sequestration). Perfluorocarbons, hydrofluororcarbons, sulphur hexafluoride and nitrogen trifluoroide are not expected to be a significant source of emissions from this project (**Appendix A**; Dillon Consulting Limited 2017). Canada's GHG target for 2030 is 523 Mt of CO_2e, however modelled projections range from 697 to 790 Mt of CO_2e (Environment and Climate Change Canada 2017b).

6.1.1.4 Noise

Because the RAA is predominately undeveloped, with the exception of local communities and a few hunting lodges, noise is limited and restricted to local sources such as airplanes, vehicles on First Nation reserve roads, vehicular traffic along the winter road and snowmobile and ATV traffic on trails. Sustained sources of noise originate only from the communities of Manto Sipi Cree Nation, Bunibonibee Cree Nation, God's Lake First Nation and God's Lake Northern Affairs Community. While no ambient noise survey was conducted in the RAA, baseline ambient noise levels measured between April and June 2015 as part of the P4 Project ranged from 43.7 dB during the morning to 46.2 dB at night (overall average of 45.0 dB). Given that both the P4 and proposed Projects are situated in remote environments dominated by boreal forest interspersed with patches of bogs/fens and due to the absence of human settlement, development and industry in the region, these values would be representative of the RAA.

Few human receptors to noise are present, primarily only in the adjacent communities. There are no known residences or cabins in immediate proximity to the proposed all-season road alignment. Based on a mapping exercise done as part of the confidential Traditional Knowledge (TK) studies, the nearest cabin is approximately 400 m from the proposed all-season road alignment (HTFC Planning & Design 2017a). The nearest residences to the all-season road are approximately 250 m in Manto Sipi Cree Nation, 1.5 km in Bunibonibee Cree Nation and God's Lake First Nation and 3 km in God's Lake Narrows Northern Affairs Community. Project-related construction or operational noise would be well below levels which would affect human health given the distance between the all-season road and buildings in the communities. Noisy construction activities such as blasting are confined to daylight times (8 AM to 6 PM) by Manitoba Regulations (*The Mines and Minerals Act*) and within construction areas. More information regarding the low population density in the LAA and RAA is provided in **Section 6.1.12**.

6.1.1.5 Ambient Light Levels

The average day (light hours from sunrise to sunset) in June 2016 was 17 hours and 10 minutes long, with the longest day of the month lasting 17 hours and 16 minutes (Edwards 2017). The average day in December 2016 was 7 hours and 22 minutes long, with the shortest day of the month lasting 7 hours and 16 minutes (Edwards 2017). Along the proposed Project, outside of the communities of Manto Sipi Cree Nation, Bunibonibee Cree Nation, God's Lake First Nation and God's Lake Northern Affairs Community, there are no permanent light sources within the RAA and therefore no night-time light levels regardless of seasons and weather conditions.

6.1.2 Geology and Geochemistry

6.1.2.1 Bedrock and Surficial Geology

The bedrock geology in the vicinity of the proposed Project consists of Precambrian rock from the Archean era (Manitoba Growth, Enterprise and Trade 2017; Betcher *et al*. 1995). Bedrock geology belongs to the Superior Province and the Churchill/Superior Boundary Zone. In the Oxford Lake area, the lithotec consists of late metasedimentary and metavolcanic rocks (Oxford Lake Group, Island Lake Series, San Antonio formation). The unit consists of greywacke, conglomerate, arkose and arenite, as well as mafic and felsic fragmental volcanic rocks and porphyritic mafic to felsic flows (**Figure 6-4**). In the vicinity are late intrusive rocks of granodiorite, minor tonalite, migmatite and granite. In the God's Lake area, the lithotec dominantly consists of metamorphosed early intrusive rocks, gneisses and migmatites. Early metavolcanic and metasedimentary rocks (Rice Lake Group, Hayes River Group) occur at the north and south ends of the lake. The units consist of tonalite, minor granodiorite, granite, related gneiss, as well as basalt, minor andesite, minor sedimentary and mafic intrusive rocks, ultra mafic rocks and 7 differentiated ultramafic/mafic intrusions. Metamorphic supracrustal rocks with amphibolite also occur (Manitoba Growth, Enterprise and Trade 2017). Due to the limited geological information available in the area, cross-section maps are not available and therefore have not been provided.

The surficial geology of the area is characterized by discontinuous till deposits over bedrock outcrops, organic deposits and glaciolacustrine sediments (Smith *et al*. 1998). The general distribution of surficial geology in the LAA is illustrated in **Figure 6-5** (Manitoba Growth, Enterprise and Trade 2017). Till deposits are of silt diamicton, largely derived from Phanerozoic carbonate rocks from the Hudson Bay Lowland and are generally of low-relief. Organic deposits, in low-lying areas, are from less than 1 to 5 m thick and accumulate in fen, bog, swamp and marsh settings. In permafrost areas, patterned ground and peat palsas are common. The glaciolacustrine sediments are low relief, massive and laminated deposits of clay, silt and minor sand, deposited by deep water of glacial Lake Agassiz. Deposits were commonly scoured and homogenized by icebergs. Glaciofluvial sediments range from fine sand, minor gravel, thin silt and clay interbeds deposited as subaqueous outwash fans to sand and gravel complex deposits with esker ridges and kames. The bedrock outcrops are generally subglacially eroded and unweathered intrusive, metasedimentary and metavolcanic rocks with a glacially scoured irregular surface with high local relief. In areas of permafrost, frost shattered, angular boulder fields occur (Matile and Keller 2006).

Baseline concentrations of contaminants of concern within the local, regional and downstream environments and characterization of geochemical leaching potential of contaminants of concern from

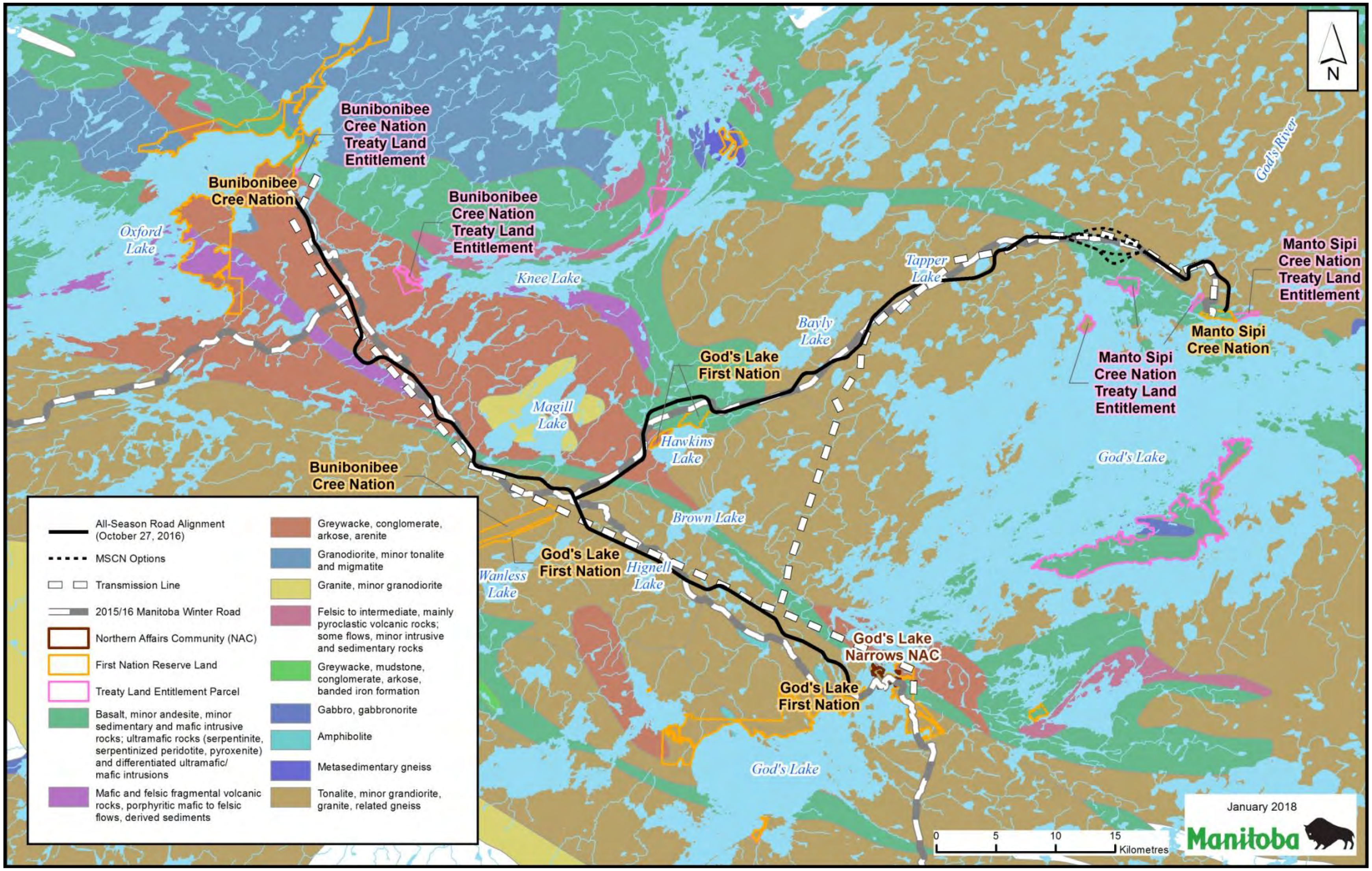


Figure 6-4: Bedrock geology in the vicinity of the proposed Project

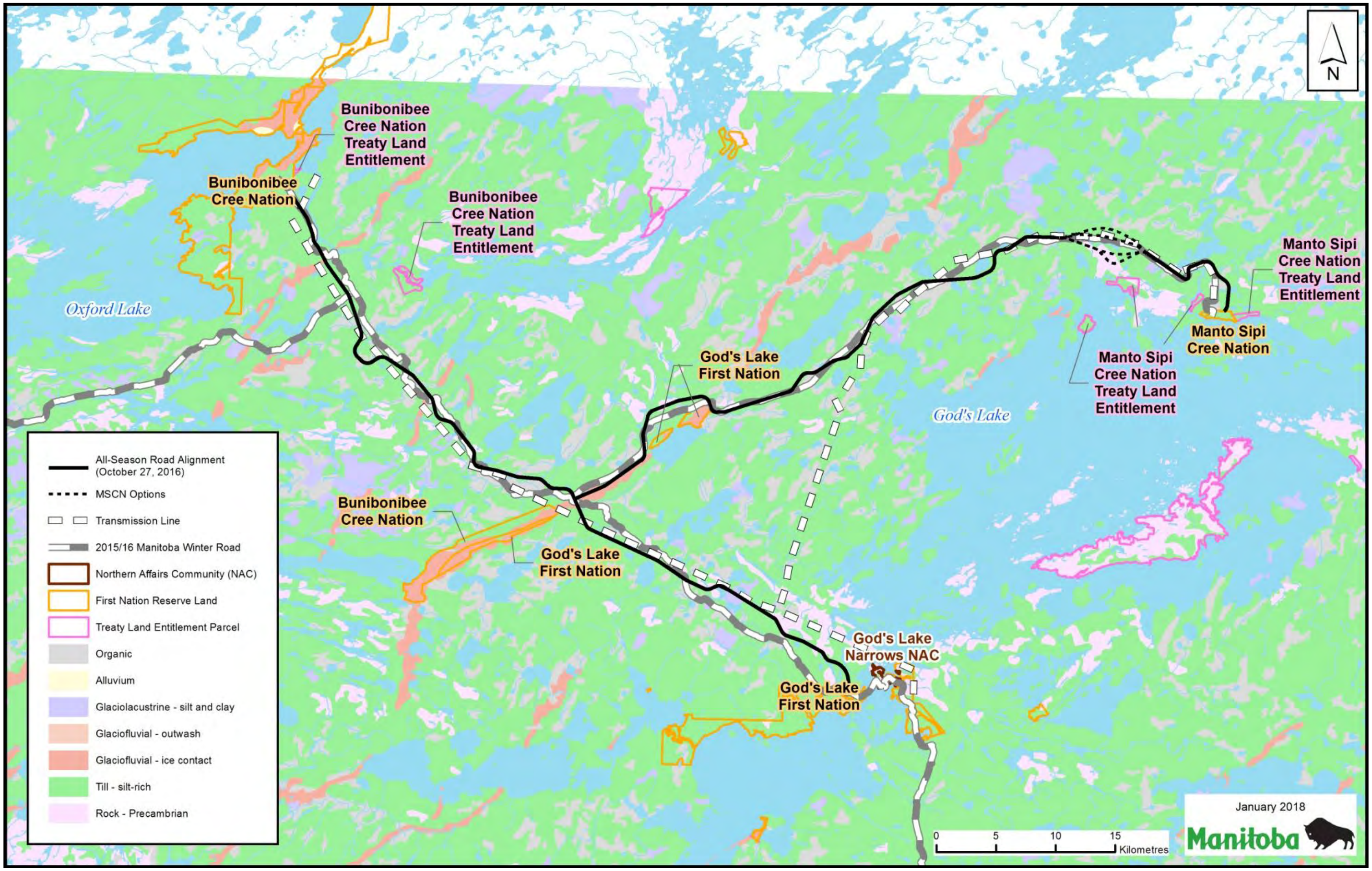


Figure 6-5: Surficial geology in the vicinity of the proposed Project

overburden and potential construction material were not collected as this is beyond the scope of the Environmental Assessment (EA). Given the nature of the all-season road, there is little to no likelihood of significant adverse effects due to acid rock generation resulting from the Project. An evaluation of the potential for local bedrock formations to generate acid drainage would be undertaken in the future during project design. This would be done by examining available geological and mineralogical data for the quarry areas such as records of known sulphide mineralization including pyrite lithologies. As part of the quarry site selection criteria, potential sites and construction materials would be assessed for presence of sulphide mineralization or pyritic lithologies as discussed in Environmental Protection Procedure (EP) EP20 (Quarry Site Selection Requirements) (**Chapter 8, Appendix 8-2**) using methods such as visual inspection for presence/absences and laboratory testing of bedrock samples. Rock with acid rock drainage potential would be avoided.

6.1.2.2 Mining and Quarry Activity

There are no mineral leases, patent mining claims, potash withdrawals, private quarry permits or quarry and surface leases in the vicinity of the proposed Project. There are however various mines, mining claims, quarry withdrawals, mineral exploration licences and casual quarry permits (annually-issued) (**Figure 6-6**). There are 8 mine sites within the Indigenous Land/Resource Use (Indigenous) RAA (**Section 6.1.9**) with the closest approximately 18.3 km from the all-season road alignment well outside the Indigenous LAA (**Section 6.1.9**). There are four and 103 mining claims within the Indigenous LAA and RAA, respectively, with the closest approximately 1 km from the alignment. There are eight quarry withdrawals and eight active casual quarry permits within the Indigenous LAA with a total of 14 and 9 of each, respectively within the Indigenous RAA. Four of the quarry withdrawals and five of the casual quarry permits overlap the proposed all-season road alignment. The location of potential rock quarries for construction of the all-season road are also shown in **Figure 6-6** and discussed in **Chapter 3, Section 3.3.5**.

6.1.2.3 Geological Hazards

6.1.2.3.1 Seismic Activity

While earthquakes occur in all Canadian regions, the relative hazard risk varies greatly. The RAA and the province of Manitoba as a whole, is in a region rated as the lowest hazard for earthquakes in Canada (Natural Resources Canada 2017b). There is less than a 1% chance that a strong earthquake will occur in the RAA within 50 years (Natural Resources Canada 2017b). No record of seismic activity in the project area could be found.

6.1.2.3.2 Isostatic Rebound

Isostatic rebound is the slow rise of land masses that were depressed by the weight of ice sheets during glaciation. A Canadian Base Network station at God's Lake Narrows shows that vertical isostatic rebound in the area is approximately 6 mm/year (Henton *et al*. 2006; Natural Resources Canada 2017a).

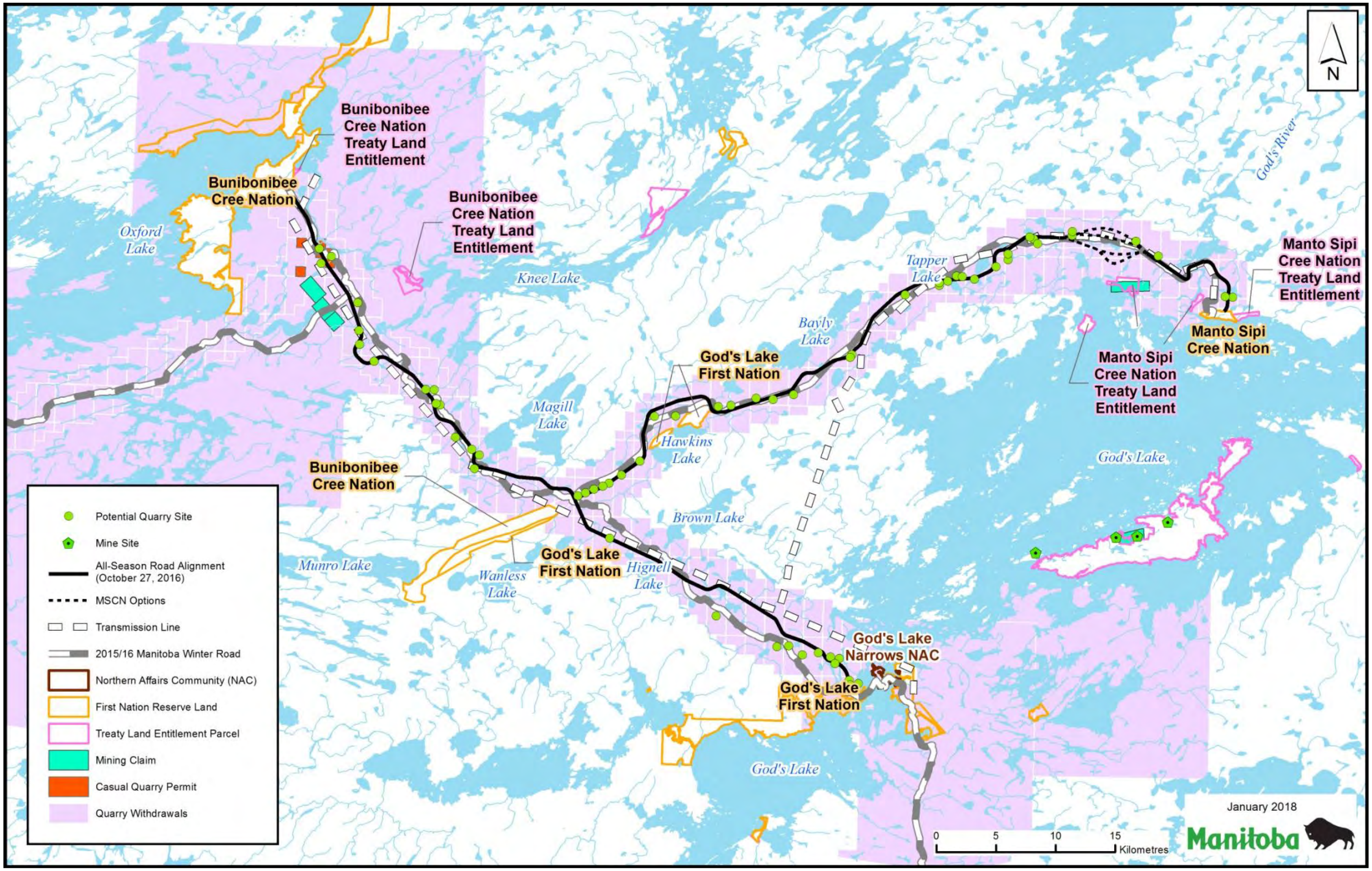


Figure 6-6: Quarry and mining activity in the vicinity of the proposed Project and potential construction quarry sites

6.1.2.3.3 Landslides, Slope Erosion and Ground Instability

Landslides can pose a risk to people and infrastructure by slope failures and the downward movement of rock and sediment. The topography of the LAA is relatively flat and there are no records of major landslides in the vicinity of the Project. Smaller scale slope erosion can occur along watercourses depending on sediment composition and water conditions. While the all-season road has 53 crossings, most are at well-vegetated bog/fen areas consisting of predominantly grasses and shrubs with little to no flow. Erosion mitigation is a standard construction best management practice (**Section 6.4.3**). Ground stability would be addressed as part of the geotechnical investigations to be completed in the future during detailed design to confirm the geotechnical characteristics along the all-season road alignment and of the construction materials.

6.1.3 Topography and Soil

6.1.3.1 Physiography

The Hayes River Upland Ecoregion is underlain by crystalline Archean massive rocks which form broad sloping uplands and lowlands. The area was strongly glaciated and is characterized by ridged to hummocky bedrock outcrops covered with discontinuous areas of acidic sandy till to the south and calcareous, sandy to loamy cobbly glacial till to the north. Local areas of ridged fluvioglacial deposits occur, with slopes ranging from 10 to 30 percent, with relief which can exceed 30 m (Smith *et al*. 1998).

The majority of the proposed all-season road alignment is within the God's Lake Ecodistrict (**Figure 6-7**). The ecodistrict is an undulating to hummocky morainal plain of calcareous, sandy to loamy till deposits. Clayey glaciolacustrine veneers and blankets occur throughout and are common on lower slopes and in depressions (Smith *et al*. 1998). The glaciolacustrine sediments are often covered by peat. Local areas of prominent kettled fluvioglacial deposits also occur. Elevations in the ecodistrict range from approximately 274 masl in the southwestern section to approximately 183 masl in the northeast. Slopes range from level in peat-filled depressions to about 10 to 15 percent along hummocky surfaces and to over 20 percent along some drumlin and bedrock slopes. Rocky hummocky highs and drumlins provide local relief that can stand 20 m above lakes and peat-filled depressions (Smith *et al*. 1998).

The north-east section of the Project near Manto Sipi Cree Nation is in the Knee Lake Ecodistrict (**Figure 6-7**), which is an undulating to ridged, loamy morainal plain that extends from God's Lake and Knee Lake in the south to Stephens Lake in the north. Elevations range from approximately 213 masl in the south to 150 masl in the north (Smith *et al*. 1998). Veneer bogs are common on gently sloping glaciolacustrine blankets and veneers and on lower slopes of drumlins. Peat bogs and fens occupy extensive areas and are generally underlain by clayey glaciolacustrine sediments. Local areas of prominent eskers consisting of kettled fluvioglacial deposits rise 20 to 30 m above the surrounding terrain. Slopes in this ecodistrict range from level in peat-filled depressions to about 10 to 30 percent on drumlin ridges (Smith *et al.* 1998).

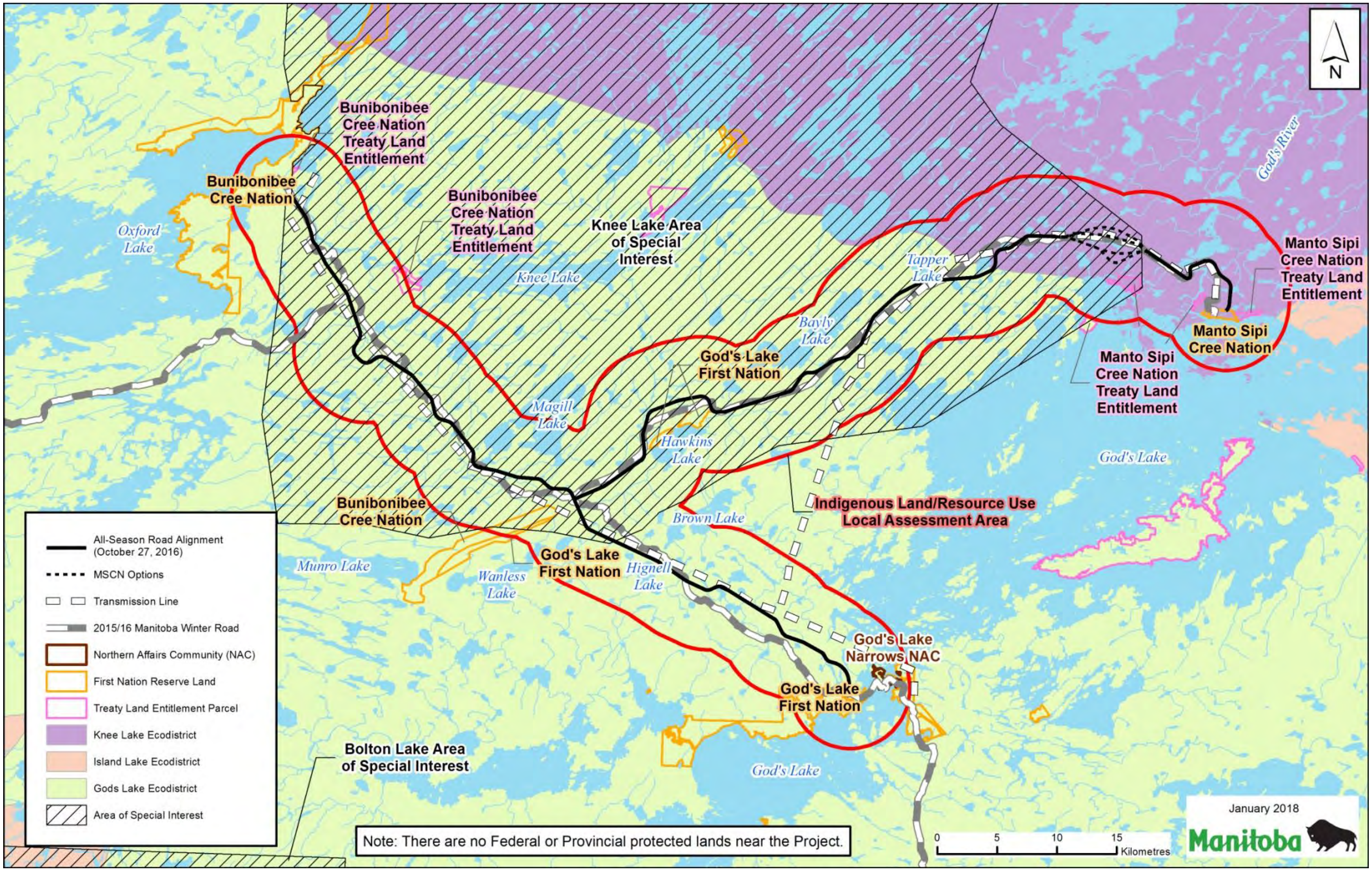


Figure 6-7: Ecodistricts and Areas of Special Interest in the vicinity of the proposed Project

6.1.3.2 Soils

Soils in the God's Lake Ecodistrict are well to imperfectly drained, mineral soils comprising eluviated eutric brunisols and grey luvisols, which can be found on upland clayey glaciolacustrine deposits. Peat-filled depressions form poorly drained bogs and fens. Soils within bogs consist of deep slightly decomposed sphagnum and feather moss peat (fibrosols), moderately decomposed moss and forest peat (mesisols) and areas of permafrost (organic cryosols). Deeper layers of peat are generally more decomposed than those closer to the surface. Clayey subsoils are found beneath most organic soils (Smith *et a*l. 1998). Organic cryosols are found in the northern section of the ecodistrict and in peatlands where permafrost is present.

The dominant soils in the Knee Lake Ecodistrict are organic soils including organic cryosols associated with widespread permafrost in peatlands such as veneer and peat plateau bogs. The non-frozen organic soils are deep and shallow fibrisols and mesisols, which are associated with veneer bogs (shallow), flat bogs and patterned fens (deep). Origin of the organic material is mainly woody, forest peat and sedge peat. Significant areas of mineral soils are imperfectly drained eluviated eutric brunisols on loamy to sandy calcareous till and sandy to gravelly fluvioglacial deposits. Areas of gray luvisols can be found on well to imperfectly drained clayey deposits. Soil profiles on clayey sediments often exhibit uneven horizon development, while the surface shows a pattern of low relic earth hummock. These features are evidence of the effect of past and present permafrost conditions on soil development.

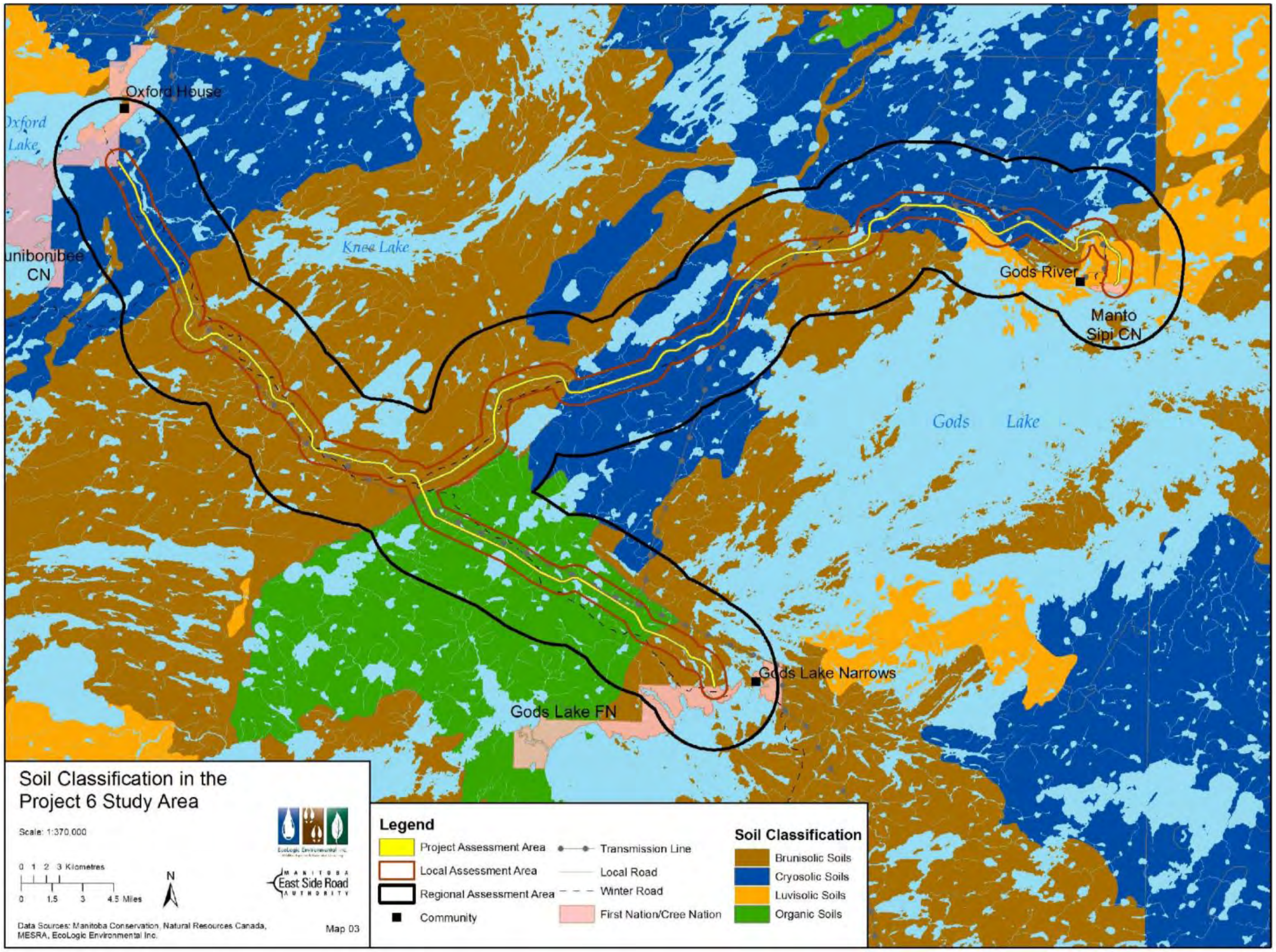
The area and percent cover of the main soil classification types within the Project Footprint and the vegetation assessment areas are provided in **Table 6.2**. The general distribution of soil types in the vicinity of the Project is shown in **Figure 6-8.**

Table 6.2: Area (km^2) and Percent Coverage of Soil Classes Among Assessment Areas

Soil Classification	Project Footprint		Local Assessment Area		Regional Assessment Area	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Brunisolic	13.6	48.2	135.2	47.6	695.8	48.6
Cryosolic	8.8	31.1	89.6	31.6	460.6	32.2
Organic	4.5	15.8	44.8	15.8	210.6	14.7
Luvisolic	1.4	4.8	14.4	5.1	58.3	4.1
Unclassified	-	-	-	-	5.3	0.4

Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017b

Soil surveys were conducted in association with vegetation surveys along the all-season road. Soil pits were dug at each sample location to record soil characteristics, horizons, depths and depth to bedrock. Soils horizons, structure and texture were classified according to the Canadian System of Soil Classification (Soil Classification Working Group 1998). Soil descriptions are grouped by the type of forest community in which they were located. Forested sites were classed into eleven forested



Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017a

Figure 6-8: Soil classification in the vicinity of the proposed Project (Vegetation LAA and RAA shown) vegetation community types using the Forest Ecosystem Classification for Manitoba (Zoladeski *et al*. 1995) based on the vegetation composition and structure and soils present at each site (see **Section 6.1.4.1.1** for more information). Additional details regarding soil survey locations and the distribution of forest communities are shown in **Appendix B-1, Section 3.2 and 4.1** (Szwaluk Environmental Consulting Ltd. *et al*. 2017a).

No maps depicting soil depth by horizon and soil order are available however a description of soil horizons is provided below. Areas that would be disturbed would have topsoil stripped and stockpiled for future reclamation and restoration. Soils would be adapted and amended if necessary to ensure it is suitable for rehabilitation of disturbed areas. Geotechnical investigations would be completed in the future, as part of detailed design, to provide additional information such as soil depth by horizon, soil order, soil suitability for reclamation and rehabilitation, site specific permafrost conditions and the potential for thaw settlement and terrain instabilities.

6.1.3.2.1 Soils within Forest Community Types

Aspen Hardwood, V5 (1 soil pit) - An eluviated dystric brunisol was classified at the one site within this forest community type. The soil was characterized as having a humus form thickness of 5 cm. Soil horizons consisted of an Ahe (3 cm), sandy clay Bt (16 cm), loamy sand Bm horizon (22 cm) followed by a sandy clay C horizon (22 cm). Bedrock was encountered at a depth of 62 cm.

Trembling Aspen Mixedwood/Tall Shrub, V8 (2 soil pits) - The soils associated with this vegetation type were classified as orthic gray brown luvisols. Humus form thickness ranged from 6 to 10 cm. The soils were characterized as having an Ah horizon (2 to 3 cm), an Ae horizon (2 cm) and a silty clay to clay loam Bt horizon (17 to 23 cm). The silty clay loam/silty clay C horizons were encountered at a depth ranging from 22 to 25 cm and thickness ranged from 74 to 92 cm.

Trembling Aspen Mixedwood/Low Shrub, V9 (1 soil pit) - The soil at this site was an orthic gray brown luvisol. Humus form thickness was 8 cm and soil horizons included an Ae of 5 cm, a silty clay loam Bt of 29 cm and a clay loam C horizon 56+ cm.

Black spruce Mixedwood/Feathermoss, V18 (2 soil pits) - Soils at these sites were classified as an eluviated eutric brunisol and an orthic gray brown luvisol. The eluviated eutric brunisol had a humus form thicknesses of 6 cm followed by Ah (2 cm) and Ae (3 cm) horizons. Under the A horizon, occurred a sandy loam Bm horizon 20 cm thick, followed by a loamy sand C horizon. Bedrock was encountered at a depth of 55 cm. The orthic gray brown luvisol was characterized as having a humus form that was 6 cm thick, followed by an Ah horizon, 2 cm thick. A clay Bt horizon underlies the A horizons and is 30 cm thick. The sandy clay C horizon was encountered at 32 cm and was 67 cm thick. Bedrock was found below the C horizon.

Jack pine/Feathermoss, V25 (1 soil pit) - The soil at this site was classified as an eluviated eutric brunisol with a humus form 5 cm thick followed by an Ah horizon (3 cm), loamy sand Ae horizon (14 cm) and loamy sand Bm horizon (33 cm thick). The loamy sand C horizon occured at 50 cm and was 30+ cm thick.

Jack pine- Black spruce/Lichen, V26 (2 soil pits) - Soils that were classified for these sites include an eluviated dystric brunisol and orthic eutric brunisol. The humus form thickness ranged from 2 to 5 cm. The humus layer was underlain by either a thin Ah horizon (1 cm) or sandy Bm horizon (12 to 15 cm thick cm), followed by a sandy to silty clay C horizon ranging from 18 to 90+ cm in thickness. At one site bedrock was encountered at 25 cm deep in the soil profile.

Black spruce/Shrub- and herb-poor, V27 (1 soil pit) - The soil found at this site was classified as an orthic eutric brunisol. Soil horizons consisted of an Of horizon (14 cm thick) followed by an Ah horizon (5 cm thick) then a sandy loam Bm horizon (73 cm thick). Rock and coarse fragments were encountered at a depth of 78 cm and seepage was also observed at this depth.

Jack pine- Black spruce/Feathermoss, V28 (1 soil pit) - The soil associated with this vegetation type was an eluviated eutric brunisol. The site had a humus form thickness of 5 cm. The soil was characterized with an Ah horizon (2 cm) followed by an Ae (2 cm) horizon. Following horizons included a silty clay loam Bt horizon of 20 cm, loamy sand Bm horizon of 21 cm, a silty clay loam C1 horizon (25 cm) and a sandy C2 horizon approximately 40+ cm thick.

Black spruce/Feathermoss, V29 (4 soil pits) - Orthic gray brown luvisols were classified at these sites. These soils had a humus form thickness of 5 cm. The uppermost soil horizons were identified as being Ah, Ae or Ahe horizons with thickness ranging from 2 to 9 cm. These horizons were followed by a clay loam, silty clay or silty clay loam Bt horizon ranging from 26 to 40 cm, followed by a sandy clay, clay, silty clay or clay loam C horizon. Seasonal ice was encountered in the C horizon at two of the field sites.

Black spruce/Labrador tea/Feathermoss Sphagnum, V30 (3 soil pits) - Three different soils were classified for this vegetation type, a humic luvic gleysol, rego humic gleysol and rego gleysol. The humic luvic gleysol had a humus form thickness of 17 cm that was underlain by an Ah horizon (30 cm thick), silty clay Btg horizon (30 cm), then a sandy clay C horizon (40+ cm thick). Water seepage was evident in the soil pit and seasonal ice was present near to the soil pit. The rego humic gleysol had an Of horizon 15 cm thick followed by an Om horizon 8 cm thick. Soil horizons included an Ah (12 cm) and sandy loam Cg horizon (27 cm thick) that had evidence of mottling. Bedrock was encountered at 62 cm depth. The site with the rego gleysol had an Of horizon (10 cm thick), followed by an Om horizon (15 cm thick), then an Oh horizon (8 cm thick). The organic layers were underlain by an Ah horizon approximately 2 cm thick followed by a Cg horizon 55+ cm thick with evidence of gleying. Seasonal ice was found within the soil profile.

Black spruce/Herb poor/Sphagnum, V32 (8 soil pits) - The organic soils encountered included terric humisols, terric mesic humisols, terric humic fibrisol and humic mesisol. The terric humisols were classified as having an Oh horizon of 45 cm or an Of horizon (10 cm thick) followed by an Om horizon (10 cm thick) then an Oh horizon (22 cm thick). The sandy clay and clay C horizons were encountered at a depth ranging from 42 to 80 cm. The terric mesic humisols encountered at some sites were classified as having an Of ranging from 10 to 230 cm thick, Om horizon (30 to 35 cm thick) and an Oh horizon ranging from 22 to 40 cm thick. The clay C horizon was encountered at a depth of 80 cm. Seasonal ice was also present in the terric mesic humisols. Terric humic fibrisol and mesic humisol were identified at one site each. The terric humic fibrosol was characterized by an Of horizon (20 cm thick), followed by an Om horizon (10 cm thick) and an Oh horizon (20 cm thick). The clay C horizon was encountered at 70 cm and seasonal ice was present in the soil profile. The mesic humisol was comprised of an Of horizon, 9 cm thick, followed by an Om horizon, (88 cm thick), then an Oh horizon approximately 123 cm thick. The clay C horizon was reached at a depth of 220 cm.

In addition to the organic soils characterized above, two field sites sampled, had soil profiles comprised of organic material but were unable to be classified to the great group as a result of the presence of seasonal ice which hindered soil augering.

6.1.3.2.2 Soils within Wetland Community Types

Treed Bog, V33 (6 soil pits) - A terric fibrisol, humic mesisol, terric mesic humisol and terric humic fibrisols were the organic soils characterized at the treed bog sites. In addition to these soils, another organic soil was encountered, that was not able to be classified due to seasonal ice prohibiting augering past 38 cm in depth. The terric fibrisol had an Of horizon (65 cm), Om horizon (10 cm) and an Oh horizon (10 cm) underlain by a clay Cg horizon (29+ cm). Seasonal ice was present at a depth of 29 cm. The humic mesisol was characterized as having a 26 cm Of horizon, followed by 74 cm Om horizon, then a 120+ cm Oh horizon. Seasonal ice was encountered at a depth of 26 cm. The terric mesic humisol encountered at one of the treed bog sites was identified as having an Of horizon (32 cm), Om horizon (26 cm) and an Oh horizon (35+ cm), with the organic horizons underlain by an Ah horizon (21 cm) followed by a C horizon (6+ cm). Seasonal ice was encountered at a depth of 18 cm in the soil profile. The terric humic fibrisols were identified as having Of horizons ranging from 20 to 57 cm, followed by 5 to 8 cm Om horizons, then Oh horizons of 18 to 20 cm. An Ah horizon (8 cm) underlaid the organic horizons at one of the sites. At both sites, the terric humic fibrisols had 20+ cm thick clay to clay loam C horizons. Seasonal ice was found at depths ranging from 28 to 40 cm.

Treed Poor Fen (1 soil pit) - A mesic humisol was classified at this site and was characterized as having an Of horizon (10 cm), Om horizon (75 cm) and an Oh horizon (85 cm). Seasonal ice was noted on a plateau near the site.

Shrub Rich Fen (1 soil pit) - The soil classified at this site was a rego gleysol which was characterized as having organic surface horizons comprised of an Of horizon (10 cm), followed by an Om horizon (15 cm), then a thin Oh horizon (approximately 8 cm). Underlying the organic horizons, was a clay C horizon with evidence of gleying. Seasonal ice was also present at this site at a depth of approximately 25 cm.

Graminoid Rich Fen (2 soil pits) - Soils found at the graminoid rich fens sites included a humic fibrisol and a typic humisol. The humic fibrisol identified had an Of horizon (90 cm), underlain by an Om (30 cm) then an Oh (100+ cm) horizon. The typic humisol was characterized as having a Of horizon (10 cm), followed by an Om horizon (35 cm) which was underlain by an Oh horizon (185+ cm). Seasonal ice was encountered in the soil pit at a depth of 15 cm.

Graminoid Poor Fen (2 soil pits) - Soils found at the graminoid poor fens sites included a humic mesisol and a soil that was likely organic but could not be identified further as a result of the presence of seasonal ice that hindered augering at a depth of 30 cm. The humic mesisol was characterized as having an Of (40 cm), followed by an Om (70 cm), then an Oh (100+ cm) horizon. Seasonal ice was encountered at a depth of 20 cm in the soil profile.

6.1.3.3 Permafrost and Thaw Settlement

The RAA is within an area which consists of sporadic discontinuous permafrost (10% to 50%) and low (less than 10%) ground ice content in the upper 10 to 20 m of the ground (Heginbottom *et al*. 1995). Permafrost in the Hayes River Upland Ecoregion is most widespread in peatlands and poorly drained clayey soils. Permafrost in mineral soils is only found in the northern half of the ecoregion (Smith *et al*. 1998). It has been predicted that climate change may result in the complete thawing of discontinuous permafrost (University of Manitoba Transport Institute 2003).

In regions of discontinuous permafrost, thawing may produce thickening of the active layer, settlement and terrain instability (Batenipour 2012). As previously noted, further geotechnical investigations would be completed as part of detailed design of the road to identify areas, degree (ice content) and the extent (depth) of permafrost along the proposed alignment. The road through these areas would be designed to minimize the disturbance to the subgrade soils/peat moss to protect the frozen soils from permafrost degradation. It is important that proper drainage of the road alignment is achieved to avoid ponding water which act as a “heat sink” and accelerate the thawing process. Appropriate construction strategies would be implemented to minimize the potential for ground thawing such as removing the layer of permafrost (if shallow), limiting the removal of peat moss from the subgrade and timing of construction (building permafrost affected areas in winter). The proper design and mitigation measures are dependent on the degree and extent of the permafrost in each area identified. If following construction there are areas that thaw and settle these would be addressed with road maintenance.

6.1.4 Riparian, Wetland and Terrestrial Environments

6.1.4.1 Vegetation

Field and desktop studies were conducted to characterize the vegetation species present in the LAA and the existing plant communities at the regional level (**Appendix B-1 and B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a; b). For the assessment of vegetation related effects the Vegetation LAA considers the area within a 2 km corridor centred on the all-season road alignment, while the Vegetation RAA is the area beyond the LAA within a 10 km corridor centred on the all-season road alignment **(Figures 6-1** and **6-2)**.

The vegetation characterization included a description of the Ecological Land Classification, physical environment (including the influence of fire and fire history for the region), landscape level vegetation, local flora and Indigenous traditional knowledge (**Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a).

A list of plant species expected to occur within the Vegetation RAA was compiled from available data sources including provincial data, herbarium records, regional flora and existing literature (**Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). This preliminary flora list contains all species that have been previously collected or recorded in the region, including 241 vascular species from 60 families, which occur in terrestrial, wetland and aquatic habitats. The full list of species is provided in the Botanical and Vegetation Resource Survey Field Report (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017b).

6.1.4.1.1 Landscape Level Vegetation

Vegetation in the Hayes River Upland Ecoregion consists primarily of black spruce on both upland and organic sites. Canopies are more open and of medium height compared to areas further south. Forest fire has replaced some upland spruce with jack pine, often the dominant species on regenerating sites, while trembling aspen occurs occasionally. Mixed stands of white spruce, balsam fir, trembling aspen and balsam poplar are generally restricted to favorable sites along lakes and rivers. Areas of rocky outcrops favour jack pine, with an understory of ericaceous shrubs, herbs, mosses and lichens. Low growing black spruce with open canopies grow in bogs, along with ericaceous shrubs, sphagnum and other mosses. Tamarack occurs in fens and is mixed with black spruce in transitional peatlands (Smith *et al*. 1998).

Vegetation classes within the Project Footprint Area, Vegetation LAA and Vegetation RAA, as derived from the Land Cover Classification, consist predominantly of coniferous forest, with abundant wetland areas and smaller areas of deciduous forest, mixedwood and tall (**Figure 6-9**; **Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). The area and proportion of land cover classes among the vegetation assessment areas are summarized in **Table 6.3**.

Forested sites were further classed into eleven forested vegetation community types, using the Forest Ecosystem Classification for Manitoba (Zoladeski *et al*. 1995) based on the vegetation composition and structure and soils present at each site (**Photos 6-1 to 6-11**; sourced from **Appendix B-1**, Szwaluk Environmental Consulting Ltd. *et al.* 2017a). Site locations, vegetation community classification, species compositions, soil type and site surface information are provided in the Botanical and Vegetation Resource Survey Field Report (**Appendix B-1**, **Section 4.1.1**; Szwaluk Environmental Consulting Ltd *et al*. 2017a).

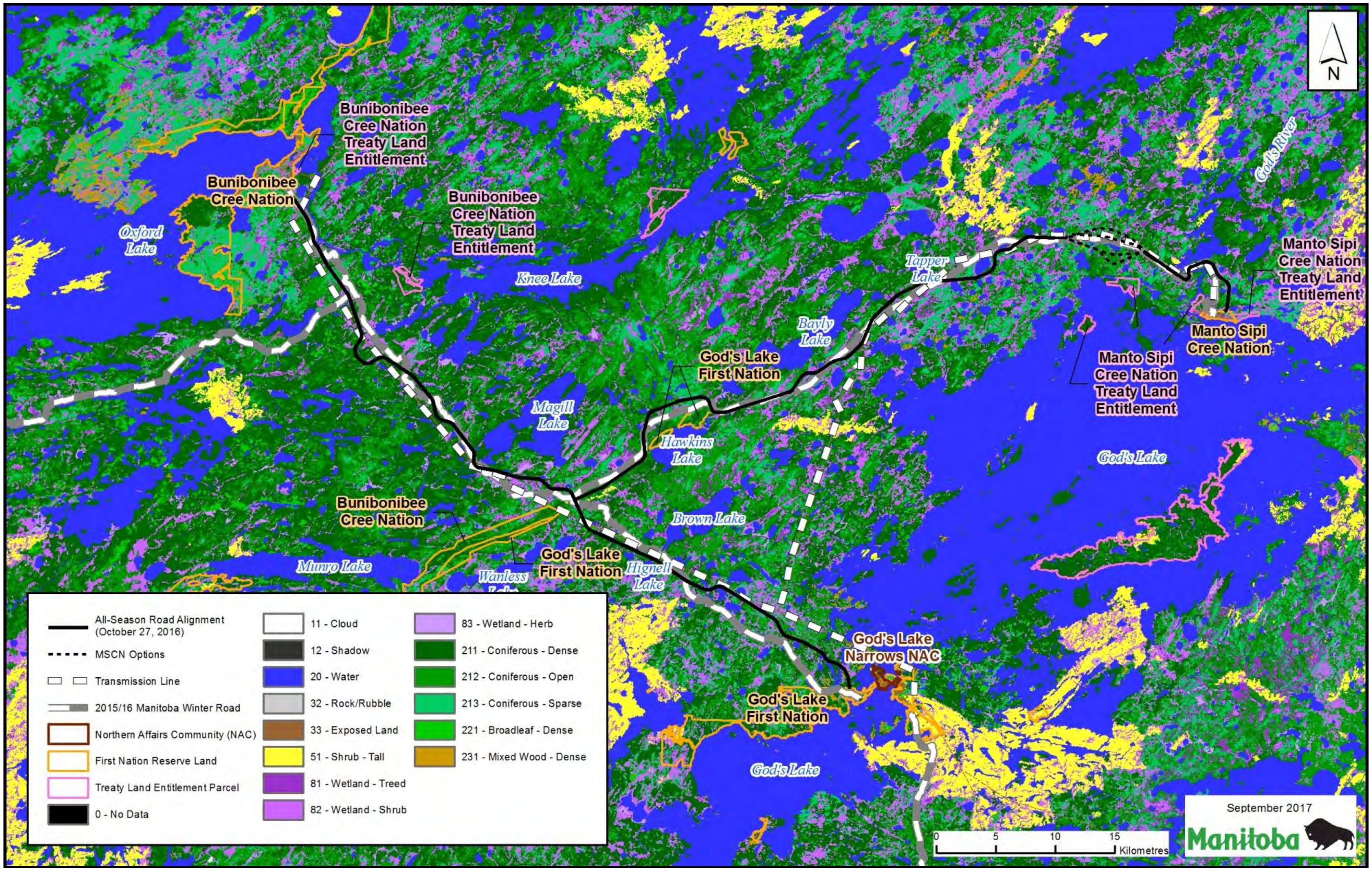


Figure 6-9: Land cover in the vicinity of the proposed Project

Table 6.3: Vegetation Cover Classes among Vegetation Assessment Areas

Land Cover Classification	Project Footprint		Local Assessment Area		Regional Assessment Area	
	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)	Area (km^2)	Proportion (%)
Water	0.2	0.6	25.3	8.9	283.9	19.8
Exposed land	0.7	2.5	7.3	2.6	16.9	1.2
Shrub tall	-	-	0.8	0.3	23.0	1.6
Wetland treed	0.4	1.3	5.4	1.9	24.9	1.7
Wetland shrub	3.0	10.6	46.2	16.3	193.5	13.5
Wetland herb	0.2	0.5	2.8	1.0	12.1	0.8
Coniferous dense	10.7	38.1	82.6	29.1	382.4	26.7
Coniferous open	9.0	31.8	81.8	28.8	351.4	24.6
Coniferous sparse	3.6	12.9	29.4	10.4	126.1	8.8
Broadleaf dense	0.4	1.2	1.7	0.6	9.2	0.6
Mixedwood dense	<0.1	0.2	0.4	0.1	6.8	0.5
Unclassified	0.1	0.3	0.2	0.1	0.4	<0.1

Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017b

Photograph 6-1: Aspen Hardwood (V5)

Photograph 6-2: Trembling aspen mixedwood/tall shrub (V8)

Photograph 6-3: Trembling aspen mixedwood/low shrub (V9)

Photograph 6-4: Black spruce mixedwood/feathermoss (V18)

Photograph 6-5: Jack pine/ feathermoss (V25)

Photograph 6-6: Jack pine- black spruce/lichen (V26)

Photograph 6-7: Black spruce/shrub- and herb- poor (V27)

Photograph 6-8: Jack pine- black spruce/ feathermoss (V28)

Photograph 6-9: Black spruce/ feathermoss (V29)

Photograph 6-10: Black spruce/ Labrador tea/feathermoss (Sphagnum) (V30)

Photograph 6-11: Black Spruce/herb poor/Sphagnum (feathermoss) (V32)

6.1.4.1.2 Forest Fire History

The fire history of the area suggests that some of these forests are very mature stands. Notably in four black spruce stands, the largest trees were aged at over 100 years, (101 to 156 years). Other species were also long lived; five stands had either jack pine, trembling aspen or tamarack aged at over 90 years (91 to 97 years). The oldest tree measured was 165 years, from a treed bog wetland (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al*. 2017b). The provincial fire history data available for the region dates back to the 1940s. The history of fire distribution by decade is shown in **Figure 6-10** and the estimated area and percent of land within the Project Footprint, Vegetation LAA and Vegetation RAA is summarized in **Table 6.4**.

Table 6.4: Land Burned by Forest Fire among Vegetation Assessment Areas.

Fires by Decade	Project Footprint		Local Assessment Area		Regional Assessment Area	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
1940 to 1949	0.6	2.2	5.2	1.8	8.3	0.6
1950 to 1959	4.8	17.2	42.7	15.0	181.1	12.7
1960 to 1969	0.4	1.6	2.5	0.9	15.0	1.0
1970 to 1979	0.6	2.0	3.2	1.1	18.5	1.3
1980 to 1989	<0.001	<0.01	0.4	0.2	11.7	0.8
1990 to 1999	0.4	1.6	3.8	1.3	54.8	3.8
2000 to 2009	-	-	0.1	<0.1	2.2	0.2
2010 to 2014	-	-	<0.01	<0.01	0.2	<0.1

Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017b

The greatest fire activity in this area occurred during the 1950s, with 12.7% of the land within the RAA cumulatively burned between 1950 and 1959. During the same time period, cumulative fire activity appears slightly more concentrated in the LAA (15.0%) and Project Footprint (17.2%). From the 1960s to the present, comparatively less fire activity has been documented, with fires affecting between 0 to 2% of the land base in the Project Footprint, LAA and RAA. An exception is the slight rise in fire activity to

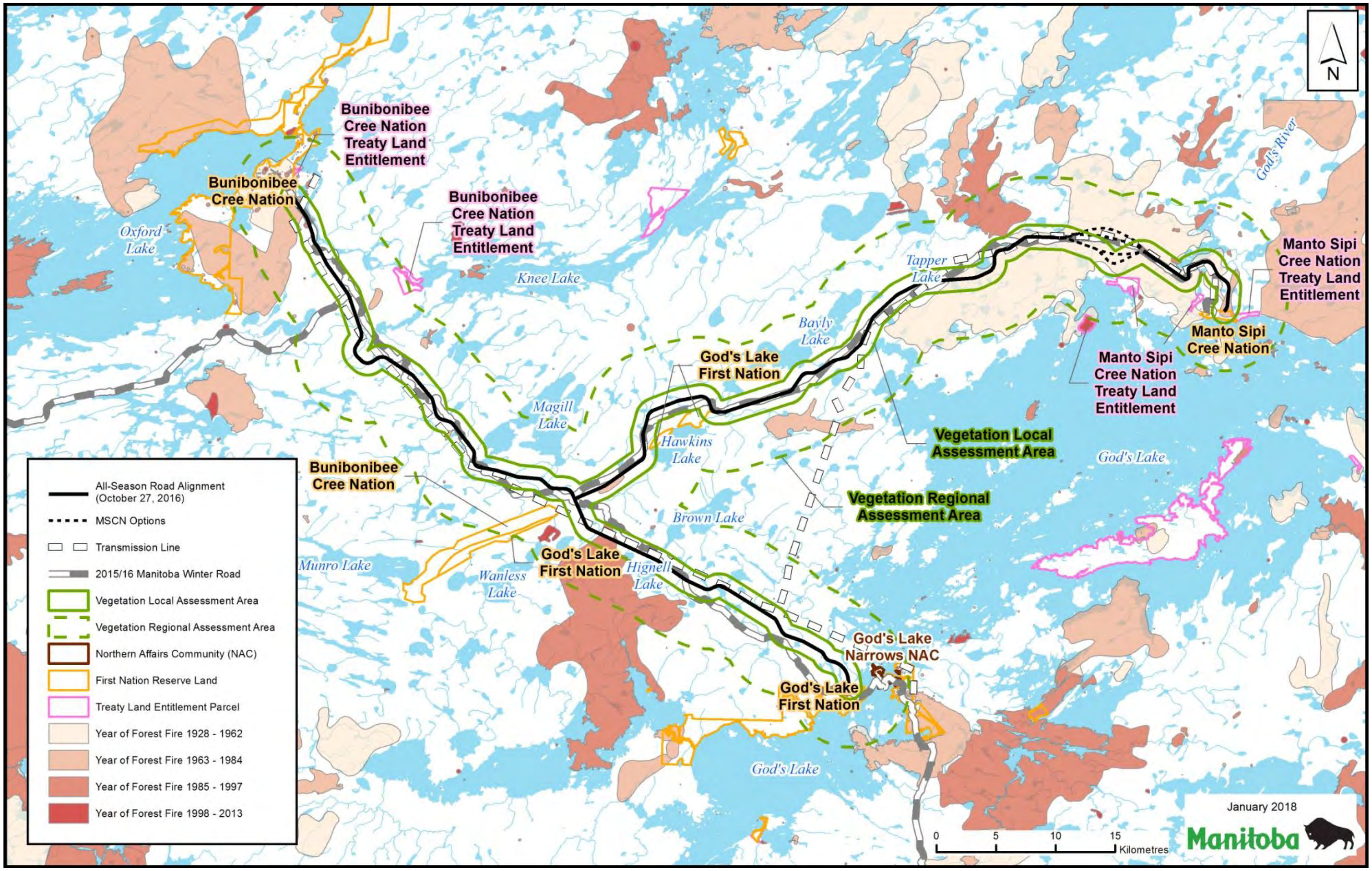


Figure 6-10: Fire history in the vicinity of the proposed Project

3.8% seen at the regional scale during the 1990s. Although after the year 2000, there is a marked reduction in fire activity across the Project Footprint, LAA and RAA, according to available information.

6.1.4.1.3 Summary of Field Investigations

Vegetation surveys were conducted within the Vegetation LAA where most direct environmental effects are likely to occur. Fieldwork was conducted to record information on the local flora, describe vegetation types and forest conditions, search for species at risk, document culturally important species and classify soils (**Appendix B-2**; Szwaluk Environmental Consulting Ltd *et al*. 2017b).

Thirty-eight forested and wetland sites were sampled among Manto Sipi Cree Nation, Bunibonibee Cree Nation and God's Lake First Nation along the proposed all-season road alignment and quarry areas. Forested sites were classed into 11 vegetation community types using the Forest Ecosystem Classification for Manitoba (Zoladeski *et al*. 1995) and wetland sites were classed into five community types (Ducks Unlimited Canada 2015). Of the 38 sites sampled, 26 sites were forested and consisted of deciduous (4 sites), mixedwood conifer (2 sites) and conifer (20 sites) tree canopies. The remaining 12 sites were wetland sites (see **Section 6.1.4.4**). Over the study area, each habitat type present is represented in the sample of sites and the predominance of black spruce sites reflects the area's dominant coniferous forest cover.

A total of 143 plant species were observed in the Vegetation LAA (**Appendix 6-1**). Recorded plants included 116 angiosperms (37 monocotyledons and 79 dicotyledons), eight primitive vascular plants (ex: ferns and horsetails), 5 gymnosperms (ex: conifers) and 14 non-vascular plants (ex: mosses and lichens) (**Appendix B-2**; Szwaluk Environmental Consulting Ltd *et al*. 2017b).

Eight documented uncommon species (S3 to S3S4) (uncommon to abundant throughout their range in the province) were recorded at or near survey sites. Species included oblong-leaved sundew (*Drosera anglica*), round-leaved bog orchid (*Platanthera orbiculata*), parsley fern (*Cryptogramma acrostichoides*), trailing club-moss (*Diphasiastrum complanatum*), black twinberry (*Lonicera involucrata*), alpine bearberry (*Arctous alpina*), Greenland primrose (*Primula egaliksesis*) and satin willow (*Salix pellita*).

Oblong-leaved sundew (*Drosera anglica*) is a boreal species that occurs on calcareous substrates in fens and drainage tracks in peat bogs. It is uncommon to widespread in Manitoba (S3S4), recorded here in a single graminoid rich fen site, as a frequently occurring species.

Round-leaved bog orchid (*Platanthera orbiculata*) is found in moist coniferous and deciduous forests and fen forests. It is uncommon to widespread in Manitoba (S3S4), observed here in three sites with scattered or incidental occurrence, under trembling aspen, trembling aspen mixed wood and jack pine – black spruce canopies.

Parsley fern (*Cryptogramma acrostichoides*) can be found on non-calcareous cliff crevices and rock outcrops, often in relatively dry habitats. It is uncommon to widespread in Manitoba (S3S4). It was observed in a single jack pine- black spruce site on a granite outcrop, with scattered occurrence.

Trailing club-moss (*Diphasiastrum complanatum*) occurs in dry open coniferous or mixed forests. It is uncommon to widespread in Manitoba (S3S4), observed here in two sites with incidental occurrence, under black spruce mixedwood and black spruce canopies.

Black twinberry (*Lonicera involucrata*) has been found to occur in spruce woods and on limestone ledges. It is uncommon to widespread in Manitoba (S3S4), observed in a single site with incidental occurrence, under jack pine – black spruce canopy.

Alpine bearberry (*Arctous alpina*) is found in open boggy coniferous woods, lichen heaths, gravelly beach ridges and tundra. It is uncommon to widespread in Manitoba (S3S4), recorded here in two sites with scattered or incidental occurrence, in black spruce communities.

Greenland primrose (*Primula egaliksesis*) can be found along stream banks and in bogs. It is uncommon in Manitoba (S3) and was observed incidentally at two sites, located in the vicinity of black spruce forest and treed bog vegetation.

Satin willow (*Salix pellita*) occurs on sandy or gravelly floodplains, stream and lake margins, marshes, fens and metamorphic or calcareous substrates. It is uncommon to widespread in Manitoba (S3S4), recorded here in a single treed poor fen site, as a frequently occurring species.

6.1.4.1.4 Species at Risk

For the purpose of this EA, Species at Risk[5] are defined as:

- federal species listed under the federal SARA or designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) for listing on Schedule 1 of the federal *Species at Risk Act* (SARA), including species in the risk categories of extirpated, endangered, threatened and special concern (Canadian Environmental Assessment Agency 2017a)
- provincial species listed as Endangered or Threatened under *The Endangered Species and Ecosystems Act* of Manitoba (ESEA)
- species listed as very rare (provincial status of S1) or rare (provincial status of S2) throughout their range as listed by the Manitoba Conservation Data Centre (MBCDC)

No plant Species at Risk were observed during field studies. Vascular Species at Risk were not expected to occur as the assessment area is beyond the range for these plants (**Appendix B-2**; Szwaluk Environmental Consulting Ltd *et al*. 2017b). Species at Risk are discussed further in **Section 6.1.8**.

[5] In the Project Description for the proposed Project, MI referred to "Species at Risk" as "Species of Conservation Concern". The term "Species at Risk" is used in the Environmental Impact Statement as it is consistent with the "Guidelines for the Preparation of an Environmental Impact Statement pursuant to the *Canadian Environmental Assessment Act, 2012*" (Canadian Environmental Assessment Agency, September 2017).

6.1.4.1.5 Introduced Species

During the surveys conducted in June 2016 for the Project, no invasive and non-native species were observed in the study plots. A number of introduced (non-native) and invasive species are expected to occur in the region surrounding the Project. These species are ranked SNA (conservation status rank is not applicable) by MBCDC (2016). Non-native and invasive plants in boreal habitats are commonly perennial herbs and grasses, particularly from among the Asteraceae (composites), Fabaceae (legumes) and Poaceae (grasses) plant families (Langor *et al*. 2014). Although not naturally found in undisturbed boreal forest habitats, many of these species are introduced along roads, rivers and streams, often following human activities. The boreal shield has a relatively high number of invasive plants, compared to other ecozones in Canada (Canadian Food Inspection Agency 2008). Introduced species are those that grow outside of their region of origin and generally thrive on disturbed sites, they are often prolific seed producers and can tolerate poor or disturbed soils (Langor *et al*. 2014). Invasive species compete with native species, forming dense populations that may subsequently spread to other areas. Invasive species have been cited as risk factors for species at risk (Canadian Food Inspection Agency 2008).

Of the 241 preliminary species expected to occur in the region surrounding the Project, there are 13 introduced species, ranked SNA by MBCDC (2016) (**Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). The Invasive Species Council of Manitoba lists two of these species (*Arctium minus* and *Sonchus arvensis*) as invasive capable of further spread, with pathways for further spread present (Invasive Species Council of Manitoba 2016). Of the preliminary species previously recorded for this area, none are listed with the Global Invasive Species Database (2015).

6.1.4.1.6 Species of Local Interest

Plant species of interest, such as those traditionally used for medicine, subsistence and cultural purposes, were recorded in the field where observed. Prior to the field studies, a list of culturally important species was compiled based on available literature and traditional knowledge studies. Generally these include a variety of vegetation including trees, shrubs, flowers, mosses, lichens (Davidson-Hunt *et al*. 2012). Locations where culturally important plant species resided within the LAA were identified by comparing all plant species recorded during the vegetation field surveys to the culturally important species list developed.

Indigenous communities have long histories of living on the land as well as knowledge, experience and an appreciation for the plants growing in their resource areas. Traditional knowledge studies conducted by Manitoba Infrastructure (MI) in 2016 identified several species of trees, shrubs and herbs as being important to the communities of Manto Sipi Cree Nation, Bunibonibee Cree Nation and God's Lake First Nation. As a result of workshops and personal interviews with local community members, more than 17 plants, plus wood and firewood resources were identified as important for sustenance and cultural practices. Common food plants include blueberry, raspberry, strawberry, cloudberry, cranberry, cherry and saskatoon. Over six medicinal plants were identified, including black spruce, sweet flag and Labrador tea. Firewood and willow stick collection and wood cutting was also valued.

Plant species identified as having sustenance and cultural value to the local communities, were identified at sites surveyed along the proposed all-season road and quarry areas (**Table 6.5**). From the vegetation surveys, 12 cultural plant species were observed in the LAA at 38 sampled sites. Of these, eight species were food plants, three were medicinal plants and three were other uses. Food plants observed included saskatoon (*Amelanchier alnifolia*), strawberries (*Fragaria virginiana*), cherry (*Prunus spp*.), swamp gooseberries (*Ribes spp*.), cloudberries and head berries (*Rubus chamaemorus*), mossberries (*Vaccinium oxycoccus*), blueberries (*Vaccinium spp*.) and cranberries (*Vaccinium vitis-idaea*). Medicinal plants observed included juniper (*Juniperus spp*.), black spruce (*Picea mariana*) and Labrador tea (*Rhododendron spp*.), while plants of other uses were willow sticks (*Salix spp*.), strawberries and Labrador tea (Szwaluk Environmental Consulting Ltd. *et al.* 2017a).

Table 6.5: Plants of Sustenance and Cultural Value Identified by Members of the Manto Sipi Cree Nation, Bunibonibee Cree Nation and God's Lake First Nation Within the Vegetation Local Assessment Area

Community	Local Name	Scientific Name	Observed in Sample Plots (P6-)
Food Plants			
GLFN	Weekays	*Acorus americanus*	not observed
MSCN	Saskatoon	*Amelanchier alnifolia*	10, 16, 30, 31, 33
MSCN	Strawberries	*Fragaria virginiana*	1, 8, 10, 14, 15, 16, 21, 27, 30, 31
MSCN	Cherry	*Prunus spp.*	15, 31
GLFN	Swamp gooseberries	*Ribes spp.*	1, 5, 21
BCN, MSCN	Cloudberries, head berries (mistegonemina)	*Rubus chamaemorus*	3, 7, 20, 28, 29, 34
MSCN, BCN, GLFN	Raspberries	*Rubus idaeus*	not observed
GLFN	Mossberries	*Vaccinium oxycoccus*	2, 3, 4, 6, 7, 11, 18, 19, 20, 22, 23, 24, 28, 32, 36, 38
MSCN, GLFN	Blueberries	*Vaccinium spp.*	1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 34, 36, 38
BCN, GLFN	Cranberries	*Vaccinium vitis-idaea*	3, 4, 5, 6, 7, 9, 12, 13, 15, 16, 18, 19, 20, 22, 26, 29, 30, 32, 33, 34, 36
GLFN	Medicines	various, unspecified	unspecified
BCN	Historic berry picking area	various, unspecified	unspecified
Medicinal Plants			
MSCN, BCN, GLFN	Weekays	*Acorus americanus*	not observed
GLFN	Water calla	*Calla palustris*	not observed
GLFN	Juniper	*Juniperus spp.*	15, 27, 33, 36
GLFN	Black spruce bark	*Picea mariana*	1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 36, 38

Community	Local Name	Scientific Name	Observed in Sample Plots (P6-)
MSCN	Spruce	*Picea spp.*	1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 36, 38
MSCN, GLFN	Labrador tea	*Rhododendron spp.*	1, 3, 4, 5, 6, 7, 9, 10, 13, 14, 18, 19, 20, 22, 24, 26, 28, 29, 30, 31, 32, 33, 34, 36, 38
MSCN, GLFN	Ginger root	unknown	unknown
BCN	Medicinal plant gathering location	various, unspecified	unspecified
BCN	Plants for tea	various, unspecified	unspecified
GLFN	Berries	various, unspecified	unspecified
GLFN	Muskeg leaves	various, unspecified	unspecified
Other Uses			
GLFN	Strawberries	*Fragaria virginiana*	1, 8, 10, 14, 15, 16, 21, 27, 30, 31
GLFN	Labrador tea	*Rhododendron spp.*	1, 3, 4, 5, 6, 7, 9, 10, 13, 14, 18, 19, 20, 22, 24, 26, 28, 29, 30, 31, 32, 33, 34, 36, 38
GLFN	Raspberries	*Rubus idaeus*	not observed
GLFN	Willow sticks	*Salix spp.*	2, 3, 4, 6, 7, 9, 11, 13, 14, 17, 18, 19, 21, 22, 23, 24, 25, 26, 30, 31, 33, 34, 35, 36, 37, 38
GLFN	Ginger root	unknown	unknown
BCN	Firewood harvest	various	various
MSCN	Wood cutting	various	various

Note: MSCN = Manto Sipi Cree Nation, BCN = Bunibonibee Cree Nation, GLFN = God's Lake First Nation.
Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017a

The most frequent species observed in sampled plots was black spruce (31 plots), blueberries (28 plots), willows (26 plots) and Labrador tea (25 plots). Other species with high occurrences included cranberries that were recorded in 21 plots and mossberries which were recorded in 16 plots. Several other plant species were unspecified such as berry picking areas and plant gathering locations. Firewood harvest and wood cutting areas were also identified as important areas and occur at various sites.

Three environmentally sensitive sites were identified from field assessments along the proposed all-season road (**Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). Each of these sites supported older growth black spruce forest greater than 120 years age at 121 years, 156 years and 165 years in the three plots (**Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). Old growth forests are stands that have achieved great age without significant disturbance. Trees in the boreal forest generally live 100 years and according to the Canadian Council of Forest Ministries, with old growth onset for black spruce at 110 to 160 years (Canadian Council of Forest Ministries 2017). Two other plots supported black spruce trees near this onset age, with trees 101 years and 106 years old. Old growth forests serve as natural reservoirs of genetic diversity and remain important to a balanced ecosystem (Canadian Council of Forest Ministries 2017).

6.1.4.2 Topography, Drainage, Geology and Hydrogeology

A description of geology is provided in **Section 6.1.2**, while a description of topography is provided in **Section 6.1.3** and a description of drainage and hydrogeology is provided in **Section 6.1.5**. Soil that is stripped during construction would be used for road construction as well as regrading and restoration of disturbed areas. Sediment and soil disposal areas would not be used and a description of the physiochemical characteristics not required.

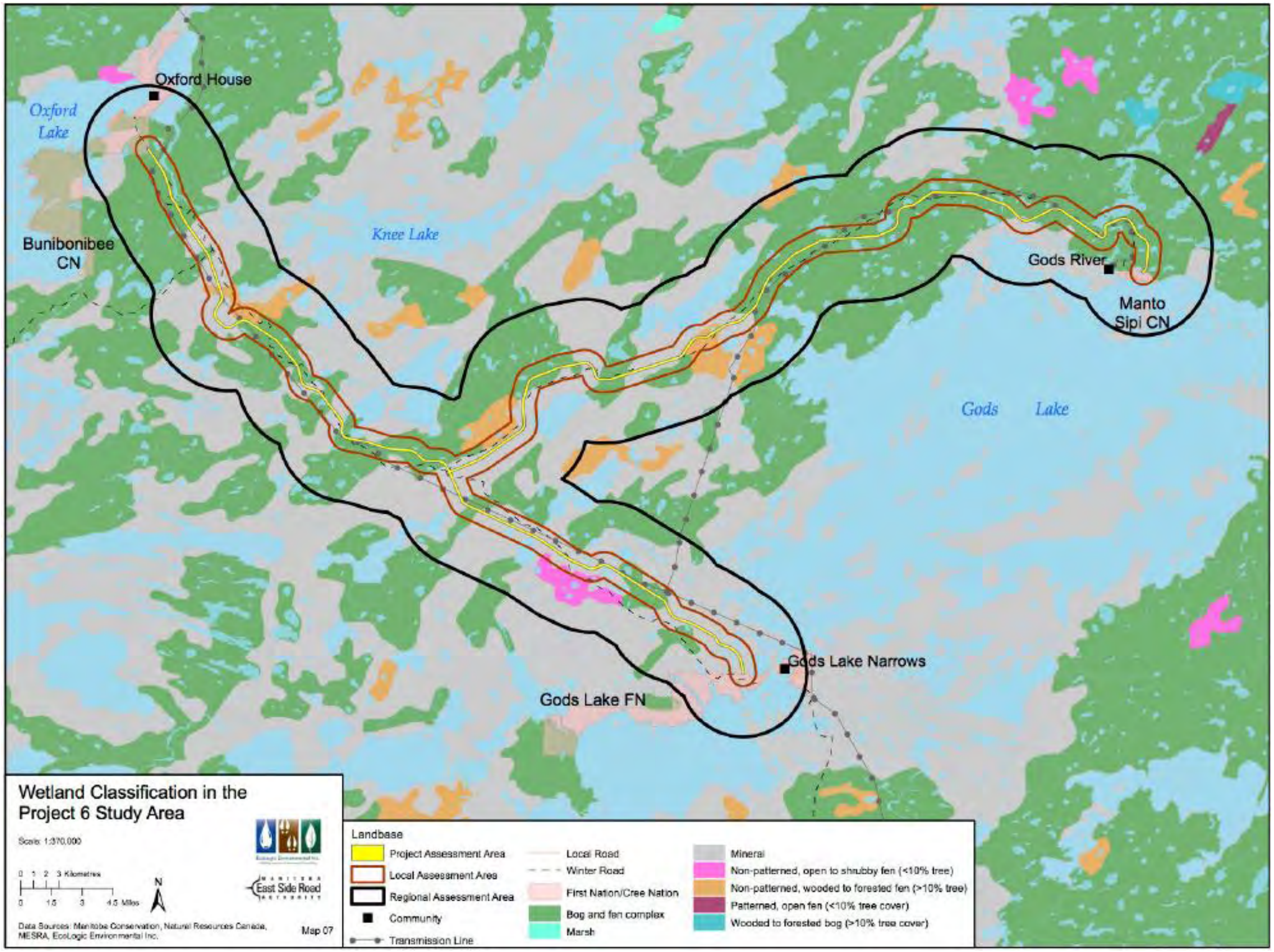
6.1.4.3 Wetlands

Approximately 85% of Canada's wetland areas are located in the boreal forest (Ducks Unlimited Canada 2015) and it has been estimated that wetland areas cover 43% of the terrestrial landscape in Manitoba, with peatlands representing 90% of wetland areas (Halsey *et al.* 1997). The ecological importance of boreal wetland areas is well documented, including the importance of calcareous wetland areas (ex: fens) and their potential to support species at risk (Bond *et al*. 1992; Foster *et al.* 2004; Locky *et al.* 2005; Ducks Unlimited Canada 2015; Goldsborough 2015). Wetlands have a range of functions including the management of water flow, enhancing water quality, buffering shorelines against erosion and providing wildlife habitat. They also provide an important socioeconomic and cultural role by providing areas to hunt, fish and trap (Bond *et al.* 1992).

According to the Canadian Wetland Classification System, wetlands are separated into five classes including bog, fen, marsh, swamp and shallow water (National Wetlands Working Group 1997). Ducks Unlimited Canada (2015) further identifies 19 minor wetland classes based on an enhanced wetland classification system of the five major wetland classes, which considers moisture, water movement and nutrients, as well as plant structure and cover (ex: trees, shrubs, grasses, sedges, mosses) to differentiate wetland sites using field-collected data.

The Canadian Wetland Classification System defines fens as peatlands with a fluctuating water table, rich in dissolved minerals due to ground and surface water movement. The greater nutrient availability in fens supports unique vegetation, related to the depth of the water table. The vegetation of nutrient poor fens, with waters low in dissolved minerals, is characterized by *Sphagnum* mosses and ericaceous shrubs with black spruce occasionally present. Moderately rich fens are dominated by graminoids (sedges) and brown mosses. Drier, rich fens support shrubs (birch, willow and tamarack) and trees such as black spruce and tamarack can be found on moss hummocks up to 20 cm above the water table (National Wetlands Working Group 1997).

Bogs are characterized by an accumulation of peat, with a surface that is raised or level with the surrounding terrain. Precipitation and snowmelt are primary water sources, resulting in acidic bog waters low in dissolved minerals, enhanced by the decomposition of acidic Sphagnum moss leaves. Vegetation largely consists of *Sphagnum*-dominated peat mosses, ericaceous shrubs (Labrador tea, leather leaf and bog cranberry) and where present, black spruce in sparse to closed stands (National Wetlands Working Group 1997).



Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017a

Figure 6-11: Wetland classification in the vicinity of the proposed Project (Vegetation LAA and RAA shown)

The distribution of wetlands across the region, as shown in **Figure 6-11**, is based on digitized data from a study on wetland types and their distribution in Manitoba (Halsey *et al*. 1997). Here, wetlands are distinguished by wetland class (bog, fen, marsh, swamp, shallow water), the presence/absence of a tree canopy (open, wooded, forested) and a landform modifier (ex: patterned, non-patterned). For the sake of mapping at this scale, in many cases wetland complexes, rather than individual wetlands were identified. In the wetland complex class, 30 to 70% of land is comprised of a mosaic of fen and bog habitats, (while upland habitat occupies the inversely remaining 70 to 30%) of a given polygon. This method results in a slight overestimation of wetland habitat area across the landscape, due to the inclusion of small mineral upland pockets within the wetland complex areas (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017b).

This roughly corresponds to the wetland cover classes of the Land Cover Classification described in **Section 6.1.4.1.1**, which are differentiated solely on the basis of vegetation structure. 'Treed wetlands' encompass treed bog and fen complexes; 'tall shrub wetlands' include shrubby bogs and fens; and 'herbaceous wetlands' include open fens (both patterned and non-patterned). Because both data sets were originally compiled differently and at different scales, the area calculations of classes are not necessarily directly comparable in this region (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017b).

Non-patterned open fens lack the presence of linear hummocky ridges and hollow depressions and are characterized by the presence of a continuous sedge cover and sparse to no trees. Fens can be poor, or moderately to extremely rich in dissolved nutrients. Birch and willow shrubs may be present and the ground cover in wet poor fens is Sphagnum mosses (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017b). Non-patterned open fens can occur as collapse scars in association with peat plateaus, associated with bog islands, or as small isolated basins (Halsey *et al*. 1997).

Non-patterned treed fens have a variable range in tree cover (ex: wooded greater than 6 to 70% to forested greater than 70%) in some combination of black spruce/tamarack, with a common shrub understory of birch and willow, ground mosses are Sphagnum or brown mosses. These fens can be poor, or moderately to extremely rich in dissolved minerals (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017b).

The distribution of wetlands types in the Project Footprint, Vegetation LAA and Vegetation RAA includes primarily bog and fen complexes, with occasional non-patterned fens classed as shrubby, or with an open (less than 10%), or treed (greater than 10%) canopy as shown in **Table 6.6**. Patterned fens (as distinguished by the presence of linear hummocky ridges and hollow depressions), marshes and treed bogs are present over the greater landscape, although not found within Vegetation RAA (**Appendix B-2**; Szwaluk Environmental Consulting Ltd. *et al.* 2017b).

Table 6.6: Area and Proportion of Wetland Types Among Vegetation Assessment Areas

Wetland Types	Project Footprint		Local Assessment Area		Regional Assessment Area	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Bog-fen complex, 30 to 70% wetland	15.6	55.3	156.0	54.9	646.4	45.2
Fen non-patterned, open-shrubby	1.0	3.7	1.6	0.6	12.3	0.9
Fen non-patterned, treed	-	-	11.4	4.0	45.0	3.1
Mineral soils, <30% wetland	11.6	41.0	115.1	40.5	726.9	50.8
Marsh	0.0	0.0	0.0	0.0	0.0	0.0
Patterned, open fen	0.0	0.0	0.0	0.0	0.0	0.0

Source: Szwaluk Environmental Consulting Ltd. *et al.* 2017b

The percent cover for bog-fen complex are roughly comparable across all assessment area scales. The mosaic bog and fen wetland complexes account for 55.3%, 54.9% and 45.2% in the Project Footprint, LAA and RAA, respectively. Road design would favour the mineral soil (higher elevation) component of this complex. The next dominant class, mineral soils, may have a wetland component present over no more than 30% of the given area. This dominantly upland class accounts for 41.0%, 40.5% and 50.8% of the Project Footprint, LAA and RAA, respectively. Fen habitats are minimally represented. Non-patterned treed fens occur in 3.1 to 4.0% of the LAA and RAA (absent within the Project Footprint), whereas open and shrubby non-patterned fens cover less than 1.0% of the LAA and RAA and 3.7% of the land base within the Project Footprint.

Twelve of the 38 vegetation sampling sites were in wetlands. Five types of wetland areas were found within the Vegetation LAA during field studies conducted in June 2016 (**Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). Wetlands were classed into wetland community based on soil type, vegetation composition and height and water regime (Ducks Unlimited Canada 2015). The wetland area types include treed bog, treed poor fen, shrub rich fen, graminoid rich fen and graminoid poor fen. The characteristics of these wetland area types are shown in the representative **Photographs 6-12 to 6-16** (sourced from **Appendix B-1**; Szwaluk Environmental Consulting Ltd. *et al.* 2017a). A description of the vegetation and soils of the community types encountered including site locations and site surface information are detailed in **Appendix B-1** (Szwaluk Environmental Consulting Ltd. *et al.* 2017a). Wetland species composition is provided in **Section 6.1.4.1.3** (vegetation), **Section 6.1.4.5** (mammals), **Section 6.1.4.6** (amphibians and reptiles), **Section 6.1.6** (fish) and **Section 6.1.7** (birds).