Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Habitat Rehabilitation Implementation and Success Monitoring Report

TEMP-2022-06

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KEEYASK

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KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2022-06

HABITAT REHABILITATION IMPLEMENTATION AND SUCCESS MONITORING

Prepared for

Manitoba Hydro

By

ECOSTEM Ltd.

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SUMMARY

Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. The vast majority of construction activities had been completed by fall 2021.

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the generating station on the terrestrial environment. Monitoring results will help the KHLP, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the generating station are affecting the environment, and whether or not more needs to be done to reduce harmful effects.

This report describes the results of the terrestrial habitat rehabilitation monitoring conducted during the eighth summer of Project construction.

Why is the study being done?

Terrestrial habitat rehabilitation mitigates adverse Project effects on terrestrial habitat and plants (e.g., habitat loss, erosion, invasive plant spread), restores wildlife habitat and improves aesthetics, among other benefits.

The Project's Vegetation Rehabilitation Plan, which is part of the overall Environmental Protection Program, provides the framework for rehabilitating terrestrial habitat in areas impacted by the Keeyask Infrastructure Project (KIP) and the Project. Terrestrial habitat will be rehabilitated in areas not required for Project operation (i.e., temporary Project areas) and in some permanent Project areas (e.g., along access roads).

What was done?

Monitoring is verifying that terrestrial habitat rehabilitation measures are being completed in accordance with the Environmental Impact Statement commitments and the Vegetation Rehabilitation Plan.

Monitoring in 2021 focused on documenting the:

- Extent to which pre-existing access trails that meet up with the Construction Footprint had been blocked and were revegetating;
- Degree of vegetation regeneration in the temporary Project areas; and,
- Rehabilitation of the temporary areas that are planned to eventually become a woodland or a forest.

The KHLP seeded the side slopes of the access road at various times since the start of Project construction.

The KHLP carried out the first efforts to rehabilitate forest or woodland habitats in 2016 at five locations, including three borrow areas developed by the KIP along the North Access Road, one cleared area near the Start-Up Camp and one cleared area near the Main Camp. Additional rehabilitation efforts were carried out in 2020 at four new locations, including an additional borrow area near the Main Camp area, an excavated material placement area along the South Dike, and two borrow areas adjacent to the South Access Road. Rehabilitation measures included grading to reduce steep slopes in the borrow areas and using a discer to loosen compacted mineral substrates. Tree planting was done in all five locations in 2016, and two locations in 2020. Approximately 231,360 jack pine and 19,720 black spruce seedlings were planted in 2016 and 77,400 jack pine and 28,700 black spruce seedlings were planted in 2020. In total, approximately 357,180 seedlings were planted between the two planting years (308,760 jack pine and 48,420 black spruce). Two locations in 2020 were also harrowed and seeded with native grass species.

In 2021, the 47 trails being monitored by this study were surveyed for measures installed to block access, vegetation regeneration and evidence of recent human use on the trails.

Vegetation regeneration was mapped for 1,138 ha of the Construction Footprint. The Construction Footprint includes the areas that were cleared or disturbed by the Project during construction, which is considered to have largely been completed in September 2021 for the purposes of terrestrial monitoring.

Tree regeneration surveys were conducted in the areas that were planted with tree seedlings in 2016 and 2020.

What was found?

Trail monitoring in 2021 found that there were no substantive changes to blocking and revegetation since the trails were last surveyed in 2017. Adequate trail blocking measures were installed at several trails. Natural vegetation regeneration after the 2013 wildfire has obscured most of the other trails and removed the need for these trails to be blocked by other means.

The evaluations of vegetation regeneration in the temporary portions of the Construction Footprint (i.e., the temporary Project areas) and tree regeneration are preliminary because they are using approximate boundaries for the temporary Project areas and initial determinations of the target habitat types. Boundaries for the temporary Project areas were approximate as some of these areas had not yet been, or were in the process of being, decommissioned. Additionally, once the boundaries of the temporary Project areas have been finalized, field surveys will be conducted to gather the information needed to finalize the target habitat type for each of the rehabilitation locations (e.g., substrate type, moisture regime). Additionally, for the areas that will become either woodland or forest, the prescriptions for these areas were awaiting the determination as to which of the habitat types had the highest actual Project effects during construction as these are the types that are prioritized for rehabilitation.

Monitoring in 2021 determined that just over half of the mapped temporary Project area had vegetation cover of 10% or higher. Vegetation cover was higher than >10% in 81% of the total temporary area monitored along the access roads. Barren areas and sparse vegetation (i.e., < 25% cover) generally occurred next to the roadbed.

Outside of the access roads, 61% of the mapped temporary Project area was barren. This was expected as construction was still active or had only recently ended in a number of the areas. Most of the barren and sparse vegetation cover was found in the active or recently active portions of these areas. In contrast, most of the area that was not barren had moderate to high vegetation cover, which was mostly low shrub and/or graminoid and/or bryoid cover. Natural regeneration was quickly establishing in areas where there was little to no disturbance after they were cleared.

More than half (58%) of the total area seeded with native grass in 2020 had at least sparse vegetation cover in 2021. Moderate or higher cover made up 35% of the seeded area. The sparse and barren portions along the access roads generally occurred next to the permanent roadway and/or other permanent infrastructure.

Tree seedlings had been planted in seven Project areas, with a combined area of 64.2 ha, in 2016 and 2020. Tree regeneration surveys conducted the year after the seedlings were planted found that the implementation of the tree planting prescriptions likely occurred as planned.

For the areas planted with tree seedlings in 2016, monitoring found that combined jack pine and black spruce tree density was above 2,500 stems/ha in 13 of the 15 areas. Both of the areas with lower densities only had black spruce plantings. Stem density changes from 2017 to 2021 indicated that planted black spruce seedlings were struggling to thrive in several of the 2016 planting areas. However, planted seedling mortality was being partially offset by natural black spruce regeneration.

Few of the areas planted in 2020 had a stem density higher than 2,500 stems/ha as of September 2021. In part, this was because the planting density in some areas was lower than planned due to the presence of substrates that were unsuitable for tree seedlings (e.g., gravel, water). Tree seedlings generally appeared healthy in the 2020 planting areas. This suggested that most of the stems still living in 2021 will continue to survive, barring unusual circumstances.

To date, natural tree regeneration has been limited to a few of the planting areas.

What does it mean?

Monitoring has found that trail blocking and revegetation as of 2021 were consistent with assumptions in the EIS. Monitoring is no longer necessary for most of the 47 trails originally selected for monitoring. It is recommended that each of the trails should be re-assessed to determine which ones, if any warrant continued monitoring during Project operation.

Areas along the access roads appeared to be on a pathway to achieving adequate revegetation. Most of the area had at least sparse vegetation. Also, it is expected that more plants will naturally establish in these areas, and that existing vegetation will expand its cover. Future monitoring will confirm this has happened.

Outside of the access roads, the high percentage (59%) of barren area was expected and is not a concern. Construction was still active or had only recently ended in a number of the areas (most of the barren and sparse vegetation cover was found in such areas) and plants were quickly establishing in areas where there had been little to no disturbance after they were cleared.

It is too soon to provide any evaluations about the eventual regeneration of woodland or forest in the areas where tree seedlings were planted. Among other things, accurate tree density results await the final boundaries of the temporary Project areas and mapping the portions of these areas that cannot be planted. Also, natural regeneration is expected to contribute additional stems in some of the planting areas.

What will be done next?

The boundaries for each of the temporary footprint areas will be finalized and used to determine which areas require ground surveys. This information will be used to finalize a target habitat type and prescriptions for each of the temporary footprint areas.

Monitoring in 2022 will include surveys of the areas that were planted with trees in 2020 and 2021.

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STUDY TEAM

Dr. James Ehnes was the project manager and study designer.

Fieldwork in 2021 was conducted by Brock Epp, Alanna Sutton, Gabriel Schmid, Kerry Kirkness (TCN) and Alex Snitowski.

Data analysis and report writing in 2021 were completed by Brock Epp, Meghan Noonan, James Ehnes and Alanna Sutton. GIS analysis and cartography were completed by Alex Snitowski.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOS

1.0 INTRODUCTION

The Keeyask Generation Project (the Projepct) is a 695-megawatt hydroelectric generating station (GS) and the associated facilities. The Project is located at Gull Rapids on the lower Nelson River in northern Manitoba where Gull Lake flows into Stephens Lake, 35 km upstream of the existing Kettle GS.

Project construction began in July 2014. The vast majority of construction activities had been completed by fall 2021. The reservoir was first brought to full supply level in September 2020 and the final generating unit went into service on March 9, 2022.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project (KHLP 2012a). Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TE SV; KHLP 2012b).

The *Keeyask Generation Project Terrestrial Effects Monitoring Plan* (TEMP; KHLP 2015a) was subsequently developed as part of the licensing process for the Project. Monitoring activities for various components of the terrestrial environment were described, including the focus of this report, habitat rehabilitation, during the construction and operation phases.

EIS predictions for all of the key topics were directly or indirectly based on assumptions regarding the effectiveness of habitat rehabilitation efforts and natural regeneration processes. These key topics included intactness, ecosystem diversity, terrestrial habitat, and priority plants.

Terrestrial habitat rehabilitation mitigates adverse Project effects on terrestrial habitat and plants (e.g., habitat loss, erosion, invasive plant spread), restores wildlife habitat and improves aesthetics, among other benefits. Terrestrial habitat will be rehabilitated in areas not required for Project operation and in some areas that are required for Project operation (e.g., along access roads). Some of the planned rehabilitation addresses potential adverse Project effects on intactness by blocking or hindering access from Project areas to surrounding areas.

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan for rehabilitating terrestrial habitat. The *Keeyask Generation Project Vegetation Rehabilitation Plan* (the VRP; KHLP 2015b), which is part of the overall Environmental Protection Program, provides the framework for rehabilitating terrestrial habitat in areas impacted by Keeyask Infrastructure Project (KIP) and the Project. The VRP provides the framework for how the areas that were temporarily required for construction but are not required for operation of the generating station or long-term maintenance of the associated infrastructure (e.g., borrow areas) will be rehabilitated. Best efforts will be made to re-establish the habitat types that existed prior to construction. Preference will be given to rehabilitating the most affected priority habitat types. Plant species that are important to the partner First Nations will be incorporated into habitat restoration, where feasible. Permanent Project features that require sight lines for safety purposes will be revegetated with plant species that are appropriate for the site.

Monitoring is needed to verify the implementation and effectiveness of terrestrial habitat rehabilitation measures. The terrestrial habitat rehabilitation monitoring program (TEMP, Section 2.2) includes a single study, Habitat Rehabilitation Implementation and Success, that periodically evaluates the implementation and effectiveness of terrestrial habitat rehabilitation measures.

The goal of this study (Habitat Rehabilitation Implementation and Success) is to verify whether each site has achieved, or is on a pathway to achieving, its rehabilitation targets. However, it will take many years for habitat to regenerate in highly disturbed areas (e.g., borrow areas), and decades for a forest to regenerate where this is the target habitat type. Consequently, this monitoring study initially focuses on verifying adequate implementation of rehabilitation efforts, survival of plantings and seeding, and natural plant colonization and expansion. Future monitoring increasingly focuses on evaluating successful achievement of the rehabilitation targets.

The objectives of this study are to:

- Confirm that trails intersecting the Construction Footprint (except for existing resource-use trails and those required for operation) are blocked and initial revegetation efforts are adequate;
- Confirm that the revegetated portions of the blocked trails are regenerating successfully and are expected to restore a habitat type similar to adjacent areas; Verify the implementation of rehabilitation prescriptions set out in the Vegetation Rehabilitation Plan; and,
- Verify the effectiveness of rehabilitation efforts at restoring native habitat where this is the target prescription, and at restoring ecologically appropriate vegetation in the remaining areas.

Monitoring for the Terrestrial Habitat Rehabilitation study was conducted in 2017 and 2021. Results for the monitoring conducted in 2017 are provided in a previous report by ECOSTEM (2018). The following presents the monitoring conducted in 2021.

2.0 REHABILITATION EFFORTS TO DATE

Each winter, Manitoba Hydro provides information on the actual rehabilitation treatments carried out to date. This information is used to plan monitoring for the next growing season. The following summarizes treatments carried out since Project construction began.

2.1 TRAIL BLOCKING AND REHABILITATION

The 2012 EIS includes a commitment to block access along selected cutlines and trails that intersect the Project Footprint. Due the effects of the 2013 wildfire, cutline and trail blocking were not implemented as originally planned. Two trails were blocked in 2017 with piled soil and vegetation, as planned. However, dense vegetation regeneration following the 2013 wildfire effectively blocked the cutlines and remaining trails, making many of them nearly indistinguishable from the surrounding area (ECOSTEM 2018).

2.2 VEGETATION REGENERATION

In areas that were not targeted to become a forest or woodland, vegetation regeneration efforts consisted of applying a native grass seed mixture. Some road side areas along the North Access Road were initially hydroseeded in 2013 and then a large portion of the road side areas were broadcast seeded in 2019 and 2020. The road side areas along the South Access Road were broadcast seeded in 2016. In 2020, portions of Borrow Areas B-3 and Q-9 were seeded to establish low vegetation under the transmission lines.

2.3 TREE PLANTING AREAS

2.3.1 APPROACH

The first efforts to rehabilitate forests or woodlands in selected borrow areas and excavated material placement areas (EMPAs) occurred during construction in 2016 (areas developed as part of the KIP), and in 2020 and 2021 (areas developed as part of the KGP). The areas planted with tree seedlings in 2021 are not considered in this report as the first monitoring occurs one year after planting.

To develop woodland or forest habitat types in Project disturbed areas, site preparation is often implemented prior to trees being planted. Site preparation may include grading to reduce steep slopes and/or loosening compacted substrates.

Trees are planted at a predetermined spacing to achieve a tree density target. The spacing at which tree seedlings are planted is higher when the target is to achieve a forest versus a woodland habitat type as a forest has a higher tree density at maturity than a woodland.

Two considerations when selecting the spacing for tree planting are that some of the planted seedlings are expected to die, and that natural tree regeneration may at least somewhat offset this seedling mortality. Seedling mortality can arise from a number of sources such as seedlings drying out while being stored prior to planting, hot and dry conditions following planting, or winter browsing by snowshoe hare. Natural tree regeneration includes seedlings that establish from seeds, or pre-existing seedlings and saplings that survived vegetation clearing. For some tree species, vegetation clearing can stimulate stems to sprout from roots (e.g., trembling aspen) or root collars (e.g., white birch).

Assuming that there will be no natural regeneration to offset any seedling mortality, the ultimate spacing to achieve a forest is 1 m x 1 m compared with 2 m x 2 m for a woodland. The spacing is “ultimate” since the planting can occur over more than one year (i.e., two-stage initial planting), if needed, to reduce the risk that a high proportion of the planted seedlings will be eliminated by an unusual event (e.g., a drought, excessive winter browsing). For example, the 1 m x 1 m spacing for a forest can be achieved by planting at 2 m x 2 m in one year, and then completing a second offset 2 m x 2 m planting within the next few years. An advantage of completing an initial planting, in addition to reducing the risk of high seeding mortality, is that amount of planting needed can be reduced in locations where substantial natural regeneration is already occurring. Conversely, a higher planting density can be used, if needed, for areas where monitoring has demonstrated high seedling mortality.

It cannot be determined what proportion of the temporary Project areas targeted for a treed habitat type will be forest, which requires a higher stem density than woodland, until the following is known: (i) the amounts and locations of the habitat types that were actually affected by the Project during construction (i.e., the most highly affected priority habitat types); (ii) which areas will not be required for Project operation; and, (iii) substrate conditions in areas targeted for a treed habitat type are mapped (which is somewhat dependent on the previous two criteria).

Most of the areas planted in 2016 were done at a 1 m x 1 m spacing. This was due to them being decommissioned areas from the Keeyask Infrastructure Project, already completed prior to Project construction (which meant that the first two criteria in the previous paragraph had been met) and there were a large number of seedlings available for planting that year.

2.3.2 2016 PLANTINGS

In 2016, trees were planted at five locations (rehabilitation locations) along the North Access Road (Table 2-1; Map 2-1). These locations included areas near the Start-up Camp, Main Camp, and Borrow Areas KM-1, KM-4 and KM-9. The location near the Main Camp was added at the time that the seedlings were being planted to use up surplus seedlings. A recently burned area near the cemetery site along the NAR was also planted with surplus seedlings. This site is not being monitored as it was not disturbed by the Project.

Table 2-1: Rehabilitation efforts including area, year, and type, by location

Location	Area Treated (ha)	Year	Site Treatment	Vegetation Treatment	Planned Tree Spacing (m)
Borrow Area KM-1	4.6	2016	Disced	Tree planting	1x1 and 2x2
Borrow Area KM-4	9.0	2016	Disced	Tree planting	1 x 1
Borrow Area KM-9	6.0	2016	Disced	Tree planting	1x1 and 2x2
Near Start-Up Camp	2.7	2016	None	Tree planting	1x1
Main Camp Entrance	0.8	2016	None	Tree planting	1x1
Cemetery	0.4	2016	None	Tree planting	1x1
Borrow Area G-3	16.4	2020	Partially Disced	Tree planting	2x2
EMPA D27(4)-E	20.7	2020	None	Tree planting	2x2
Borrow Area Q-9	4.9	2020	Harrow	Grass seeding	n/a
Borrow Area B-3	7.6	2020	Harrow	Grass seeding	n/a
All	**73.2**				

Rehabilitation treatments in 2016 consisted of tree planting in all of the target locations, as well as one or more other measures in some areas. These measures included grading to reduce slopes to less than 4:1 where needed in borrow areas. In some areas, a Rome TRCW16 discer (Photo 2-1 and Photo 2-2) pulled behind a tractor loosened compacted surface material. Site preparation generally occurred on exposed mineral substrates. Areas where the original surface organic layer was intact were not treated (see examples Figure 2-1). See Table 2-1 for details.

Photo source: Manitoba Hydro

Photo 2-1: Discer used for site preparation

Photo 2-2: Treatment area 09 in Borrow Area KM-9 that was prepared with a discer

Surface organic material between 1 and 5 cm thick	Surface organic material between 10 and 15 cm thick

Figure 2-1: Examples of undisturbed surface organic material along transects in 2017

Tree planting was planned for approximately 21.6 ha in 2016. The actual total area planted was determined by substrate suitability, the actual total number of seedlings received, and other factors (e.g., water pools, worker availability). Typically, some of the areas planned for planting are found to be unsuitable, while other sites outside of the planned planting area were added because they were more suitable, or to utilize surplus seedlings.

Surplus seedlings were available after the planned planting areas were fully planted in 2016. Therefore, two additional areas were planted, including the entrance to the Main Camp and the cemetery site, bringing the total planted area in 2016 up to 23.6 ha. Comparisons of planned versus actual planted area in 2016, including maps, are provided in ECOSTEM (2018).

For the areas planted with black spruce (*Picea mariana*), the planting spacing was 2 m by 2 m, which equates to an initial tree density of 2,500 stems/ha. For the areas planted with jack pine (*Pinus banksiana*), the planting spacing was 1 m by 1 m, which equates to an initial tree density of 10,000 stems/ha. For the areas planted with both species, the planting spacing was 1 m by 1 m.

Table 2-2 provides the estimated number of jack pine and black spruce seedlings planted in 2016 by rehabilitation location. Jack pine and black spruce were planted in distinct portions of each of the borrow areas. Only jack pine was planted near the Start-up Camp, at the Main Camp entrance and at the cemetery site. Borrow Area KM-4 received more than half of the jack pine seedlings, which was more than any other location by far. Borrow Area KM-9 received most of the black spruce seedlings.

Table 2-2: Approximate area planted, number of seedlings planted and planting density in 2016, by location

Location	Species	Area Planted (ha)	Number of Seedlings	Overall Density (stems/ha)
Borrow Area KM-1	Black spruce	1	1,577	1,542
	Jack pine	3.5	40,258	11,366
Borrow Area KM-4	Black spruce	0.7	2,760	3,970
	Jack pine	9	120,307	13,310
Borrow Area KM-9	Black spruce	4.5	15,383	3,397
	Jack pine	3.4	23,136	6,709
Near Start-up Camp	Jack pine	2.7	34,704	12,720
Main Camp Entrance	Jack pine	0.8	9,254	11,632
Cemetery[1]	Jack pine	0.41	3,701	9,253
Total	Black spruce	6.2	19,720	3,157
	Jack pine	20	231,360	11,595

Notes: [1] Number of seedlings planted and estimated area planted at cemetery provided by Manitoba Hydro.

Planted tree stem densities were calculated using the estimated number of seedlings planted in a location as provided by Manitoba Hydro, and the approximate total area planted. On this basis, overall black spruce planting density in 2016 ranged from 1,542 to 3,970 stems/ha while overall jack pine planting density ranged from 9,253 to 13,310 stems/ha.

2.3.3 2020 PLANTINGS

In 2020, rehabilitation treatments consisted of tree planting at two locations, and seeding with native grass species at two other locations (Table 2-1; Map 2-1). Tree seedlings were planted in a total of 37.1 ha, including a portion of Borrow Area G-3 and in EMPA D27(4)-E adjacent to the South Dike. Grass seeding occurred in Borrow Areas Q-9 and B-3 along the South Access Road.

In the tree planted locations, slope grading was carried out where needed. In Borrow Area G-3, some additional substrate preparation with a discer was carried out where it was required. In the seeded locations, areas were prepared using a harrow attached to a quad. The preparation loosened the surface substrate and created furrows for the seed. Grass species included in the native seed mix are provided in Table 2-3.

Table 2-3: Native grass species included in seed mix for 2020 seeded locations

Species	Common name
Koeleria macrantha	Prairie junegrass

Festuca saximontana	Rocky mountain fescue
Bromus anomalus	Nodding bromegrass
Elymus lanceolatus	Thick-spike wildrye
Elymus canadensis	Canada wildrye
Poa alpina	Alpine bluegrass

Tree planting was planned for approximately 48 ha in 2020. The total area actually planted was 37.1 ha. Jack pine and black spruce were planted at a spacing of 2 m by 2 m in each planting area, equating to an initial density of 2,500 stems/ha.

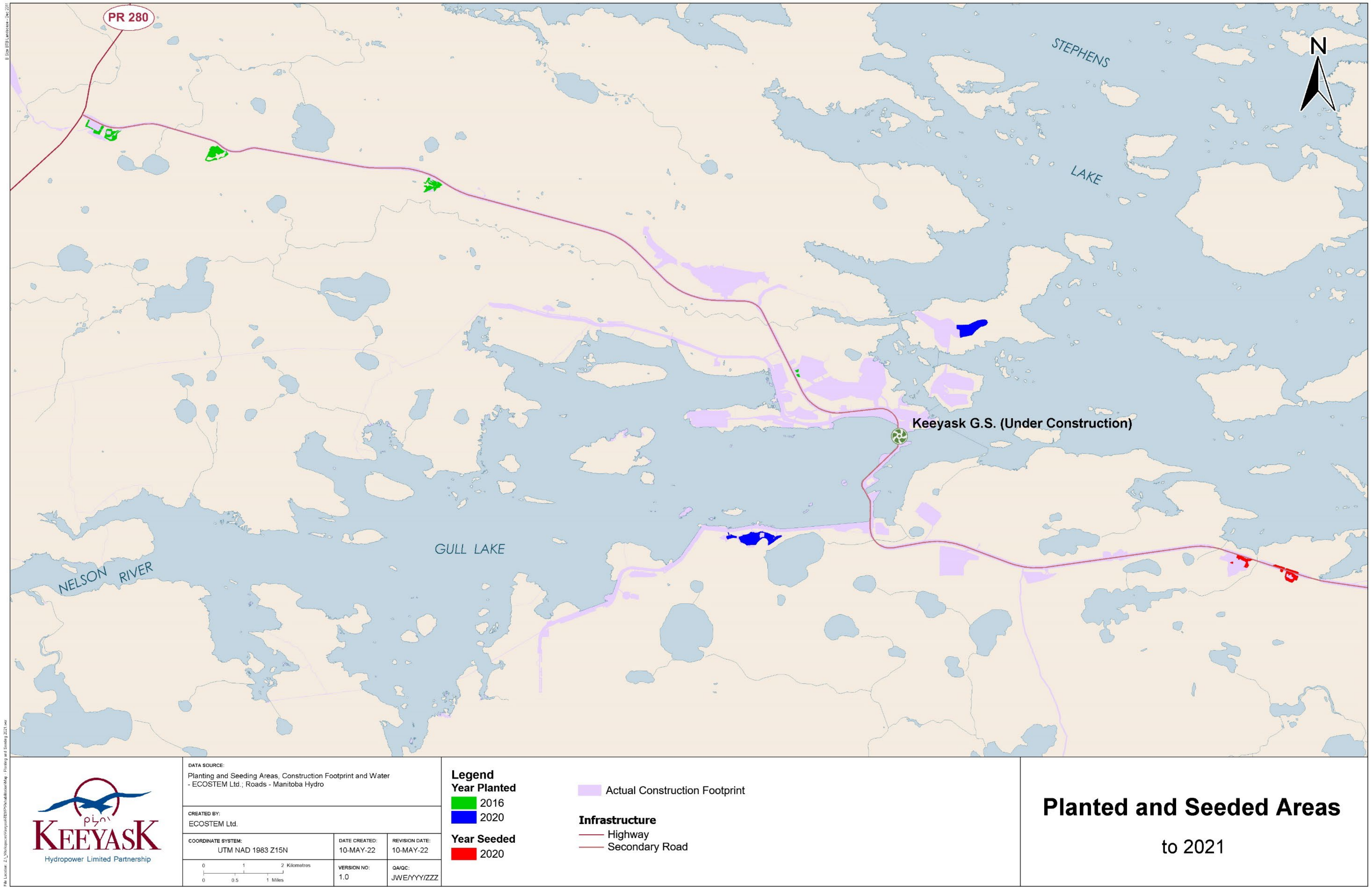
Table 2-4 provides the estimated number of jack pine and black spruce seedlings planted within each rehabilitation location in 2020. A larger proportion of the black spruce seedlings were planted in EMPA D27(4)-E. That location was characterized as having a mixture of wet, peaty substrates in lower areas and dry, sandy substrates in higher areas. Borrow Area G-3 was characterized with predominantly dry sandy and clayey substrates. Within each of the locations, the two species were planted as a mixture.

In 2020, overall planting density ranged from 313 to 1,282 stems/ha for black spruce, and 1,720 to 2,542 for jack pine. Planting density for the two species combined was greater than 2,500 stems/ha within both locations.

Table 2-4: Approximate area planted, number of seedlings planted and planting density in 2020, by location

Location	Species	Number of Seedlings[1]	Area Planted[2] (ha)	Overall Density (stems/ha)
Borrow Area G-3	Black spruce	2,100	6.7	313
	Jack pine	41,800	16.4	2,542
EMPA D27(4)-E	Black spruce	26,000	20.3	1,282
	Jack pine	35,600	20.7	1,720
Total	Black spruce	28,100	27.0	1,041
	Jack pine	77,400	37.1	2,084

Notes: [1]Number of seedlings planted provided by Manitoba Hydro. [2]The area planted for Borrow Area G-3 and Excavated Material Placement Area D27(4)-E is based on field data because this information was not available prior to the 2021 surveys.



Map 2-1: **Locations where rehabilitation measures were implemented in 2016 and 2020.**

3.0 METHODS

Section 2.2.2 of the TEMP details the methods for the Habitat Rehabilitation Implementation and Success monitoring study, which began in 2017. This study monitors habitat regeneration in areas that have received some form of trail blocking or habitat rehabilitation.

The areas actually cleared or physically disturbed by the Project during the construction phase are referred to as the Construction Footprint. ECOSTEM (2022) provides the Construction Footprint and the methods used to produce it. In brief, the Construction Footprint includes all areas where there was Project clearing or physical disturbance up to September 2021. The Construction Footprint includes terrestrial and dewatered aquatic areas.

During the construction phase, the primary focus of this study is on the implementation of the rehabilitation prescriptions in the Construction Footprint since several years are required before it can be determined whether vegetation and soil targets are on the desired recovery pathway. The spatial extent and degree of habitat regeneration success are ultimately documented through high resolution remote sensing (i.e., data about objects or areas obtained from a distance) and/or field surveys. As it takes some years for vegetative cover to develop after rehabilitation treatments, this mapping is generally undertaken after rehabilitation is completed.

The following summarizes the monitoring conducted in 2021.

3.1 TRAIL BLOCKING AND REHABILITATION

The 47 distinct trails intersecting the Construction Footprint that were identified as needing trail blocking and regeneration were surveyed in 2017 and 2021. The objective for the 2021 monitoring was to determine if there was any change in status of the trails since they were surveyed by foot in 2017. The trails were surveyed using digital stereo photos collected on October 4, 2021. Additional sources of information included helicopter photography acquired on September 10 and 13, 2021 and Worldview 2 imagery acquired on July 11, 2017 and August 30, 2021.

For each trail, the following information was recorded:

- The presence and nature of measures that could block access to the trail;
- Any disturbance of vegetation regeneration on the trails by the Project; and,
- Evidence of recent trail use by non-Project sources.

3.2 VEGETATION REGENERATION

3.2.1 ALL TEMPORARY PROJECT AREAS

Vegetation regeneration in the terrestrial portions of the temporary Project areas was mapped using remote sensing that was acquired in 2021. Vegetation cover was mapped for areas along the North and South access roads and the temporary Project areas.

Vegetation regeneration was primarily mapped from digital stereo photos acquired on October 4, 2021. Additional data sources included helicopter photography acquired between September 10 and 13, 2021 and Worldview 2 imagery acquired on August 30, 2021.

The temporary Project areas along the North and South access roads, were subdivided into polygons based on total vegetation cover using the cover classes provided in Table 3-1. Vegetation structure was mapped in the remaining temporary areas using the classes provided in Table 3-2.

Table 3-1: Classes and codes for vegetation structure cover

Cover Class	Code	Cover Range	Interpretation Notes
Barren	B	<10%	Little to no discernable vegetation
Sparse	S	11 - 25%	Discernable vegetation covers less than 25% of the polygon overall
Moderate	M	26 – 75%	Discernable vegetation >25% cover, obvious gaps in cover and bare patches too small to map
High	H	76 – 100%	Very few gaps in cover to apparently continuous cover

Table 3-2: Classes and codes for vegetation structure

Vegetation structure Type	Code	Description
Forest	F	61% - 100% trees
Forest/ Tall Shrub	F/ TS	61% - 100% trees in upper canopy/ > 25% tall shrubs in lower canopy
Woodland	D	26% - 60% trees
Woodland/ Tall Shrub	D/ TS	26% - 60% trees in upper canopy / > 25% tall shrubs in lower canopy
Sparsely Treed	S	10% - 25% trees
Sparsely Treed/ Tall Shrub	S/ TS	10% - 25% trees in upper canopy / > 25% tall shrubs in lower canopy

Vegetation structure Type	Code	Description
Heterogeneous mixture of woodland and sparsely treed	M	Mixture of woodland and sparsely treed
Heterogeneous mixture of woodland and sparsely treed/ Tall Shrub	M/ TS	Mixture of woodland and sparsely treed with TS lower canopy
Tall Shrub	TS	<10% tree cover and > 25% tall shrub cover
Low Shrub and/or Graminoid and/ or Bryoid	L	<10% trees and < 25% tall shrub and > 10% ground cover
Emergent	E	> 25% emergent vegetation cover
Barren	B	< 10% vegetation cover
Unclassified Young Regeneration	R	Burned after 1992, insufficient information to classify into vegetation structure type
Forest	F	61% - 100% trees

3.2.2 SEEDING AREAS

The locations seeded with grass in 2020 were subdivided into “seeding areas” based on similar types of site preparation (harrowing) and grass seeding. The seeding areas were initially mapped using maps provided by Manitoba Hydro that showed the approximate areas seeded. Borrow Area B-3 was subdivided into four seeding areas and Borrow Area Q-9 was subdivided into two seeding areas. The extents of the seeding areas were further refined by ECOSTEM staff using high-resolution digital stereo photography collected on October 4, 2021, and helicopter photography acquired on September 10 and 13, 2021. The areas were refined to exclude features such as bedrock and water ponds, where site preparation and seeding could not occur. Note that the boundaries of the seeding areas are approximate and will be refined in the future using the available information.

Graminoid cover was mapped using the same remote sensing identified in the previous paragraph. The seeding areas were subdivided based on vegetation cover class and vegetation type. Polygons were digitized directly on the 3D imagery using Summit Evolution and ArcMap. Digitizing was conducted at a scale of 1:590, with a minimum polygon size of 400 m^2.

Each polygon was assigned a cover class based on the overall percent foliage cover of vegetation (Table 3-3), and a cover type based on the dominant type of vegetation in the polygon (Table 3-4).

Table 3-3: Classes and codes for seeding area vegetation cover

Cover Class	Code	Cover Range	Interpretation Notes
Barren	B	~0%	No discernable vegetation
Sparse	S	<25%	Discernable vegetation covers less than 25% of the polygon overall
Moderate	M	26 – 75%	Discernable vegetation >25% cover, obvious gaps in cover and bare patches too small to map
High	H	76 – 100%	Very few gaps in cover to apparently continuous cover

Table 3-4: Cover type classes and codes

Cover Type	Code	Description
Graminoid	G	Dominant vegetation cover are grasses or sedges
Forb	F	Dominant vegetation cover are broadleaf herbs
Low shrub	LS	Dominant vegetation cover are low shrub species
Tall shrub	TS	Dominant vegetation cover are tall shrub species
Treed	T	Dominant vegetation cover are tree species
Unknown	U	Unknown vegetation cover

3.3 TREE PLANTING AREAS

The locations where tree planting occurred were subdivided into "planting areas". The term "planting areas" used in this report is equivalent to the term "treatment areas" used in the previous rehabilitation monitoring annual report (ECOSTEM 2018). In the previous annual report, "planting areas" referred to the areas that were planned for planting, while "treatment areas" referred to the areas that were actually planted (which differed in some cases). In this report, "planting areas" refers to the areas that were actually planted.

The planting areas were mapped based on having relatively homogeneous conditions for tree species planted, site preparation, substrate and topographic conditions. The way that this was initially accomplished was different for the areas planted in 2016 compared to those planted in 2020.

3.3.1 DELINEATING THE PLANTING AREAS

3.3.1.1 2016

In 2016, the planting areas were initially mapped in early 2017 using maps of the planned planting area that were provided by Manitoba Hydro. In each planting area either jack pine, black spruce or both species (i.e., jack pine and black spruce mixture) were planted. The species planted in each area roughly corresponded with substrate conditions. Field studies in 2017 further refined the planting area boundaries, and updated the species planted based on what was actually planted there (some areas were infilled with the extra jack pine seedlings, for example). Details outlining the development of the 2016 planting areas are provided in ECOSTEM (2018).

Locations that were planted in 2016 were initially subdivided into 16 planting areas excluding the Cemetery location (see Section 2.0). Monitoring surveys in 2017 determined that one planned planting area (PA-11) in Borrow Area KM-9 was not planted, reducing the total number of planting areas sampled in 2017 to 15.

Tree regeneration surveys were conducted along pre-determined belt transects within the planting areas. Transect lengths and locations were tailored to the shape of the planting area. The goal was to have at least two belt transects within each planting area. In wide planting areas, such as the centre of a borrow pit, sample transects were spaced approximately 50 metres apart. In narrow planting areas (<50 m wide), usually perimeter areas, where 2 parallel transects were required, a formula ([mean area width in meters minus 4]/2) was used to determine the spacing. In very narrow planted strips (<16 m wide), a single transect was sampled along the middle of the area.

In the field, surveyors navigated to each of the pre-determined transects using a handheld GPS (Garmin Map 62 or Map 78). Plastic (PVC) pipes and pin flags were inserted into the ground as markers at the beginning, end, and inflection points of each transect so the same locations could be re-sampled in the future. A waypoint was also recorded at each marker.

Tree regeneration surveys were conducted along a total of 57 belt transects, in 15 distinct planting areas across the five 2016 rehabilitation locations (Table 3-5).

All the transects sampled in 2017 were re-sampled on September 12 to 16, 2021. Map 3-1 to Map 3-4 show the planting areas and transect locations sampled in 2017 and 2021.

Table 3-5: Species planted, area planted, and number and length of transects surveyed by planting area in 2021 for the 2016 rehabilitation locations

Location	Planting Area	Planted Species[1]	Area Planted	Transects Sampled	
				Number	Length (km)
Borrow Area KM1	1	Black spruce	0.3	2	0.084
	2	Jack pine	3.5	10	1.009
	3	Black spruce	0.7	3	0.149
Borrow Area KM4	4	Both	0.3	2	0.264
	5	Both	0.4	3	0.219
	6	Jack pine	8.3	12	2.078
Borrow Area KM9	7	Both	1.9	5	0.396
	8	Jack pine	1.5	3	0.392
	9	Black spruce	2.1	3	0.306
	10	Black spruce	0.5	2	0.279
Near Start-up Camp	12	Jack pine	0.5	2	0.187
	13	Jack pine	1.6	4	0.473
	15	Jack pine	0.6	2	0.37
Main Camp Entrance	16	Jack pine	0.4	2	0.143
	17	Jack pine	0.4	2	0.135
All[2]			23.2	57	6.484

Notes: [1] Actual planted species based on species identified during field surveys not including natural regeneration.
[2] Numbers in a column may not add to the total shown due to rounding.

3.3.1.2 2020

In 2020, maps provided by Manitoba Hydro indicated the overall extent of planting in the two rehabilitation locations (i.e., Borrow Area G-3, EMPA D27(4)-E). These locations were not subdivided into planting areas like for 2016. To establish planting areas, a botanist conducted a preliminary foot survey of the rehabilitation location and delineated the planting areas on a paper map. Planting areas were delineated based on a combination of surface substrate material, topography (e.g., level, slope, basin), and the species planted. The planting areas were mapped after the 2021 field surveys.

For both of the rehabilitation locations, belt transects were established in the general planting areas provided by Manitoba Hydro. For both Borrow Area G-3 and EMPA D27(4)-E, the planted areas were large and relatively continuous. The transects were spaced approximately 50 meters apart and extended across the narrower axis of the planted areas in both locations. Along each transect, the boundaries of the field-mapped planting areas were marked with flagging and a GPS waypoint. After the field surveys, transects were subdivided at the mapped planting area boundaries.

Transect start and end points were marked with PVC pipes and pin flags using the same method as for the 2016 planted areas.

Map 3-5 and Map 3-6 show the planting areas and transect locations sampled on September 12 to 16, 2021 in the 2020 rehabilitation locations.

Tree regeneration surveys were conducted along a total of 106 belt transects, in 15 distinct planting areas across the two 2020 tree planting rehabilitation locations (Table 3-6).

Table 3-6: Species planted, area planted, and number and length of transects surveyed by planting area in 2021 for the 2016 rehabilitation locations

Location	Planting Area	Planted Species[1]	Area Planted	Transects Sampled	
				Number	Length (km)
Borrow Area G-3	1	Jack pine	1.2	3	0.182
	2	Jack pine	0.7	3	0.127
	4	Both	5.6	14	1.135
	5	Jack pine	4.9	11	0.907
	6	Jack pine	0.8	11	0.128
	7	Jack pine	2.1	10	0.452
	8	Both	1.1	9	0.147
EMPA D27(4)-E	1	Both	7.3	15	1.453
	2	Both	1.5	4	0.334
	3	Both	1.3	8	0.245
	4	Jack pine	0.4	1	0.052
	7	Both	6.9	6	1.348
	8	Both	1.6	5	0.331
	9	Both	0.2	1	0.104
	10	Both	1.6	5	0.309
All[2]			37.1	106	7.3

Notes: [1] Actual planted species based on species identified during field surveys not including natural regeneration.
[2] Numbers in a column may not add to the total shown due to rounding.

3.3.2 DATA COLLECTION

Live and dead tree species stems were counted within a 1 m wide belt centered on the transect (Figure 3-1). Information recorded for each stem included species, height class (Table 3-7), vigor class (Table 3-8), natural regeneration class (Table 3-9; Figure 3-2), and damage class (Table 3-10). Additional notes regarding transect environmental conditions (other regenerating vegetation, and general comments) were recorded. Reference photos were taken at the beginning and end points of each transect. For the 2020 rehabilitation locations, the planting area ID was also recorded.

Table 3-7: Tree height class

Class	Description
Seedling	Trees ≤ 50 cm tall
Sapling	Trees > 50 cm and ≤ 1.3 m tall
Tree	Trees > 1.3 m tall

Table 3-8: Tree vigor class

Class Code	Class Name	Description
0	Older dead	Appears to have been dead for at least one year
1	Dead	Appears to have died within the past year
2	Almost dead	Appears dead except a few needles still green
3	Dead leader	The top of the main stem appears dead
4	Dead lower branches	Most of the lower branches appear dead, but rest of plant appears healthy
5	Mostly living	Mostly healthy; a few dead needles
6	Alive	No signs of mortality

Table 3-9: Natural regeneration class

Class code	Class name
D	Definitely natural regeneration
P	Possibly natural regeneration
N	Not natural regeneration (planted)
U	Could not be determined due to herbivory or some other form of damage

Table 3-10: Damage class

Class code	Class name
M	Mechanical damage
H	Herbivory
E	Undermined or washed over by erosion and/or sediment deposition
N	None

Flagged sampling transect in Main Camp entrance

Sampling a transect in Borrow Area KM-1

Figure 3-1: Tree regeneration sampling in 2017

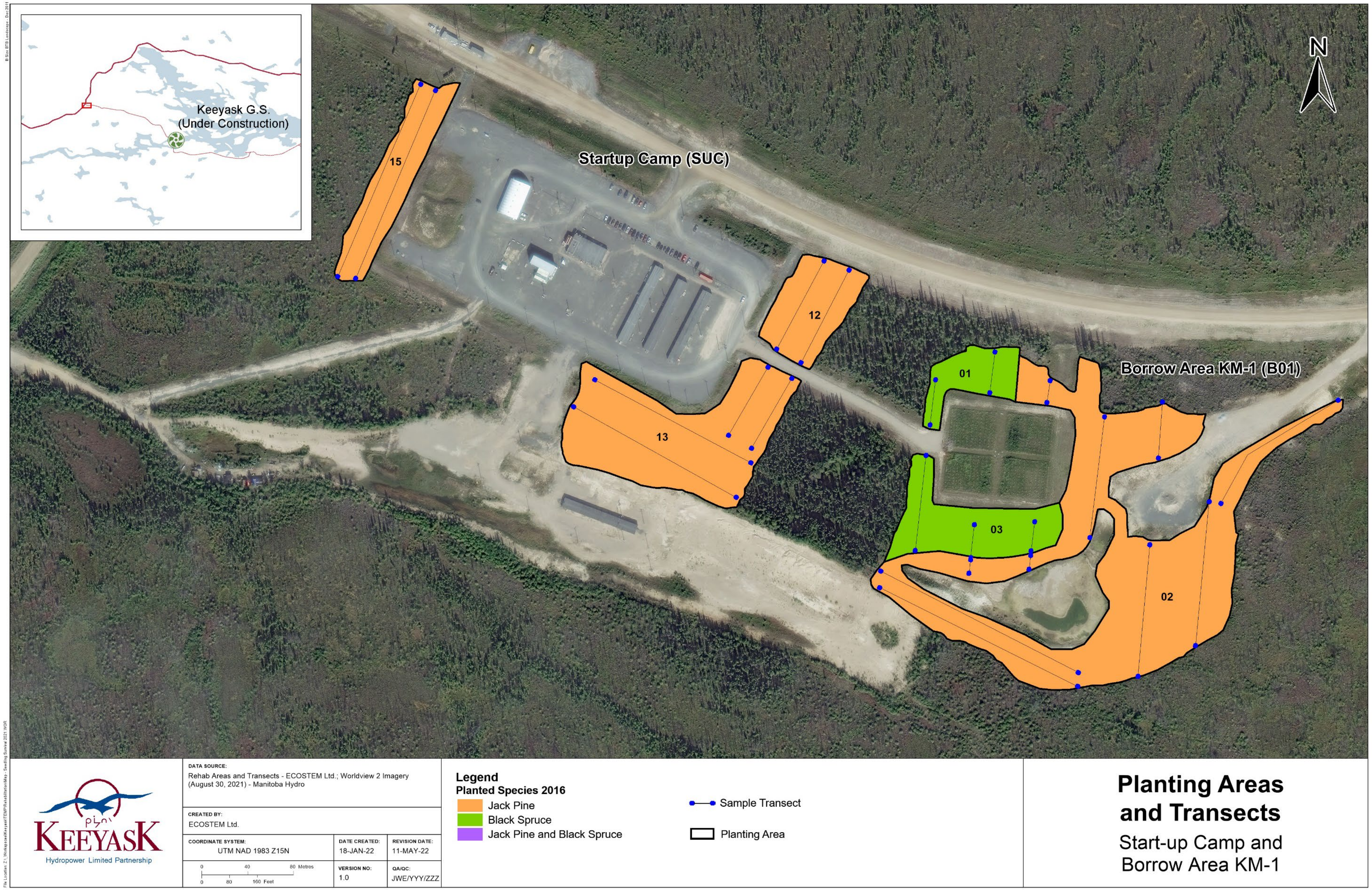
Planted jack pine in Borrow Area KM-4

Mixture of naturally regenerating (foreground) and planted (background) jack pine in Borrow Area KM-4

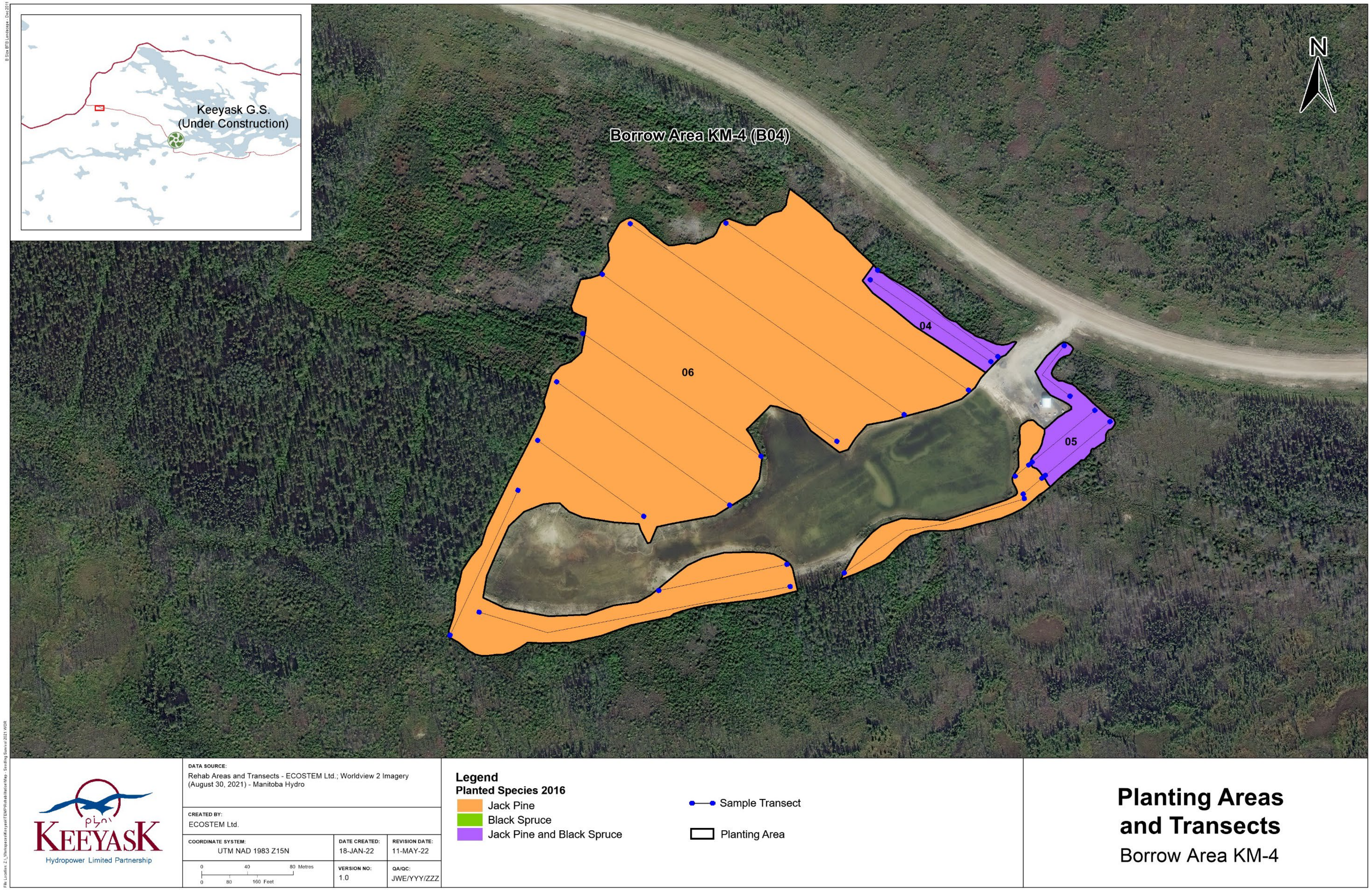
Black spruce planting area in Borrow Area KM-1

Naturally regenerating black spruce with planted jack pine in Borrow Area KM-4

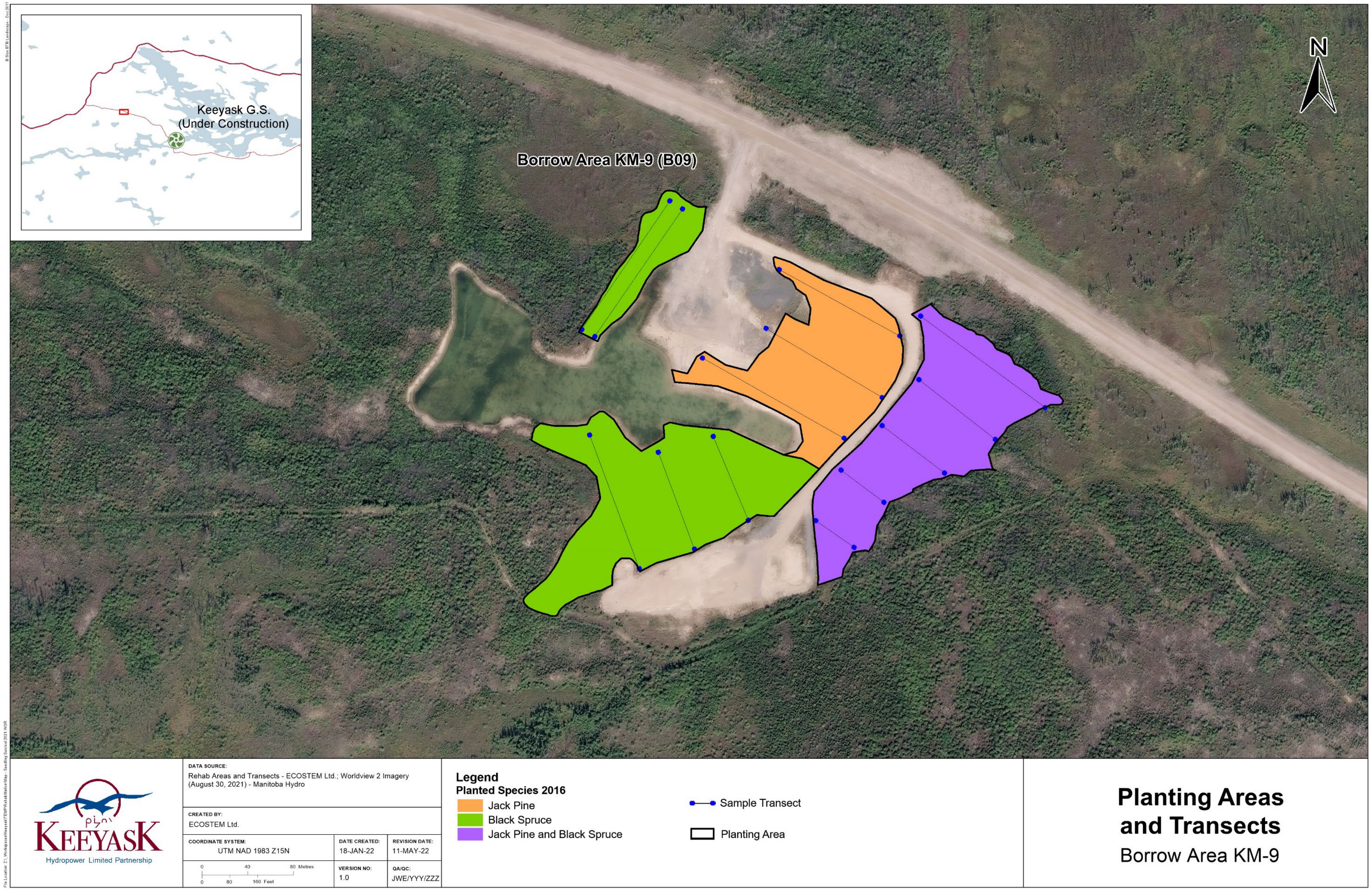
Figure 3-2: Examples of different types of regeneration observed in planting areas in 2017



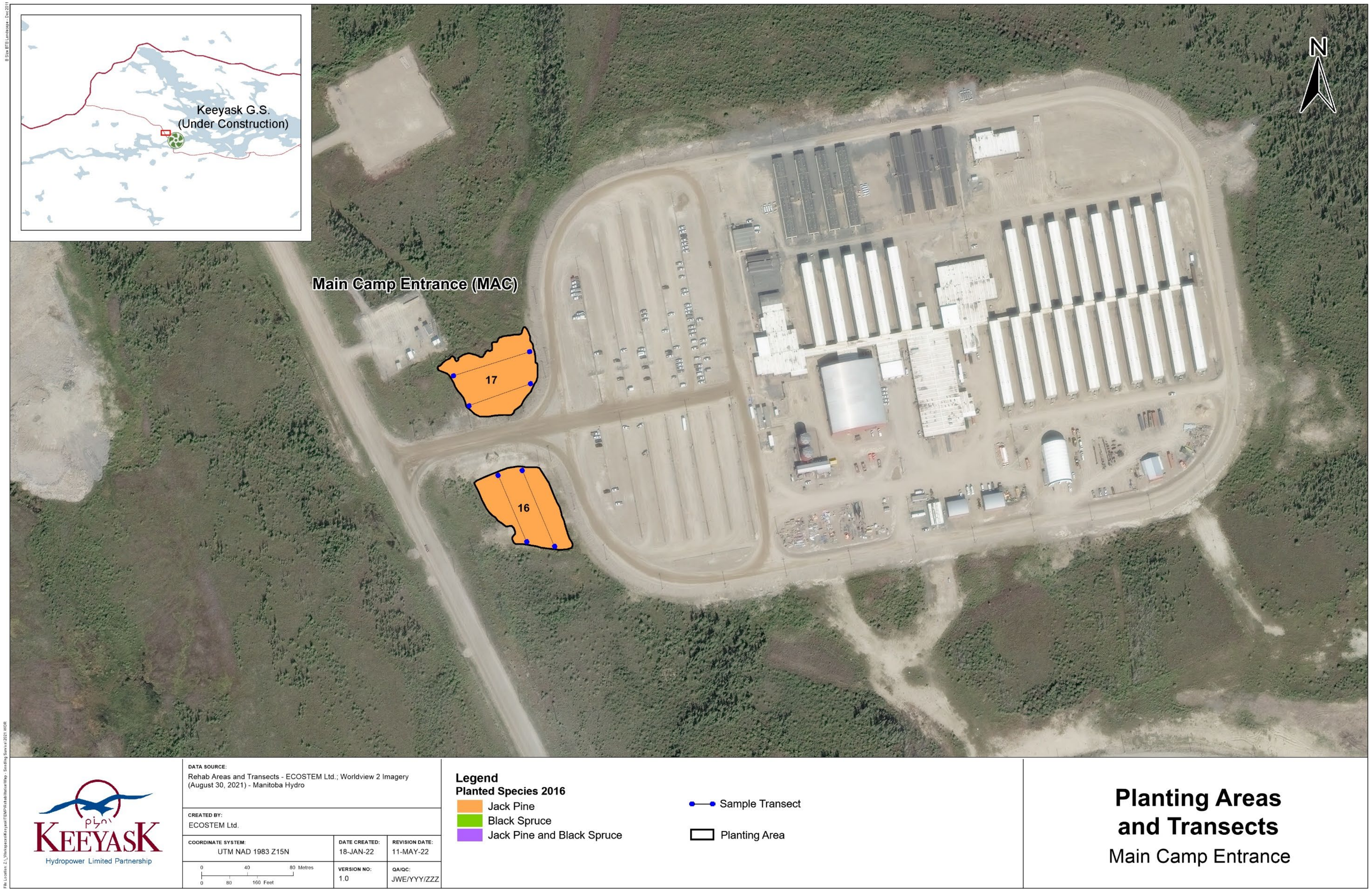
Map 3-1: Locations of rehabilitation planting areas and transects for 2021 sampling near Start-up Camp and Borrow Area KM-1



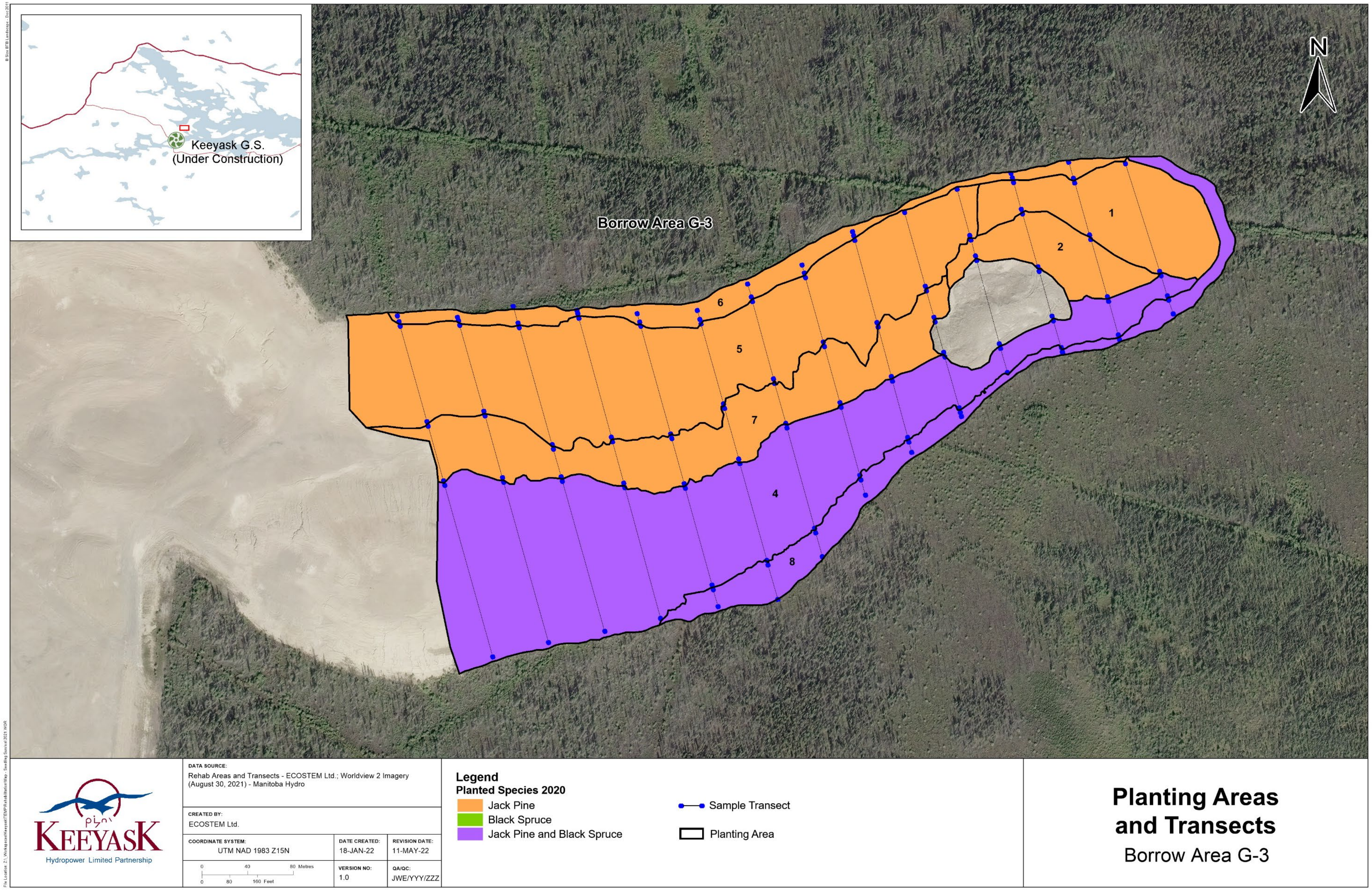
Map 3-2: Locations of rehabilitation planting areas and transects for 2017 sampling in Borrow Area KM-4.



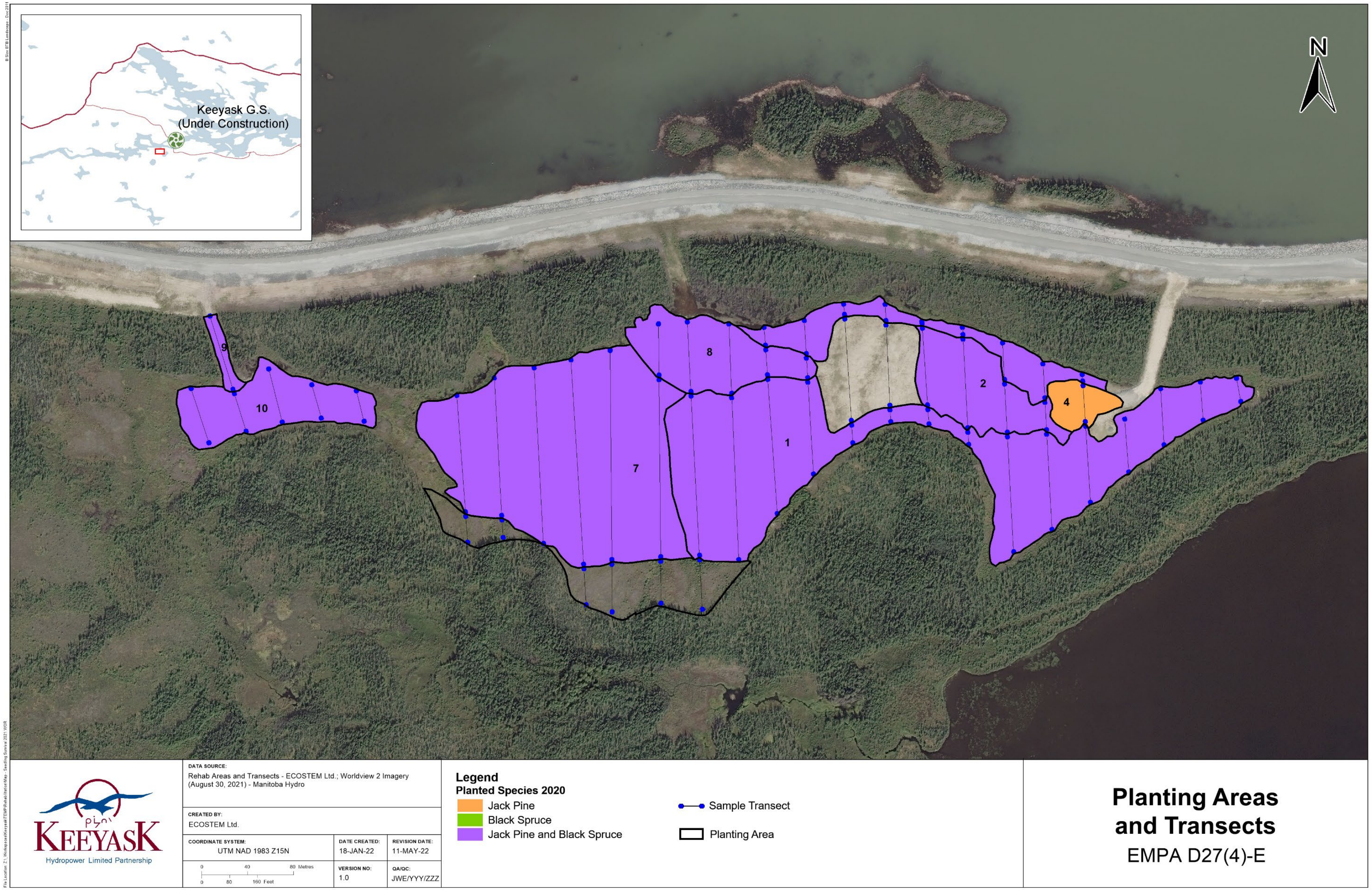
Map 3-3: Locations of rehabilitation planting areas and transects for 2017 sampling in Borrow Area KM-9.



Map 3-4: Locations of rehabilitation planting areas and transects for 2017 sampling at the Main Camp entrance.



Map 3-5: Locations of rehabilitation planting areas and transects for 2021 sampling at Borrow Area G-3.



Map 3-6: Locations of rehabilitation planting areas and transects for 2021 sampling at EMPA D27 (4)-E.

3.3.3 DATA ANALYSIS

3.3.3.1 REHABILITATION IMPLEMENTATION

Planned planting densities were compared to the estimated actual stem densities from the transect data to assess whether the planting was carried out as planned. For each rehabilitation location, transect data were pooled. If trees were planted for more than one planned density in a rehabilitation location, transects planted at the same density were pooled. For areas planted in 2016, the 2017 data were used, and for areas planted in 2020, the 2021 data were used. Only the planted seedlings, whether living or dead, were considered (i.e., natural regeneration was ignored).

A planned planting stem density was considered achieved if the lower end of the 95% confidence interval of the sample mean stem density met or exceeded the planned density. A one-tailed t-test in R (R Core Team 2021) was used to compare the transect mean total planted stem densities to the planned stem densities. To consider the rehabilitation as meeting the planned density, the mean stem density must be significantly greater than the planned stem density minus one (e.g., 10,000 – 1 = 9,999 stems/ha), at $\alpha = 0.05$. A Shapiro-Wilk test was used to check for violations of normality in the transect data. If the assumption of normality was violated, the t-test result was still considered interpretable provided the number of samples (transects) was at least 30. If that criterion was not met, the non-parametric one-sample Wilcoxon signed rank test was used.

4.0 RESULTS

4.1 TRAIL BLOCKING AND REHABILITATION

For the 47 trails included, monitoring data found no change in vegetation regeneration status or trail blocking measures since 2017. Also, there was no additional Project-related disturbance or clearing in any of the monitored trails (see Photo 4-1).

Signs of recent activity were present along two trails in 2021 (Table 4-1). In both cases, the activity was recent ATV use. This activity was not Project-related.

One of these trails is connected to the clearing at the south side of the Start-up Camp (Photo 4-2). Signs of recent use extended approximately 75 m along the trail, then continued along a fork leading south to a lake (Figure 4-1). The other trail extends northwest from the north end of Borrow Area G-5 (Photo 4-3), which is outside of the North Access Road security gate, on the opposite side of Highway 280. This trail appears to be connected to a well-established network of trails.

Table 4-1: Condition of surveyed trails in 2021

Trail Condition	Number of Trails	Percent of Trails
Blocked	2	4
Tree planting	0	0
Signs of recent activity[1]	2	4
Natural tree and/or tall shrub regeneration	36	77
Natural tree regeneration	28	60
Natural tall shrub regeneration	28	60
Burned in 2013	26	55
Total trails surveyed	**47**	**-**

Notes: [1] Recent activity other than Project clearing or disturbance.

Figure 4-1: Recent activity along Trail 41 attached to the Start-up Camp

Photo 4-1: Trail with advanced regeneration leading off the NAR.

Photo 4-2: Trail off of the Start-up Camp with evidence of recent activity on the south fork (towards the left of the photo).

Photo 4-3: Trail north of Borrow Area G-5 with signs of use.

4.2 VEGETATION REGENERATION

4.2.1 ALL TEMPORARY PROJECT AREAS

The temporary Project areas encompassed 1,138 ha and included the cleared portion of the access road rights-of-way (but not including the roadbed), borrow areas, excavated material placement areas (EMPAs), and camp and work areas not required for Project operation (Map 4-1).

Just over half (52%) of the mapped area was vegetated (including both planted/seeded areas and naturally revegetating areas) as of September 2021 (Table 4-2). The Moderate vegetation cover class was the most widespread class, at 30%. High and Sparse vegetation covered 13% and 9%, respectively.

Table 4-2: Vegetation cover by class as percentage of the total area

Vegetation cover	Area (ha)	Percentage of Area (%)
Barren	542.3	48
Sparse	103.7	9
Moderate	339.0	30
High	152.7	13
Total Area	*1,137.8*	*100*

4.2.2 ACCESS ROADS

Vegetation cover was mapped for 362.3 ha of area along the Project access roads, including 140.8 ha for the NAR (Map 4-1) and 221.5 ha for the SAR (Map 4-2).

Overall, 19% of the mapped access road area was determined to be barren (i.e., less than 10% vegetation cover) as of September 2021 (Table 4-3). The Moderate cover class had the highest coverage of all classes, with 47%, followed by the High class at 24%. In total, 71% (257.2 ha) of the entire access road was found to have moderate to high vegetation coverage.

Along the NAR, 75% of the surveyed area had moderate to high vegetation cover. Only 8% of the NAR survey area had sparse vegetation, while 17% was barren. In general, the sparse or barren areas were located adjacent to the roadbed, or other permanent infrastructure. The exceptions were a large portion of the ditch near Borrow Area KM-9 and the road to the Cemetery site (Photo 4-4), the ditch opposite the entrance to the well road and some areas around the work area entrances.

For the SAR, 69% of the mapped area had moderate to high vegetation coverage. Eleven percent of the area was sparse and 20% was barren. The sites that were sparse or barren were mostly associated with older infrastructure, such as the decommissioned Butnau Road (Photo 4-5). The remaining sparse or barren areas were generally found to cover large portions of the entire ditch intermittently along the road, rather than occurring continuously along the side of the roadway.

Table 4-3: Vegetation cover along the North and South Access roads as percentage of the total area by cover class

Footprint Component	Area (ha)	Vegetation Cover Class (% of total)			
		Barren	Sparse	Moderate	High
North Access Road	140.8	17	8	41	34
South Access Road	221.5	20	11	51	18
Total	*362.3*	*19*	*10*	*47*	*24*

Photo 4-4: Wide area barren of vegetation (left hand side), surrounded with moderate to high cover, along the NAR near the road to the Cemetery site.

Photo 4-5: Areas of barren, sparse, moderate and high vegetation cover on the old Butnau road along the SAR.

4.2.3 REMAINING TEMPORARY AREAS

The remaining temporary areas encompassed 773.8 ha (Map 4-1 to Map 4-4). Overall, 61% (472.6 ha) of this total area was barren (i.e., less than 10% total cover; Table 4-4). For the areas that were not barren, vegetation cover was mostly moderate or high (i.e., 78% of the 301.2 ha). Most of the Moderate to High cover classes were comprised of the Low Shrub and/or Graminoid and/or Bryoid vegetation structure type (Table 4-4).

The Low Shrub and/or Graminoid and/or Bryoid vegetation structure type was the dominant vegetation structure type, covering 234.2 ha (30%) of the remaining temporary areas. Tall shrub vegetation type covered 30.8 ha (4%). Unclassified Young Regeneration, Sparsely Treed/ Tall Shrub, Sparsely Treed and Woodland structure types all covered less than 11 ha (less than 1% of the total area). The other vegetation structure types encountered in the remaining temporary areas were Woodland/ Tall Shrub, Emergent and Forest.

Table 4-4: Vegetation structure by cover class for temporary areas except for access roads

Vegetation Structure	Vegetation Cover Class (ha)				Total Area (ha)
	Barren	Sparse	Moderate	High	
None	472.6	0.0	0.0	0.0	472.6
Woodland	0.0	0.0	3.8	3.4	7.2
Woodland/ Tall Shrub	0.0	0.0	0.0	0.4	0.4
Emergent	0.0	0.1	0.2	0.3	0.5
Low Shrub and/or Graminoid and/ or Bryoid	0.0	66.4	129.6	38.1	234.2
Sparsely Treed	0.0	0.3	1.6	5.9	7.7
Sparsely Treed/ Tall Shrub	0.0	0.1	5.6	3.0	8.8
Tall Shrub	0.0	0.1	17.2	13.4	30.8
Unclassified Young Regeneration	0.0	0.6	10.0	0.4	10.9
Forest	0.0	0.0	0.0	0.8	0.8
Total	472.6	67.7	168.0	65.6	773.8

4.2.3.1 FOOTPRINT COMPONENTS

Borrow areas represented the largest portion (517.6 ha) of the remaining footprint areas. The most common structure type was None, comprising 65.3% of the total area (Table 4-5). Low shrub/graminoid/bryoid vegetation structure covered 26.7% of the area. Tall shrub (3.9%) and unclassified young regeneration (1.9%) accounted for a small amount of the borrow areas, and the remaining vegetation structure types together accounted for 2.3% of the area.

Large areas of barren and sparse vegetation were found in most of the borrow areas (Table 4-6), except in portions that had been cleared, but were never actually used. This was the case in the western portion of Borrow Area G-1 and the southwest portion of Borrow Area S-2a (Photo 4-6). Fewer large barren or sparse areas were recorded in the older borrow areas, such as Borrow Area KM-1.

The camp areas, which included the Start-up Camp (SUC) and the Main Camp (MAC), encompassed a total of 18.3 ha. Low shrub/graminoid/bryoid was the most common vegetation type, at 40.3% of the camp area, followed by None at 27.4%. Sparsely treed/tall shrub, Woodland, Tall shrub and Sparsely treed represented 16.2%, 9.7%, 4.0% and 2.0%, respectively. Emergent was the only other type encountered, at less than 1%. The sparse and barren areas within the camps were mainly found in the large excavated area south of the SUC (Photo 4-7), and along the edges of the permanent roadways and infrastructure.

The EMPAs covered an area of 157.7 ha. The most common vegetation structure type identified in the EMPAs was None (62.9%), followed by the low shrub/graminoid/bryoid type at 32.9%. Tall shrub, sparsely treed, sparsely treed/tall shrub, emergent and woodland all represented less than 2.5% of the EMPA area. The highly vegetated EMPAs were mainly found along the north dike (Photo 4-8), and in areas that were cleared, but not actually used, such as the southern portion of EMPA D12(1)-E, or parts of the central and western end of EMPA D27(4)-E.

The portage route, consisting of the boat launch areas along the north dike (Photo 4-9) and east of the main work areas, covered 2.2 ha. Nearly half of this area was covered by low shrub/graminoid/bryoid (46.7%). The remaining area was barren (26.7%), tall shrub (19.7) or woodland (6.9%).

Work areas covered 78 ha. Low shrub/graminoid/bryoid and none vegetation structure types accounted for 45.6% and 38.5%, respectively. Tall shrub, sparsely treed, woodland and unclassified young regeneration each accounted for between 1% and 10% of the work area coverage. Sparsely treed/tall shrub and emergent together accounted for less than 1% of the area. The barren and sparse portions of the work area were found mainly in portions of Work Area A and Work Area C. The portions of Work Area A that were cleared and not used were generally covered by moderate to high vegetation cover (Photo 4-10). Small portions of the well road ditch had sparse vegetation, however the majority had moderate to high cover.

Table 4-5: Vegetation structure by footprint type

Footprint type	Total Area (ha)	Vegetation structure (% of Footprint type area)									
		None	Woodland	Woodland / Tall Shrub	Emergent	Low Shrub and/or Graminoid and/ or Bryoid	Sparsely Treed	Sparsely Treed/ Tall Shrub	Tall Shrub	Unclassified Young Regeneration	Forest
Borrow Area	517.6	65.3	0.6	0.1	0.0	26.7	0.5	0.9	3.9	1.9	0.1
Camp	18.3	27.4	9.7	0.0	0.2	40.3	2.0	16.2	4.0	0.0	0.0
EMPA	157.7	62.9	0.1	0.0	0.1	32.9	1.3	0.5	2.3	0.0	0.0
Portage Route	2.2	26.7	6.9	0.0	0.0	46.7	0.0	0.0	19.7	0.0	0.0
Work Area	78.0	38.5	2.5	0.0	0.3	45.9	3.3	0.6	7.4	1.5	0.0
Total	773.8	61.1	0.9	0.1	0.1	30.3	1.0	1.1	4.0	1.4	0.1

Table 4-6: Vegetation cover by footprint type

Footprint type	Total Area (ha)	Vegetation cover (% of Footprint type area)			
		10	25	75	100
Borrow Area	517.6	65.3	8.1	21.1	5.5
Camp	18.3	27.4	9.9	31.3	31.4
EMPA	157.7	62.9	11.7	15.2	10.2
Portage Route	2.2	26.7	18.4	26.8	28.0
Work Area	78.0	38.5	6.3	36.5	18.7
Total	773.8	61.1	8.7	21.7	8.5

Photo 4-6: Cleared, but vegetated (foreground) and barren portions of Borrow Area S-2a.

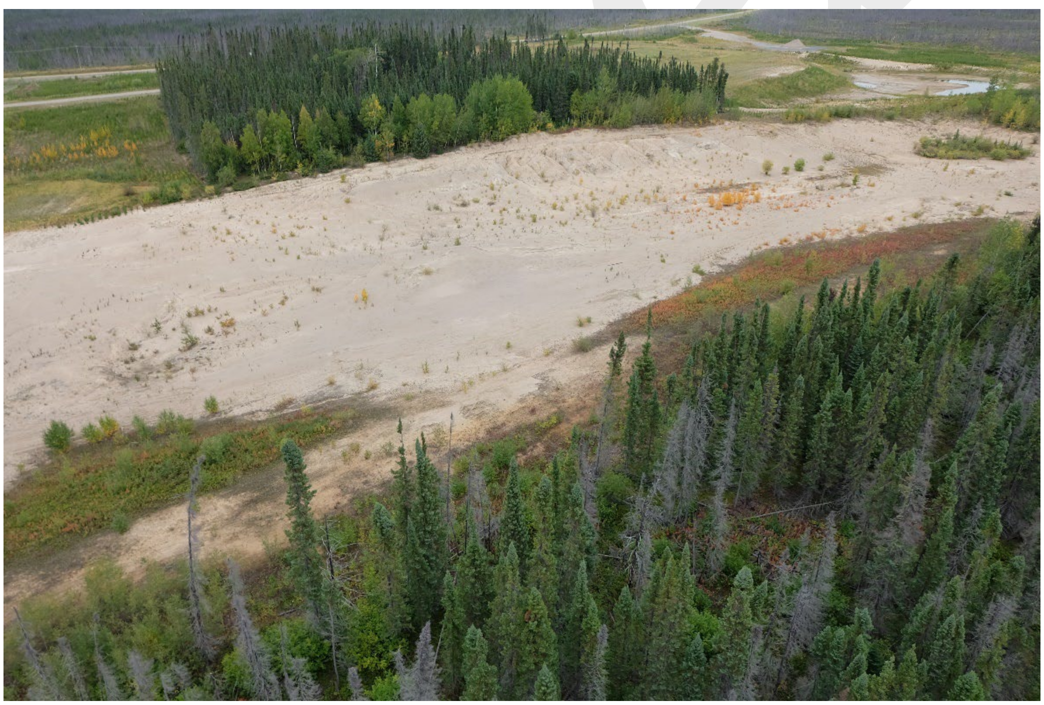


Photo 4-7: Barren areas in the excavated area of the SUC.

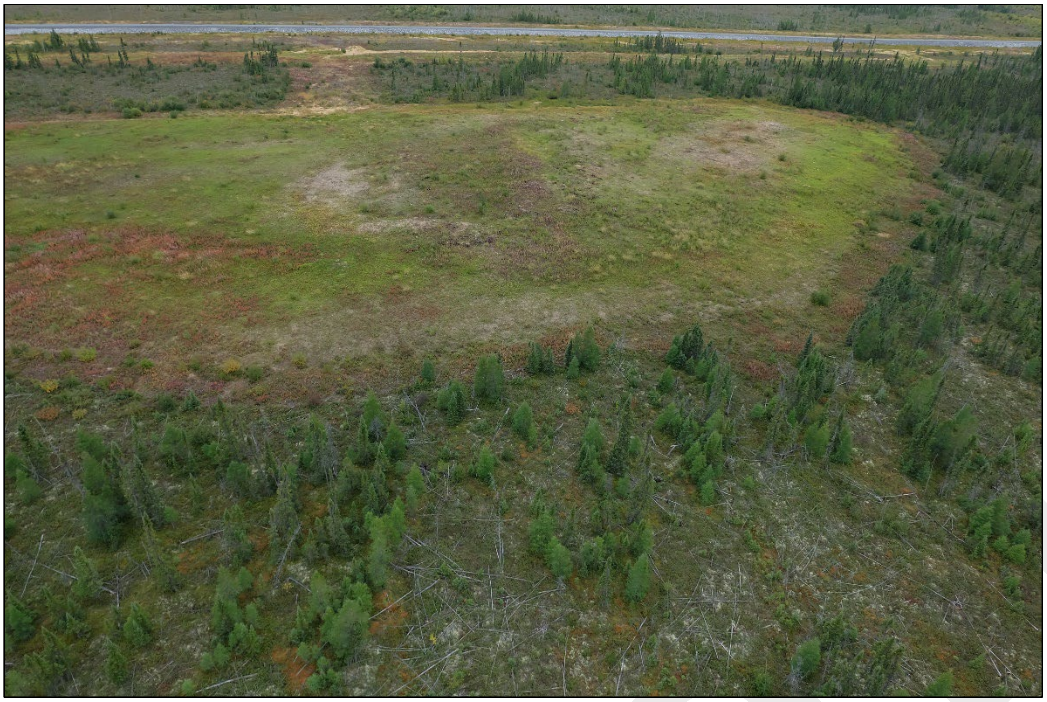
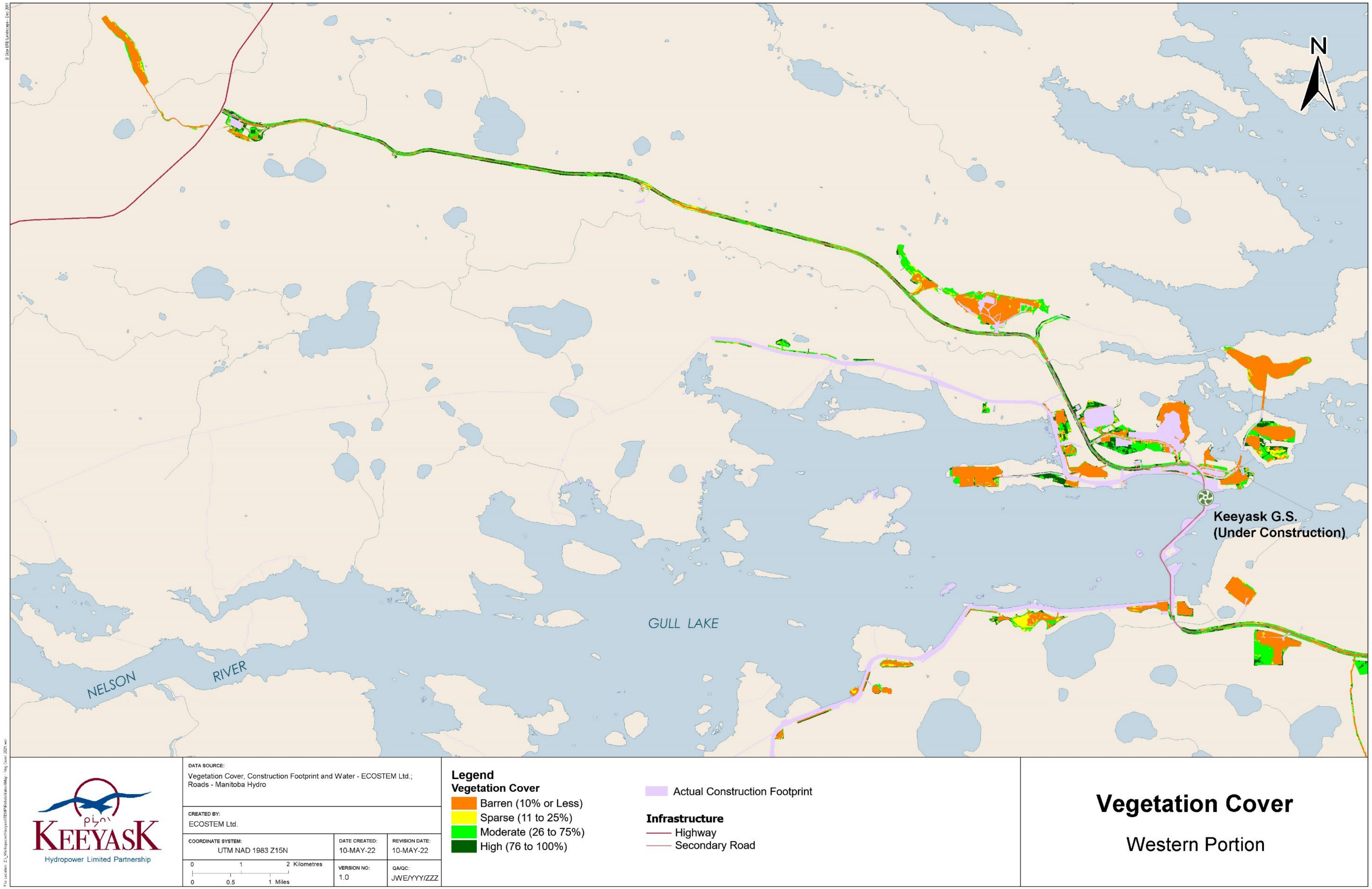


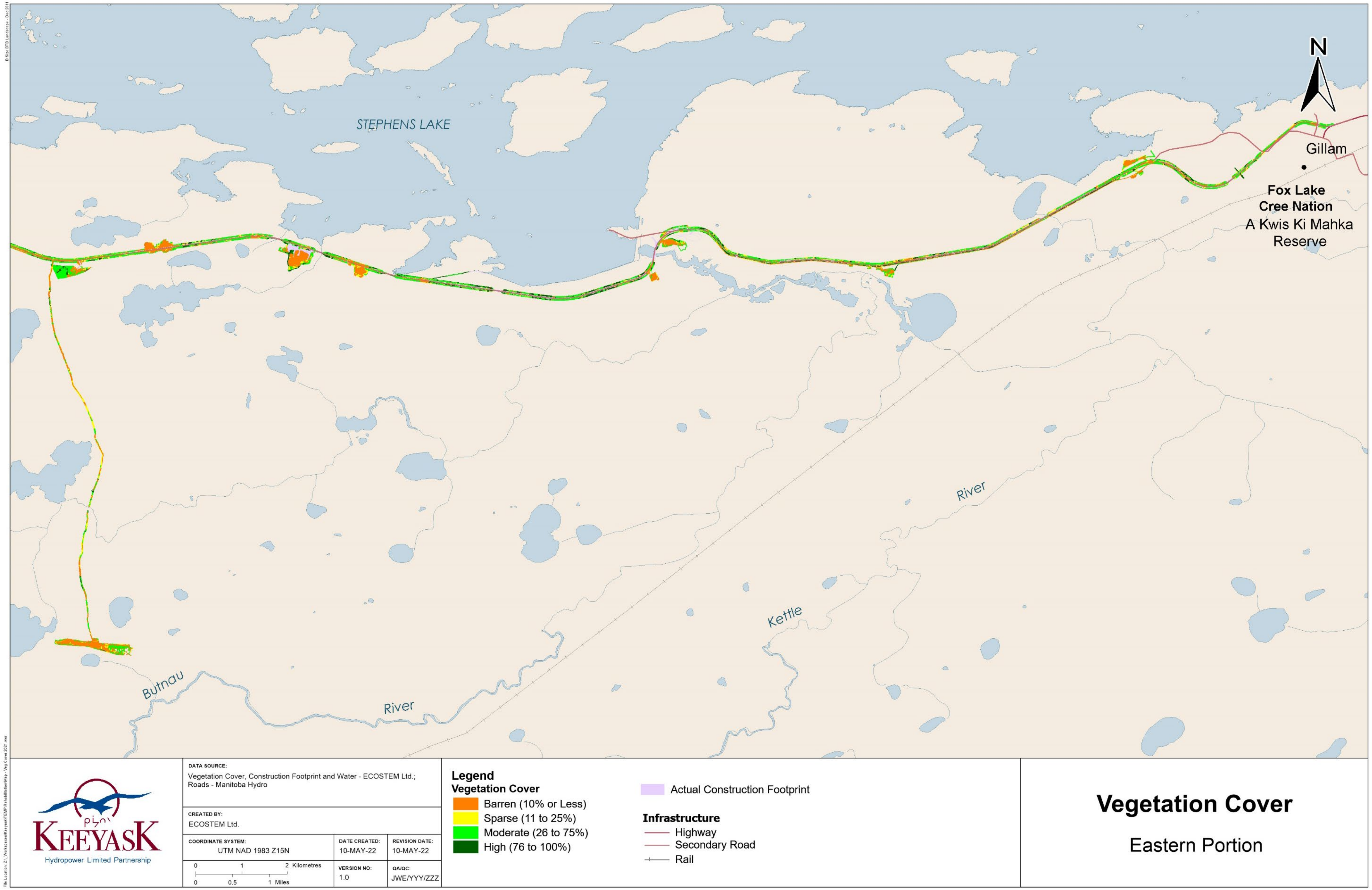
Photo 4-8: Vegetated EMPA D3-E along the North Dike.

Photo 4-9: Portage route area on the North Dike, showing surrounding areas with barren and sparse vegetation.

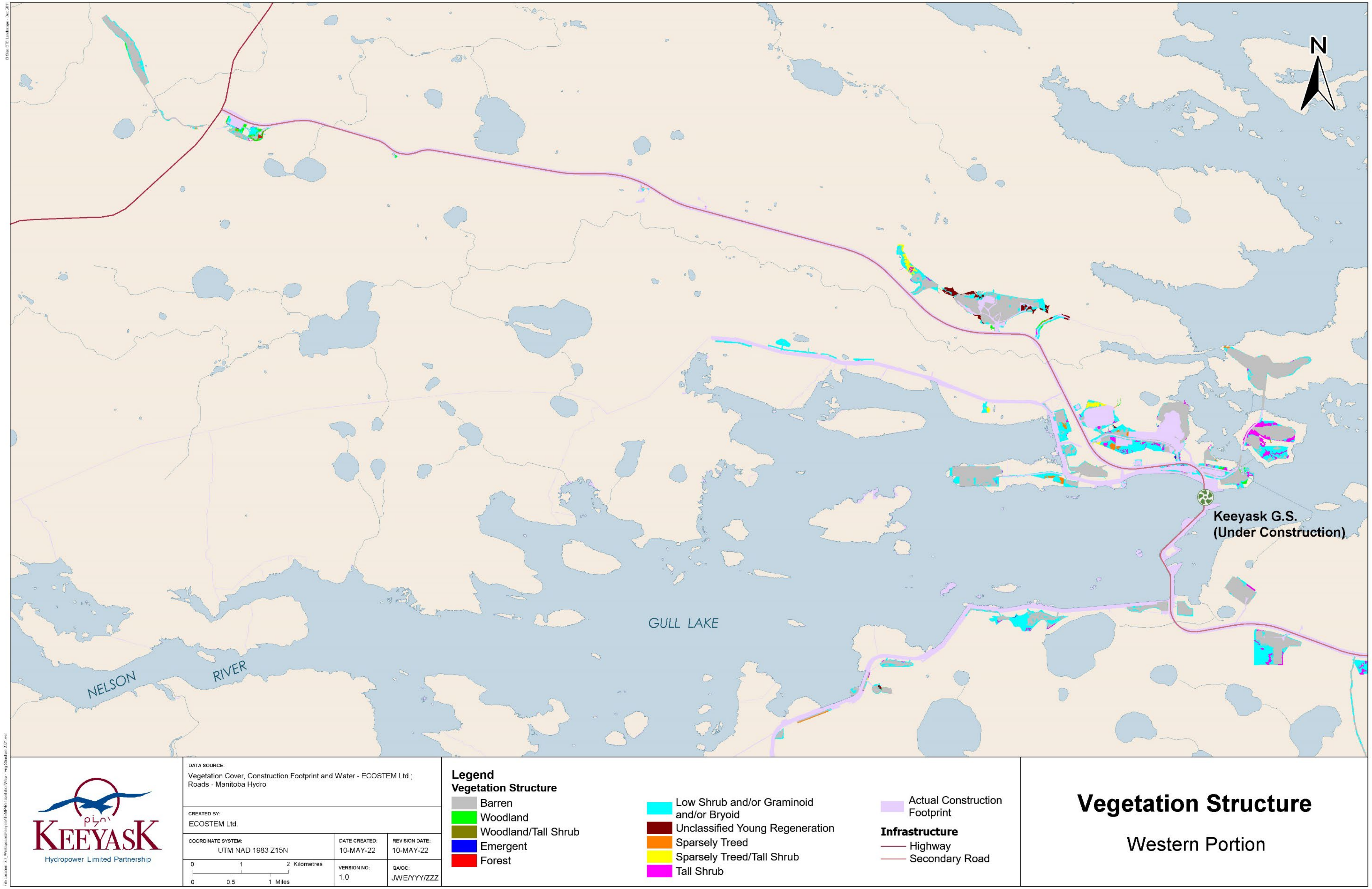
Photo 4-10: Work area A, showing barren and moderately to highly vegetated areas.



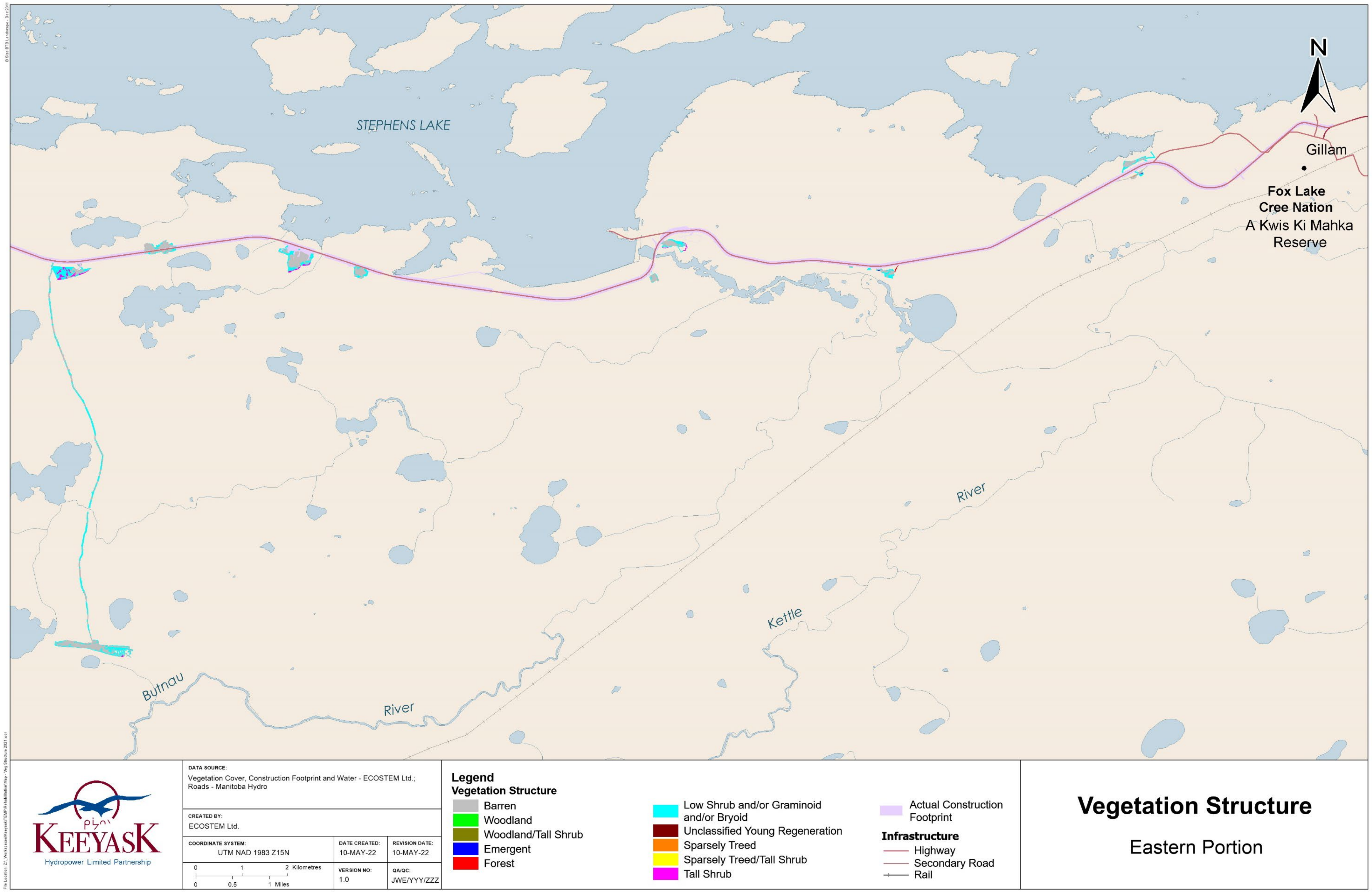
Map 4-1: Vegetation cover in the western portions of the Construction Footprint as of September 2021



Map 4-2: Vegetation cover in the eastern portions of the Construction Footprint as of September 2021



Map 4-3: Vegetation structure in the western portions of the temporary Project areas as of September 2021



Map 4-4: **Vegetation structure in the eastern portions of the temporary Project areas as of September 2021**

4.2.4 SEEDING AREAS

Based on visible vegetation and evidence of site preparation in the 2021 photos, the total estimated area seeded with native grasses in 2020 was 10.99 ha (Table 4-7). Approximately 7.12 ha was seeded in Borrow Area B-3, and 3.86 ha in Borrow Area Q-9. Because precise extents of the seeded areas were not available, it was difficult to determine the actual boundaries of some of the seeded areas in Borrow Area Q-9. Approximately 48% of the area mapped in Borrow Area Q-9 was classified as being uncertain with respect to actual seeding area. Areas that were uncertain were mainly areas close to the edge of the steep rock quarry banks, in areas that appeared to have a large amount of natural vegetation growth, in areas outside of the Transmission Line ROW or in other areas where it was difficult to determine from aerial photography if site preparation had occurred. All of these areas are included in the results below, except for the large portion located on the south side of the Borrow Area, outside of the Transmission Line ROW.

Overall, 57.7% of the seeded area had at least sparse vegetation cover as of September 2021, and 34.5% of the seeded area had moderate to high cover (Table 4-7).

In Borrow Area B-3 (Photo 4-11), just over half (54.4%) of the seeded area was vegetated, with 35.1% of the area having at least moderate cover (Table 4-7). Proportionately, seeding areas 4 and 2 had the highest amount of moderate cover, while most of the vegetated area in SA-1 had sparse cover.

In Borrow Area Q-9, 63.7% of the seeded area was vegetated, with 33.4% of the area having at least moderate cover (Table 4-7). In SA-2, 4.4% of the area had high vegetation cover. Less than half (42.6%) of SA-1 was vegetated, most of which was sparse cover.

Graminoid cover was the dominant type in all the seeding areas (Table 4-8). Low shrub vegetation was the only other dominant cover type in the seeded areas. That type occurred in Borrow Area Q-9, SA-2, where it comprised 2% of the vegetated area.

Table 4-7: Vegetation cover as a percentage of total area in the seeded portions of the 2020 rehabilitation locations

Location	Seeding Area	Area Seeded (ha)	Percent in Vegetation Cover Class			
			High	Moderate	Sparse	Barren
Borrow Area B-3	1	0.38	-	9.1	34.2	56.8
	2	0.99	-	36.8	18.3	44.9
	3	1.22	-	24.3	17.1	58.6
	4	4.54	-	39.8	18.9	41.3
	Total	7.12	-	35.1	19.3	45.6
Borrow Area Q-9	1	0.21	-	18.1	24.5	57.4
	2	3.66	4.4	29.8	30.6	35.1
	Total	3.86	4.2	29.2	30.3	36.3
All areas		10.99	1.5	33.0	23.2	42.3

Table 4-8: Vegetation cover type as a percentage of total area with vegetation cover in the seeded portions of the 2020 rehabilitation locations

Location	Seeding Area	Vegetated Area (ha)	Percent in Vegetation Cover Type	
			Graminoid	Low Shrub
Borrow Area B-3	1	0.17	100.0	-
	2	0.54	100.0	-
	3	0.50	100.0	-
	4	2.66	100.0	-
	Total	3.88	100.0	-
Borrow Area Q-9	1	0.09	100.0	-
	2	2.37	97.8	2.2
	Total	2.46	97.9	2.1
All Areas		6.34	99.2	0.8

Photo 4-11: Seeded area regeneration in B-3.

4.3 TREE PLANTING AREAS

4.3.1 PRESCRIPTION IMPLEMENTATION

A Shapiro-Wilk test found that the planted stem densities met the assumption for normality in all rehabilitation locations except for Borrow Area B-3 and EMPA D27(4)-E. For these exceptions, the t-test results were still used as the total number of transects exceeded 30 in each area.

Results from the 2017 transect data indicated that plantings in 2016 likely occurred as planned. The estimated mean live and dead stem density was at or above the planned density (95% confidence interval) in all 2016 rehabilitation locations except for Borrow Area KM-9 (Table 4-9). In Borrow Area KM-9, the mean stem density in areas planned for planting at 2,500 stems/ha was 3,587 stems/ha, but this was not significantly higher than 2,499 stems/ha at $\alpha = 0.05$.

In the 2020 rehabilitation locations (Borrow Area B-3 and EMPA D27(4)-E), the estimated mean planted stem densities were 2,293 and 2,700 stems/ha, respectively (Table 4-9).

Table 4-9: Planned and estimated actual planted stem densities in the 2016 and 2020 rehabilitation locations one year after planting

Location	Number of Transects[1]	Mean Density (stems/ha)[2]	Standard Deviation
Borrow Area KM-1	**5**	**3,666**	709
	10	**14,046**	3,669
Borrow Area KM-4	**17**	**14,218**	2,734
Borrow Area KM-9	**5**	3,587	1,196
	8	7,712	5,901
Main Camp Entrance	**4**	**14,509**	1,684
Near the Start-up Camp	**8**	**12,508**	1,921
Borrow Area G-3	61	2,293	1,851
EMPA D27(4)-E	45	2,700	1,619

Notes: [1] Bolded values indicate the data associated with the transects met the assumption of normality. [2] Bolded values indicate mean is significantly greater than 2,499 stems/ha at $\alpha = 0.05$ using a one-tailed t-test.

4.3.2 TREE REGENERATION STATUS IN 2021

4.3.2.1 AREAS PLANTED IN 2016

4.3.2.1.1 CONDITIONS IN 2021

The two planting areas that had total jack pine and black spruce live stem density lower than 2,500 stems/ha in 2021 were Planting Area 1 (PA-1) in Borrow Area KM-1 and PA-10 in Borrow Area KM-9 (Table 4-10).

Live stem densities for planted and naturally regenerating jack pine averaged 11,441 stems/ha and ranged from 1,923 stems/ha to 15,037 stems/ha as of 2021 (Table 4-10). The areas that had the highest stem densities were PA-2 in Borrow Area KM-1 (15,037 stems/ha), and PA-12 (14,872 stems/ha) and PA-13 (14,126 stems/ha) near the Start-up Camp.

Table 4-10: Jack pine and black spruce live stem average density and standard deviation (in brackets) as of September 2021 for areas planted in 2016, by planting area

Location	Planting Area	Number of Transects	Average Density (stems/ha)	
			Black Spruce	Jack Pine
Borrow Area KM-1	1	2	**2,034 (305)**	-
	2	10	20 (64)	**15,037 (3,668)**
	3	3	**2,916 (36)**	-
Borrow Area KM-4	4	2	**2,030 (2,817)**	**11,722 (3,179)**

Location	Planting Area	Number of Transects	Average Density (stems/ha)	
			Black Spruce	Jack Pine
	5	3	**2,240 (1,631)**	**10,739 (2,736)**
	6	12	524 (1,673)	**12,430 (1,728)**
Borrow Area KM-9	7	5	**5,920 (7,044)**	**1,923 (2,570)**
	8	3	23 (40)	**12,414 (1,040)**
	9	3	**3,212 (999)**	430 (391)
	10	2	**1,936 (111)**	-
Main Camp Entrance	16	2	-	**11,242 (1,198)**
	17	2	-	**9,966 (1,671)**
Near the Start-up Camp	12	2	581 (667)	**14,872 (489)**
	13	4	418 (552)	**14,126 (1,539)**
	15	2	8,203 (8,742)	**11,377 (170)**

Notes: [1]Bolded species indicate a planned species for the given planting area. Corresponding densities occur through natural regeneration.

Black spruce live stem densities averaged 2,898 stems/ha across the planting areas, and ranged from 1,936 stems/ha to 5,920 stems/ha (Table 4-10). The planting areas with the highest densities were PA-07 and PA-09 (in Borrow Area KM-9). The highest average black spruce stem density was 8,203 stems/ha in PA-15 near the Start-up Camp. This density consisted entirely of naturally regenerating stems.

Jack pine stems that were definitely or possibly natural regeneration were identified in three planting areas. In PA-9 in Borrow Area KM-9 100% of jack pine stems were natural regeneration (Table 4-11). Average jack pine stem density in this planting area was low (430 stems/ha; Table 4-10). Naturally regenerating stems made up 54.4% of the live stem density in PA-15 near the Start-up Camp, and 0.8% of the live stem density in PA-2 in Borrow Area KM-1 (Table 4-11).

Black spruce stems that were definitely or possibly natural regeneration were identified in eight planting areas, at all rehabilitation locations except for the Main Camp entrance. Where present, the average percentage naturally regenerating stems ranged from 5.6% to 100% (Table 4-11).

Table 4-11: Average percent and standard deviation (in brackets) of naturally regenerating jack pine and black spruce stems as of September 2021 for areas planted in 2016, by planting area

Location	Treatment Area	Percent of Stems from Natural Regeneration	
		Black Spruce[1]	Jack Pine[1]
Borrow Area KM-1	1	5.6 (7.9)	-
	2	-	0.8 (2.7)
	3	0.0	-
Borrow Area KM-4	4	13.0	0.0
	5	33.3 (57.7)	0.0
	6	100.0	0.0
Borrow Area KM-9	7	24.3 (39.3)	0.0
	8	-	0.0
	9	0.0	100.0
	10	0.0	-
Main Camp Entrance	16	-	0.0
	17	-	0.0
Near the Start-up Camp	12	100.0	0.0
	13	100.0	0.0
	15	100.0	54.4 (62.6)

No stem mortality was observed for planted or naturally regenerating black spruce.

Jack pine stem mortality within the planting areas was quite low, ranging from 0% to 2.4% (Table 4-12). Stem mortality was the highest in the planting areas at the Main Camp entrance, followed by PA-13 near the Start-up Camp and PA-6 in Borrow Area KM-4 (0.7% each).

Table 4-12: Planted jack pine average percent stem mortality as of September 2021 for areas planted in 2016, by planting area

Location	Planting Area	Number of Transects	Average Percent Mortality[1]	Standard Deviation
Borrow Area KM-1	2	10	0.1	0.3
Borrow Area KM-4	4	2	0.0	0.0
	5	3	0.0	0.0
	6	12	0.7	1.7
Borrow Area KM-9	7	5	0.0	0.0
	8	3	0.0	0.0

Location	Planting Area	Number of Transects	Average Percent Mortality[1]	Standard Deviation
Main Camp Entrance	16	2	2.4	1.7
	17	2	2.2	1.1
Near the Start-up Camp	12	2	0.0	0.0
	13	4	0.7	1.2
	15	2	0.3	0.4
All Locations		47	0.5	1.1

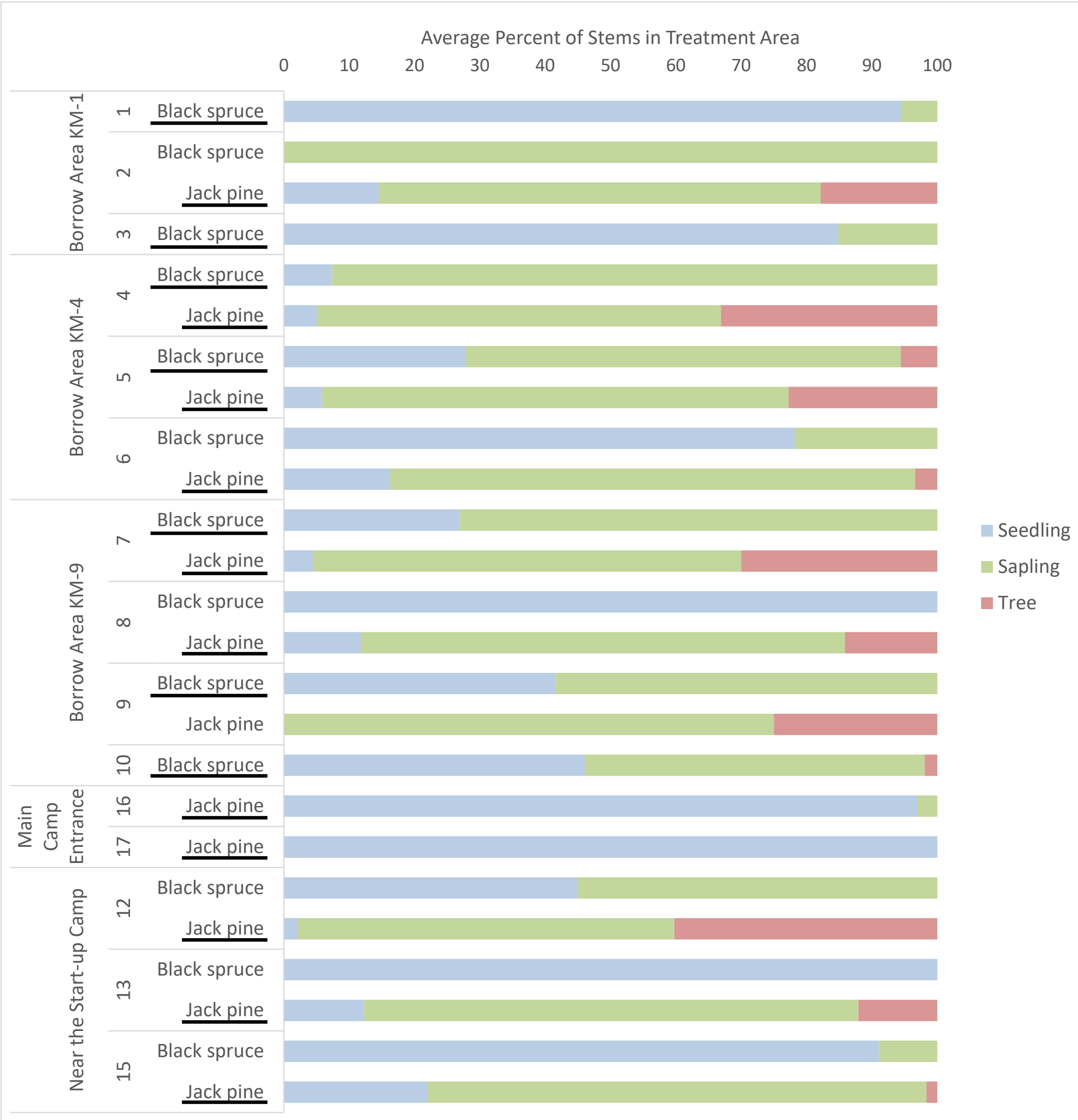
Notes: [1]Percent mortality of each transect averaged over the total number of transects in the planting area with planted jack pine

The dominant vigour class for jack pine stems was 6 (healthy), with 50% of all tallied stems falling into that class. Vigour class 5 (mostly healthy with a few dead needles) made up an additional 43% of tallied stems. Less than one percent of the stems tallied had a vigour class of 2 (almost dead) or less.

The dominant vigour class for black spruce stems was 6 (92% of all tallied stems), followed by vigour class 5 with 6%. When considering only planted stems, vigour class 6 made up 83% of the tallied stems, and vigour class 5 made up 14%. None of the tallied black spruce stems were vigour class 2 or less.

Average tree height varied across the planting areas and species. In planting areas where jack pine was a planned species, the average percent of jack pine stems in the seedling height class ranged from 2.2% to 100%, 0% to 80.3% in the sapling height class, and 0% to 40.3% in the tree height class (Figure 4-2). The percentage of stems that were seedlings was highest by far in both planting areas at the Main Camp entrance (100% and 97% of tallied trees). Stems with the highest average percent in the tree size class were tallied in PA-12 near the Start-up Camp (40.3%), PA-4 in Borrow Area KM-4 (33.1%) and PA-7 in Borrow Area KM-9 (30.0%). Saplings were the dominant size class in all jack pine planting areas, except for the two at the Main Camp entrance.

The average percent of black spruce stems in the seedling height class ranged from 7.4% to 94.4%, from 5.6% to 92.6% in the sapling height class, and from 0% to 5.6% in the tree class (Figure 4-2). Saplings were the dominant height class in all the areas planted with black spruce, except for the two (PA-1 and PA-3) in Borrow Area KM-1, where most of the tallied stems (94.4% and 84.8%, respectively) were seedlings.



Note: Underlined species indicate planned species for the given planting area.

Figure 4-2: Average percent of stems in different height classes by planting area and species

4.3.2.1.2 CHANGES BETWEEN 2017 AND 2021

Between 2017 and 2021, average jack pine stem density increased in some planting areas and decreased in others. Average stem density increased in all the planting areas near the Start-up Camp. The largest was in PA-12, from 12,031 to 14,872 stems/ha, an increase of 23.6% over

2017 density (Table 4-13). Treatment areas PA-13 and PA-15 had increases of 8.2% and 4.6%, respectively. Jack pine stem density also increased by 17.3% in Borrow Area KM-4 PA-5, by 16.9% in Borrow Area KM-9 PA-7, and by 7.9% in Borrow Area KM-1 PA-2.

Average jack pine stem density decreased in the remaining planting areas where it was planted (Table 4-13). The largest decreases were in the planting areas at the Main Camp entrance, with PA-16 decreasing by 25% (14,998 to 11,242 stems/ha), and PA-17 decreasing by 14.2% (11,611 to 9,966 stems/ha).

In 2017, naturally regenerating jack pine was recorded in PA-9 and PA-10 of Borrow Area KM-9. In 2021, no naturally regenerating stems were identified in PA-10, resulting in a 100% decrease Table 4-13). Naturally regenerating jack pine stem density did not substantially change in PA-9.

Table 4-13: Jack pine average density change between 2017 and 2021 in the areas planted in 2016

Location	Planting Area	Number of Transects	Average Density (stems/ha)		Percent Change[2]
			2017	2021	
Borrow Area KM-1	**2**	10	13,933	15,037	7.9
Borrow Area KM-4	**4**	2	11,946	11,722	-1.9
	5	3	9,154	10,739	17.3
	6	12	14,021	12,430	-11.3
Borrow Area KM-9	**7**	5	1,644	1,923	16.9
	8	3	13,959	12,414	-11.1
	9	3	435	430	-1.1
	10	2	144	0	-100.0
Main Camp Entrance	**16**	2	14,998	11,242	-25.0
	17	2	11,611	9,966	-14.2
Near the Start-up Camp	**12**	2	12,031	14,872	23.6
	13	4	13,058	14,126	8.2
	15	2	10,878	11,377	4.6

Average black spruce stem density decreased significantly between 2017 and 2021 in all areas where this species was planted. The largest decreases were in PA-10 of Borrow Area KM-9, where stem density decreased by 43.7% (3,440 to 1,936 stems/ha; Table 4-14), and in PA-1 of Borrow Area KM-1, where density declined by 42.4% (3,534 to 2,034 stems/ha). The remaining decreases in black spruce planned areas ranged from 20.0% to 39.3% compared to 2017 densities.

Table 4-14: Black spruce average density change between 2017 and 2021 in the areas planted in 2016

Location	Planting Area	Number of Transects	Average Density (stems/ha)		Percent Change
			2017	2021	
Borrow Area KM-1	**1**	2	3,534	2,034	-42.4
	2	10	64	20	-68.2
	3	3	3,754	2,916	-22.3
Borrow Area KM-4	**4**	2	3,346	2,030	-39.3
	5	3	2,806	2,240	-20.2
	6	12	660	524	-20.5
Borrow Area KM-9	**7**	5	7,483	5,920	-20.9
	8	3	27	23	-16.4
	9	3	4,017	3,212	-20.0
	10	2	3,440	1,936	-43.7
Near the Start-up Camp	12	2	632	581	-8.1
	13	4	247	418	69.4
	15	2	6,669	8,203	23.0

Average black spruce density increased in two planting areas (PA-13 and PA-15) near the Start-up Camp. Black spruce stems were naturally regenerating in these areas, and increased by 69.4% and 23%, respectively (Table 4-14).

4.3.2.2 AREAS PLANTED IN 2020

Eight of the 18 planting areas had a combined jack pine and black spruce stem density below 2,500 stems/ha as of September 2021. These eight planting areas included PA-1 and PA-10 in Borrow Area G-3, and all but PA-1 and PA-3 in EMPA D27(4)-E (Table 4-15).

The average live stem density for planted and naturally regenerating jack pine in the areas that were planted in 2020 ranged from 314 to 3,928 stems/ha (Table 4-15). The three planting areas that had the highest average live stem densities all occurred in Borrow Area G-3 (PA-8, PA-2 and PA-5), and all three planting areas with the lowest average live stem densities occurred in EMPA D27(4)-E (PA-8, PA-10 and PA-7; Table 4-15).

Table 4-15: Jack pine and black spruce live stem average density and standard deviation (in brackets) as of September 2021 for areas planted in 2020, by planting area

Location	Planting Area	Number of Transects	Average Density (stems/ha)	
			Black Spruce	Jack Pine
Borrow Area G-3	1	3	-	1,066 (1,285)
	2	3	-	3,583 (942)
	4	14	193 (264)	2,998 (884)
	5	11	64 (212)	3,267 (1,582)
	6	11	15,509 (20,468)	2,765 (2,861)
	7	10	-	1,368 (1,706)
	8	9	7,487 (9,183)	3,928 (2,824)
EMPA D27(4)-E	1	15	1,134 (1,146)	2,658 (1,413)
	2	4	83 (167)	1,581 (763)
	3	8	1,522 (1,689)	1,643 (1,227)
	4	6	-	577
	7	6	1,006 (291)	656 (286)
	8	5	556 (471)	314 (559)
	9	1	1250	769
	10	5	1,913 (1,019)	415 (337)

Table 4-16 provides possible reasons for why the combined jack pine and black spruce live stem densities were below 2,500 stems/ha in 2021 for the relevant planting areas. The most common reason was that the substrates were wet or periodically flooded, which either killed seedlings, or were unsuitable for planting at the prescribed density. Portions of other areas, particularly in EMPA D27(4)-E, had coarse, compacted substrates unsuitable for planting.

Table 4-16: Possible reasons for combined jack pine and black spruce live stem densities being below 2,500 stems/ha, by planting area

Location	Planting Area	Possible Reason
Borrow Area G-3	1	Planted at lower density for reasons unknown. Naturally regenerating vegetation abundant in area, with some naturally regenerating trees. Planted tree density appeared higher in barren patches.
	7	Stem mortality caused by flooding and sediment deposits in pit basin.
EMPA D27(4)-E	2	Compact gravelly mineral substrate and wet areas. Portions may have been unsuitable for planting.
	4	Coarse gravel substrate, much of the area unsuitable for planting.
	7	Portions of area too wet for planting. Punctuated by small ponds.
	8	Portions of area too wet for planting. Punctuated by small ponds.
	9	Portions of area too wet for planting.
	10	Portions of area too wet for planting.

Planted and naturally regenerating black spruce stem densities ranged from 64 to 15,509 stems/ha across the planting areas (Table 4-15). Both the lowest and the highest densities (PA-5 and PA-6 in Borrow Area G-3, respectively) of live black spruce stems occurred solely through natural regeneration. In Borrow Area G-3, planted black spruce was limited to PA-4 and PA-8. Planted black spruce was present in all but one of the eight planting areas in EMPA D27(4)-E. The black spruce planting area that had the lowest average live stem density was PA-2 in EMPA D27-4, with a density of 83 stems/ha.

Naturally regenerating black spruce and jack pine occurred in 7 of the 13 planting areas. Jack pine made up a smaller portion of the naturally regenerating stems than black spruce, where only 4 of the 13 planted planting areas had naturally regenerating jack pine, all of which occurred Borrow Area G-3 (Table 4-17). An average of 21.1% of the living jack pine stems in Borrow Area G-3 occurred through natural regeneration, where the percent of naturally regenerated jack pine ranged from 0% to 68.8% by planting area. The planting areas with the highest percent of jack pine regeneration were PA-8 and PA-8 where naturally regenerated jack pine stems accounted for more than 60% of the live stems in both planting areas.

Table 4-17: Average percent and standard deviation (in brackets) of naturally regenerating jack pine and black spruce stems as of September 2021 for areas planted in 2020, by planting area

Location	Planting Area	Percent of Stems from Natural Regeneration	
		Black Spruce	Jack Pine
Borrow Area G-3	1	-	22.2 (38.5)
	2	-	0.0
	4	37.2 (47.0)	0.8 (2.3)
	5	100	0.0
	6	100	60.4 (45.2)
	7	-	0.0
	8	85.5 (37.7)	68.8 (42.2)
EMPA D27(4)-E	1	0.5 (1.7)	0.0
	2	0.0	0.0
	3	0.0	0.0
	4	-	0.0
	7	0.9 (2.3)	0.0
	8	0.0	0.0
	9	0.0	0.0
	10	0.0	0.0

Black spruce natural regeneration occurred in six of the 13 planting areas, including four planting areas in Borrow Area G-3 and two in EMPA D27(4)-E (Table 4-17). Most of the tallied black spruce stems were natural regeneration in Borrow Area G-3, where 76.5% of the live stems were definitely or possibly naturally regenerated. By planting area, percent naturally regenerating stems ranged from 0% to 100%. In EMPA D27(4)-E the percent of stems attributed to natural regeneration was far lower, at 0.3% of the tallied stems on average. The average percent of naturally regenerated stems ranged from 0% to 0.9% by planting area. Notably, PA-6 in EMPA D27(4)-E, an area that was sampled but was not planted, had an abundance of naturally regenerating black spruce with a total density of 3,166 stems/ha.

The average percent mortality of planted jack pine over each of the planting areas ranged from 0% to 30.5% (Table 4-18). Overall mortality rates were higher in Borrow Area G-3 (9.1%) than EMPA 27(4)-E (5.4%). In EMPA D27(4)-E, average jack pine percent mortality ranged from 2.9% to 25.0% by planting area.

The two planting areas with the highest mortality were PA-7 in Borrow Area G-3 and PA-4 in EMPA D27(4)-E. The planting area with next-highest mortality rate in EMPA D27(4)-E was PA-8 (16.7%). Note that the coefficient of variation was high for the upper end of the range for PA-7, indicating that this value was very approximate. Additionally, the value for PA-4 may be misleading because it is based on a single transect where only 4 seedlings were tallied.

Table 4-18: Planted jack pine average percent stem mortality by planting area for 2020 rehabilitation locations as of September 2021

Location	Planting Area	Number of Transects	Average Percent Mortality	Standard Deviation
Borrow Area G-3	1	3	0.0	0.0
	2	3	7.4	9.2
	4	14	11.5	6.9
	5	11	4.8	7.4
	6	4	0.0	0.0
	7	6	30.5	41.6
	8	5	0.0	0.0
	All transects	46	9.1	17.6
EMPA D27(4)-E	1	16	3.9	4.7
	2	8	3.3	9.4
	3	7	2.9	5.5
	4	1	25.0	-
	7	6	8.1	8.8
	8	2	16.7	23.6
	All transects	40	5.4	8.6

Average percent mortality for planted black spruce ranged from 0% to 6.5% (Table 4-19). Black spruce seedling mortality was higher overall in Borrow Area G-3 (4.9%) compared to EMPA D27(4)-E (1.7%). The two planting areas with the highest percent black spruce mortality were PA-4 in Borrow Area G-3 (6.5%) and PA-7 in EMPA D27(4)-E.

Table 4-19: Planted black spruce average percent stem mortality by planting area for 2020 rehabilitation locations as of September 2021

Location	Planting Area	Number of Transects	Average Percent Mortality	Standard Deviation
Borrow Area G-3	4	6	6.5	10.7
	8	2	0.0	0.0
	All Transects	8	4.9	9.5
EMPA D27(4)-E	1	13	1.8	4.6
	2	6	2.1	5.1
	3	7	0.0	0.0
	6	1	0.0	-
	7	6	4.8	7.3
	8	4	0.0	0.0
	All Transects	37	1.7	4.5

Vigour class was variable for jack pine stems in the planting areas. In Borrow Area G-3, the dominant vigour classes were an even mixture of 3 (dead leader), 4 (dead lower branches) and 5 (mostly healthy), all with approximately 26% of the tallied stems overall. Healthy stems (vigour class 6) made up an additional 11%.

The dominant vigour class for black spruce stems was 6, at 92% of all tallied stems, followed by vigour class 5 with 6%. When considering only planted stems, vigour class 6 made up 83% of the tallied stems, and vigour class 5 made up 14%. None of the tallied black spruce stems were vigour class 2 or less.

5.0 DISCUSSION

5.1 TRAIL BLOCKING AND REHABILITATION

The 2021 monitoring of trail blocking and rehabilitation found that most of the trails continued to be obscured by vegetation regenerating after the 2013 wildfire (which was not caused by the Project), and showed no signs of recent use. Natural regeneration has removed the need for these trails to be blocked by other means.

Signs of recent activity, specifically ATV use, were present along two trails in 2021. In both cases, the trails were ones that appeared to have already been in use prior to the Project.

It is recommended that monitoring is no longer necessary for most of the 47 trails originally selected for monitoring. The trails should be re-assessed to determine which ones, if any, warrant continued monitoring during Project operation.

5.2 VEGETATION REGENERATION

This report provides a preliminary evaluation of vegetation regeneration as of the end of the construction phase. The extent of the temporary footprint areas identified in this report are approximate as some temporary portions of the Construction Footprint were in the process of being, or had not yet been, decommissioned. After the boundaries of the temporary Project areas have been delineated, habitat targets will be finalized for each of them and more robust evaluations of vegetation regeneration will be produced.

5.2.1 ALL TEMPORARY PROJECT AREAS

Most of the barren areas in the temporary Project areas as of September 2021 were in areas outside the Access Road footprints. This was expected. Most of these areas had recently been active or were still active, there had been no attempts to revegetate through planting or seeding, and/or insufficient time had passed for significant natural regeneration to develop.

The most common vegetation structure types in the non-access road temporary Project areas were low shrub, graminoid, bryoid or a combination of these. This was as expected, as portions of several of these areas had been cleared of all trees while leaving the ground cover largely left intact, and the cleared areas were not fully used during construction. In addition, low vegetation such as grasses and pioneer species are the first to take advantage of opened spaces, and/or areas where bare sandy or gravelly soil may preclude less tolerant vegetation.

Despite these limitations, over half of the originally cleared temporary project areas were already vegetated in September 2021. It appears likely that portions of the unvegetated areas will be required for Project operation, and will not be included for rehabilitation.

The sparse and barren areas along the access roads occurred mainly next to the permanent roadway and/or other permanent infrastructure. The exceptions were portions of the ditch near the road to the Cemetery site and opposite the well road.

Barren and sparse areas along the SAR were dispersed more randomly along the roadway and were more frequent along the portion of the road east of Butnau Marina (including the old, decommissioned road portions). The ditches along this portion of the road are newer and have had less time to regenerate.

5.2.2 SEEDED AREAS

One year after seeding, vegetation cover in areas seeded with grasses was generally low. More than half of the area across the two rehabilitation locations that received seed were either barren, or sparsely vegetated (i.e., <25% foliage cover).

Substrates conditions were thought to be a contributor to the degree of revegetation to date. Monitoring for the Wuskwatim Generation Project (ECOSTEM 2017) found that grass revegetation in rehabilitated areas was slow on dry, compact substrates, or coarse, rapidly drained soils. Portions of the two locations seeded in 2020 had similar substrates to these.

However, it is too soon to determine if revegetation will eventually become sufficient. It has only been one year since seeding, and grasses tend to establish slowly over several growing seasons. The plants may simply require more time to establish and spread vegetatively. Monitoring of seeded locations will continue in 2023.

5.3 TREE PLANTING AREAS

5.3.1 PRESCRIPTION IMPLEMENTATION

Monitoring found that the implementation of the tree planting prescriptions likely occurred as planned. Measured stem density in one of the areas planted in 2020 (Borrow Area G-3) was 2,293 stems/ha, which was somewhat below the planned density of 2,500 stems/ha. The likely reason for the planting density being lower than planned was the prevalence of substrate conditions that were unsuitable for planting.

5.3.2 TREE REGENERATION

5.3.2.1 AREAS PLANTED IN 2016

Combined jack pine and black spruce tree density was below 2,500 stems/ha in two of the 15 areas planted in 2016. Both of these were areas where only black spruce was planted.

Stem density changes from 2016 to 2021 indicated that planted black spruce seedlings were struggling to thrive in several of the planting areas. Direct measurement of stem mortality was not feasible given that five years had passed since planting. The highest tree mortality tends to occur in the early years after planting. Many of the stems that died during the first two years would not be tallied during surveys conducted five years later as they were not visible. By two or more years after death, the stems began to disintegrate and become increasingly difficult to detect. This was illustrated by comparing measured stem mortality in the 2016 planted areas one year after planting and 5 years after planting. While detectable dead stems made up 2.6% of the stem density overall one year after planting, this declined to 0.5% five years after planting. It is possible that some dead stems were obscured by vegetation, and went undetected.

It was anticipated that planted seedling mortality could be partially offset by natural tree regeneration. In fact, natural black spruce regeneration was a key contributor to the measured live black spruce stem densities in the areas where planted black spruce seedlings were struggling to thrive. Once the target habitat type is determined for the tree plantings areas (Section 2.3.1), subsequent monitoring will determine if additional black spruce planting is needed.

The rehabilitation locations that had stem densities that were much higher (Borrow Areas KM-1 and KM-4, and the areas near the Start-up Camp) than other locations were also initially planted at a much higher density. Mortality was also relatively low in many of the planting areas in these locations.

5.3.2.2 AREAS PLANTED IN 2020

Few of the areas planted in 2020 exceeded a target stem density of 2,500 stems/ha as of September 2021. In part, this was because the planting density in some planting areas was lower than planned, including most of the areas in EMPA D27(4)-E. The predominant reason for lower planting densities in these areas was the prevalence of substrates that were unsuitable for tree planting.

It is unclear at this time if additional tree planting will be required in the areas that are ultimately targeted to be a woodland habitat type. When the boundaries of the temporary Project areas are ultimately delineated (Section 2.3.1), it may be the case that portions of the provisionally defined planting areas are removed. Also, portions of the temporary Project areas will not be planted because they often have standing water or other conditions that are unsuitable for tree growth. Removal of such areas could result in a relatively large increase in actual stem density. Also, natural regeneration is expected to contribute additional stems in some of the planting areas.

To date, natural tree regeneration has been limited to a few of the planting areas. It is likely that natural regeneration will continue to increase total stem densities in these areas. However, natural regeneration has been low in the locations with lower planted stem densities, and where present, concentrated along the edges of the cleared areas.

To date, the majority of the natural regeneration has been black spruce. Natural regeneration has contributed a significant number of stems to planting areas in Borrow Area G-3, particularly in PA-6, which included a cleared but unexcavated perimeter adjacent to the treeline. All black spruce stems in that planting area were naturally regenerating. No natural regeneration was identified in EMPA 27-4.

Tree seedlings generally appeared healthy in the 2020 planting areas based on stem vigour results. A very small proportion of stems fell below a vigour class of 3 (dead leader). This suggested that most of the stems still living in 2021 will continue to survive, barring unusual circumstances.

In summary, some of the areas planted in 2020 may need additional planting, but it is not feasible to determine which areas this will apply to until the boundaries of the temporary Project areas are finalized, followed by mapping substrate conditions and planting limitations.

6.0 SUMMARY AND CONCLUSIONS

Terrestrial habitat rehabilitation mitigates adverse Project effects on terrestrial habitat and plants (e.g., habitat loss, erosion, invasive plant spread), restores wildlife habitat and improves aesthetics, among other benefits. Terrestrial habitat will be rehabilitated in areas not required for Project operation and in some permanent Project areas (e.g., ditches). Some of the planned rehabilitation addresses potential adverse Project effects on intactness by blocking or hindering access from Project areas to surrounding areas.

Surveys of trail blocking and habitat regeneration in 2021 found that there were no substantive changes to the status of the 47 locations since they were last surveyed in 2017. Natural vegetation regeneration following the 2013 wildfire has obscured most of the trails and removed the need for these trails to be blocked by other means. Monitoring is no longer necessary for most of the 47 trails originally selected for monitoring. It is recommended that each of the trails should be re-assessed to determine which ones, if any warrant continued monitoring during Project operation.

A preliminary evaluation of vegetation regeneration in the temporary portions of the Construction Footprint (i.e., the temporary Project areas) was completed. This evaluation was preliminary because it used approximate boundaries for the temporary Project areas as well as provisional determinations of the target habitat types. Boundaries for the temporary Project areas were approximate since some of these areas had not yet been, or were in the process of being, decommissioned. Additionally, once the boundaries of the temporary Project areas have been finalized, field surveys will be conducted to gather the information needed to finalize the target habitat type for each of the rehabilitation locations (e.g., substrate type, moisture regime).

Just over half of the area where vegetation regeneration was mapped had vegetation cover that was 10% or higher. Overall, vegetation cover along the access roads was higher than for other temporary portions of the Construction Footprint.

Vegetation cover was higher than >10% in 81% of the total temporary area along the access roads. Barren areas and sparse vegetation (i.e., < 25% cover) generally occurred next to the roadbed. Areas along the access roads appeared to be on a pathway to achieving adequate revegetation. Most of the area had at least sparse vegetation. Also, it is expected that additional colonization will occur, and that existing vegetation will expand its cover. Future monitoring will confirm this has happened.

Outside of the access roads, 61% of the temporary area used during Project construction was barren. This was expected as construction was still active or had only recently ended in a number of the areas. Most of the barren and sparse vegetation cover occurred in the active or recently active portions of the Borrow Areas, EMPAs and work areas. In contrast, most of the area that was not barren had moderate to high vegetation cover, which was mostly low shrub and/or graminoid and/or bryoid cover. Natural regeneration was quickly establishing in areas where there was little to no disturbance since they were cleared.

More than half (58%) of the total area seeded with native grass in 2020 had at least sparse vegetation cover in 2021. Moderate or higher cover made up 35% of the seeded area. As it has only been one year since seeding, it is expected that additional grass colonization will occur, and that existing vegetation will expand its cover.

The overall approach for the forest and woodland habitat rehabilitation was to complete site preparation where needed, and to then plant tree seedlings. A preliminary approach was taken for determining tree planting densities in these areas for the reasons described above. Additionally, the prescriptions for these areas were pending the determination as to which of the habitat types had the highest actual Project effects since these are the types that are prioritized for rehabilitation. Since areas that are targeted to be a forest habitat type are ultimately planted at higher density than a woodland, an initial planting suitable for a woodland has effectively been implemented for all of the areas planted to date. The ultimate desired density at a given site can be achieved by planting areas in two years, if needed. An advantage of this approach, in addition to reducing the risk of high seeding mortality, is that the amount of planting needed at some sites can be reduced in locations where substantial natural regeneration is occurring.

The first efforts to rehabilitate forest and woodland habitat occurred in 2016 at five locations along the North Access Road (NAR). Rehabilitation efforts were situated within three borrow areas (Borrow Areas KM-1, KM-4, and KM-9), an area near the Start-up Camp, and an area near the Main Camp. In the borrow areas, steep slopes were graded to a maximum slope of 4:1 and a discer loosened the top layer in compacted mineral areas. Trees were planted in all five locations.

Approximately 231,360 jack pine and 19,720 black spruce seedlings were planted in 2016 and 77,400 jack pine and 28,700 black spruce seedlings were planted in 2020. In total, approximately 357,180 seedlings were planted between the two planting years (308,760 jack pine and 48,420 black spruce). Two locations in 2020 were also harrowed and seeded with native grass species.

In 2016, in the areas planted with black spruce only, the seedlings were planted at a spacing of 2 m by 2 m, which equates to a density of 2,500 stems/ha. In areas planted with either jack pine or jack pine and black spruce, the seedlings were planted at a spacing of 1 m by 1 m, which equates to a density of 10,000 stems/ha. In 2020, all the seedlings were planted at a spacing of 2 m by 2 m. Planting occurred at the higher density in some areas in 2016 given that they already had been fully decommissioned from the Keeyask Infrastructure Project, and the large number of seedlings available for planting that year.

Tree regeneration surveys conducted the year after the seedlings were planted found that the implementation of the tree planting prescriptions likely occurred as planned. Measured stem density in one of the areas planted in 2020 (Borrow Area G-3) was 2,293 stems/ha, which was somewhat below the planned density of 2,500 stems/ha. The likely reason for the planting density being lower than planned was the prevalence of substrate conditions that were unsuitable for planting.

Regarding the prospects for the planted areas to eventually become woodland or forest habitat, monitoring found that combined jack pine and black spruce tree density was above 2,500 stems/ha in 13 of the 15 areas planted in 2016. Both of the areas with lower densities only had black spruce plantings.

Stem density changes from 2016 to 2021 indicated that planted black spruce seedlings were struggling to thrive in several of the 2016 planting areas. However, planted seedling mortality was being partially offset by natural black spruce regeneration. Once the target habitat types are finalized for the tree planting areas (Section 2.3.1), subsequent monitoring will determine if additional black spruce planting is needed.

As of September 2021, few of the areas planted in 2020 had a stem density higher than 2,500 stems/ha. In part, this was because the planting density in some areas was lower than planned. This included most of the areas in EMPA D27(4)-E, where the predominant reason for lower planting densities was a prevalence of substrates that were unsuitable for tree planting.

To date, natural tree regeneration has been limited to a few planting areas within the rehabilitation locations, and these stems will likely continue to contribute to increasing total stem densities in those areas. However, natural regeneration has been low in the locations with lower planted stem densities, and where present, generally concentrated along the edges of the cleared areas.

Tree seedlings generally appeared healthy in the 2020 planting areas. This suggested that most of the stems still living in 2021 will continue to survive, barring unusual circumstances.

It is unclear at this time if additional tree planting will be required in the areas that are targeted to eventually become a woodland habitat type. When the boundaries of the temporary Project areas are ultimately delineated (Section 2.3.1), it may be the case that portions of the provisionally defined planting areas are removed. Also, portions of the temporary Project areas would not be planted because they often have standing water or other conditions that are unsuitable for tree growth (e.g., exposed bedrock). Removal of such areas could result in a relatively large increase in actual stem density. Also, natural regeneration is expected to contribute additional stems in some of the planting areas.

In summary, some of the areas planted in 2020 may need additional planting, but it is not feasible to determine which areas this applies to until the boundaries of the temporary Project areas are finalized, followed by mapping substrate conditions and planting limitations.

Monitoring in 2022 will include surveys of the 2020 and 2021 tree planting areas. No major changes to field methods are anticipated.

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