Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Terrestrial Environment

Hydropower Limited Partnership

June 2012

SECTION 4
TERRESTRIAL INVERTEBRATES

KEEYASK
Hydropower Limited Partnership

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4.0 TERRESTRIAL INVERTEBRATES

4.1 INTRODUCTION

The environmental studies described in this section encompass the terrestrial **invertebrate** community. Terrestrial invertebrates (animals without backbones) are a diverse group of organisms that play a key role in the function of **boreal** ecosystems. For example, they enhance soil fertility (*e.g.*, earthworms and nematodes), pollinate plants (*e.g.*, butterflies, beetles, flies, bees, *etc.*), and are often food for other animals (*e.g.*, frogs, birds) and some plants (*e.g.*, pitcher plant). A brief description of the study area, and information sources and methods used in the assessment of the terrestrial invertebrate community are provided in Section 4.2. The historic and current invertebrate community conditions for the study area are described in Section 4.3. Project effects, including construction, operation, residual and **cumulative effects** and **mitigation** are described in Section 4.6 along with **environmental monitoring** and follow-up programs.

4.2 APPROACH AND METHODOLOGY

4.2.1 Overview to Approach

No field studies for terrestrial invertebrates were conducted within the Invertebrate Local or **Regional Study Areas** (Zone 3 and 4 respectively, in Section 1, Map 1-1). Instead, descriptions of terrestrial invertebrates known to occur in boreal forest communities within the Regional Study Area or similar regions were based on a compilation of pre-existing data records published in scientific literature and other reputable sources. Terrestrial invertebrates often inhabit an area based on the presence of preferred soil characteristics (*e.g.*, sand/clay composition, pH, *etc.*) and related plant associations. This relationship enables use of invertebrate information gathered from previous studies conducted in areas that are similar, in terms of soil and plant communities, to the Regional Study Area.

Thus, information gathered from other studies conducted within the Boreal Shield Ecozone (within which the Regional Study Area occurs) were used to characterize the existing environment for terrestrial invertebrates and evaluate potential effects of Project-related activities on individual invertebrate species/communities of interest. Much of the terrestrial invertebrate data utilized in this assessment has been compiled from studies conducted in boreal regions of British Columbia, Alberta, Ontario and to a small extent Manitoba. The following description of terrestrial invertebrates includes species:

- Detected near the Project location (Gillam, Thompson);
- Mentioned as having a distribution in the boreal forest of Manitoba, but published in a document describing **arthropods** of a province other than Manitoba; and
- Recorded as occurring in a province other than Manitoba, but in an ecozone and ecoregion with plant communities and climatic conditions very similar to those found in the Regional Study Area.

4.2.2 Study Area

For the assessment of terrestrial invertebrate communities, Zone 3 was used as the Invertebrate Local Study Area and Zone 4 was the Invertebrate Regional Study Area (Section 1, Map 1.1).

4.2.3 Information Sources

4.2.3.1 Aboriginal Traditional Knowledge

Information regarding invertebrates from Aboriginal traditional knowledge (ATK) in the Regional Study Area has not been provided to date. Information on invertebrates for the purpose of the Project effects assessment was obtained primarily through reviewing previous scientific studies.

4.2.3.2 Existing Published Information

Peer-reviewed and non-peer-reviewed literature on terrestrial invertebrates inhabiting in the Boreal Shield and Hudson Plain Ecozones is limited (Rickey *pers comm*. 2008). Although a portion of the data on invertebrates within the Regional Study Area that is presented in this section has been collected as incidental observations alongside the lower Nelson River and Burntwood River (Wuskwatim, Keeyask and Conawapa sites), most of the invertebrate occurrence records referred to in this document were taken from reports of observation in northern boreal ecosystems throughout Canada. Care was taken to select terrestrial invertebrate data from research conducted in the Boreal Shield and Hudson Plain Ecozones, or from ecosystems with similar habitat types, *i.e.*, plant communities, soil and climatic conditions. The Wuskwatim Environmental Impact Statement (Manitoba Hydro 2003) also provided information on terrestrial invertebrate communities in a boreal ecosystem adjacent to the Regional Study Area.

These data compilation methods were used to select invertebrate arthropod records from reputable sources including an assessment of species diversity produced by the Ecological Monitoring and Assessment Network (EMAN). This report contains descriptions of species that occur in the boreal bioclimatic zones (Meidinger and Pojar 1991) of the Montane Cordillera Ecozone (Scudder and Smith 1998); arthropod species occurring in this ecozone are likely to occur under comparable conditions of the Project Regional Study Area. Many records of arthropod occurrence associated with this database include descriptions of species with distributions throughout Canada.

Information gathered in the Regional Study Area between 2001 and 2007 has been combined with available literature to produce an overall understanding of the invertebrate community within the Regional Study Area. This information has been used to assess the expected effects of the proposed Project development, and suggest measures to mitigate and minimize those potential effects (Section 3.4).

Invertebrate information was also acquired through scientists familiar with particular plant communities and associated invertebrates.

4.2.3.3 Environmental Impact Studies

Terrestrial invertebrate-focused environmental field studies did not occur within the Regional Study Area. However, all information gathered on incidental terrestrial invertebrate observations in the lower Nelson River area (*e.g.*, Keeyask and Conawapa Regional Study Areas) during environmental studies was incorporated into the assessment.

4.2.4 Assessment Methods

Impacts of the Project on the terrestrial invertebrate community were assessed based on existing conditions as described by other scientific studies conducted in similar boreal regions of Canada.

4.3 ENVIRONMENTAL SETTING

4.3.1 Historic Conditions

Danks and Foottit (1989) compiled entomological reports from 1965 through 1988 of insects observed in the boreal, subarctic and arctic zones of Canada. They reported the occurrence of insects in each zone as percentages of selected insect families throughout Canada. This compilation provides family names for a large subset of insect present in the boreal zone. This list of insects included bark beetles, leaf-hoppers, moths, "pirate bugs" (Anthocoridae), rove beetles, tree-fungus beetles, dragonflies and water beetles. Within this subset, dragonflies were most numerous, water beetles second and moths third. Overall, these insect families in the boreal zone comprised only 40% of the same families' occurrence across Canada.

Historic records of invertebrates in Manitoba are mainly focused on southern regions of the province. Records from observations in the Boreal Shield and Hudson Plains Ecozones of Manitoba (Map 4.1-1) are scarce and cover mainly insects, with a focus on those insects that are pests to forestry resources (conifers). Although major research has been conducted to review and synthesize scattered studies throughout the boreal forest (Danks and Foottit 1989), much of the invertebrate research in northern Manitoba consists of single-species accounts or collections made near historically established towns such as Gillam and Churchill.

4.3.2 Current Conditions

Invertebrates comprise 97% of all known animal species. Invertebrates are currently classified into 30 **phyla**, many of which occur in aquatic environments. Terrestrial invertebrates are represented within four phyla:

- Nematoda (unsegmented worms, *e.g.*, roundworms);
- Annelida (segmented worms; *e.g.*, earthworms);
- Mollusca (*e.g.*, snails); and
- Arthropoda (*e.g.*, spiders, insects, crayfish).

Within the phylum Arthropoda is the class Insecta, which includes many of the commonly known invertebrate species. An estimated 32,000 insect species inhabit the boreal forests of North America (HWW 2008). The roles of terrestrial invertebrates in a boreal forest ecosystem are illustrated in Figure 4A-1 and Figure 4A-2. The vast majority of terrestrial invertebrates in the **nematode**, **annelid** and **mollusc phyla** that are present in the Boreal Shield **Ecozone** have not been the subject of ecological research and are not documented within the Regional Study Area (Yu *pers comm*. 2008).

Many invertebrates present throughout the boreal forest have an aquatic larval life stage and a terrestrial adult life stage. Invertebrates with a terrestrial adult life stage are examined in this section to describe their role as predators on other terrestrial invertebrates or their function as prey for terrestrial vertebrates, and to describe potential Project-related impacts on these species' terrestrial life stages.

Most terrestrial invertebrates are predators, **parasites**, decomposers or nectar feeders. Short growing seasons in the boreal forest and in the Project area provide a narrow window for pollinators such as beetles, moths, and flies to visit flowering plants. Decomposer activity is limited by freezing temperatures in fall, winter, and spring. Invertebrates living as predators on, or parasites within, warm-blooded animals potentially experience longer periods of seasonal activity. Most invertebrates living on the ground or in the canopy die in an adult life stage before winter, or they overwinter in a dormant adult or pupal life stage.

The diversity of plant communities present in the Manitoba boreal forest (Section 2.3) gives rise to equally diverse terrestrial invertebrate communities. Such invertebrate communities include species living in the soil (nematodes, earthworms), on the ground (beetles, spiders), in the air (butterflies, moths, flies), and within the vegetation canopy (spiders, aphids, beetles). The boreal forest is a highly productive breeding ground for many **Neotropical** migrant songbirds due in large part to seasonally abundant flying insect prey (Boreal Songbird Initiative 2007).

Terrestrial invertebrate communities are likely to have overlapping distributions among plant communities (*e.g.*, black spruce mixedwood, broadleaf mixedwood and peatland throughout the Regional Study Area (Section 2.3.1.3.5). Some species may be closely associated with unique plant communities (white spruce or jack pine stands) or specific types of habitats (peat plateau bog, upland spring).

Plant-eating invertebrates (**herbivores**), predacious invertebrates (carnivores and **omnivores**) and invertebrates that eat decomposing material (**detritivores**) represent **trophic** levels within each community (Figure 4A-1; Table 4A-1). Interactions among these trophic levels can be described in terms of the position of invertebrate species in a food chain. Examples of food chains found in the Canadian boreal forest and likely to be found in the study area include invertebrate herbivores, invertebrate predators, and vertebrate predators in upland (Figure 4A-2) and riparian ecosystems (Figure 4A-1).

For the purposes of this document, coverage of terrestrial invertebrates will also include taxa that forage and breed above the surface of aquatic ecosystems, even though larval life forms may be aquatic. Terrestrial invertebrates include four **phyla**: **nematodes**, **annelids**, **molluscs**, and **arthropods** (Table 4A-1).

4.3.2.1 Nematodes

Terrestrial nematodes are tiny round worms that live freely in soil and as parasites in plants and animals. Nematodes eat bacteria, fungi, protozoans and other nematodes. Nematodes are important ecologically for their role as **consumers** (Malakhov 1994; Yeats 2007). This is especially true in terms of their function in nutrient cycling (Neher 2001). Although many nematodes are considered harmful to plants and animal hosts (*e.g.*, hare, white-tailed deer, wolves and red fox), some species have been recognized for their benefits as biological control agents against arthropod pests (Saunders 1973; Hajek *et al.* 2006; Yu *pers. comm*. 2008). Nematode assemblages that are likely to occur in the Canadian boreal forest, including the Regional Study Area are listed in Table 4A-2 (Cobb 1921; Mulvey 1963). All species of earthworms (annelids) found in the Regional Study Area are exotic species introduced from Europe (Gates 1982; Fox 2004; Römbke *et al.* 2006).

4.3.2.2 Annelids

Terrestrial annelids typically inhabit the upper 10 to 20 cm of **humic** soil, where they assist in decomposition and provide a food source to many species of birds and mammalian **invertivores** (shrews) found in the Regional Study Area (Werner 1990; McLean and Parkinson 1997, 2000). Earthworm species are known to occur in acidic soils of boreal forests in Canada and are likely present in the Regional Study Area (Table 4A-3; Römbke 2006; Tiunov *et al.* 2006).

4.3.2.3 Molluscs

Terrestrial molluscs in the Regional Study Area are represented by gastropods, namely small (2 mm to 2.5 cm) land snails and slugs (McKoy and Nudds 1997). Both slugs and snails require moist habitats and feed on living and dead plant material, fungi and animal remains (Martin and Sommer 2004; Hylander *et al.* 2005). Snails are prey for a wide variety of vertebrates and hosts for many invertebrates. While gastropod diversity and abundance is greatest in hardwood forests (Mozley 1937; Kralka 1986; Hylander *et al.* 2005), some species of snails prefer conifer forests (Kralka 1986; Table 4A-4). Molluscs generally prefer neutral pH soil conditions and are affected by disturbances such as erosion and flooding (Martin and Sommer 2004; Hylander *et al.* 2005).

4.3.2.4 Arthropoda

The phylum Arthropoda is the largest in the animal kingdom, comprising 84% of the known animal species, *e.g.*, spiders, centipedes, millipedes, isopods (pill bugs) and insects (Table 4A-5).

Ground-dwelling terrestrial arthropods are species that spend most of their time on the ground or in litter (*e.g.*, centipedes, isopods, beetles, grasshoppers, mites, ants, and some spiders). Important ecological functions provided by ground-dwelling terrestrial arthropods include decomposition of decaying plant and animal material, predation of pest species, and the role of prey for other animals. Evaluation of arthropods (namely ground beetles and spiders) as indicators of boreal forest health, disturbance and ecological function has been proposed and widely practiced (Duchesne and McAlpine 1993; Willet 2001; Marusik and Koponen 2002; Pearce and Venier 2005; Langor and Spence 2006). Species of terrestrial

spiders and beetles likely to occur in the Regional Study Area are described in Table 4A-5 and Table 4A-6.

4.3.2.5 Canopy-dwelling Terrestrial Arthropods

Canopy-dwelling terrestrial arthropods that occur in the boreal forests of Canada, including the Regional Study Area include butterflies, wasps, bees, flies, arboreal ants, and arboreal spiders (Table 4A-7 and Table 4A-8). Important ecological functions provided by canopy-dwelling terrestrial arthropods include pollination of flowering plants, predation of pest species, and as prey for invertebrate and vertebrate predators (*e.g.*, canopy-foraging birds, bats and predatory flying insects; Whitaker *et al.* 2000).

Most terrestrial invertebrate species that forage and spend a majority of their time in the air above muskeg, rivers, and/or streams have aquatic larval life stages (Table 4A-9). The edges between forested and riparian areas can be focal points for birds and bats foraging for insects that fly in relatively close proximity to waterbodies (van den Driessche 1999; Whitaker *et al.* 2000; Mosley *et al.* 2005). Edges often contain a higher diversity of organisms including species that inhabit wetland and forest communities, as well as those adapted to live in margins between the two areas (Gates and Griffen 1991; Harper and Macdonald 2001). Riparian-associated invertebrates (*e.g.*, dragonflies, mosquitoes, damselflies, stoneflies, midges, mayflies, and some spiders) forage on a diversity of food resources in wetlands and adjacent forested environments. They are an important prey for vertebrate predators (*e.g.*, birds) that forage along forest edges and play an important role in plant pollination and production of large volumes of flying insects available as prey for neotropical migrant birds.

4.3.3 Current Trends

Habitat requirements of boreal terrestrial invertebrates are complex, involving availability of myriad forested and wetland habitats. Often terrestrial invertebrate species have an aquatic life phase making hydrological resources and characteristics important. Availability and characteristics of important terrestrial and aquatic resources may include access to fresh clean water, seasonal hydrologic flows, and composition and structure of plant communities. Changes in resource availability as well as fluctuations in predator population levels or influx of native and non-native competitors may have profound impacts on boreal invertebrate communities.

The boreal forest currently provides habitat required for thriving populations of terrestrial invertebrates. The quality of this habitat can be affected by habitat loss, degradation and **fragmentation**. Encroachment of human activity into natural areas may involve draining wetlands or deforestation, thereby reducing habitat size and quality. Road construction often results in habitat fragmentation, separating breeding areas from foraging areas and forcing wildlife to cross roads during certain periods of their lifecycles. Increased traffic and habitat fragmentation are expected to increase the likelihood of traffic-related mortalities.

To date, no forestry activities or expansion of road networks are planned for the Keeyask area and large-scale expansion of human habitation in the study area is unlikely. Therefore, terrestrial invertebrate habitat loss, degradation or fragmentation is likely to be minimal. If the Project does not proceed and no appreciable changes in present levels of human activity occur in the Nelson River region, habitat quality

and availability in the Keeyask Regional Study Area are expected to change in association with natural forest community succession or forest fires.

Although it is likely that some terrestrial invertebrate species are used opportunistically for bait or other purposes, it remains unknown whether terrestrial invertebrates are currently harvested by Tataskweyak Cree Nation (TCN), War Lake First Nation (WLFN), Fox Lake Cree Nation (FLCN) or York Factory First Nation (YFFN) Members. Unless unforeseen circumstances arise, it is assumed that local and traditional terrestrial invertebrate use levels will not substantially change in the foreseeable future, independent of Project development.

4.4 RARE/PRIORITY ORGANISMS

4.4.1 Species Potentially Occurring in the Region

None of the terrestrial invertebrate species currently listed under Schedule 1 of SARA and/or MESA (Appendix 4A, Table 4.4-1) are recognized as having the potential to occur in northern Manitoba, including the Regional Study Area (Firlotte *pers. comm.* 2010). Scientists acknowledge that data coverage of these species is evolving and descriptions of species' distributions may change as new information becomes available.

None of the terrestrial invertebrates listed as candidate species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) have distributions within or habitat requirements satisfied by the boreal forest vegetation communities present in the Regional Study Area. Continued documentation of Traditional and local knowledge, and incidental observations of terrestrial invertebrates is necessary to augment and maintain an understanding of invertebrate population fluctuations or changes in invertebrate communities throughout the course of the Project development and operation.

4.4.2 Historical Records of Rare/Priority

There are no historical records of rare terrestrial invertebrates inhabiting the Regional Study Area.

4.4.3 Current Locations of Rare/Priority

There are no known occurrences of rare terrestrial invertebrates inhabiting the Regional Study Area.

4.5 VALUED ECOSYSTEM COMPONENTS

None of the terrestrial invertebrate species or groups inhabiting the Regional Study Area have been identified as VECs.

4.6 PROJECT EFFECTS, MITIGATION AND MONITORING

4.6.1 Construction

Terrestrial invertebrate (*e.g.*, slugs, beetles, spiders) habitat covers almost the entire Local Study Area and is found within the soils, ground cover, understory and canopy of the various habitat types. Since the larval stages of some terrestrial invertebrates require aquatic environments, the entire Regional Study Area is considered as habitat for terrestrial invertebrates. Therefore, approximately 31% of terrestrial invertebrate habitat within the Local Study Area could be lost or altered if the project proceeds.

4.6.1.1 Habitat Changes

During construction, land-clearing activities associated with reservoir, generating station, access road and other infrastructure development could result in the direct loss and/or degradation of terrestrial invertebrate habitats. The majority of habitat affected by land clearing is black spruce treed on shallow peatland, black spruce treed on uplands and young regeneration on shallow peatland (Section 2.4.2.1, Table 2-3). These coarse habitat types provide suitable habitat for species of nematodes and annelids tolerant of acidic soil/organic material conditions, as well as spiders, dragonflies, butterflies and other flying invertebrate species associated with peat bogs, fens and saturated soil conditions. The removal of forest and woodland is expected to result in a lower abundance and diversity of terrestrial invertebrates due to changing the habitat and microclimate by altering air and soil temperatures, soil density, humidity, and wind speed. Forest clearing is also expected to remove or degrade terrestrial invertebrate overwintering and foraging habitat associated with leaf litter, course woody debris, and shrubs. To minimize disturbance to invertebrate communities, vegetation clearing should occur during the winter, when snow cover would provide a protective cover to soil and frozen soils might minimize ground compaction by equipment.

In areas where construction activities occur adjacent to waterways, some terrestrial invertebrate larval stages may be at risk to habitat degradation if disturbed sediments enter aquatic environments. Road construction may also disrupt flow of intermittent waterways that are not preserved through the placement of culverts, rolling ditches or other stream-crossing mitigation measures, but are suitable habitat for terrestrial invertebrate species requiring intermittent streams for nutrients or life-stage development.

In some instances, construction activity may create habitat for terrestrial invertebrates. It is anticipated that the south access road development may lead to the creation of 'artificial' ponds and/or shallow pools of standing or slow-flowing water in roadside ditches. This may provide habitat for some invertebrate species such as damselflies, beetles and mosquitoes. It is also likely that saturated soils associated with roadside ditches would provide habitat for butterflies, moths and other terrestrial invertebrates that glean nutrients from minerals available in wet soil.

Land clearing and subsequent loss and degradation of terrestrial invertebrate during construction is anticipated to be a small, short-term and reversible effect that is within the range of natural variability and limited to the Local Study Area.

4.6.1.2 Project-Related Disturbances and Access Effects

Traffic associated with construction may cause mortality for some terrestrial invertebrates. Mortality may be increased if construction traffic occurs at the same time as mating swarms or seasonal irruptive emergence of the adult life stage of a particular species (*e.g.*, spring and summer).

Pollution from road runoff that carries sediment can also have an adverse effect on terrestrial invertebrate populations (Rosenberg and Wiens 1978; Rabeni *et al.* 2005). Traffic on forest roads and associated sediment loads to adjacent land has been linked to reduction in invertebrate abundance, diversity and alterations in community characteristics (Rabeni *et al.* 2005; Sheridan and Noske 2007). The effect of road traffic on terrestrial invertebrates is generally anticipated to be limited to within the areas of the access roads.

The potential for spillage or leaks of petroleum products (*e.g.*, gasoline, diesel and heating oil) is associated with all phases of construction (*e.g.*, access road clearing and construction, development of the GS site, *etc.*). Spills or leaks have the potential to contaminate waterbodies and soils in areas where terrestrial invertebrates forage, breed, travel and overwinter (Vuori *et al.* 1998; Rabeni *et al.* 2005; Khan and Colbo 2008). While the effect of such events occurring in terrestrial habitat upon invertebrates would generally be low in magnitude and site specific, these effects have the potential to be larger if spills and leaks of hazardous materials enter a waterbody that supports larval invertebrate populations.

4.6.1.3 Mitigation

Mitigation measures to minimize degradation/loss of terrestrial invertebrate habitat will include the following:

- Mitigation for wetland function is being implemented through the development of wetlands in the Local Study Area (Section 6.5.3.4). Some of these wetland developments may provide habitat for terrestrial invertebrates;
- Roads will be watered appropriately to minimize road dust;
- Silt fences and/or vegetated buffers of shrubs and/or trees will be retained in areas where streams or waterbodies occur within or adjacent to construction sites; and,
- Proper containment and storage of fuels away from waterbodies and other potentially sensitive sites will be carried out.

4.6.1.4 Residual Effects of Construction

The **residual effect** of construction on terrestrial invertebrates is primarily associated with the alteration of habitat through land clearing, site preparation and construction activities. The residual effects of Project construction on terrestrial invertebrates are expected to be within the range of natural variability

for most species within the Regional Study Area. This is primarily related to the large invertebrate populations, their high reproductive capacities and the lack of any unique or critical habitat identified in the Regional Study Area.

4.6.2 Operation

4.6.2.1 Habitat Changes

Filling of the reservoir would result in the loss of terrestrial invertebrates and other invertebrate habitats. Over time, peatland disintegration following reservoir filling would result in the continued loss of terrestrial invertebrate communities utilizing peat habitats. Changes or losses to terrestrial invertebrate communities associated with peatlands are anticipated to be of low magnitude, as invertebrate assemblages associated with these habitat types will continue to occur in similar areas throughout the Regional Study Area.

Flooding and changes to groundwater levels associated with Project operation may result in the establishment of new wetland areas inland from the reservoir. Creation of wetlands or pooled areas of water would provide suitable habitat for some terrestrial invertebrate larval stages.

4.6.2.2 Project-Related Disturbances and Access Effects

Potential adverse effects on invertebrate adults and larval habitat are similar to those described for the construction phase (Section 4.6.1.2). Since traffic levels on access roads will be greater during the operation phase, higher levels of terrestrial invertebrate mortality is expected. Road dust, vehicle emissions, and vehicle-related mortality is expected to have a small, localised effect on terrestrial invertebrates utilizing the north and south access road ROWs.

4.6.2.3 Mitigation

The following mitigation measure will be implemented to minimize degradation of terrestrial invertebrate habitat:

- Roads will be watered appropriately to minimize road dust.

4.6.2.4 Residual Effects of Operation

There is a large population of terrestrial invertebrates and a lack of unique terrestrial invertebrate habitat within the Regional Study Area. Residual impacts to terrestrial invertebrate populations resulting from operation activities are expected to be within the range of natural variability for most species within the Regional Study Area and primarily associated with the long-term loss of habitat located within the reservoir footprint and adjacent shoreline areas. Over the long term, invertebrate communities could incur an additional loss of about 7 km^2 of potential shoreline habitat due to peatland disintegration. As the reservoir water levels stabilize, wetlands may be formed in peatland areas that support higher water tables. This may lead to the establishment of some terrestrial invertebrate habitat, as many invertebrate species require wetlands or ponds during their early life stages.

Traffic associated with the operation of the access roads could lead to some vehicle-related invertebrate mortality however; the effect of traffic mortality on the local terrestrial invertebrate population is anticipated to be minimal.

4.6.3 Cumulative Effects

Cumulative effects on terrestrial invertebrates are assessed based on expected Project-related effects in combination with impacts of existing and reasonably foreseeable future projects or activities within the Keeyask region.

The cumulative effects to terrestrial invertebrate species and communities are primarily associated with habitat loss, habitat fragmentation, and traffic along access roads. Given the abundance of terrestrial invertebrate habitat within the Regional Study Area and incremental loss associated with future infrastructure development, it is anticipated that adverse cumulative effects to terrestrial invertebrates in the Regional Study Area would be minimal.

4.6.4 Environmental Monitoring and Follow-up

No environmental monitoring is planned for terrestrial invertebrates.

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APPENDIX 4A
TABLES AND FIGURES

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4.7 APPENDIX 4A: TABLES AND FIGURES

Table 4A-1: Terrestrial Invertebrate Overview: Phyla, Class and Order of Terrestrial Invertebrates

Phylum	Class	Order	Common Name	Ecological Significance
Nematoda			Round worms, thread worms (some), whip worms, lung worms, hook worms, eel worms	Predators, decomposers, parasites
Annelida			Leeches, earthworms	Decomposers, parasites
Mollusca			Slugs, land snails	Scavengers, decomposers, predators
Arthropoda	Malacostraca	Isopoda	Isopods, pillbugs, woodlice	Decomposers
	Arachnida		Mites, ticks, spiders, scorpions	Parasites, predators
	Chilopoda		Centipedes	Predators
	Diplopoda		Millipedes	Decomposers, herbivores
	Entognatha	Collembola	Springtails	Decomposers, herbivores
	Insecta	Coleoptera	Beetles	Scavengers, predators, herbivores
		Dermaptera	Earwigs	Omnivores, decomposers
		Diptera	Mosquitoes, gnats, midges	Parasites, nectivores
		Hymenoptera	Wasps, ants, bees, sawflies	Predators, nectivores, herbivores
		Lepidoptera	Butterflies, moths	Nectivores

Table 4A-1: Terrestrial Invertebrate Overview: Phyla, Class and Order of Terrestrial Invertebrates

Phylum	Class	Order	Common Name	Ecological Significance
		Orthoptera	Grasshoppers, crickets, katydids, locusts	Herbivores
		Thysanura	Bristletails, silverfish	Decomposers, herbivores

Source: BIOSIS Zoological Record 2007

Table 4A-2: Nematode genera Likely to Occur in Boreal Forest of Northern Canada

Genus	No. Species
Plant-Parasitic Nematodes	
Anguina	1
Ditylenchus	1
Suspected Plant-Parasitic Nematodes	
Ditylenchus	4
Tylenchus	4
Tylenchorhynchus	2
Criconemoides	1
Helicotylenchus	1
Psilenchus	2
Aphelenchoides	3
Hexatylus	1
Neotylenchus	1
Soil-Inhabiting Nematodes	
Dorylaimus	2
Eudorylaimus	5
Ethmolaimus	1
Achromadora	1
Cylindrolaimus	1
Tylencholaimus	1
Wilsonema	1
Monhystrella	1
Cryptonchus	1
Prismatolaimus	1
Alaimus	1
Acrobeles	3
Chiloplacus	3
Teratocephalus	1
Euteratocephalus	1
Punctodora	1
Tripyla	1
Plectus	2
Predaceous Nematodes	
Mononchus	2
Prionchulus	3

Source: Cobb 1921; Mulvey 1963

Table 4A-3: Annelid Species Likely to Occur in Boreal Forests of Northern Canada

Family	Species	Habitat Preferences	Distribution in Northern Canada
Lumbrididae	Aporrectodae calignosa	Boreal forests; tolerance for acidic soils	Widespread and abundant
	Denfobaena octaedra	Boreal forests; tolerance for acidic soils	Widespread and of medium abundance
	Denfobaena rubidus	Boreal forests, prefers low pH soils	Widespread but rare, with northernmost population at southern edge of Hudson Bay
Enchytraeidae	*Cognettia glandulosa*	Boreal forests; tolerance for acidic soils; prefers moist soils and freshwater sediments	Widespread and fairly common, seldom dominant in northern sites
	Cognettia sphagnetorum.	Boreal forests; tolerance for acidic soils; inhabits upper litter layers	Widespread and abundant
	Enchytraeus norvegicus	Boreal forests, prefers acidic soils	Unknown

Source: Römbke *et al.* 2006

Table 4A-4: Terrestrial Gastropods of Manitoba with Distributions in Boreal and Alpine Communities

Family	Species	Location in Manitoba
Slugs		
Agriolimacidae	*Agriolimax laeve*	Generally more southerly distribution, moist areas, widespread but low in abundance
Agriolimacidae	*Agriolimax reticulatus*	Generally more southerly distribution, evidence of northward expansion
Snails		
Ellobiidae	*Carychium exiguum*	Widespread and abundant in treed muskegs and moist, calcareous meadows
Cionellidae	*Cochlicopa lubrica*	Northern distribution in less disturbed areas, found among spruce, aspen, willow, wild rose
Discidae	*Discus whitneyi*	Widespread in forested and non-forested areas in leaf litter
Euconulidae	*Euconulus fulvus*	Widespread in conifer and deciduous forests, open sites and disturbed ground
Euconulidae	*Euconulus polygyratus*	Found mostly in mesic litter in upland areas
Pupillidae	*Gastrocopta contracta*	Widespread and common in northern forested areas
Daudebardiidae	*Nesovitrea binneyana*	Widspread throughout the north, inhabits mixedwoods, found more frequently than N. electrina
Daudebardiidae	*Nesovitrea electrina*	Widespread throughout the north
Zonitidae	*Novisuccinea ovalis*	Northern distributions in boreal communities
Zonitidae	*Striatura exigua*	Northern distribution, common and abundant in black spruce wetlands
Strobilopsidae	*Strobilops affinis*	Rare and scattered, prefers permanently damp but well-drained calcareous areas
Vitrinidae	*Vallonia pulchella*	Widespread from prairies to alpine latitudes in open or lightly wooded areas that are often seasonally dry
Vertiginidae	*Vertigo modesta*	Northern distribution in dry to mesic forests and alpine areas among dwarf willow
Gastrodontidae	*Zonitoides arboreus*	Widepread and common throughout northern distribution, in dry and moist spruce, pine or mixedwood forests
Valloniidae	*Zoogenetes harpa*	Northern distribution in hardwoods through frequently mixed with spruce, mesic to dry sites

Source: Howe and Findlay 1972; Beetle 1960; Christy1885; Mozley 1926

Table 4A-5: Manitoban Spider Species Likely to Occur in the Keeyask Regional Study Area

Species Name	Location Code*	Distribution and Habitat Preference
Species Selected by Location Code		
Metaphidippus flavipedes	A3, A4, EI, G3, H2, **H4**	Nearctic. Boreal. Coniferous woods, bogs. Coniferous foliage †
Metaphidippus montanus	**H4**	Nearctic. Boreal. Coniferous Woods. Coniferous foliage †
Misumenta vatia	A2-4, B3, B4, EI, E2, FI, H2, **H4**	Holarctic. Trees. shrubs, herbs. Flowers.
Pardosa fuscula	AI-4, B2, B3, CI, C2, E2, I4, J4, K2, K3	Nearctic. Bogs, swamps, beaches, sloughs. Litter. under stones, grass.
Pardosa groenlandica	A2-4, B2, C2, D1, D2, E1, H2, **H4**, I5, J4	Holarctic. Pebbly beaches, roadsides, fields, river banks. On gravel, ground debris.
Pardosa hyperborea	A4, B4, C2, C4, F1, H1, H2, **H4**, J4	Holarctic. Boreal. Bogs, coniferous woods. Leaf litter
Pardosa uintana	A3, C2, H1, H2, **H4**, J4	Nearctic. Boreal. Bogs, meadows. On ground debris.
Pardosa xerampelina	A2-4, B1-4, C4, EI, FI, F2, HI, H2,I4, K3	Nearctic. Boreal forest, aspen parkland. Deciduous and coniferous woods, river banks, bogs,
Wabasso questio	I5	Holarctic. Boreal. Boreal forest. Shrubs †
Walckenaeria pallida	A2, A3, H3, C2, C3	Nearctic. Boreal forest, aspen parkland. Deciduous woods, mixed woods. Deciduous leaf litter
Xysticus triangulosus	EI, **H4**, J4	Nearctic. Boreoalpine. Coniferous woods. Coniferous foliage †
Xysticus triguttatus	E1, **H4**, J4	Nearctic. Prairies, fields. Grass, shrub foliage †
Species Selected by Distribution		
Agelenopsis utahana	A3, B3, B4, CI, C4, DI, FI, H2	Nearctic. Boreal forest, aspen parkland. Mixed woods, bogs, jack pine ridges. Webs on ground
Ceratinopsis labradorensis	H2	Nearctic. Boreal. Bogs
Cnephalocotes obscurus	H2, J4	Holarctic. Boreal forest. Bogs. Coniferous leaf litter
Cybaeopsis euoplus	A1, C4, D1, H2	Nearctic. Boreal. Boreal forest. Bogs
Dictyna brevitarsus	A2-4, B3, D3, F3, F4, H2	Nearctic. Boreal. Boreal forest. Bogs

Table 4A-5: Manitoban Spider Species Likely to Occur in the Keeyask Regional Study Area

Species Name	Location Code*	Distribution and Habitat Preference
Diplocentria rectangulata	B2, H2	Holarctic. Boreal. Bogs.Coniferous leaf litter, moss
Dismodicus alticeps	A2-4, B2, B3, CI, DI, D3, H2	Nearctic. Boreal forest. Bogs, mixed woods. Coniferous leaf litter
Grammonota angusta	A2-4, BI-3, CI, C4, E1, F4, H2	Nearctic. Boreal. Bogs. Coniferous foliage †
Microlinyphia pusilla	J4	Holarctic. Boreal. Moist ground
Nuctenea cornuta	A2-4, B1-3, D2, E1, F1, H2, J4	Holarctic. Marshes, meadows, fields, bogs, mixed woods. Tree and shrub foliage, tall grass †
Nuctenea patagiata	A2-4, B2, B3, C1, C4, D2, D3, E1, F1, F3, G2, G3, H2, K2, J4	Holarctic. Tree trunks, bridges, buildings
Oxyopes scalaris	A2, A4	Nearctic. Bogs. Under larch trees
Pardosa furcifera	H2, I4, J4	Nearctic. Subarctic. Bogs
Pardosa fuscula	AI-4, B2, B3, CI, C2, E2. I4, J4, K2, K3	Nearctic. Bogs, swamps, beaches, sloughs. Litter. under stones, grass
Pardosa mackenziana	A4, BI-4, C1, C4, FI, HI, H2, K3	Nearctic. Boreal. Boreal forest. Bogs, coniferous woods, deciduous woods. Ground litter.
Philodromus placidus	A3, A4, BI-3, C2, D3, EI, G3	Nearctic. Coniferous woods. Coniferous foliage †
Pityohyphantes limitaneus	B3, D3, E1, E4, F3, G2, G3, **H4**	Nearctic. Boreal. Boreal forest. Coniferous foliage †
Pocadicnemis americana	A3, C4, E2, H2	Nearctic. Mixed woods, bogs. Leaf litter, moss, lake shore debris
Sitticus palustris	AI, A3, A4, B2, J4	Nearctic. Boreal. Mixed woods, bogs, meadows. Deciduous tree foliage †
Wabasso questio	I5	Holarctic. Boreal. Boreal forest. Shrubs
Zelotes fratris	AI-4, B2, CI, C2, C4, E1, H2, J4	Holarctic. Boreal forest, aspen parkland. Mixed woods, meadows, bogs, river banks. Litter, grass

Source: USGS 2007
* See Figure 6-1 map of Manitoba for location code; bold codes overlay Project Area
† denotes canopy-dwelling species – all others are ground-dwelling species
H4 represents the Project Area in the Province of Manitoba

Table 4A-6: List of Ground Beetle Species (Family Carabidae) Likely to Occur in Boreal Forest in Manitoba

Species Name	Boreal Shield Microhabitat	Foraging Strategy
Agonum gratiosum	Forest openings	Carnivorous
Agonum placidum	Grassy forest openings	Carnivorous
Agonum retractum	Forest with lush understorey	Carnivorous
Bembidion grapei	Open ground	Carnivorous
Calathus advena	Forest generalist	Unknown
Calathus ingratus	Forest generalist	Carnivorous
Calosoma calidum	Grassy openings	Carnivorous, caterpillars
Calosoma frigidum	Open woodlands	Carnivorous, arboreal
Carabus serratus	Sparse vegetation, gravel	Carnivorous
Carabus taedatus	Widespread	Carnivorous
Cymindis cribricollis	Forests with dry sandy soils	Omnivorous
Harpalus fulvilabris	Grassy openings	Herbivorous
Harpalus pleuriticus	Grassy openings	Herbivorous
Loricera pilicornis	Moist areas	Carnivorous
Notiophilus intermedius	Forest floor	Carnivorous, small arthropods
Patrobus foveocollis	Generalist, shady leaf litter	Carnivorous
Platynus decentis	Spruce forests, dense ground cover	Omnivorous
Platynus mannerheimii	Older forests	Carnivorous
Pterostichus adstrictus	Wooded areas, habitat generalist	Carnivorous, ground insects
Pterostichus brevicornis	Forest generalist	Carnivorous
Pterostichus femoralis	Dry grassy openings	Carnivorous, ground insects
Pterostichus melanarius	Moist areas	Carnivorous, ground insects
Pterostichus mutus	Generalist, meadows	Carnivorous, ground insects
Pterostichus pensylvanicus	Hardwood, moss, gravelly	Carnivorous
Pterostichus punctatissima	Forest generalist	Carnivorous
Scaphinotus bilobus	Forest generalist	Carnivorous, snails
Sphaeroderus nitidicollis	Forest specialist	Carnivorous, snails
Sphaeroderus stenostomus	Mixed forest	Carnivorous, snails
Syntomus americanus	Sunny, sparse, low vegetation	Unknown
Synuchus impunctatus	Wooded areas and fields	Unknown
Trechus apicalis	Shaded shrubby areas	Carnivorous
Trechus rubens	Moist forested areas	Unknown

Source: Wytrykush 2001; Saint-Germain *et al.* 2005; Klimaszewski *et al.* 2005; Latty *et al.* 2006

Table 4A-7: Lepidoptera Detected in the Northern Boreal Forest in the Vicinity of the Keeyask Regional Study Area

Family	Scientific Name	Common Name	Habitat
Hesperioidea	*Erynnis Ipersius*	Persius Dusky Wing	Trails, roads through bogs, boreal forest edges and openings
Hesperioidea	*Erynnis lucilius*	Columbine Dusky Wing	Deciduous, mixed forests
Hesperioidea	*Hesperia comma manitoba*	Manitoba Skipper	Rocky outcrops in pine forests and openings, clearings in boreal forests
Hesperioidea	*Pyrgus centaureae*	Grizzled Skipper	Forest edges and opening
Lycaenidae	*Callophrys augustus*	Brown Elfin	Open pine woods, bogs, glades, forest edges and roads
Lycaenidae	*Callophrys eryphon*	Western Pine Elfin	Pine forest edges abd openings, forest meadows, spruce bogs
Lycaenidae	*Callophrys polios*	Hoary Elfin	Sandy pine woods, forest openings and edges, rocky outcrops w/bearberry
Lycaenidae	*Celastrina argiolus*	Spring Azure	Spruce forests in Gillam, open forests, brushy areas, glades, clearings, roadsides
Lycaenidae	*Everes amyntula*	Western Tailed Blue	Forest edges and clearings, meadows and roadsides
Lycaenidae	*Glaucopsyche lygdamus*	Silvery Blue	Open forest and edges, in brushy burned over areas, ditches, streams in open terrain
Lycaenidae	*Lycaeides idas*	Northern Blue	Open areas, roads, trails in boreal forests
Lycaenidae	*Lycaena dorcas*	Dorcas Copper	Black spruce, tamarack bogs and meadows w/cinquefoil shrubs, occ. roads
Lycaenidae	*Plebejus saepiolus*	Greenish Blue	Forest edges and clearings, meadows and roadsides, and disturbed areas w/clover

Table 4A-7: Lepidoptera Detected in the Northern Boreal Forest in the Vicinity of the Keeyask Regional Study Area

Family	Scientific Name	Common Name	Habitat
Lycaenidae	*Vacciniina optilete*	Yukon Blue	Wet areas beside roads and streams or near bogs where cranberries are found
Nymphalidae	*Boloria bellona*	Meadow Fritillary	Open jack pine stands, roads and trails, near wooded areas
Nymphalidae	*Boloria eunomia*	Bog Fritillary	Black spruce and tamarak bogs, usually in open areas or along edges
Nymphalidae	*Boloria freija*	Freija Fritillary	Willow bogs and open grassy areas in boreal forests
Nymphalidae	*Boloria frigga*	Frigga Fritillary	Boreal forest in wet sphagnum and willow bogs
Nymphalidae	*Boloria polaris*	Polaris Fritillary	Moist open tundra flats
Nymphalidae	*Boloria selene*	Silver Bordered Fritillary	Meadows, marsh areas, roadsides, willow bogs, usually in or near forests
Nymphalidae	*Boloria titania*	Purple Lesser Fritillary	Openings in spruce and tamarak bogs, wet willow bogs, meadows, roadsides
Nymphalidae	*Limenitis arthemis*	White Admiral	Deciduous forests, along trails, roads, forest openings
Nymphalidae	*Nymphalis antiopa*	Mourning Cloak	Forest openings, glades, stream banks
Nymphalidae	*Nymphalis milberti*	Milbert's Tortoiseshell	Forest glades and trails
Nymphalidae	*Nymphalis vau-album*	Compton's Tortoiseshell	Coniferous forests
Nymphalidae	*Phyciodes batesii*	Tawny Crescent	Wet areas in forest opening, meadows, trails and roadsides
Nymphalidae	*Phyciodes morpheus*	Northern Pearl Crescent	Forest openings, meadows, roadsides and stream banks
Nymphalidae	*Polygonia gracilis*	Hoary Comma	Forests, clearings, riverbanks
Nymphalidae	*Polygonia progne*	Gray Comma	Forests, especially deciduous, clearings, trails

Table 4A-7: Lepidoptera Detected in the Northern Boreal Forest in the Vicinity of the Keeyask Regional Study Area

Family	Scientific Name	Common Name	Habitat
Nymphalidae	*Polygonia satyrus*	Satyr Anglewing	Forest glades and edges, streams, disturbed areas
Nymphalidae	*Speyeria atlantis*	Atlantis Fritillary	Deciduous and coniferous forest openings, glades, moist meadows, streams uplands
Nymphalidae	*Vanessa cardui*	Painted Lady	Fields, meadows, open areas, towns, forests
Papilionoidea	*Papilio glaucus*	Tiger Swallowtail	Deciduous woods and coniferous forest edges, opening, meadows, river banks
Papilionoidea	*Papilio machaon*	Old World Swallowtail	Open pine woods and coniferous forest edges, roads, clearings, trails
Pieridae	*Colias gigantea*	Giant Sulpher	Moist, willow area including boreal forest
Pieridae	*Colias palaeno*	Palaeno Sulpher	Shrubby edges, bilberry and openings of spruce, tamarack forests
Pieridae	*Euchloe ausonides*	Creamy Marblewing	Open pine forests and openings and glades in mixed, boreal forests
Pieridae	*Pontia occidentalis*	Western Checkered White	Forest openings, grassy areas
Pieridae	*Pieris napi*	Veined White	Coniferous and mixed wood openings, trails, glades
Satyridae	*Coenonympha tullia*	Ringlet	Roadsides, dry meadows
Satyridae	*Erebia disa*	Disa Alpine	Moist black spruce sphagnum bogs, usually thick tree stands, occ. adj open sedge
Satyridae	*Erebia rossi*	Ross' Alpine	Wet, open scrub tundra at treeline
Satyridae	*Oeneis chryxus*	Chryxus Arctic	Open pine forests
Satyridae	*Oeneis jutta*	Jutta Arctic	Black spruce and tamarak bogs w/ moderate tree stands over labtea, leatherleaf, moss

Source: Klassen *et al.* 1989

Table 4A-8: A List of Terrestrial Dipteran Species Likely to Occur in Northern Manitoba Boreal Forest and the Keeyask Regional Study Area (family names in parentheses)

Robber Flies (Asilidae)		
Asilus sp.	*Laphria fumipennis*	*Laphria monticola*
Cyrtopogon bimacula	*Laphria gilva*	*Laphria posticata*
Cyrtopogon dasyllis	*Laphria huron*	*Laphria sacrator*
Cyrtopogon glarialis	*Laphria index*	*Laphria sadales*
Laphria columbica	*Laphria insignis*	*Lasiopogon aldrichii*
Laphria divisor	*Laphria janus*	*Neoitamus sp.*
Laphria flavicollis	*Laphria milvina*	*Rhadiurgus variabilis*
Hover Flies (Syrphidae)		
Blera sp.	*Cheilosia sp.*	*Sericomyia chrysotoxoides*
Brachyopa media	*Criorhina sp.*	*Sericomyia lata*
Brachyopa notata	*Eristalis barda*	*Sericomyia militaris*
Brachyopa perplexa	*Eristalis dimidiata*	*Sphegina campanulata*
Chalcosyrphus libo	*Eristalis tenax*	*Sphegina keeniana*
Chalcosyrphus nemorum	*Eristalis transversus*	*Spilomyia quadrifasciata*
Chalcosyrphus plesius	*Rhingia nasica*	*Xylota quadrimaculata*
Horse and Deer Flies (Tabanidae)		
Chrysops ater	*Chrysops lateralis*	*Hybomitra epistates*
Chrysops calvus	*Chrysops mitis*	*Hybomitra illota*
Chrysops carbonarius	*Chrysops niger*	*Hybomitra lasiophthalma*
Chrysops excitans	*Chrysops univittatus*	*Hybomitra trepida*
Chrysops frigidus	*Hybomitra arpadi*	-
Crane Flies (Tipulidae)		
Dolichopeza obscura	*Tipula platymera*	*Tipula trivittata*
Tipula angulata	*Tipula senega*	*Tipula sp.*
Tipula entomophthorae	*Tipula triplex*	-
Bot Flies (Oestridae)		
Cuterebra grisea	*Cuterebra fontinella*	*Cuterebra emasculator*
Bee Flies (Bombyliiidae)		
Anthrax sp.	*Bombylius major*	-

Source: University of Guelph 1998

Table 4A-9: Riparian Arthropods Expected to Occur within the Regional Study Area

Scientific Name	Habitat Preference
Order: Odonata (Dragonflies and Damselflies)	
Aeshna cyanea	Widespread throughout Canadian boreal forest
Aeshna eremita	Widespread throughout the Canadian boreal forest
Aeshna interrupta	Widespread throughout Canadian boreal forest
Aeshna juncea	Widespread throughout the Canadian boreal forest
Aeshna septentrionalis	Peatland obligate
Aeshna sitchensis	Boreal distribution, peatland obligate
Aeshna subarctica	Boreal distribution, peatland obligate
Aeshna tuberculifera	Peatland obligate
Aeshna umbrosa	Forest lakes and slow-moving streams
Calopteryx aequabilis	Widespread through northeastern Canada among rivers and large creeks
Cordulia shurtleffi	Widespread throughout the Canadian boreal forest
Lestes congener	Marshes and peatlands
Lestes disjunctus	Widespread throughout the Canadian boreal forest
Lestes dryas	Small potentially ephemeral ponds
Lestes forcipatus	Ponds and marshy lakes
Leucorrhinia borealis	Not found east of the Hudson Bay
Leucorrhinia hudsonica	Widespread throughout the Canadian boreal forest
Somatochlora albicincta	Widespread throughout the Canadian boreal forest
Somatochlora franklini	Widespread throughout the Canadian boreal forest
Somatochlora whitehousei	Widespread throughout the Canadian boreal forest
Sympetrum danae	Widespread throughout the Canadian boreal forest
Coenagrion resolutum	Widespread throughout the Canadian boreal forest
Coenagrion interrogatum	Northern boreal near northern treeline
Enallagma boreale	Widespread throughout Canadian boreal forest
Enallagma carunculatum	Lake shores
Enallagma cyathigerum	Widespread throughout the Canadian boreal forest
Enallagma ebrium	Lake shores, avoids peatlands and acidic conditions
Nehalennia irene	Sedge meadows and lakes bordered by sedges
Order: Plecoptera (Stoneflies)	
Acroneuria abnormis	Large warm streams and rivers
Acroneuria lycorias	Large cool water streams and rivers
Allocapnia pygmaea	Free flowing, small streams

Table 4A-9: Riparian Arthropods Expected to Occur within the Regional Study Area

Scientific Name	Habitat Preference
Capnia manitoba	Free flowing, small streams
Order: Ephemeroptera (Mayflies)	
Stenacron interpunctatum	Streams and rivers with substrate dominated by sand and silt
Heptagenia pulla.	Streams and rivers with substrate dominated by sand and silt
Stenonema vicarittm	Streams and rivers with substrate dominated by sand and silt
Nixe inconspicua	Streams and rivers with substrate dominated by sand and silt
Nixe lucidipennis	Streams and rivers with substrate dominated by sand and silt
Leucrocuta hebe	Streams and rivers with substrate dominated by sand and silt
Heptagenia pulla	Stream and river substrate dominated by bedrock, sand and silt
Stenonema vicarium	Stream and river substrate dominated by bedrock, sand and silt
Stenacron interpunctatum	Stream and river substrate dominated by bedrock, sand and silt
Hexagenia sp.	Lake-bottom-dwelling, burrowing larvae indicate high-quality boreal riparian systems
Order: Diptera (Mosquitoes, blackflies, midges)	
Pseudosmittia forcipata	Boreal fens and peatlands
Gymnometriocnemus acigus	Boreal fens and peatlands
Doithrix villosa	Boreal fens and peatlands
Pseudorthocladius destitutus	Boreal fens and peatlands
Pseudorthocladius curtistylus	High quality boreal streams
Paramerina smithae	Boreal fens and peatlands
Limnophyes minimus	Boreal fens and peatlands
Smittia nudipennis	High quality boreal streams, fens and peatlands
Simulium sp.	Boreal fens and peatlands
Einfeldia sp.	Boreal fens and peatlands
Tipula sp.	Boreal fens and peatlands

Source: Cannings and Cannings 1998; University of Guelph Insect Collection 1998; Whiting and Sheared 1990

Figure 4A-1: Role of Terrestrial Invertebrates in a Boreal Forest Riparian Ecosystem Food Chain

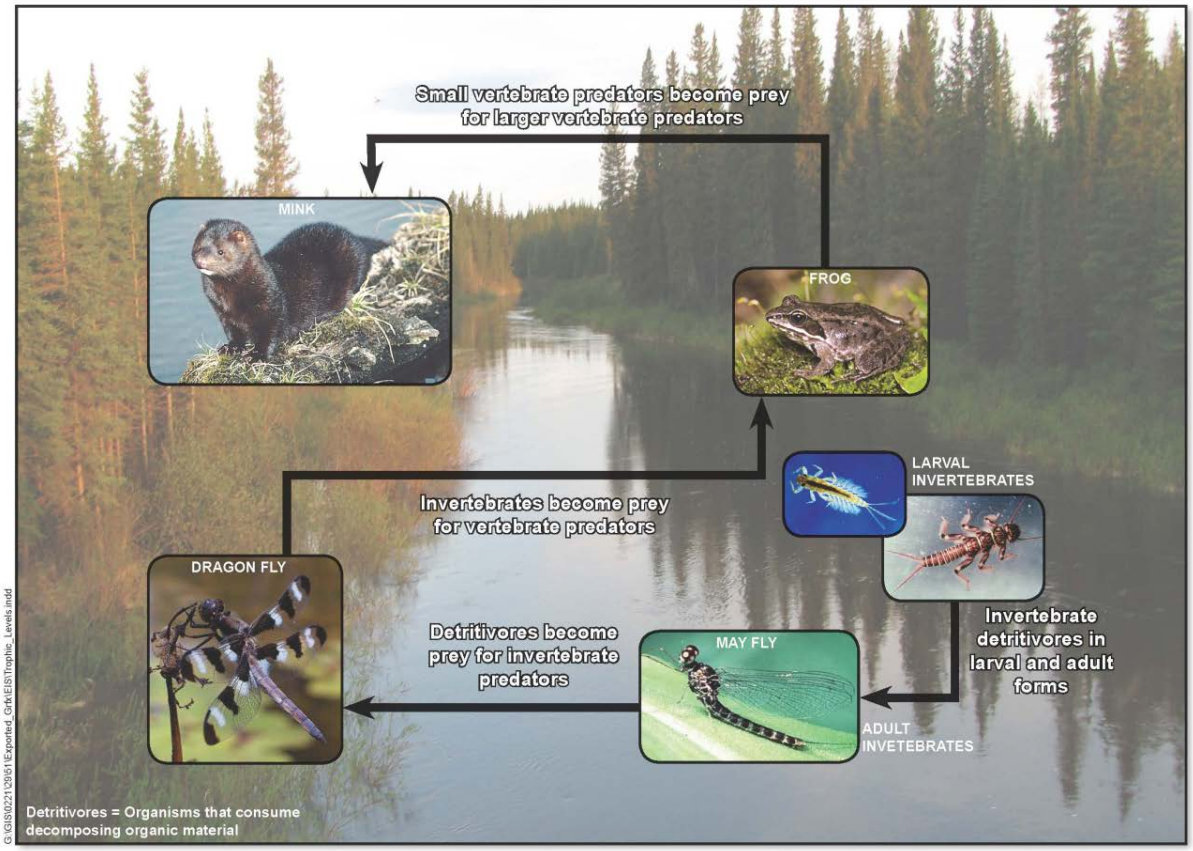

Figure 4A-2: Role of Terrestrial Invertebrates in a Boreal Forest Upland Ecosystem Food Chain