, fall (hunting season is worst) - Alive seen weekly
DEER 36	Priority	- 1 mortality per month, all year, fall (hunting season is worst) - Alive seen weekly

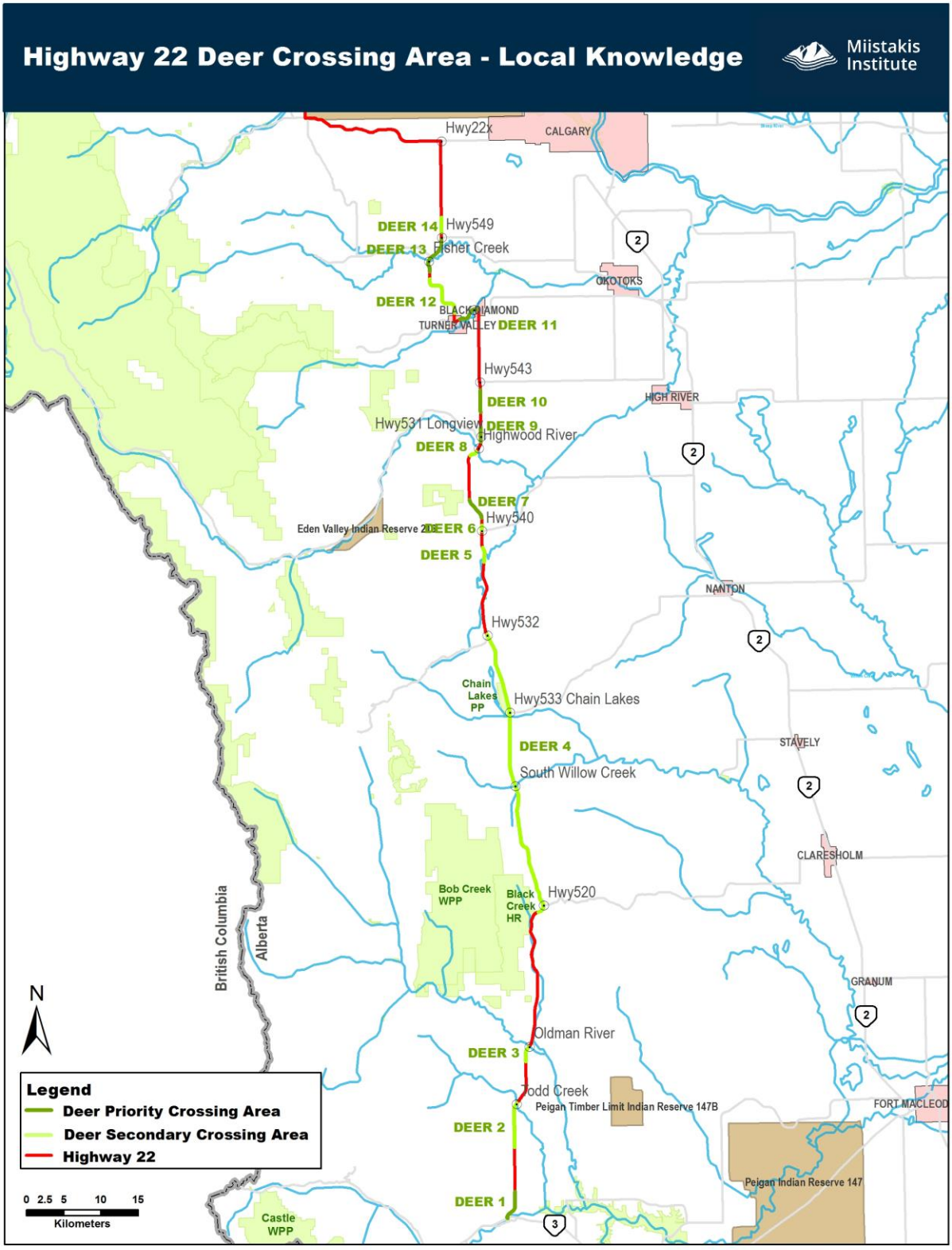


Figure 6: Deer Spp. zones along Highway 22 segment 1 (junction Highway 3 to Priddis)

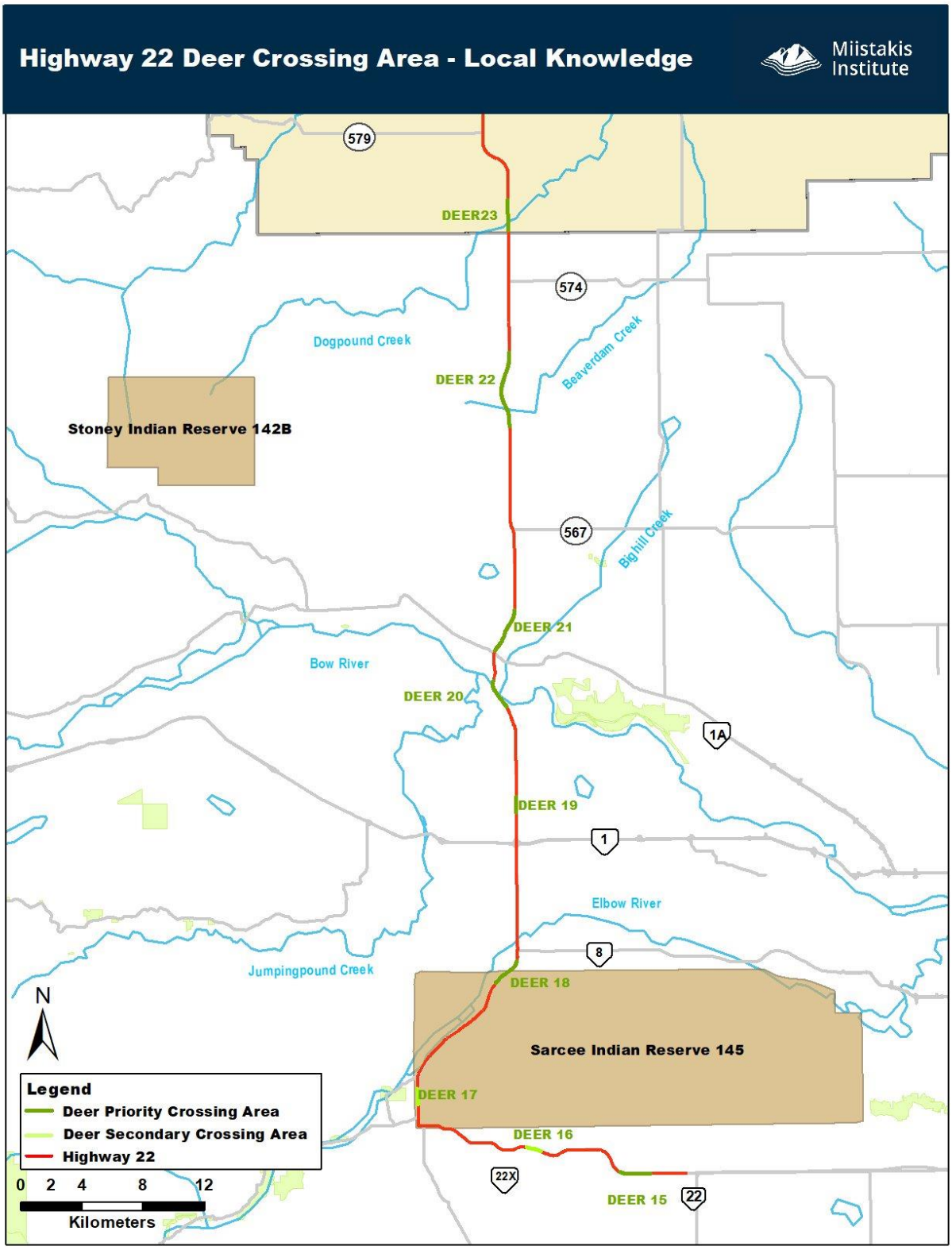


Figure 7: Deer spp. zones along Highway 22 segment 2 from Priddis to junction of Highway 579

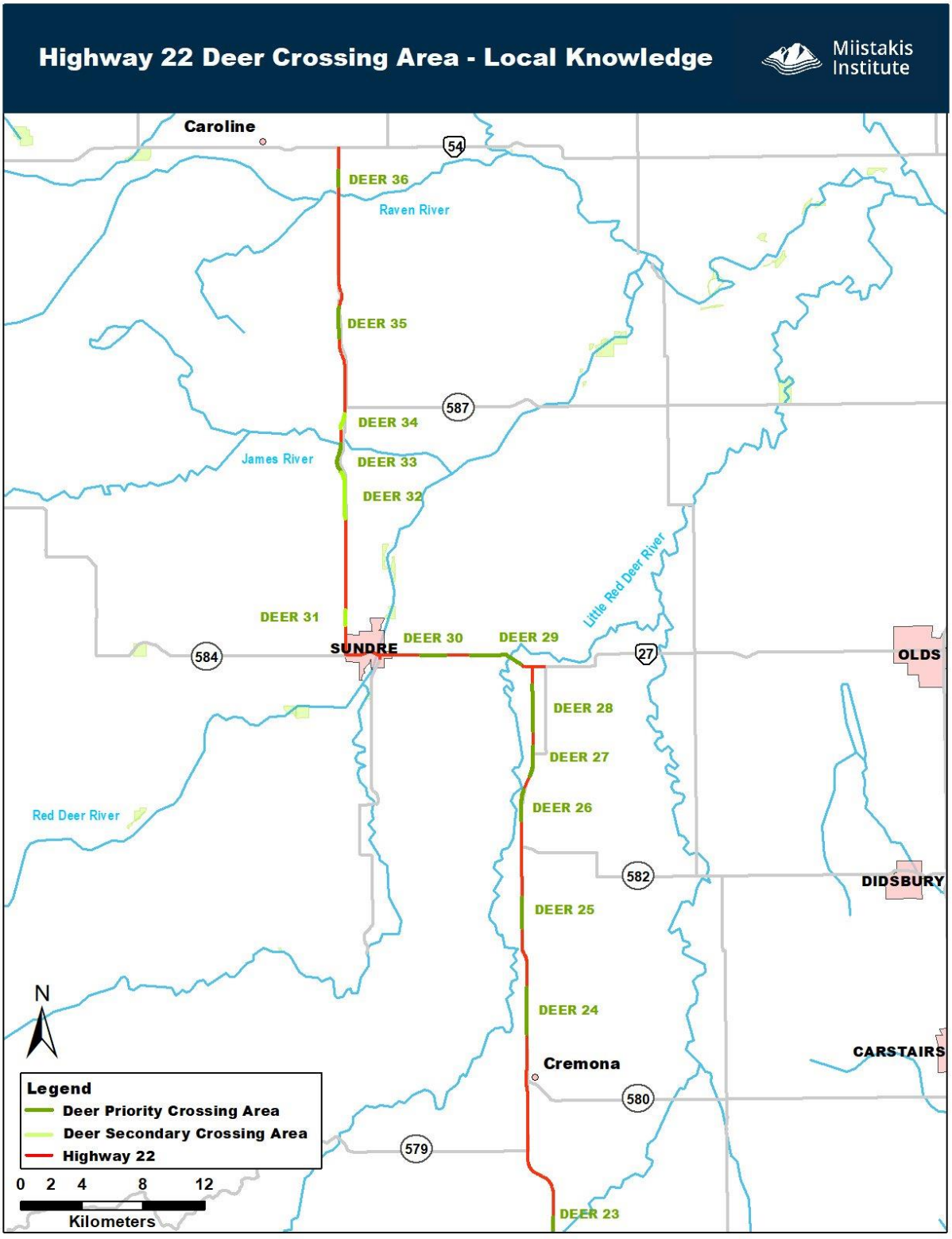


Figure 8: Deer Spp. zones along Highway 22 segment 2 from junction of Highway 579 to Caroline

ELK

Local knowledge experts identified twelve elk zones (Figure 9 and Figure 10) along Highway 22, with 3 zones identified as priority zones (Table 2). Many of the elk zones were noted as seasonal occurrences and/or represented areas where elk are crossing the road to forage on agriculture fields. These are important considerations when developing strategies around mitigation action.

Table 2: Elk Zones of movement based on expert opinion

Zone	Priority	Comments
ELK 1	Priority	- Spring time high (May/June), large herds attracted to hayfields on east side of road
ELK 2	Secondary	- Occasionally at this location - Northern 1km of ELK 2: is mainly an issue in the spring (east side of the road is a hay field that the elk are attracted to)
ELK 3	Priority	- Spring time/winter (January/February)
ELK 4	Secondary	- From 520 south for 3km (top 3rd of ELK 4):mainly in winter - (Bottom 2/3rd of ELK 4): Calving time for elk (May/June) - (Bottom 2/3rd of ELK 4): Winter - (Bottom ½ of ELK 4) early summer, coulees to have calves
ELK 5	Secondary	None
ELK 6		- Southern half of ELK 5 (Bar 11 to Riley Rd. (TSP Rd. 143B)): winter elk
ELK 7	Secondary	None
ELK 8	Secondary	None
ELK 9	Secondary	- Herd of 200 elk, spring and fall
ELK10	Primary	- Fall, crossing between two areas. 6 mortality in last few years, 40 in herd - Springbank road area
ELK 11	Secondary	- Westbrook school - Mortality; running in ditch (12 in ditch), can't jump tall fence along west side of ditch (elk proof), force movement along ditch; hayfields; - Fall - West to east access
ELK 12	Secondary	- October to November, not often - Agreement provided - Extended north

		- Seen weekly alive adjacent to highway - Occasionally (2 times per year) seen south of this segment

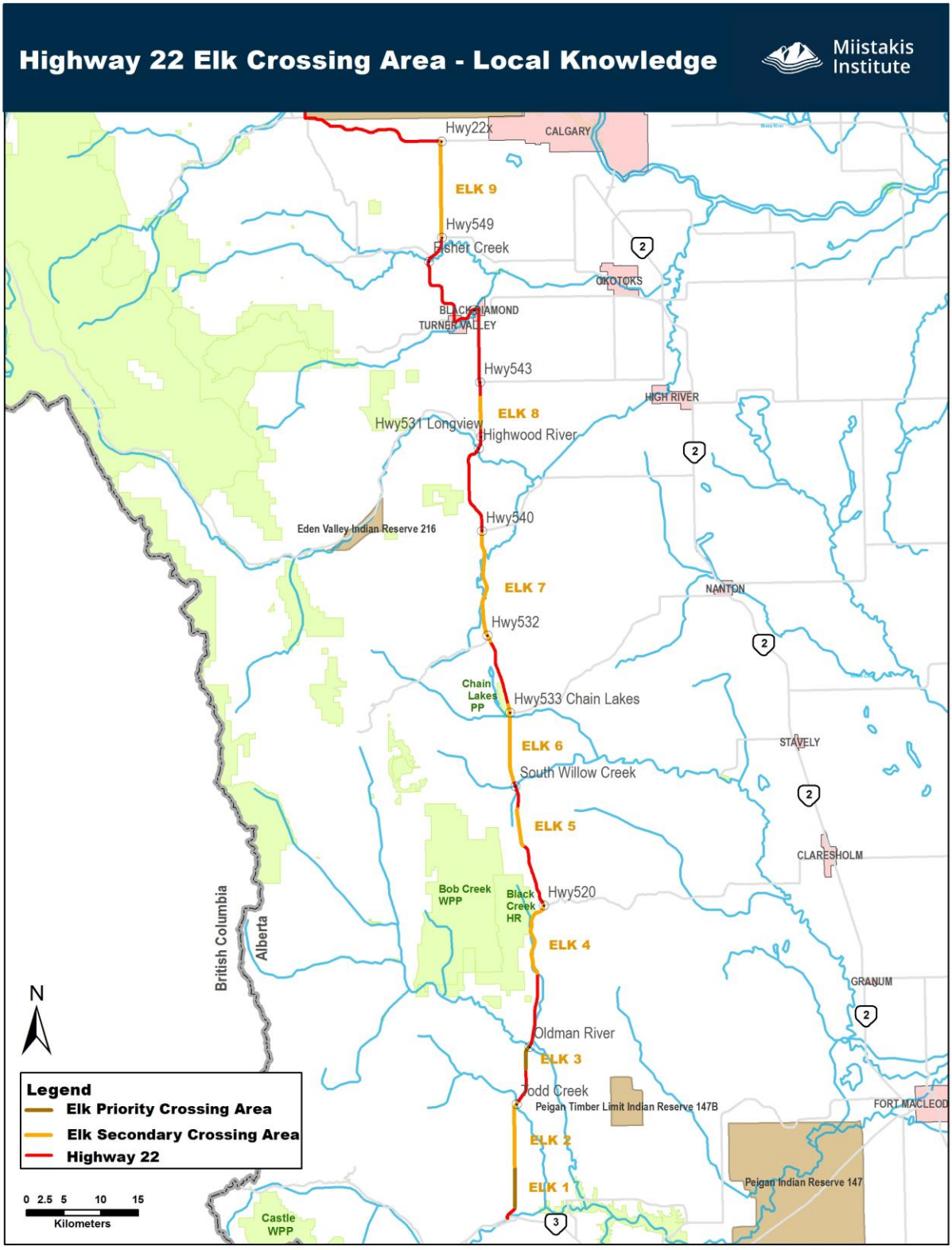


Figure 9: Elk zones along Highway 22 segment 1 from Highway 3 junction to Priddis

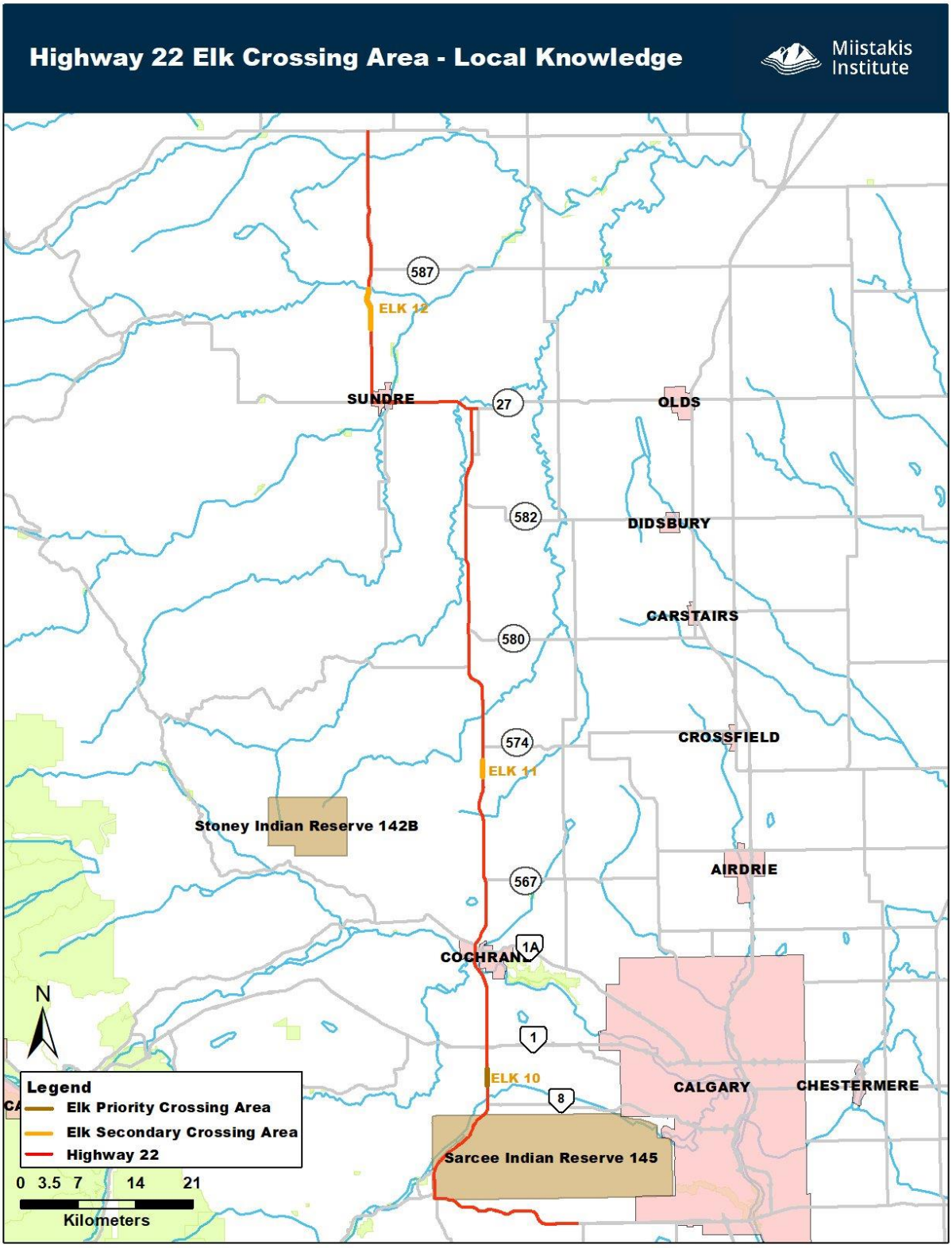


Figure 10: Elk zones along Highway 22 segment 2 from Priddis to Highway 587

MOOSE

Local knowledge experts identified thirteen moose zones (Table 3) along Highway 22, with three identified as priority zones (Figure 11, Figure 12, and Figure 13).

Table 3: Moose Zones of movement based on expert opinion

Zone	Priority	Comments
MOOSE 1	Secondary	None
MOOSE 2	Priority	None
MOOSE 3	Secondary	None
MOOSE 4	Secondary	None
MOOSE 5	Priority	- Old hay field south of 533 - From just south of 533 to north end of priority – lots of willow regrowth, moose always in this area
MOOSE 6	Secondary	None
MOOSE 7	Secondary	None
MOOSE 8	Priority	- 4 Moose mortality in one year
MOOSE 9	Secondary	- Once every two months
MOOSE 10	Secondary	- 1-2 mortality per year, spring
MOOSE 11	Secondary	- 1-2 mortality per year, fall - Agreement provided
MOOSE 12	Secondary	- 1 moose mortality last year
MOOSE 13	Secondary	- Crossing, 2 times per month, alive, all year - Agreed and extended north

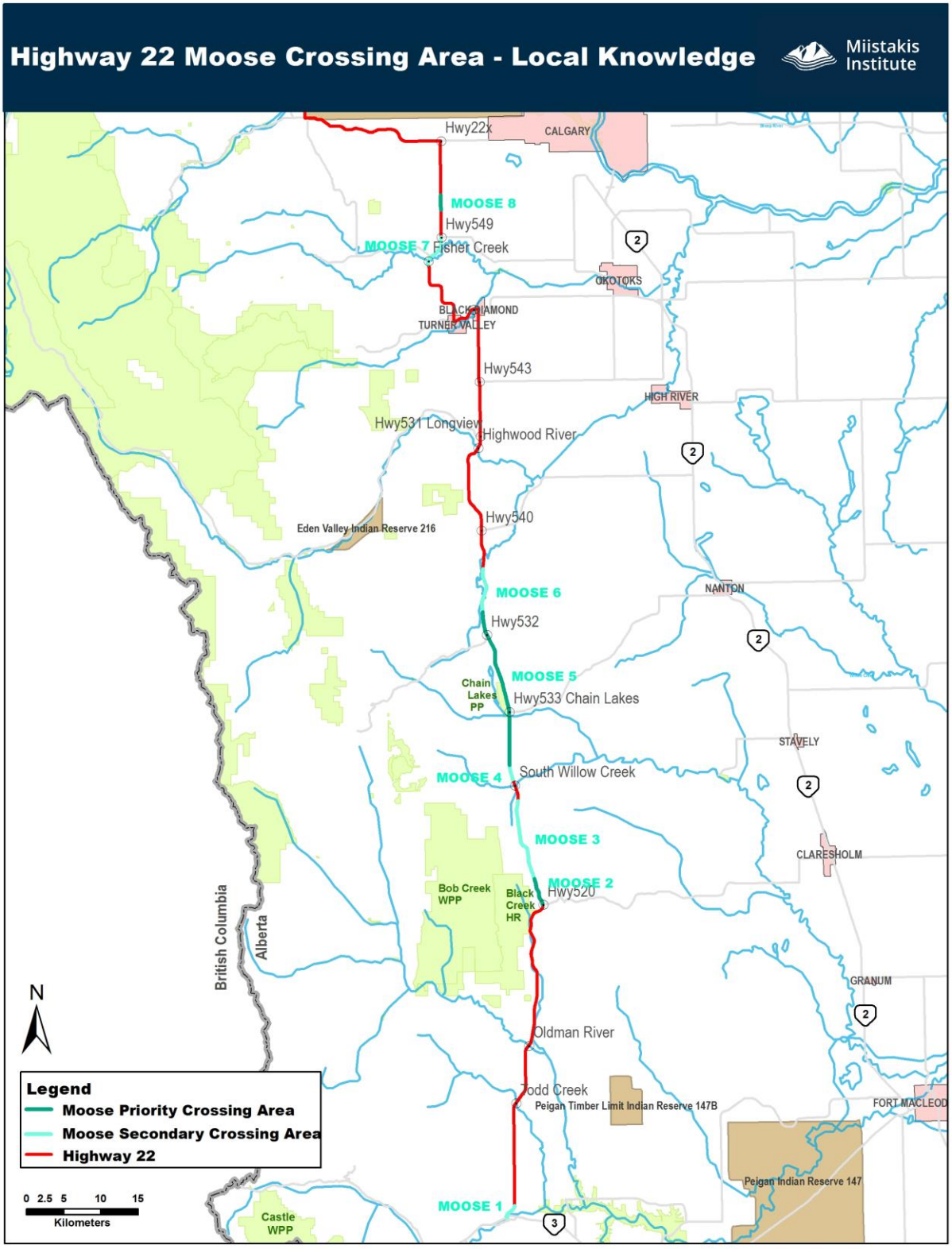


Figure 11: Moose zones along Highway 22 segment 1 from Highway 3 junction to Priddis

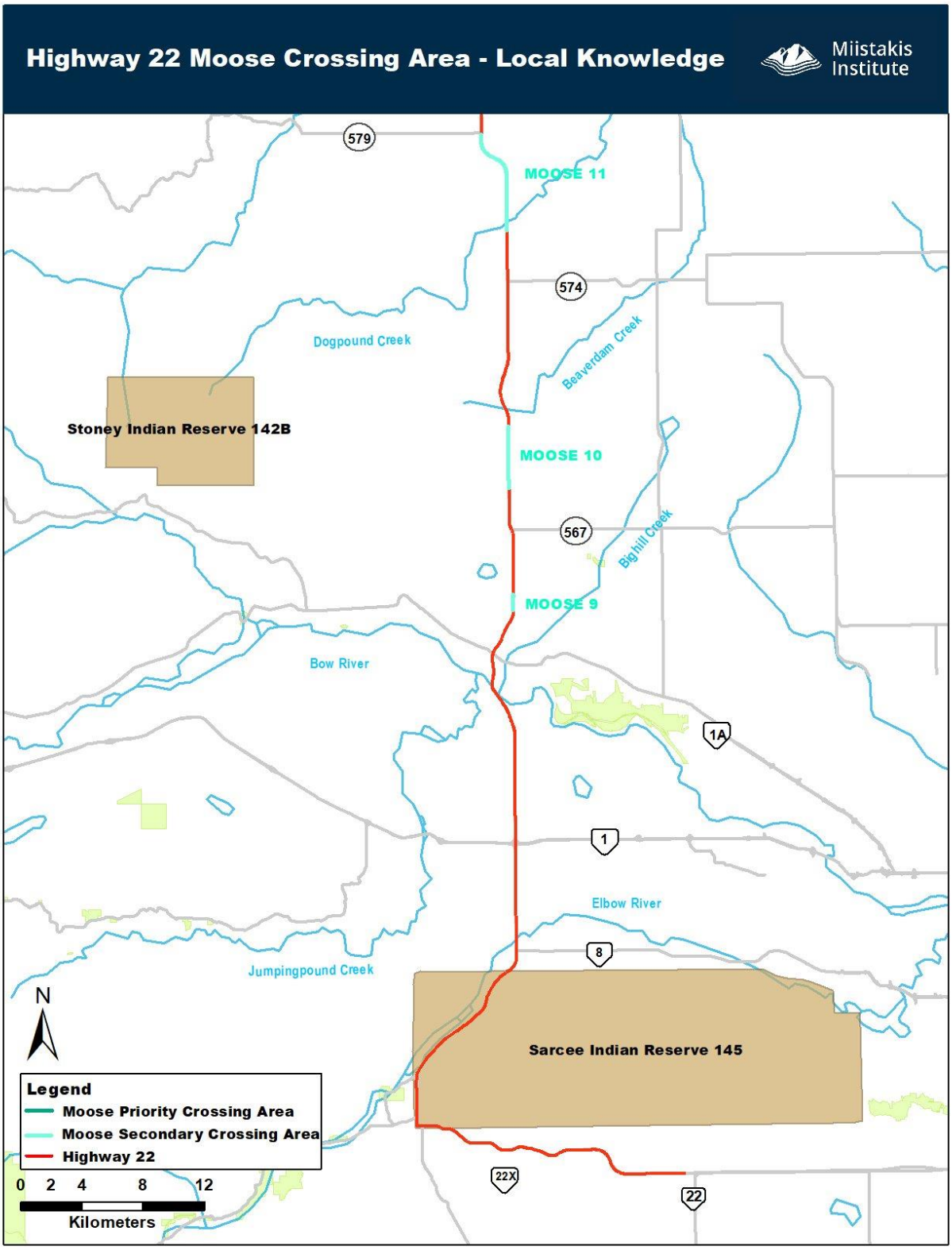


Figure 12: Moose zones along Highway 22 segment 2 from Priddis to junction with Highway 597

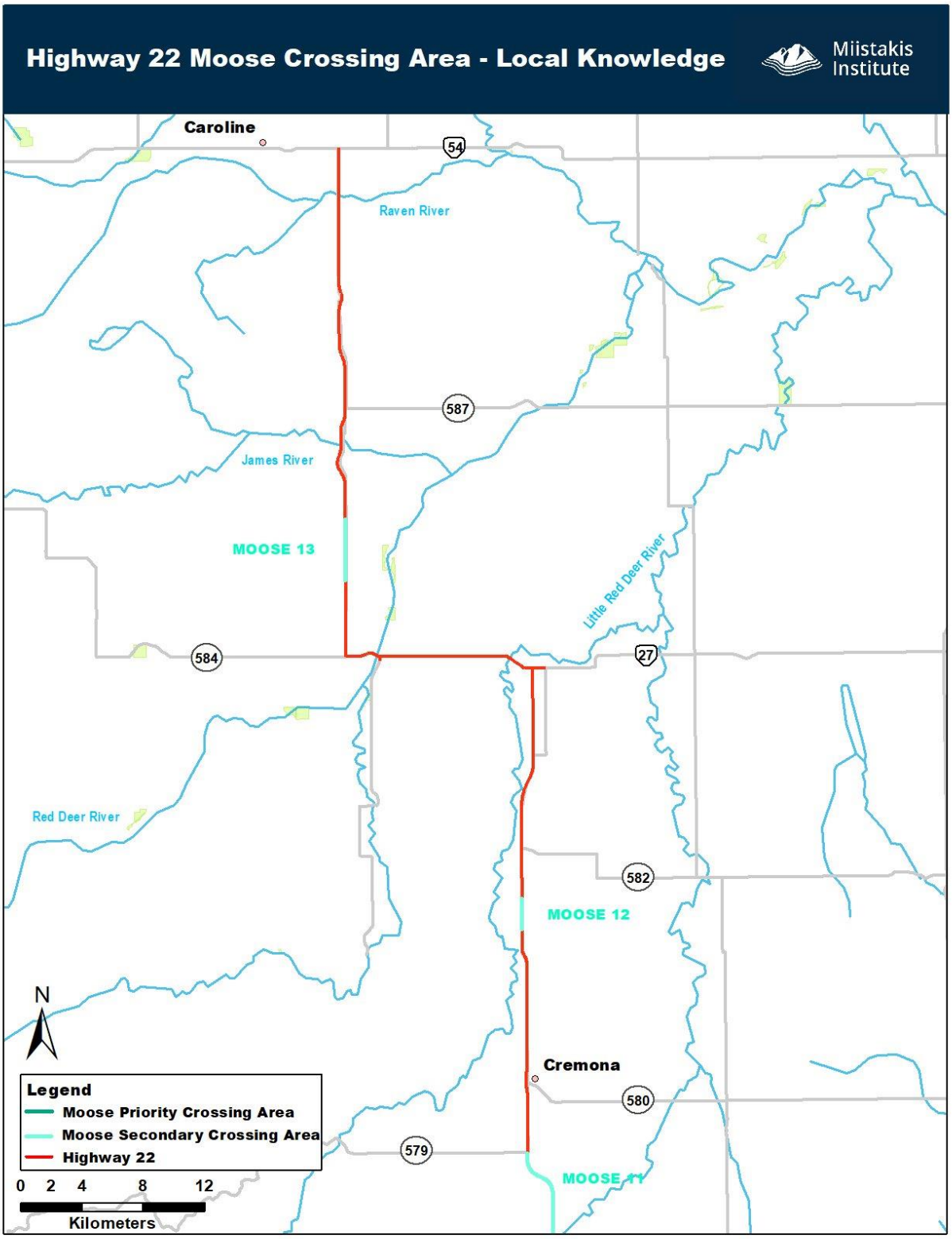


Figure 13: Moose zones along Highway 22 segment 2 from Highway 597 to Caroline

Summary of Ungulate Movement Zones

Elk, moose, and deer zones were summed to represent ungulate zones along Highway 22 (Figure 14 and Figure 15: Ungulate (elk, moose and deer) summary of crossing zones along Hwy 22 from Priddis to Caroline.where 1 = 1 ungulate species zone, 2= 2 overlapping ungulate species zones and 3 = 3 overlapping ungulate species zones. The zones do not reflect high number of animal vehicle collisions but instead identify areas where diversity of ungulate crossing is highest.

Movement areas for all three species include three key zones:

- Range road 21b to South Willow Creek;
- South Willow Creek to Highway 533 junction; and
- Highway 532 junction.

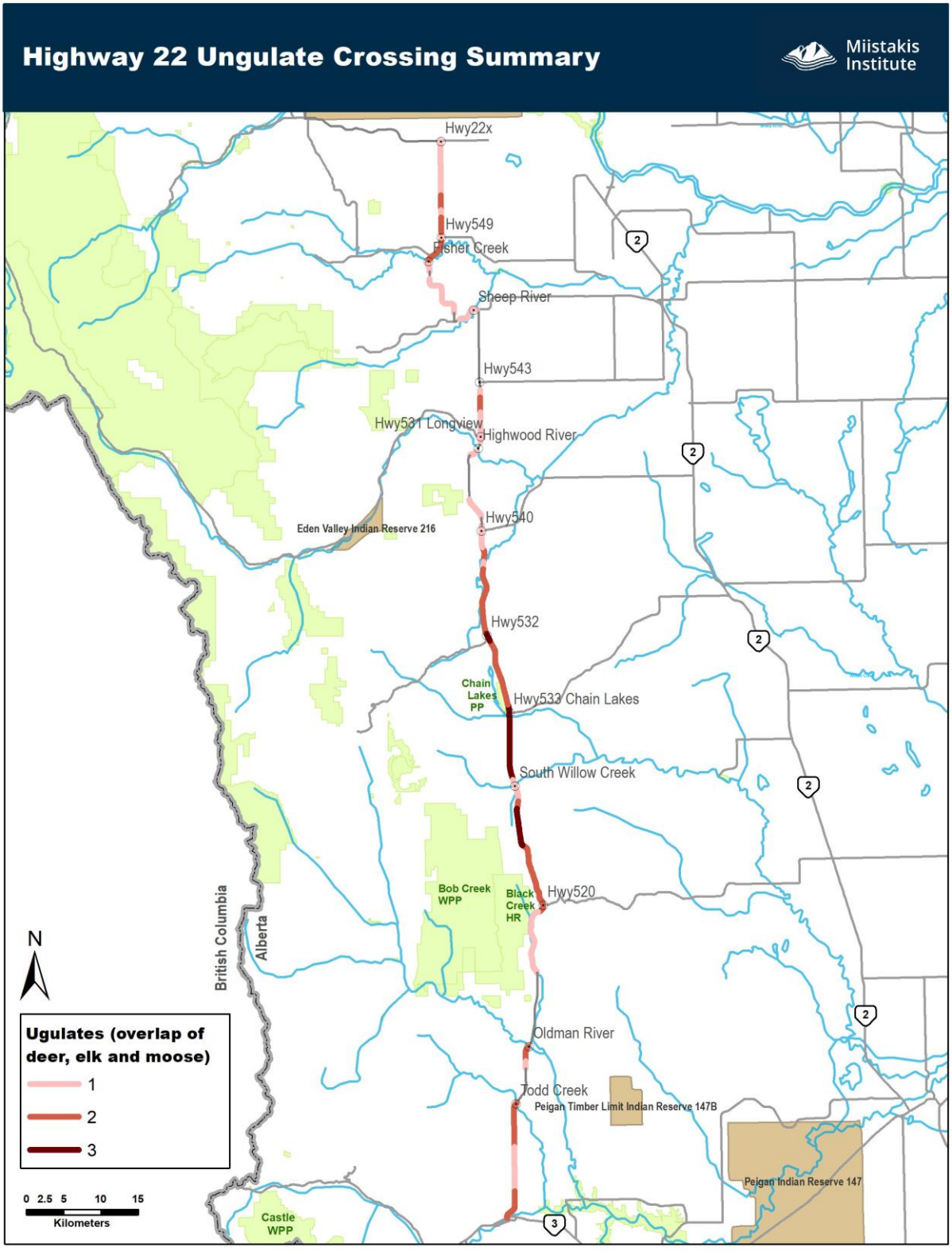


Figure 14: Ungulate (elk, moose and deer) summary of crossing zones along Hwy 22 from Highway 3 to Priddis.

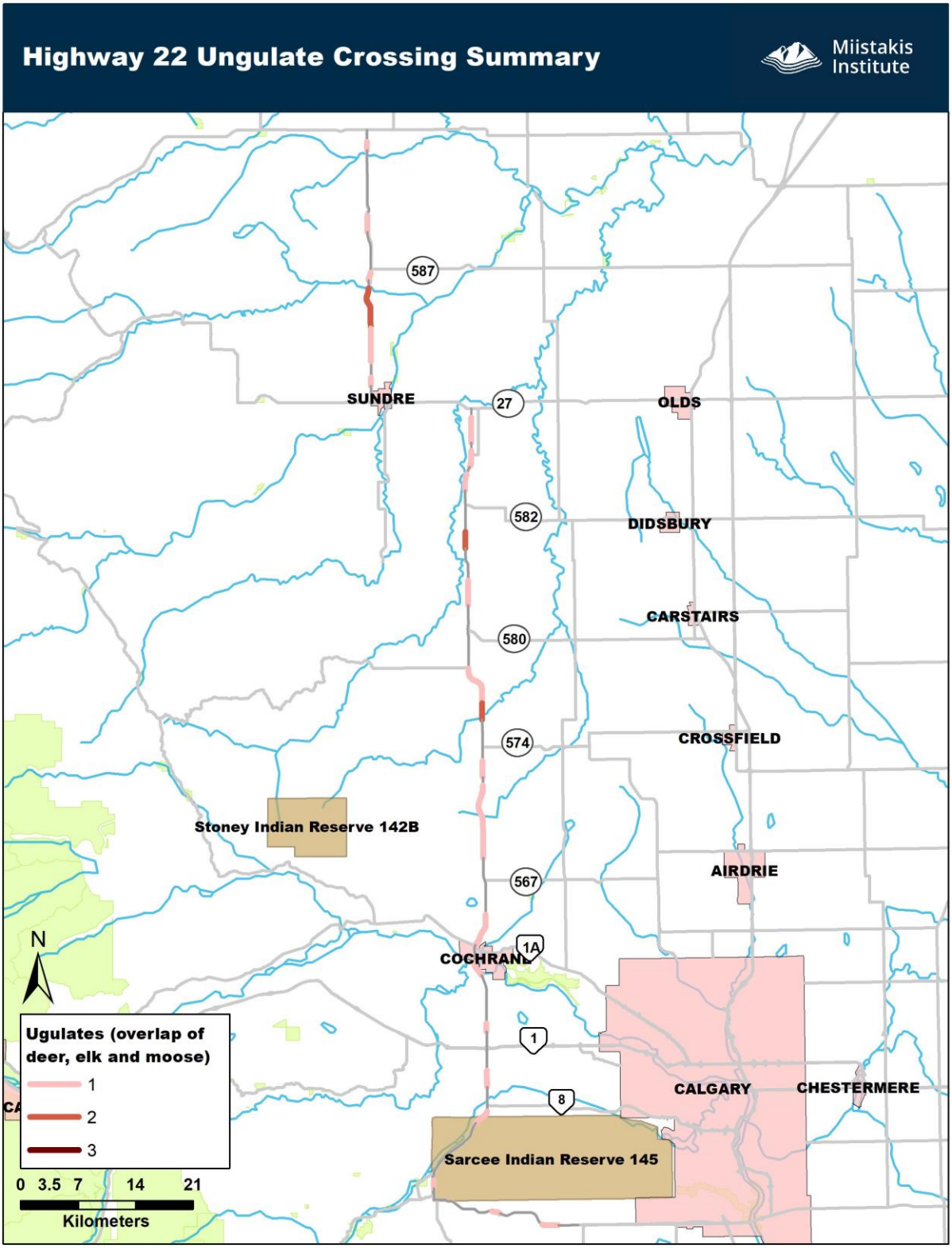


Figure 15: Ungulate (elk, moose and deer) summary of crossing zones along Hwy 22 from Priddis to Caroline.

Grizzly Bear Mortality and Movement

Grizzly bears are classified as 'threatened' in Alberta, and the province has released a *Draft: Alberta Grizzly Bear (ursus arctos) Recovery Plan* (Alberta Environment and Parks 2016). Roads impact grizzly bear populations as they are a contributing factor to habitat fragmentation due to avoidance behaviour and grizzly bear mortality from collisions with vehicles (Proctor et al. 2015, 2012). Avoidance behaviour results in roads acting as barriers to habitat and movement of bears around the landscape. The human use of the road determines the level of avoidance exhibited by the grizzly bears, with higher use roads being avoided more often than lower use roads (Northrup et al. 2012; Boulanger and Stenhouse 2014).

Highway 22 bisects important grizzly bear habitat in provincial bear management area (BMA) 5. Within BMAs there are two types of recovery zones, core and secondary. Highway 22 falls along the eastern edge of the support zones for Grizzly bears in BMA 5 from the junction with the Oldman River to Priddis. The support zone is an area outside of core zones and includes significant areas of private land. It may contain important habitat or be on the periphery of critical habitat and is an area where human-grizzly bear interaction commonly occurs and management of interactions is necessary to support the recovery of the grizzly bear population.

ENFOR data reports four grizzly bear mortalities along Highway 22 from April 2014 to July 2017 between the junctions of Highway 520 and Highway 532 and local knowledge experts identified 2 additional mortalities within this same area. In addition, connectivity modeling from Lee et al. (2017) based on movement between core security patches indicates key movement areas across Highway 22 between the Oldman River and Highway 520 junction (Figure 16). This portion of Highway 22 should be carefully considered in relation to grizzly bear recovery since mortality is high from collisions with vehicles relative to other major highways which bears may be avoiding (Highway 1 or 3).

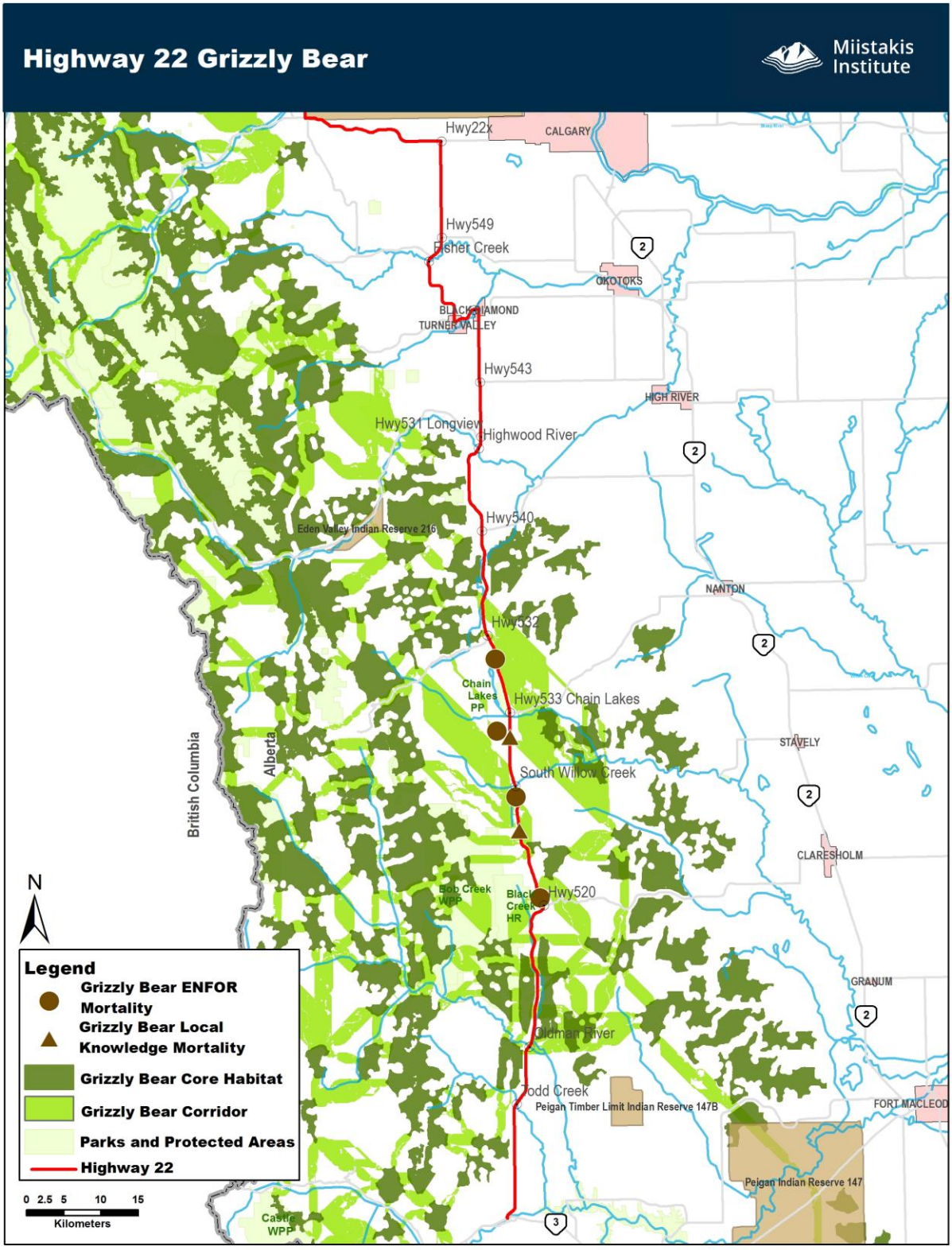


Figure 16: Grizzly bears and Highway 22

Other Carnivore Species

ENFOR data and local knowledge identified additional carnivore species involved in AVCs or observed along Highway 22. Black bear, cougar, bobcat and wolf mortality and crossing observations are displayed on Figure 17. Similar to grizzly bear the section of Highway 22 between the junctions of Highway 520 to 532 were the most common areas for movement.

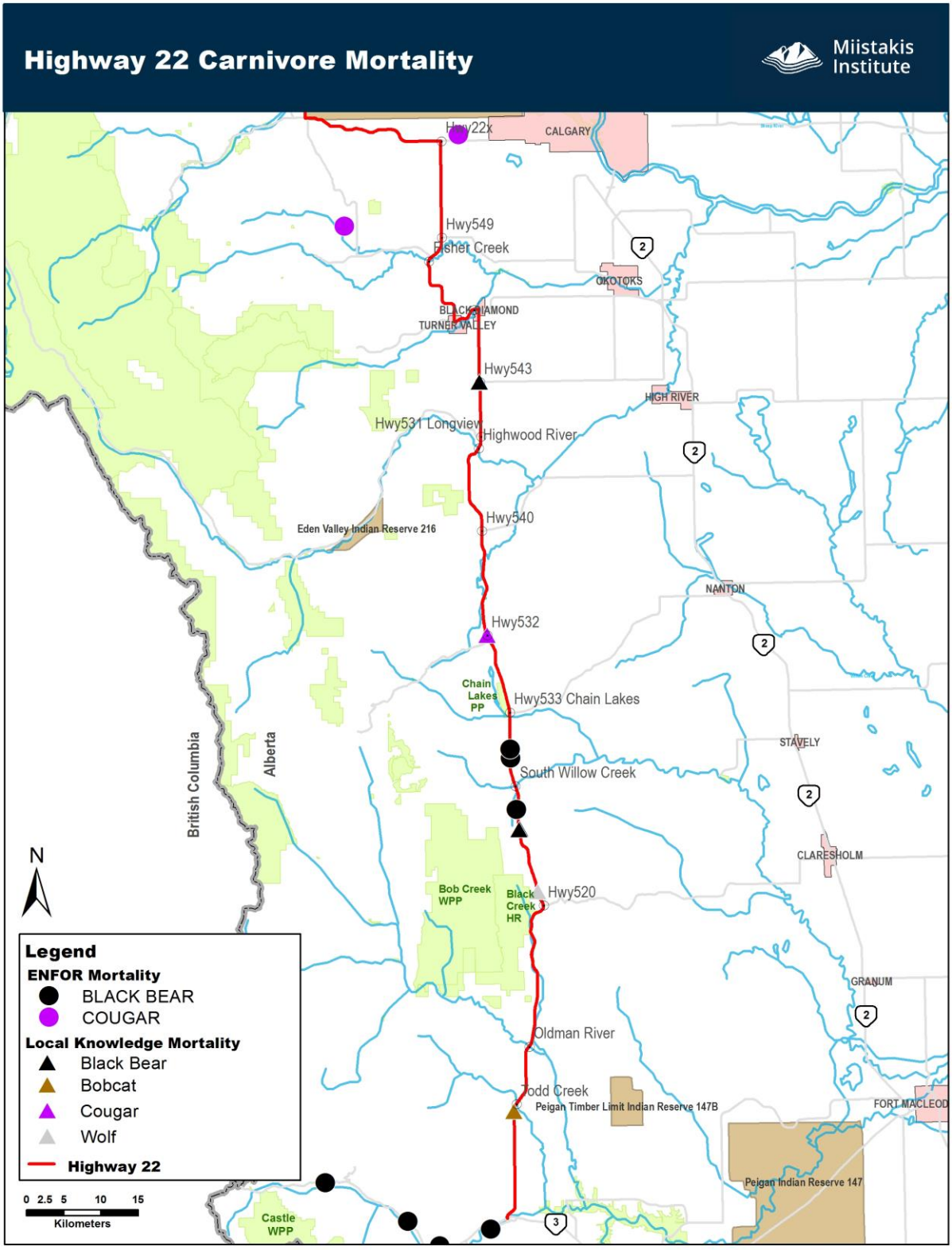


Figure 17: Carnivore species AVCs or observations along Highway 22

Conclusion

Highway 22 is situated along Alberta's Eastern Slopes which supports the full complement of large mammal species common in the Rocky Mountains. Highway 22 from the junction of Highway 3 to Caroline is a 325 km stretch of road with high variability in traffic volumes ranging from 2,000-13,000 annual average daily traffic (AADT) depending on the highway section. Land use along Highway 22 is predominately agriculture (ranching), resource extraction and a number of small rural towns. Highway 22 is considered a scenic corridor for tourism as it runs parallel to the Canadian Rocky Mountains.

Wildlife including black and grizzly bears, elk, deer and moose, as well as many other medium-sized mammals currently use the area and move across Highway 22. However, there is little documentation to inform where wildlife movement across Highway 22 is common or where human safety risk is high due to animal vehicle collisions. We therefore documented the current state of knowledge on animal vehicle collision and identified wildlife movement zones based on local knowledge.

Using a collection of data sources and local expert knowledge we identified a number of considerations for improving wildlife and human safety along Highway 22:

- In the southern portion of Highway 22, Animal Vehicle Collisions (AVCs) are highest between Priddis and the junction of Highway 567 (to the north of Cochrane), coinciding with highway sections experiencing the highest traffic volumes and in close proximity to Calgary. There are also some smaller highway sections where AVCs were high in rural areas. If the goal is to reduce overall collision numbers, these highway sections would be the focus of mitigation strategies.

- Human Safety Risk Index per individual is highest along sections of Highway 22 from the junction with Highway 3 to Priddis through rural areas where wildlife are likely crossing more frequently. If the goal is to reduce human safety risk to individual motorists these highway sections would be the focus of mitigation strategies.

- AVCs and human safety risk index overlap at key rural highway sections, such as at the **junction of Highway 3**; **junction of Highway 533** (**Chain Lakes Provincial Park)**; **around towns of Black Diamond and Millarville**; **Between 247 Ave West junction to Priddis; Highway 762 junction; and Township Road 280a junction**. These highway sections therefore represent areas where both individual human safety risk and number of animal vehicle collision show agreement, possibly representing the best value to society from a mitigation perspective. It is likely there are highway sections in the northern portion, but we were not able to obtain AVC data for this portion of Highway 22.

- Traffic volume is an important consideration in wildlife and human safety discussions. At certain traffic volumes, below 2,000 vehicle per day, collision risk is low, between 2,000 and 10,000 collision risk increases and above 10,000 vehicles per day, collision risk decrease but wildlife avoidance of the highway may act as a barrier to movement. Highway 22 experiences a wide range of traffic volumes but large sections of the highway, from the Highway 3 junction to Bragg Creek and from Highway 567 junction to Caroline represent areas of high collision risk. The highway section between Cochrane and Cochrane Lake Road are over 10,000 AADT and wildlife may potentially avoid these areas. This may be more concerning for specie at risk where fragmentation of landscape has been identified as a concern.

- Wildlife movement across Highway 22 was identified using local knowledge from highway maintenance contractors, Shell personnel that regularly drive Highway 22 and the local ranching community. Movement zones were identified for each species including, 36 deer zones, 12 elk zones and 13 moose zones. A summary of ungulate diversity was produced to identify areas where all three species overlapped. **Highway sections representing common zones of movement for all three ungulate species include,**
    - **Range Road 21b to South Willow Creek;**
    - **South Willow Creek to Highway 533 junction; and**
    - **Highway 532 junction.**

- Information provided by local knowledge experts provides important contextual antidotes for informing highway mitigation strategies. For example, many of the elk zones are highly seasonal relating to crops on one side of the highway.

- Grizzly bears are a threatened species in Alberta and human caused mortality is a key threat including collisions with vehicles. From April 2014 to April 2017, four grizzly bear mortalities from collisions with vehicles were reported to the ENFOR database. Grizzly bear modeling and mortality observations all occur along **Highway 22 between Highway 520 and Highway 532.** Other carnivore species recorded in this stretch included wolf, cougar, and black bear.

Addressing both wildlife and human safety requires different considerations and priority highway sections may not align. To summarize findings eleven mitigation zones with consideration of one or a combination of human safety risk, total animal vehicle collisions and wildlife connectivity (ungulate zones or grizzly bear zone) (Figure 18). If mitigation planning focused on these ten sites, significant improvements to both human and wildlife safety could be achieved.

Specific mitigation sites were not identified during this process. This is an important next step in mitigation planning but one that requires field visits to identify appropriate locations and expertise of road ecologists and transportation engineers. Mitigation measures are both expensive and often fixed (i.e., not portable), therefore it is critical that their installation is strategic to maximize return on investment in meeting the management priorities of both wildlife and transportation agencies.

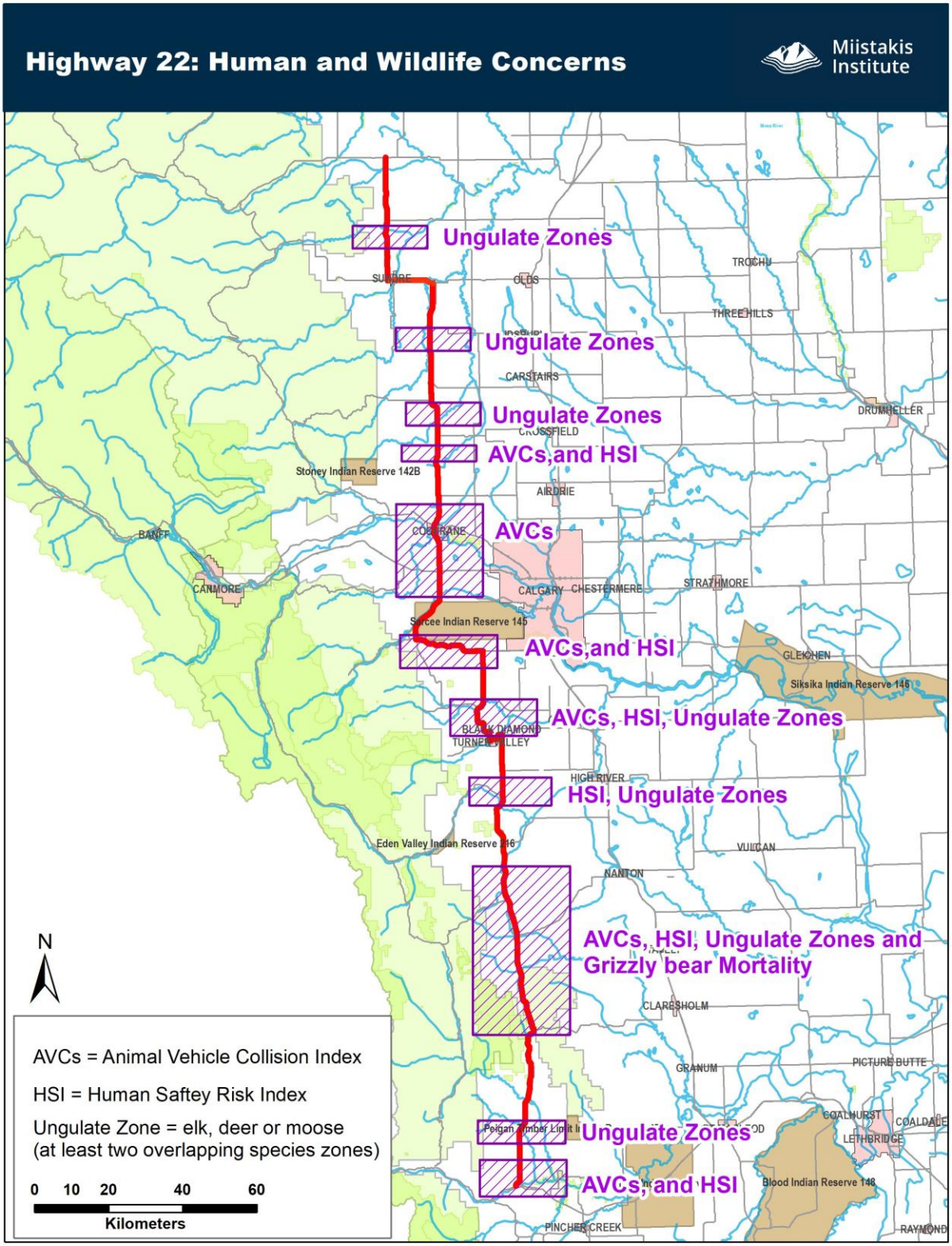


Figure 18: Mitigation Zones (displayed as purple boxes) based on assessment or animal vehicle collision index, human safety index, ungulate local knowledge zones and grizzly bear movement zones.

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Appendix A: Participants

The following individuals were consulted in the process and helped identify local knowledge movement zones for ungulate:

- Bruce, Alberta Highway Services, Caroline shop
- Cam Gardner, Municipal District of Ranchlands
- Colin Anton, Shell Canada Limited
- Craig Harding, Nature Conservancy Canada
- George Stanjeck, Alberta Highway Services Olds Shop
- Ian Campbell, Wood PLC
- Kathy Wiebe, Municipal District of Ranchlands
- Kristen Schmidt, Shell Canada Limited
- Len Gibson, Volker Stevin Contracting Limited, Cochrane/Cremona Shop
- Len H., Volker Stevin Contracting Limited, Pincher Creek Shop
- Rob Schaufele, Collision Count, Miistakis Institute
- Scott Judson, Volker Stevin Contracting Limited, Elbow River Shop
- Thalia Aspeslet, Shell Canada Limited
- Dr. Tony Clevenger, Consultant

Furthermore, individuals from Volker Stevin Cochrane/Cremona and Pincher Creek, Shell Caroline Gas Plant also assisted and are not listed here.