Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Invasive Plant Spread and Control Monitoring Report

TEMP-2019-05

KEEYASK

Manitoba Sustainable Development Client File 5550.00
Manitoba Environment Act Licence No. 3107

2018 -2019

KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2019-05

INVASIVE PLANT SPREAD AND CONTROL MONITORING

A Report Prepared for

Manitoba Hydro

By

ECOSTEM Ltd.

June 2019

This report should be cited as follows:

ECOSTEM Ltd. 2019. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2019-05: Invasive Plant Spread and Control Monitoring. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2019.

SUMMARY

Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. 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.

Non-native plants are those plant species that are not naturally found in the Keeyask region. Invasive plants are the non-native plant species that can out-compete or even replace native plants. This report describes the results of invasive and other non-native plant monitoring conducted during the fifth summer of Project construction.

Why is the study being done?

Invasive and other non-native plants are of concern because they can crowd out native plants, or prevent native plants from growing where they are normally found. In extreme cases, invasive plants can change the kind of vegetation, soils or other natural things on the land. Non-native plants are also a concern because they could be invasive in some local conditions or in the future with changing climate, or they could interfere with rehabilitating native habitat in sites no longer being used by the Project.

Surveys are being done to determine how Project development is affecting how many non-native plants are present, where these species are found, and to help decide where to carry out measures to control the plants that can become quite a problem at the Project site.

What was done?

In 2018, non-native plant surveys were carried out within most of the cleared Project areas between July 5 to 9, and again between August 17 and 30. Some cleared areas were not surveyed because the people doing the surveys could not safely access them due to construction activity, or because they were very recently cleared and non-native plants would not yet have had time to establish.

What was found?

While the late summer cover and extent of all non-native plants combined increased between the 2017 and 2018 surveys, non-native plants still covered less than 1% of the surveyed area. As was the case in 2017, most of the non-native plant cover was within cleared areas that were either there before the Project (e.g., cutlines, borrow areas and ditches along the Butnau Road

portion of the South Access Road) or were developed as part of the Keeyask Infrastructure Project (KIP), and are now being used by the Project.

A total of 22 non-native plant species were found during the 2018 surveys. While this was the same total number of species as in 2017, some of the species were different. One new species (common tansy) was recorded in 2018, two previously recorded species (bird's-foot trefoil and black medick) were not observed, and one species (common burdock) that was recorded in 2016 but not 2017 was recorded again in 2018.

Lamb's quarters remained the most abundant non-native plant species in 2018. Narrow-leaved hawksbeard cover increased by more than eight times since 2017, becoming the third-most abundant non-native species in 2018.

Of the 22 non-native plant species found in 2018, ox-eye daisy, scentless chamomile and common tansy are the ones of highest invasive concern for the Project site. Field staff manually removed all of these plants as soon as they were found during the surveys. Scentless chamomile and ox-eye daisy were not found at the locations where they had been removed in previous years.

Six of the 22 non-native plant species found in 2018 are of moderate invasive concern for the Project site. At several locations in 2017, ECOSTEM field staff manually removed and disposed of field sow-thistle and Canada thistle, but these plants returned to those locations in 2018.

To minimize further spreading of invasive plants, herbicides were applied in a few key Project areas in late July 2018. Much of the living non-native plant cover was reduced in the treated areas following the herbicide application. Surveys in 2019 will assess the effectiveness of the treatment in continuing to reduce non-native plant cover.

What does it mean?

As expected, some further spreading of some non-native plant species is happening during Project construction. However, all species combined still cover a very small portion (less than 1%) of the Project footprint.

Given their potential to spread rapidly, an evaluation was made as to whether or not there are practical ways to reduce invasive and other non-native plant species in the Project footprint, or to prevent them from spreading further. Many of these species are commonly found in disturbed areas in the Keeyask region, particularly along roadsides, making it difficult to prevent vehicles and people from accidentally spreading these species into the Project site.

Monitoring results from 2018 showed that immediate manual removal was generally effective for species that do not have the ability to produce many new plants from pieces of roots left in the ground. Staff conducting the monitoring surveys will continue to manually remove plants at sites where there are one to a few plants except for two situations: if the plants are from a species that can create many new plants from broken roots and if the plants are already mature or if plants from this species were removed in the previous year, then they will not be manually removed.

The herbicide treatment completed in July 2018 was effective in reducing non-native plant cover in treated areas. The longer-term effectiveness of this treatment will be assessed based on results from the monitoring conducted in 2019.

What will be done next?

Additional invasive plant control recommendations are being developed for the 2019 growing season based on the monitoring results to date. Monitoring fieldwork for invasive and other non-native plants will continue in 2019. Where appropriate, additional control measures will be recommended based on what is found during the monitoring.

ACKNOWLEDGEMENTS

ECOSTEM Ltd. would like to thank Rachel Boone, Sherrie Mason and the on-site Manitoba Hydro staff, including Kim Bryson, Megan Anger, Michelle Ewacha, Tyler Fourre, Brian Fournier, Tanner Booth and Linda Campbell for their support and assistance in planning field activities and access to the sites. Rachel Boone and Sherrie Mason are also gratefully acknowledged for coordinating the terrestrial monitoring studies.

Chiefs and Councils of Tataskweyak Cree Nation (TCN), War Lake First Nation (WLFN), York Factory First Nation (YFFN) and Fox Lake Cree Nation (FLCN) are gratefully acknowledged for their support of this program.

We would also like to thank North/South Consultants Inc., in particular Ron Bretecher, Shari Fournier and Regan Caskey for their guidance, logistical support and other resources that made these studies possible.

Custom Helicopters is gratefully acknowledged for providing transportation during fieldwork and Nicole Pokornowska for coordinating the logistics.

STUDY TEAM

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

Fieldwork in 2018 was conducted by Brock Epp and Nathan Ricard.

Data analysis and report writing in 2018 were completed by Brock Epp and James Ehnes. GIS analysis and cartography was completed by Brock Epp and Nathan Ricard.

TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 METHODS 3
2.1 PROJECT COMPONENTS 3
2.2 DATA COLLECTION 4
2.3 MAPPING 8
2.4 INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES 10
2.4.1 Background 10
2.4.2 Invasive Concern Classification 11
2.4.3 General Approach to Management 15
2.5 SPECIES TREATED SEPARATELY 16
3.0 RESULTS 20
3.1 TOTAL AREA SURVEYED 20
3.1.1 Early summer 20
3.1.2 Late summer 20
3.2 SEASONAL PATTERN IN NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE 22
3.3 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE 23
3.4 CHANGES TO SPECIES DISTRIBUTION AND ABUNDANCE 34
4.0 EFFORTS TO MANAGE INVASIVE PLANTS 37
4.1 RAPID MANUAL REMOVAL AND OTHER NON-CHEMICAL ACTIONS 37
4.1.1 Level 1 Non-Native Species 37
4.1.2 Level 2 Non-Native Species 41
4.1.3 Level 3 Non-Native Species 44
4.1.4 Level 4 Non-Native Species 45
4.2 HERBICIDE TREATMENTS AT KEY SITES 46
4.2.1 Treatments 46
4.2.2 Efficacy of Treatments 47
5.0 DISCUSSION 57
5.1 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE 57
5.2 CHANGES IN SPECIES DISTRIBUTION AND ABUNDANCE 58
5.3 EFFORTS TO MANAGE INVASIVE PLANTS 59
5.3.1 Prevention 60

5.3.2 Eradication and Control 60
6.0 SUMMARY AND CONCLUSIONS 62
6.1 NEXT STEPS 63
7.0 LITERATURE CITED 64
7.1.1 Background 71
7.1.2 Invasive Concern Classification 74

LIST OF TABLES

Table 2-1: General Project components and their associated activity prior to 2018 surveys 4
Table 2-2: Cover class and associated percent cover ranges used for non-native plant surveys 7
Table 2-3: Levels of invasive concern for plants in the Project footprint 12
Table 2-4: Classification of non-native plant species recorded in the Project footprint into levels of invasive concern 13
Table 3-1: Total area (ha) surveyed for non-native plants by year and Project component 21
Table 3-2: Percentage of Project footprint area included in the non-native plant surveys by year and Project component 22
Table 3-3: Total late summer non-native plant extent as a percentage of total area surveyed, by year[1] and Project component 24
Table 3-4: Total late summer non-native plant cover as a percentage of total area surveyed, by year[1] and Project component 25
Table 3-5: Total approximate late summer non-native species cover (m^2) in the Project footprint, by year 35
Table 3-6: Total approximate cover of a non-native species as a percentage of total cover for all non-native species, by year 36
Table 4-1: Non-native species cover in herbicide-treated sites before and after treatment in 2018 49
Table 4-2: Non-native species cover in herbicide-treated sites before and after treatment in 2018, by treatment site 50
Table 7-1: Estimated radius and derived area for individual plant species 69
Table 7-2. ISCM invasive plant categories, criteria for inclusion and minimum management criteria 75
Table 7-3: Invasive concern classifications for non-native plant species that could potentially occur in the Project footprint 77
Table 7-4: Total early and late summer non-native plant extent as a percentage of total area surveyed by year and Project component 107
Table 7-5: Total early and late summer non-native plant cover as a percentage of total area surveyed by year and Project component 108
Table 7-6: Total approximate non-native species cover (m^2) and number of species in the Project footprint, by year and season 109
Table 7-7: Total late summer non-native plant extent by project and year as a percentage of area surveyed 110
Table 7-8: Total late summer non-native plant cover by project and year as a percentage of area surveyed 110
Table 7-9: Percentage of total non-native plant cover with mortality by treatment area 110

Table 7-10: Percentage of total non-native plant cover with mortality by species 111
Table 7-11: Non-native species cover in herbicide-treated patches before and after treatment in 2018 111
Table 7-12: Changes in the overall cover[1] of the species specifically targeted for herbicide treatment that were in the treatment areas before and after treatment in 2018 112
Table 7-13: Changes in the overall cover[1] of the species at Levels 1 and 2 of invasive concern that were in the treatment areas before and after treatment in 2018... 112

LIST OF FIGURES

Figure 4-1: High priority sites in Borrow Area G-1 (A) and the NAR Gate staging area (B) recommended for herbicide treatment in 2018 that were not treated. 51
Figure 4-2: Recommended patches that were treated (A) and untreated (B) by herbicide in the Main Camp in 2018. 52
Figure 4-3: Recommended patches that were treated by herbicide in the Start-up Camp (A) and Work Area B (B) in 2018. 53
Figure 4-4: Recommended patches that were treated by herbicide in the SAR Camp in 2018 54
Figure 7-1. Scentless Chamomile infestation in Manitoba municipalities in 2011 72

LIST OF MAPS

Map 2-1: Early summer non-native plant survey areas in 2018 17
Map 2-2: Late summer non-native plant survey areas in 2018..... 18
Map 2-3: Project components..... 19
Map 3-1: Distribution of non-native plants within the Project footprint during early summer, 2018 28
Map 3-2: Distribution of non-native plants during late summer 2018, in the Project footprint along the western portion of the North Access Road 29
Map 3-3: Distribution of non-native plants during late summer 2018, in the Project footprint along the eastern portion of North Access Road..... 30
Map 3-4: Distribution of non-native plants during late summer 2018, in the Project footprint along the western portion of the South Access Road..... 31
Map 3-5: Distribution of non-native plants during late summer 2018, in the Project footprint along the eastern portion of the South Access Road 32
Map 3-6: Distribution of non-native plants during late summer 2018, in the Project footprint along the South Dyke 33
Map 4-1: Key areas selected for invasive plant herbicide control in 2016..... 55
Map 4-2: Key areas (Priority 1 areas) selected for invasive plant herbicide control in 2018 56
Map 7-1: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the western portion of the North Access Road in late summer, 2018 80
Map 7-2: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the eastern portion of the North Access Road in late summer, 2018 81
Map 7-3: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the western portion of the South Access Road in late summer, 2018 82
Map 7-4: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the eastern portion of the South Access Road in late summer, 2018 83
Map 7-5: The distribution and abundance (cover class) of common dandelion in the Project footprint along the western portion of the North Access Road in late summer, 2018 84
Map 7-6: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the North Access Road in late summer, 2018 85
Map 7-7: The distribution and abundance (cover class) of common dandelion in the Project footprint along the western portion of the South Access Road in late summer, 2018 86

Map 7-8: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the South Access Road in late summer, 2018 87
Map 7-9: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the western portion of the North Access Road in late summer, 2018 88
Map 7-10: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the eastern portion of the North Access Road in late summer, 2018 89
Map 7-11: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the western portion of the South Access Road in late summer, 2018 90
Map 7-12: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the eastern portion of the South Access Road in late summer, 2018 91
Map 7-13: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the North Access Road in late summer, 2018 92
Map 7-14: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the North Access Road in late summer, 2018 93
Map 7-15: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the South Access Road in late summer, 2018 94
Map 7-16: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the South Access Road in late summer, 2018 95
Map 7-17: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the western portion of the North Access Road in late summer, 2018 96
Map 7-18: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the eastern portion of the North Access Road in late summer, 2018 97
Map 7-19: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the western portion of the South Access Road in late summer, 2018 98
Map 7-20: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the eastern portion of the South Access Road in late summer, 2018 99
Map 7-21: Locations of ox-eye daisy found before and during Project construction monitoring 100

Map 7-22: Locations of scentless chamomile identified during Project construction monitoring 101
Map 7-23: Location of common tansy identified during Project construction monitoring 102
Map 7-24: Canada thistle locations identified during Project construction monitoring 103
Map 7-25: Common burdock locations identified during Project construction monitoring 104
Map 7-26: Tufted vetch locations identified during Project construction monitoring 105
Map 7-27: Reed canarygrass locations identified before and during Project construction monitoring 115

LIST OF APPENDICES

Appendix 1: Non-Native Plant Individual Areas 68
Appendix 2: Invasiveness Rankings and Management Strategies 70
Appendix 3: Non-native Plant Distribution Maps 79
Appendix 4: Additional Non-native Plant Results 106
Appendix 5: Reed Canarygrass Results 113

1.0 INTRODUCTION

Construction of the Keeyask Generation Project (the Project), a 695 megawatt hydroelectric generating station (GS) and associated facilities, began in July 2014. 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.

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 *Terrestrial Effects Monitoring Plan* (TEMP) was developed as part of the licensing process for the Project (KHLP 2015). Monitoring activities for various components of the terrestrial environment were described, including the focus of this report, invasive plants, during the construction and operation phases.

Non-native plants are those plants that are growing outside of their country or region of origin. Invasive plants are non-native plants that can out-compete or even replace native plants. Invasive plants are of concern because they can crowd out other plant species and, in extreme cases, change vegetation composition or other ecosystem attributes. Invasive plants have been described as one of the greatest threats to natural areas in Canada (Canadian Food Inspection Agency 2008).

Non-native plant species that are not generally invasive may be problematic for some local conditions or may become so in the future with changing climate (Hellman *et al.* 2008). For example, well-established patches of non-native plants will be a consideration for areas where native habitat will be regenerated.

Since all invasive plants are non-native, this report generally uses “non-native” except when discussing species that are of higher invasive concern for the Project area.

The goals of the Invasive Plant Spread and Control study are to determine the degree to which the Project contributes to introducing and spreading invasive and other non-native plants, and to evaluate the effectiveness of mitigation measures. The overall objectives of the Invasive Plant Spread and Control study are to:

- Verify that appropriate seed mixtures were used where seeding is implemented as a rehabilitation or erosion control measure;
- Document the degree of invasive and other non-native plant introduction and spread;
- Recommend appropriate control and eradication programs; and,
- Verify the efficacy of any programs implemented to control or eradicate invasive plants.

The Invasive Plant Spread and Control study includes two components. The first component monitors non-native plant distribution and abundance in Project areas. In the event that control or eradication programs are needed, the second study component provides recommendations and monitors their effectiveness.

A previous monitoring study and report (ECOSTEM 2015) evaluated non-native plant spread during construction of the Keeyask Infrastructure Project (KIP), which ended in June 2014. This study is monitoring non-native plant distribution during Project construction and operation. To date, surveys have been conducted in each year from 2015 to 2018. Results for the monitoring conducted in 2015, 2016 and 2017 are provided in previous reports by ECOSTEM (2016, 2017 and 2018, respectively). The following presents the monitoring conducted during 2018.

2.0 METHODS

Section 3.3.2 of the TEMP details the methods for this study. The following summarizes the activities conducted in 2018.

2.1 PROJECT COMPONENTS

There were far too many individual Project footprint components to evaluate each one separately for patterns of non-native plant spread. Therefore, the Project footprint was subdivided and grouped into general components (Table 2-1) based on the general type of activity occurring there. Activity type may be an important influence on non-native plant spread or establishment. For example, the “Camp and Work Areas” Project component is dominated by foot and light vehicle traffic, with minimal to no ongoing excavation, while the “Borrow Areas” component is often characterized by ongoing excavation and heavy equipment traffic. For reservoir clearing areas, the ground vegetation and soils are generally undisturbed, which means there is a poor seedbed for non-native plant colonization.

It should be noted that because the subdivision of the Project footprint into activity types is generalized, there may be small areas within a specific footprint that are from a different type. Nevertheless, this categorization aids in the interpretation of broad patterns and trends across the Project site. Map 2-3 shows the locations of the Project components as well as some of their constituent features.

A second level of analysis was based on the length of time since an area was first cleared, the current level of construction activity, and the projects it was used for (e.g., portions of areas cleared for the Keeyask Infrastructure Project (KIP) are also being used for the Project). All of these factors can influence non-native plant distribution and abundance. The categories used for the second level of analysis included:

- Areas used either for the KIP only or minimally affected by the Project;
- Areas used by both the KIP and the Project; and
- Areas used only by the Project.

Areas used for the KIP only are included because they were developed prior to the Project and may be an important seed source for the spreading of non-native plants into other nearby areas.

Table 2-1: General Project components and their associated activity prior to 2018 surveys

Project Component	Description	Activity
North Access Road	Road and right of way	Light and heavy vehicle traffic
South Access Road	Road and right of way	Light and heavy vehicle traffic
Camp and Work Areas	All camps, work areas and attached excavated material placement areas	Foot and light vehicle traffic
Borrow Areas	All borrow areas accessible by road, cleared or excavated, and attached excavated material placement areas	**Active:** Clearing, excavation and heavy equipment traffic **Inactive:** Regenerating vegetation
North Dyke	North dyke clearing, associated excavated material placement and borrow areas, and north channel rock groin	Clearing, excavation, light and heavy vehicle traffic
South Dyke	South dyke clearing and associated excavated material placement and borrow areas	Clearing, excavation, light and heavy vehicle traffic
Generating Station Areas	Generating station, spillway, dam and coffer dam infrastructure, and associated excavated material placement areas	Excavation, construction, heavy and light vehicle traffic
Reservoir Clearing Area	Vegetation clearing in the reservoir areas that are close to Project areas that will be outside of the reservoir	Clearing only

2.2 DATA COLLECTION

Early and late summer non-native plant surveys have been conducted in each year from 2014 to 2018, inclusive.

The methods for the 2018 surveys were the same as those used in 2017. The 2017 methods were somewhat modified from previous years. Starting in 2017, the early summer survey was less detailed than the late summer survey. The purpose of the early summer survey was to provide a rapid, spatially focused survey that still allowed for early detection and control of non-native plants that had spread into new areas. For this reason, this survey was spatially focused on two types of areas: (i) the areas that were newly cleared since August 2017; and, (ii) the areas that were cleared as of August 2017 and that had few to no non-native plants. Further details on methods and rationale are provided in the 2018 report (ECOSTEM 2018).

Results from the early summer surveys were not expected to be representative of non-native plant distribution and abundance for the entire Project footprint. The purpose of the early summer surveys was to identify sites that may require a timely management response.

Consequently, the locations selected for survey were intentionally those that were believed to both have a higher likelihood to support non-native plants and be new candidates for eradication or control efforts (e.g., identifying locations where non-native plants have recently appeared in recently cleared or excavated locations). In each year, results from the previous late summer survey had already provided the bulk of the information needed to select sites for treatment in the current summer.

Results from the late summer surveys were expected to overestimate non-native plant distribution and abundance for the entire Project footprint. With the exception of the North and South Access roads, surveys of the Project footprint were not conducted in areas where non-native plants were expected to be completely or virtually absent based on results from similar types of areas and in previous years. The two predominant types of areas that were not surveyed were the portions of the Project footprint that were not safe to access due to construction activity (the remainder was not surveyed due to recent bear activity) and the cleared future reservoir area. Inclusion of the zero or very low values from these areas would have reduced the non-native plant percentages for the entire Project footprint.

Given the differences in objectives and associated field methods, results from the 2018 early and late summer surveys are not directly comparable.

Early summer surveys were conducted on July 3 to 6, 8 and 9, 2018 at the locations shown in Map 2-1. Late summer surveys were conducted from August 17 to 18 and 22 to 30, 2018 at the locations shown in Map 2-2.

Data generally recorded during the early summer surveys included a GPS waypoint where non-native plants were encountered, and notes on species abundance and extent. The exception was when a species of high invasive concern for the Project (Section 2.4) was encountered. In these situations, detailed data were collected using the late summer survey method (see below).

Methods for the 2018 late summer non-native plant surveys were the same as those used during the 2017 surveys. These surveys were conducted in the portions of the Project footprint that had been cleared or disturbed prior to the surveys, and were safe to access. A botanist and trained environmental technician conducted surveys on foot and by truck within the cleared areas that were both safe to survey and were not undergoing clearing at the time of the surveys. Due to safety-related access restrictions, some active construction areas, or portions thereof, were not surveyed in 2018.

Three approaches to selecting survey locations were employed, depending on the nature of the footprint.

For the North and South Access roads, a combination of systematic sampling on foot and mobile truck-based surveys were employed. Sample locations were established every 2 km along each access road. Non-native plants were sampled at every stop except where construction or haul truck activity made stopping unsafe. At each stop, a 100 m transect on each side of the road (*i.e.*, two 100 m transects at each stop) was surveyed by foot. Additionally,

the roadsides were scanned while driving approximately 40-50 km/h between each stop and observations of species of high concern or unusual conditions were recorded. It was expected that smaller patches and individual plants would not be recorded.

Spatially focused foot surveys were conducted in the cleared areas along the South Dyke and the Ellis Esker access corridor in 2018 for several reasons: large portions of this footprint had only recently been cleared (particularly for Ellis Esker access); the clearing was distant from known non-native plant seed sources; and, access was difficult. Locations for the foot surveys were selected in two ways - first, by flying over the newly cleared areas in a helicopter and identifying the most likely locations to support non-native plants; and second, by targeting areas that had non-native plants in 2017. Because searches in the south dyke and Ellis Esker footprints were focused on locations that were believed to have a higher likelihood to support non-native plants, results were expected to overestimate the abundance of non-native plants for the entire south dyke and Ellis Esker footprints.

Most of the North Dyke was also surveyed by a combination of helicopter and foot surveys due to its length, and inaccessibility by non-construction vehicles. The helicopter was flown at a low altitude above the centre-line of the dyke in two passes, surveying each side of the clearing. Non-native plant cover was recorded using notes and GPS waypoints. Foot surveys were conducted where needed to confirm plant identification, or to map more complicated patches of plants.

For the remaining areas (which accounted for the majority of the surveyed area), field surveys traversed all cleared areas using a combination of perimeter and meandering walks. The perimeter of each cleared area was generally surveyed because the non-native plants tended to be clustered in these locations. For the remainder of a cleared area, the surveyor walked to all remaining vegetation patches that had the potential to include non-native plants. The exception to this was areas that posed safety concerns (primarily related to the presence of heavy construction activity).

Data recorded at each location included spatial coordinates, species spatial extent and species abundance. Additional notes were also recorded and photos were taken.

Non-native plant spatial extent at a location was recorded either as a point with an associated number of individuals or as a patch. The “point with number of individuals” method was typically used in locations where there less than 20 individual plants covering a very small area. In these situations, the number of plants and a GPS waypoint (using a Garmin Map 62 or Map 78) were recorded as close to centre of the patch as possible for the species.

For the remaining non-native plant locations, recorded patch data included estimated non-native plant cover in the vegetation patch by species and the patch boundaries. Patch boundaries were obtained using a handheld GPS for each vegetation patch that included one or more non-native plant species. The percent cover of each non-native species within the vegetation patch boundaries was then visually estimated.

Vegetation patch boundaries were recorded in one of three ways:

1. **Point:** Used for small patches (20 or fewer plants) that had a relatively regular shape. Typically applied to small patches in open areas where the boundaries were visible from a single point. In these situations, a GPS waypoint was taken at the patch center whenever possible, with an associated ocular estimate of patch radius (in meters) for circular patches or the dimensional length (e.g. 2m x 4m) for rectangular patches.
2. **Band:** Used for patches too large to be recorded as a point and that were linear with a relatively constant width. In these situations, the length of the band of the non-native species (e.g. along a ditch) was walked while a GPS recorded a track log for the species. An estimate of the average bandwidth in meters was recorded. For some wider bands, the bandwidth was recorded using distinct features such as a specific impact area (e.g. width of the transmission line right-of-way).
3. **Defined Area:** Used if the patch could not be recorded as a point or a band. In these situations, the surveyor generally walked around the perimeter of a large homogeneous patch with non-native species cover while recording a GPS track log for the patch. Alternately, the surveyor walked through the area in a zig-zag transect so that the points generally corresponded to the boundaries of the patch. The former method was used when the non-native species could be observed throughout the patch from the outer boundaries, which typically occurred in open barren, or low vegetation areas. The latter method was used in heavily vegetated areas where non-native plants were not visible over a long distance. In this method, waypoints were added while recording the species tracklog to indicate if there was a change in cover.

For each non-native species patch, percent plant cover was estimated and recorded into one of the six classes listed in Table 2-2.

Table 2-2: Cover class and associated percent cover ranges used for non-native plant surveys

Cover Class	Percent Cover Range
Very sparse	>0 - 2%
Sparse	3 - 10%
Low	11 - 25%
Moderate	26 - 50%
High	51 - 75%
Very high	76 - 100%

Based on the 2017 invasive plant mapping, several areas were recommended for herbicide application (see Section 4.2 for herbiciding details). These were areas which contained invasive species of high concern that had high potential to spread into other areas. Manitoba Hydro treated these areas on July 23 and 24, 2018. Surveys were conducted in the treated areas to document the treatment efficacy.

The recommended treatment areas were visited prior to the herbicide treatment during the early summer plant surveys. Photo control points were established at strategic locations in the treatment areas so that pre- and post-treatment comparison photos could be acquired. At each photo control location, a marker pipe was planted, and one or more photos, along with the associated bearing(s) and orientation(s) (portrait or landscape) were recorded. During the late summer surveys, non-native plants in the treatment areas were recorded according to the standard survey methods. In addition to the standard data, the percent of dead foliage for each non-native species in the patch was also recorded. The photo control locations were re-visited and photos were taken of the same bearing and orientation as the pre-treatment photos.

2.3 MAPPING

This report includes detailed non-native plant distribution and abundance mapping derived from the non-native plant cover estimates. These maps show plant patches, by cover class, in the surveyed portions of the Project footprint. The mapping detail is the same as that in the 2017 annual report (ECOSTEM 2018).

The analysis evaluated non-native plant distribution and abundance in the context of precise clearing and disturbance mapping produced for 2018 (see ECOSTEM 2019). The primary focus of this report is on the patterns and changes observed in 2018. A detailed comparison of non-native plant spread over all construction years will be provided at the end of Project construction in the monitoring synthesis report.

Non-native plant distribution and abundance maps for late summer as well as the spatially focussed early summer surveys were produced by converting species spatial extent and cover data from the field surveys into GIS polygons. Where the patch extent method (Section 2.1) was used to record non-native species in the field, patch polygons were created from the GPS tracklogs. Polygons for locations where plants were recorded as individuals in the field were created by applying a fixed radius buffer around the location coordinate. The radius applied for each species at each point was a fixed value for the species multiplied by the number of plants recorded. The radius for one plant of a particular species was the estimated typical area covered by an individual plant (Appendix 1, Table 7-1). Since there were situations where plants were close enough to each other to have overlapping buffers, this method slightly overestimates total non-native plant cover.

The non-native plant mapping provided two measures of plant cover in the footprint components. One measure was the overall spatial extent of one or more non-native plant species, which also indicated species distribution. The other measure was the area covered by each species (approximate plant cover), which was used to indicate abundance. Non-native plant cover will usually be lower than plant extent due to less than complete canopy closure within most of the mapped patches.

Non-native plant cover was derived from the patch cover class (Table 2-2) for locations recorded using the “patch method” or from multiples of individual plant area (Appendix 1, Table

7-1) for locations recorded using the "number of individuals" method. The area covered by a species in a mapped patch was calculated by multiplying the patch area by the midpoint of the percent cover class (Table 2-2). For example, a 10 m^2 non-native plant patch with sparse cover for Species A would have a derived area of: 10 m^2 x 6.5% = 0.65 m^2 for Species A.

Factors that affected how the data generated from the mapping were interpreted included GPS accuracy, interpreter bias and variability, total plant cover and access. For GPS accuracy, non-native patch mapping relied on GPS waypoints and track logs for positioning. Depending on the terrain and satellite signal, accuracy of the GPS could vary approximately several meters during and between surveys. The same patch, mapped during different surveys may show different positions or extents from track logs and waypoints even if its boundaries remained unchanged. Such year-to-year differences were expected to be small relative to the size of the footprint of interest.

While efforts were made to calibrate plant cover estimates between the different individuals conducting the surveys, some individual bias is always inherent in this measurement method. Furthermore, even for the same individual, there may have been differences in the approach taken to map a particular patch of non-native plants in one year compared with the previous year. For example, an area with very sparse cover of a particular species may have been recorded as a series of individual points during one survey and as a single patch with very sparse cover during another survey (generally because the number and extent of individual points changed). While the actual cover and number of plants may have been the same between surveys (when limiting the comparison to the same spatial extent as the previous year), the current year patch limits and plant cover class could be different. Consequently, results for the area covered by a species could reflect the mapping approach, and not actually a change in non-native plant extents. To minimize this effect, whenever possible, the same individuals were used to conduct the surveys over the monitoring period, and an effort was made to subdivide the areas surveyed by each individual in the same way each time. This element of the field methods was not expected to create a large bias in the overall results even though there could be relatively large differences at specific sites.

As cleared areas regenerate, native vegetation cover may obscure non-native plants, confounding estimates of cover. This could result in a bias toward underestimating non-native plant cover in areas with dense or taller native plants. This could also result in a seasonal bias in which non-native plant cover for some species was underestimated during spring surveys because the plants were small and obscured by other vegetation.

During construction, some areas could not be safely accessed at the time when surveys were conducted due to construction activity (e.g., generating station area, Borrow Area N-21). While effort was made to observe these areas from a distance, it is possible that non-native plants were present but not recorded (note that this does not refer to sites where non-native plants definitely could not be seen if present; such areas are not included as part of the surveyed area). This could result in total cover being underestimated for certain areas in some years. However, any bias was expected to be small as the areas surveyed from a distance were typically in active borrow areas (i.e., the new substrate was recently exposed). Because the total

area surveyed varies due to these reasons, the results are related to total area surveyed, rather than total footprint area, increasing comparability of results from different surveys.

Due to the above factors (particularly the first two), derived species cover, rather than polygon extents, were considered to be a more meaningful measure for interpreting changes in non-native plant abundance between years. Non-native species polygon extents should only be considered as an indication of overall distribution as well as a very broad measure of area covered.

2.4 INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES

2.4.1 BACKGROUND

The EIS and EnvPPs include standard control or eradication measures for invasive and other non-native plants, including:

- Contractors that will be using equipment and machinery that was recently used more than 150 km from the Project area will wash that equipment and machinery prior to transport to the Project area.
- Areas that are rehabilitated using a seed mixture will be seeded with a mixture that only contains native and/or non-invasive introduced plant species.
- Areas where there are patches of noxious weeds will be flagged for avoidance if they are not contained in active construction areas.
- Exposed areas shall be revegetated as quickly as possible following construction to prevent soil erosion and the establishment of noxious weeds.

This monitoring study provides additional control or eradication recommendations during construction monitoring. The following summarizes the approach taken to make recommendations regarding which non-native species to prioritize for management, and the types of locations that management efforts will focus on. Appendix 2 details the approach.

It is widely recognized that it is not practical to attempt to eradicate or even control all non-native plant species (e.g., White *et al.* 1993; Morse *et al.* 2004; Ministry of Transportation and Infrastructure *et al.* 2011). For example, some species are already too widespread and well-established to implement an approach that removes plants at a faster rate than they reappear in the same locations and establish in new locations. Many of the non-native species recorded during Project monitoring are commonly found in disturbed areas throughout the Province (e.g., field sow-thistle, white clover), particularly along roadsides, making it difficult to prevent them from being spread by human or natural sources.

To prioritize and develop management recommendations for non-native plants in the Project area, the focus is on the plant species of highest invasive concern and the situations where there are practical ways to reduce these species or prevent further spreading. The primary sources used to classify the potential for a non-native plant species to have substantial adverse effects on ecosystems or biodiversity in the Project area were the ISCM (2018), White *et al.* (1993), the Provincial *Noxious Weeds Act* (Government of Manitoba 2017a) and the Federal Weed Seeds Order (Government of Canada 2016). While the federal *Plant Protection Act* was also relevant from the regulatory perspective, few of the species currently on its list occur in Manitoba, and those that do are limited to a few locations in the southern portion of the province.

The primary additional sources of information that assisted with evaluating potential invasiveness in the Project area, and with developing management recommendations, included the Biology of Canadian Weeds Series (Canadian Weed Science Society. 2019a), the Biology of Invasive Alien Plants in Canada (Canadian Weed Science Society. 2019b), Manitoba Agriculture (2019) and results from EIS or monitoring studies for this and other projects in northern Manitoba. The last of these sources also provided some information regarding patterns of distribution and abundance in the Project region.

A limitation for some of the sources used to determine a plant's degree of invasiveness was that they did not include data from the Keeyask region. The observed degree of invasiveness for the species included in these sources was generally obtained in regions subject to much different climates than that occurring in the Project region. Local invasiveness can differ greatly from that observed in other regions (Carlson *et al.* 2008).

Of the sources used for ranking a species' degree of invasiveness listed above, ISCM (2018) and White *et al.* (1993) were considered the most relevant ones because their focus is on impacts to ecosystems and biodiversity. The Provincial *Noxious Weeds Act* and the Federal Weed Seeds Order were developed to address impacts on the agricultural economy or the viability of the agricultural operations. An upshot of this agricultural focus is that these regulations do not list some species known to be of concern for impacts on native ecosystems and biodiversity (e.g., purple loosestrife). Conversely, these regulations also list some native boreal plant species (e.g., foxtail barley) as weeds since they can be problematic for agriculture. Native boreal species appearing on these lists were not considered to be invasive for the Project area.

2.4.2 INVASIVE CONCERN CLASSIFICATION

The non-native plant species recorded during monitoring to date were classified into one of four levels of invasive concern for the Project area (Table 2-3). Level 1 was the highest level of invasive concern for the Project. Level 1 species included ISCM Category 1 and 2 species.

The second highest level of invasive concern for the Project (Level 2 species) included ISCM "other" species of concern and/or the non-native species that White *et al.* (1993) classify as

being principal or moderate invasives in Canada. These species also have the potential to crowd out native species in many of the conditions where non-native plants are found.

The third highest level of invasive concern (Level 3 species) included non-native species that White *et al.* (1993) classify as minor invasives in Canada and/or the species that government sources classify as noxious weeds or weed seed species.

The fourth and lowest level of invasive concern (Level 4 species) included all of the non-native plant species not already included in another level. Species at the third and fourth levels may become problematic in some locations and/or conditions (*e.g.*, changed climate). They will also be a consideration when developing revegetation plans for areas being rehabilitated to native habitat types.

Table 2-4 shows how the invasive concern classification was applied to the non-native plant species recorded in the Project footprint to date.

Table 2-3: Levels of invasive concern for plants in the Project footprint

Invasive Concern Level	Plant Species Included
Level 1	Species the ISCM classifies as “Category 1” or “Category 2”
Level 2	Species the ISCM classifies as “other” or White et al. (1993) classify as “high” or “moderate” invasives
Level 3	Species that either White et al. (1993) classify as “minor” invasives, or government sources classify as noxious weeds or weed seed species1
Level 4	All remaining non-native plant species

Notes: [1] The government regulations list some native boreal plant species (e.g., foxtail barley) as weeds since they focus on species that are problematic for agriculture. Native boreal species appearing on these lists are not considered to be invasive for the Project area.

Table 2-4: Classification of non-native plant species recorded in the Project footprint into levels of invasive concern

Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White et al. Category[4]	Noxious Weed[5]	Weed Seed[6]
Level 1	Scentless chamomile	*Tripleurospermum inodorum*	Category 2		Tier 2	Secondary
	Ox-eye daisy	*Leucanthemum vulgare*	Category 2		Tier 2	Primary
	Common tansy	*Tanacetum vulgare*	Category 2		Tier 2	
Level 2	Canada thistle	*Cirsium arvense*	Other	Moderate	Tier 3	Primary
	Field sow thistle	*Sonchus arvensis*	Other		Tier 3	Primary
	Common burdock	*Arctium minus*	Other		Tier 3	
	Tufted vetch	*Vicia cracca*	Other			
	White sweet clover	*Melilotus albus*		Moderate		
	Yellow sweet clover	*Melilotus officinalis*		Moderate		
Level 3	Wormwood	*Artemisia absinthium*		Minor	Tier 3	
	Alfalfa	*Medicago sativa*		Minor		
	Lamb's quarters	*Chenopodium album*			Tier 3	
	Common dandelion	*Taraxacum officinale*			Tier 3	
	Narrow-leaved hawks-beard	*Crepis tectorum*			Tier 3	
	Curly dock	*Rumex crispus*				Secondary
Level 4	Pineappleweed	*Matricaria discoidea*				
	Bird's-foot trefoil	*Lotus corniculatus*				
	Black medick	*Medicago lupulina*				
	Common plantain	*Plantago major*				
	Common timothy	*Phleum pratense*				
	Smooth catchfly	*Silene csereii*				
	Alsike clover	*Trifolium hybridum*				
	Red clover	*Trifolium pretense*				

Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White et al. Category[4]	Noxious Weed[5]	Weed Seed[6]
	White clover	*Trifolium repens*				
	Wheat	*Triticum aestivum*				

Notes: [1] See Table 2-3 for the invasive concern classification. [2] In decreasing order of concern for the Project area. [3] Invasive Species Council of Manitoba (2018). [4] White *et al.* (1993). [5] Government of Manitoba (2017b). Number in column is the Tier in the Act (see text). [6] Government of Canada (2016).

2.4.3 GENERAL APPROACH TO MANAGEMENT

The generally preferred overall strategy for addressing invasive (called “weedy” in some publications) non-native plants is a combination of prevention, early detection and eradication because this is generally considered to be the most economical and effective way to manage invasive plants (e.g., Clark 2003; Coastal Invasive Species Committee 2016).

The generally preferred approach for dealing with individual or small patches of invasive plants appearing in new areas is to eradicate them as soon as they are discovered. Level 1 non-native species at sites with a small number of plants is manual removal of the plants shortly after finding them. Ideally, this is accomplished by manually removing the plant(s) including roots, removing the soil from around the base of the plant, immediately placing all plant and soil material into a double layer of garbage bags, and, disposing of all of the collected material (preferably by burning it).

When Level 1 plants were found within the Project footprint during the 2015 and 2016 surveys, their locations were reported to Manitoba Hydro environmental site staff, who carried out their removal and disposal using the preferred method described above.

Partway through the 2017 surveys, it was decided that, going forward, ECOSTEM survey staff would manually remove and dispose of the Level 1 plants using the preferred approach described above. Immediate removal was intended to minimize the possibility for these plants to disperse seed or become well-established. Since this decision was made during the 2017 field season, some locations were not treated in this manner during 2017. As the 2017 surveys progressed, Level 2 plants were also immediately removed and disposed of at some locations, provided that the number of plants was low enough that it was practical to do so.

This final approach from 2017 was followed during the 2018 surveys.

For the remaining locations with Level 2 plants, key sites were identified for herbicide application. The key sites were selected based on where invasive plants were most prolific and had the highest potential for being spread to other Project areas due to vehicles or footwear picking up seeds and carrying them elsewhere. Section 4.0 provides details.

2.5 SPECIES TREATED SEPARATELY

Native and non-native populations of reed canarygrass (*Phalaris arundinacea*) exist in North America. According to genetic analysis of herbarium specimens, the native reed canarygrass population was widespread in North American as of the early 20th century, extending from Alaska to New Brunswick (Jakubowski *et al.* 2012).

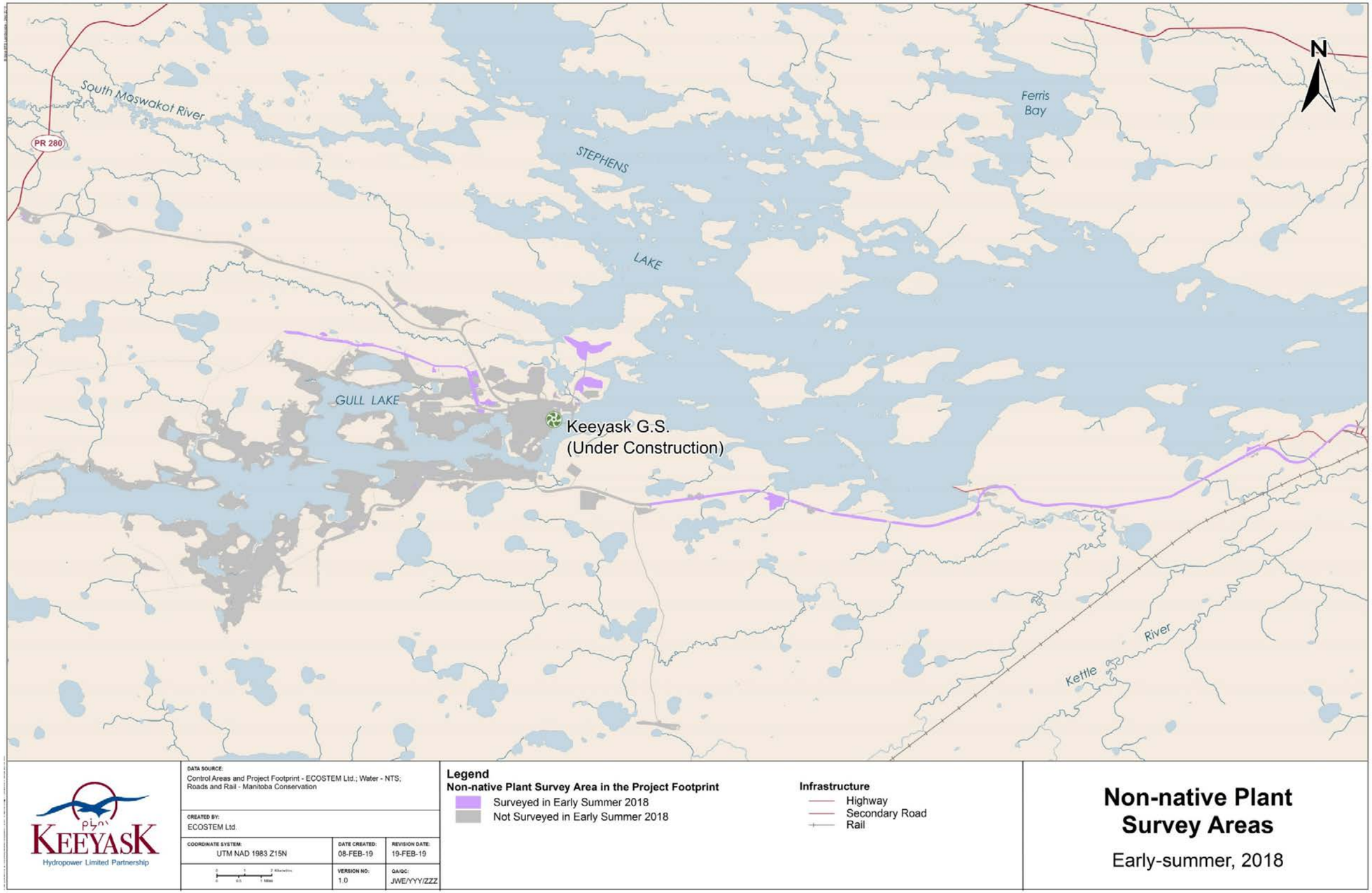
The non-native reed canarygrass population has been introduced from Eurasia on multiple occasions (Lavergne and Molofsky 2004; Lavergne and Molofsky 2007; Brodersen *et al.* 2008; Calsbeek *et al.* 2011). Genetic analysis concluded that the native and Eurasian populations are genetically distinct (Jakubowski *et al.* 2012). Additionally, non-native plants readily hybridize with native plants (Lavergne and Molofsky 2004).

Plants from the non-native or hybridized populations can be very aggressive, to the extent of crowding out native species. White *et al.* (1993) consider reed canarygrass to be a principal invasive plant in Canada.

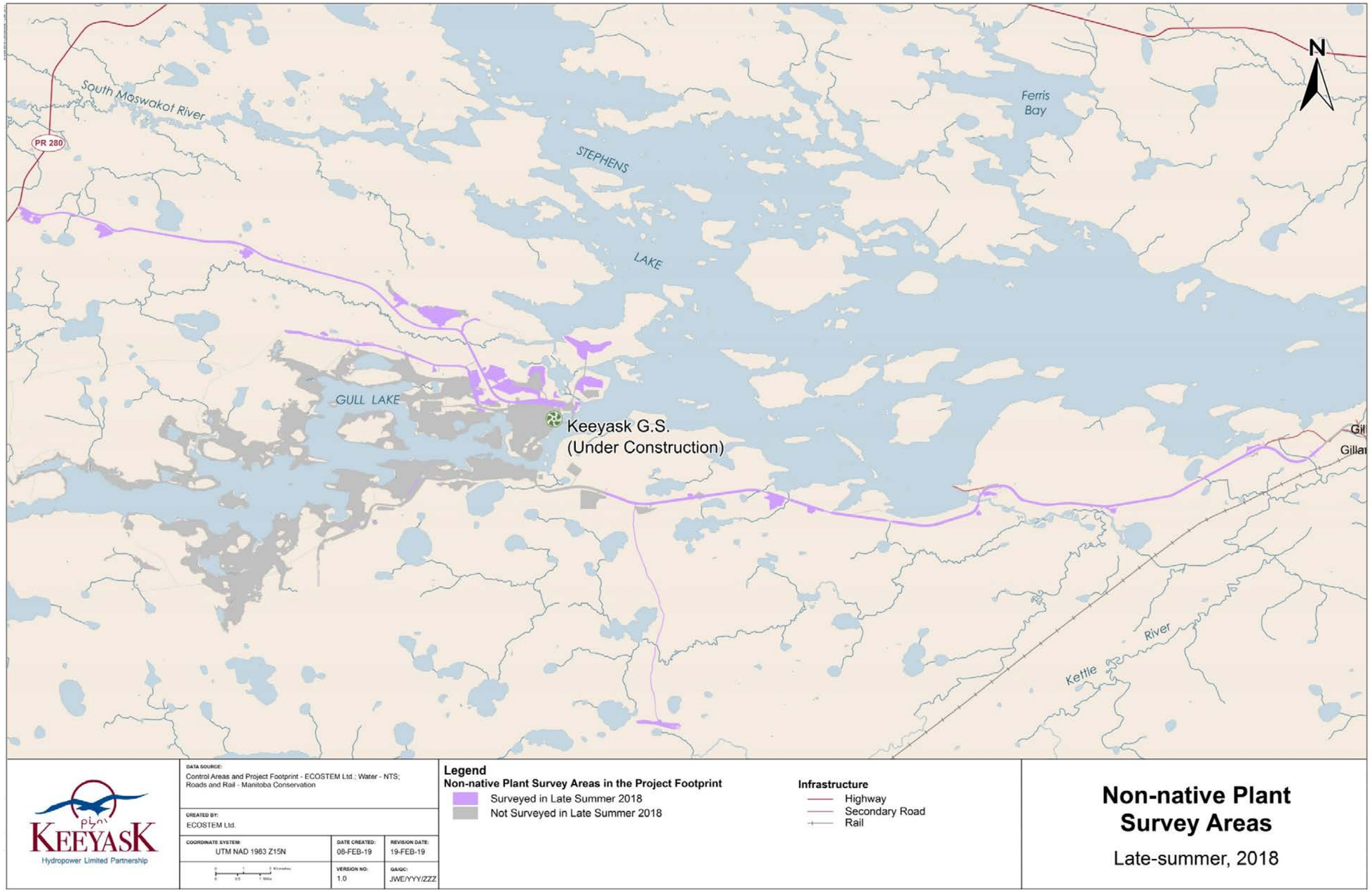
In the field, it is almost impossible to determine whether plants belong to the native, non-native or hybridized population (ISCM 2019). Some authors state that genetic analysis is the only reliable way to make this determination (Hayley 2012). As genetic analysis would be unduly onerous in many situations, some studies classify plants as native or non-native based on whether or not they are exhibiting invasive behavior (Maurer *et al.* 2003; Brodersen *et al.* 2008).

With regard to the Project footprint, evidence to date indicates that the recorded plants are likely from the native population. There is some evidence to suggest that the northern distribution limit of the non-native population in Manitoba is south of Thompson (Lavergne and Molofsky 2004; ISCM 2019). Also, more than a decade of data from the Wuskwatim Generation Project, which is also in northern Manitoba, have not demonstrated aggressive spread of the plants found there. Finally, the plants observed at Keeyask have not suggested aggressive spreading behaviour to date.

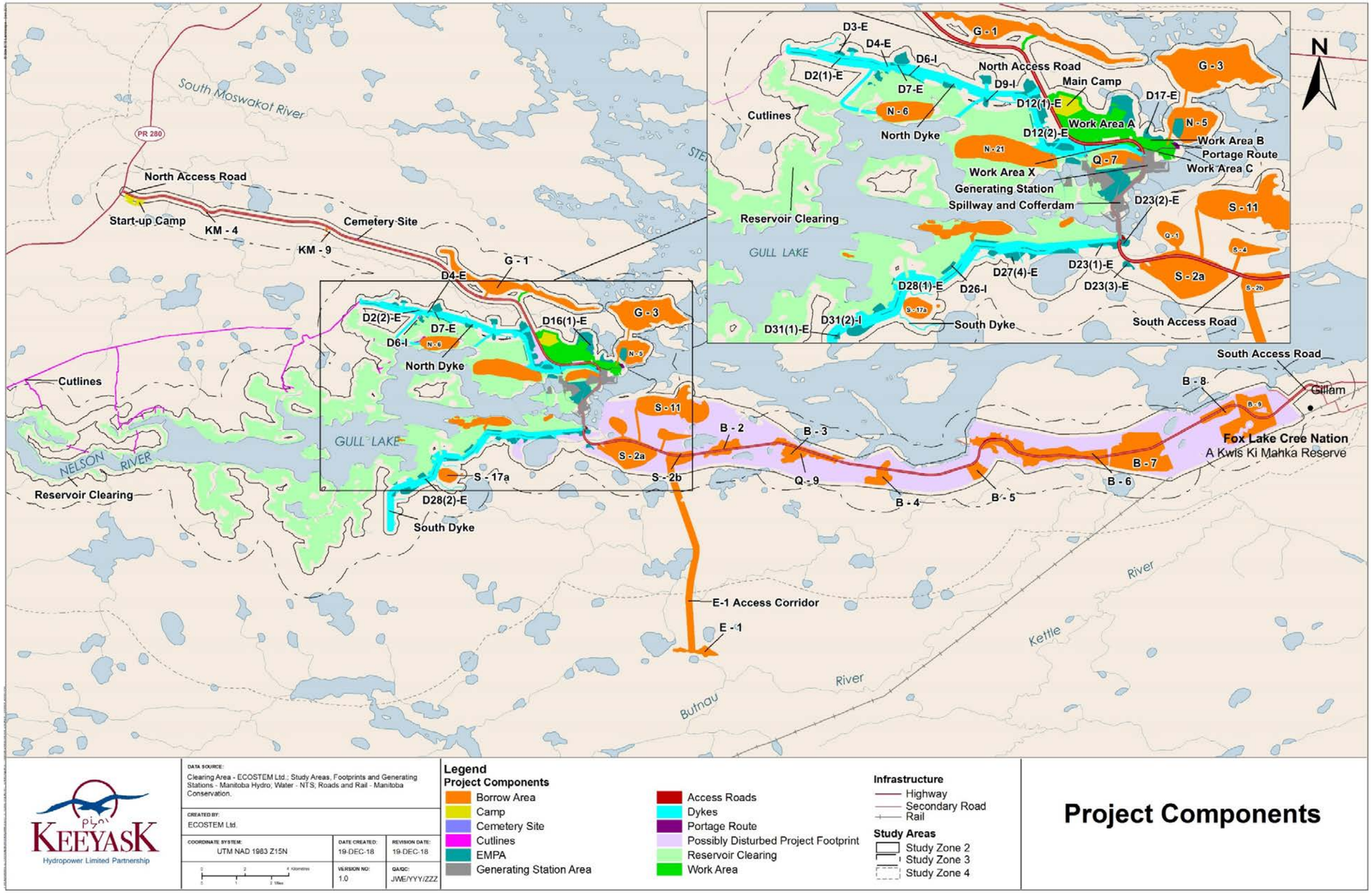
Based on the preceding information, the reed canarygrass plants recorded during Project monitoring to date are assumed to be from the native population. However, it is still possible that some or all of plants occurring in the Project footprint are actually from the non-native or hybridized population but past conditions have limited invasive behavior. For this reason, field surveys still recorded reed canarygrass using the same methods as used for other non-native plants. Reed canarygrass observations and results are provided in Appendix 5 in the event that the recorded plants do become invasive in the Project area.



Map 2-1: Early summer non-native plant survey areas in 2018



Map 2-2: Late summer non-native plant survey areas in 2018



KEEYASK Hydropower Limited Partnership

DATA SOURCE: Clearing Area - ECOSTEM Ltd.; Study Areas, Footprints and Generating Stations - Manitoba Hydro; Water - NTS; Roads and Rail - Manitoba Conservation.

CREATED BY: ECOSTEM Ltd.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	19-DEC-18	19-DEC-18
	VERSION NO: 1.0	QA/QC: JWE/YYY/ZZZ

Legend

Project Components
- Borrow Area
- Camp
- Cemetery Site
- Cutlines
- EMPA
- Generating Station Area
- Access Roads
- Dykes
- Portage Route
- Possibly Disturbed Project Footprint
- Reservoir Clearing
- Work Area

Infrastructure
- Highway
- Secondary Road
- Rail

Study Areas
- Study Zone 2
- Study Zone 3
- Study Zone 4

Project Components

Map 2-3: Project components

3.0 RESULTS

3.1 TOTAL AREA SURVEYED

3.1.1 EARLY SUMMER

In 2018, early summer non-native plant surveys occurred in approximately 516 ha (9%) of the areas that had been cleared or disturbed by the Project (Table 3-1; Table 3-2), and 18% of the Project footprint excluding the North and South Access roads and future reservoir area.

The total area included in the 2018 early summer survey was slightly higher than in 2017. There were also some differences in the areas that were surveyed due to the survey locations being targeted based on: non-native plant cover in fall 2017 (Section 2.2); and, where herbicides had been applied since the previous survey (see Section 4.2 for herbiciding details).

Non-native plant surveys were not conducted in the cleared future reservoir areas given the low likelihood that non-native plant distribution had changed, the large size of the reservoir-clearing footprint, and the fact that future flooding will eliminate plants that are not close to the shoreline. It had been determined from previous surveys, and from low-level aerial surveys of the south reservoir in 2018 that non-native plants were virtually absent. The apparent virtual absence of non-native plants was thought to be primarily due to two factors: reservoir clearing targeted vegetation taller than 5 feet (leaving the ground vegetation largely intact); and, clearing occurred during the winter, which limited seed spread by vehicles and equipment and resulted in little ground disturbance.

3.1.2 LATE SUMMER

Late summer non-native plant surveys in 2018 covered approximately 668 ha (12%) of the cleared or disturbed Project footprint (Table 3-1; Table 3-2). The late summer survey covered approximately 46% of the Project footprint excluding the North and South Access roads and future reservoir area. The future reservoir area accounted for 66% of the Project footprint in 2018.

Compared with 2017, the total area surveyed was four ha lower, primarily because construction activity precluded assess to portions of some footprints. These footprints included portions of the North and South Access roads, and two borrow areas off the west end of the South Access Road.

The locations included in the 2018 and 2017 surveys were similar for most of the Project components (Table 3-1). As noted above, most of the exceptions were due to high levels of

construction and haul truck activity. Locations not surveyed in 2018 included the generating station area, the easternmost survey stop along the North Access Road, the westernmost two survey stops along the South Access Road (SAR), and two borrow areas (S-2a and S-2b) adjacent to the South Access Road.

Portions of Borrow Area N-5 and Borrow Area G-1 were not surveyed for reasons similar to the reservoir clearing. Only the aboveground vegetation had been cleared in the unsurveyed portions of these borrow areas, and previous surveys found very few non-native plants, with little to no change in cover over time (ECOSTEM 2017; 2018).

While some borrow areas were not surveyed in 2018, the overall borrow area surveyed did not decrease substantially since 2017 because the recently cleared and excavated Ellis Esker and its access corridor were surveyed for the first time in 2018. Additionally, the amount of area surveyed along the South Dyke in 2018 was twice the area surveyed in 2017. This was because a larger area was targeted for survey due to the longer time since clearing, and there had been more construction activity along the South Dyke in 2018.

Table 3-1: Total area (ha) surveyed for non-native plants by year and Project component

Project Component	Early Summer Survey					Late Summer Survey				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
North Access Road[1]	9	9	9	-	-	10	9	8	10	9
South Access Road[1]	-	-	9	306[4]	268[4]	-	-	10	16	13
Camp and Work Areas	126	109	163	19	6	138	111	186	182	185
Borrow Areas	112	119	323	79	131	120	131	329	334	329
North Dyke	-	-	52	88	108	1	-	56	120	124
South Dyke[2]	-	-	38	7	3	-	-	21	4	8
Generating Station Area	-	-	20	10	0	-	-	10	6	-
Reservoir Clearing Area	-	-	56	0	-	-	-	-	0	-
Total surveyed area	*247*	*237*	*669*	*509*	*516*	*269*	*251*	*620*	*671*	*668*
Total footprint area [3]	*540*	*1,438*	*3,643*	*5,372*	*5,716*	*540*	*1,438*	*3,643*	*5,372*	*5,716*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Sampled area consists of a systematic sample of the road (Section 2.1). In addition, cleared areas were scanned for large patches while driving between stops.
[2] The south dyke was surveyed through a series of targeted spot checks.
[3] Approximately 75 ha of KIP borrow areas not used by the Project are included in these totals.
[4] Almost the entire south access road was surveyed by vehicle in early summer using rapid methodology (see Section 2.12).

Table 3-2: Percentage of Project footprint area included in the non-native plant surveys by year and Project component

Project Component	Early Summer Survey					Late Summer Survey				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
North Access Road[1]	5	5	5	-	-	5	5	4	5	5
South Access Road[1]	-	-	3	94[3]	82[3]	-	-	3	5	4
Camp and Work Areas	68	48	71	8	3	75	49	81	78	78
Borrow Areas	90	35	74	16	24	96	38	76	68	60
North Dyke	-	-	28	45	54	3	-	30	61	62
South Dyke[2]	-	-	31	4	2	-	-	17	2	4
Generating Station Area	-	-	9	4	0	-	-	4	3	-
Reservoir Clearing Area	-	-	3	0	-	-	-	-	0	-
All surveyed areas	*46*	*17*	*18*	*9*	*9*	*50*	*17*	*17*	*12*	*12*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Sampled area consists of a systematic sample of the road (Section 2.1). In addition, cleared areas scanned for large patches while driving between stops.
[2] The south dyke was surveyed through a series of targeted spot checks.
[3] Almost the entire south access road was surveyed by vehicle in early summer using rapid methodology (see Section 2.12).

3.2 SEASONAL PATTERN IN NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

In general, early summer and late summer surveys conducted from 2014 to 2016 indicated that there was a seasonal increase in the number of non-native plant species during each growing season. There was also a seasonal increase in plant extent and cover as a percentage of area surveyed (ECOSTEM 2017).

Results from the 2018 early summer survey confirmed that non-native plants were overwintering at locations where they were found in 2017. Additionally, plants had begun to establish in some areas that had either no, or very few, plants in August 2017. These locations included ditches along the SAR west of the Butnau Marina, along the North Dyke and in EMPA D12(2)-E (Map 3-1).

A total of 14 non-native species were identified during the 2018 early summer survey. The species appearing most frequently at new locations since the 2017 late summer survey were narrow-leaved hawks-beard (*Crepis tectorum*), sweet clover (*Melilotus* spp.), curly dock (*Rumex crispus*) and common plantain (*Plantago major*). Narrow-leaved hawks-beard was found at most of the new non-native plant locations along the North Dyke. Sweet clover and yellow dock were

spreading along the SAR west of the Butnau Marina. Common plantain was establishing along the lower slopes of EMPA D12(2)-E.

3.3 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

In what follows, the analysis of changes in non-native plant distribution and abundance focuses on the late summer survey since these data best reflect patterns and trends for these indicators (Section 2.1).

The metrics used to document changes in distribution and abundance were plant extent and plant cover, respectively (Section 2.1). Plant extent was measured as the spatial limits of a vegetation patch that included one or more non-native plant species. However, because canopy closure of a species within each mapped patch could range from very sparse to very high, the plant cover metric identified the surface area covered by each species (plant cover was derived from the cover class recorded during field surveys (Table 2-2)).

As of late summer, 2018, overall non-native plant extent had increased to 64.0 ha, or 9.6% of the total area surveyed (Table 3-3). This was more than twice the area recorded in 2017, or an increase of 35.0 ha.

Non-native plant extent increased in all of the surveyed Project components. Non-native plants were most widespread in the camp and work areas and borrow areas, and were least widespread along the South Dyke (Map 3-2 to Map 3-6). For the Project components other than the South Dyke, plants were distributed over between 7.6% and 12.8% of the surveyed areas. The largest increases in non-native plant extent since late-summer 2017 were along the North Dyke and the SAR.

Total non-native plant cover increased to 5.9 ha by late summer, 2018, or 0.88% of the total surveyed area (Table 3-4). This was a 2.9 ha increase from 2017. Cover increased in all surveyed Project components.

Table 3-3: Total late summer non-native plant extent as a percentage of total area surveyed, by year[1] and Project component

Project Component	2014	2015	2016	2017	2018	Change[3]
North Access Road	0.3	0.9	3.5	4.4	7.6	3.2
South Access Road	-	-	0.2	2.8	7.9	5.1
Camp and Work Areas	3.2	4.7	4.0	5.9	12.8	6.9
Borrow Areas	0.3	3.1	2.1	5.1	8.9	3.8
North Dyke	-	-	0.1	0.3	7.6	7.3
South Dyke[2]	-	-	0.0	0.1	0.2	0.1
Generating Station Area	-	-	0.5	0.2	-	-
Reservoir Clearing Area	-	-	-	-	-	-
All Types	1.8	3.7	2.4	4.3	9.6	5.3
Total non-native plant extent (ha)	*4.9*	*9.3*	*14.8*	*28.9*	*64.0*	
Total area surveyed (ha)	*269*	*251*	*620*	*671*	*668*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Plant extent in some components are not directly comparable with other years because surveyed areas may change due to accessibility.

[2] Proportion of non-native plant cover in south dyke area is likely an overestimate of the proportion for entire footprint because the survey locations were selected based on those with highest potential to have non-native plants (see Section 2.12).

[3] Change from 2017 to 2018; A negative sign means that extent decreased.

Table 3-4: Total late summer non-native plant cover as a percentage of total area surveyed, by year[1] and Project component

Project Component	2014	2015	2016	2017	2018	Change[3]
North Access Road	0.01	0.07	0.25	0.38	0.62	0.23
South Access Road	-	-	0.01	0.36	1.21	0.85
Camp and Work Areas	0.34	0.77	0.58	0.73	1.20	0.47
Borrow Areas	0.05	0.48	0.24	0.46	0.74	0.28
North Dyke	-	-	0.00	0.01	0.79	0.78
South Dyke[2]	-	-	0.00	0.02	0.02	0.00
Generating Station Area	-	-	0.03	0.00	-	-
Reservoir Clearing Area	-	-	-	-	-	-
All surveyed area	0.20	0.59	0.31	0.44	0.88	0.43
Total non-native plant cover (ha)	0.53	1.49	1.89	2.98	5.85	
Total area surveyed (ha)	269	251	620	671	668	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Plant extent in some components are not directly comparable with other years because surveyed areas may change due to accessibility.

[2] Proportion of non-native plant cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.

[3] Change from 2017 to 2018; A negative sign means that cover decreased.

As a percentage of surveyed area, non-native plant cover was highest (1.2%) along the surveyed segments of the SAR, followed by the camp and work areas, the North Dyke, the borrow areas and the NAR.

While non-native plants continued to colonize or spread in the more recently cleared areas, their cover remained comparatively low in these areas. The majority of the non-native species found in each year since 2015 were in the portions of the Project footprint originally created by or existing before KIP, and which are still being used by the Project (e.g., Start-up Camp, Borrow Area G-1 at KM-15).

Non-native plant extent was highest by far (23.2%) in footprints that were used for the KIP, but have not been further used by the Project (Appendix 4, Table 7-7). Non-native plant cover was highest (1.5%) in areas utilized by both KIP and the Project, which was a substantial change from 2017 (Appendix 4, Table 7-8). In portions of the footprint that had not been used since the KIP (with the exception sites where tree planting was conducted), there was a decrease in both extent and cover of non-native plants from 2017 to 2018. But in areas used for the KIP that continue to be used by the Project, both non-native plant extent and cover increased from 2017 to 2018.

Areas that were more recently cleared, and used only for the Project, had substantially lower non-native plant extent and cover (4.1% and 0.4%, respectively). However, these were also substantial increases from 2017 for both metrics.

In 2018, the distribution of non-native plants on the north and south sides of the Nelson River (Map 3-2 to Map 3-6) was broadly similar to that of 2017 (ECOSTEM 2018), particularly in areas that were utilized by the KIP and the Project. Since 2017, non-native plants expanded in Borrow Area KM-1, the surveyed portions of Borrow Area G-1, the Main Camp, the Well Road and Work Area A.

Non-native plants also increased in the Excavated Material Placement Areas (EMPAs) that appeared to have had reduced construction activity since 2017. These included EMPA D16, D17, D35, and the EMPAs along the North Dyke, particularly D12.

The largest increase in non-native plant extent and cover was observed along the North Dyke (Table 3-3 and Table 3-4). Non-native plants were very scattered along the North Dyke in 2017, but by late summer 2018, large patches were found growing in the cleared area along either side of the dyke infrastructure (Map 3-3).

Non-native plant cover in 2018 also increased around the offices and Hydro yard in Work Area B, and in Work Area C. In Work Area X the extent and cover remained similar to 2017, with a relatively small increase in total cover.

As of late summer 2017, non-native plants remained absent in Borrow Area G-3. However, by late summer 2018, plants were establishing at several locations around the perimeter of this borrow area. Plants remained absent in the central areas of the pit where active excavation was occurring. In Borrow Area N-5, cover remained similar to that recorded in 2017. In the EMPA attached to Borrow Area N-5 (EMPA D35), extent and cover had expanded.

Clearing for the Ellis Esker borrow area (Borrow Area E-1) occurred during the winter of 2017/218. Cleared areas included the winter access road corridor and the borrow area. Only a portion of the clearing for the borrow area (Map 2-2) had been excavated. In late summer 2018, non-native plants were not observed in any of the surveyed locations.

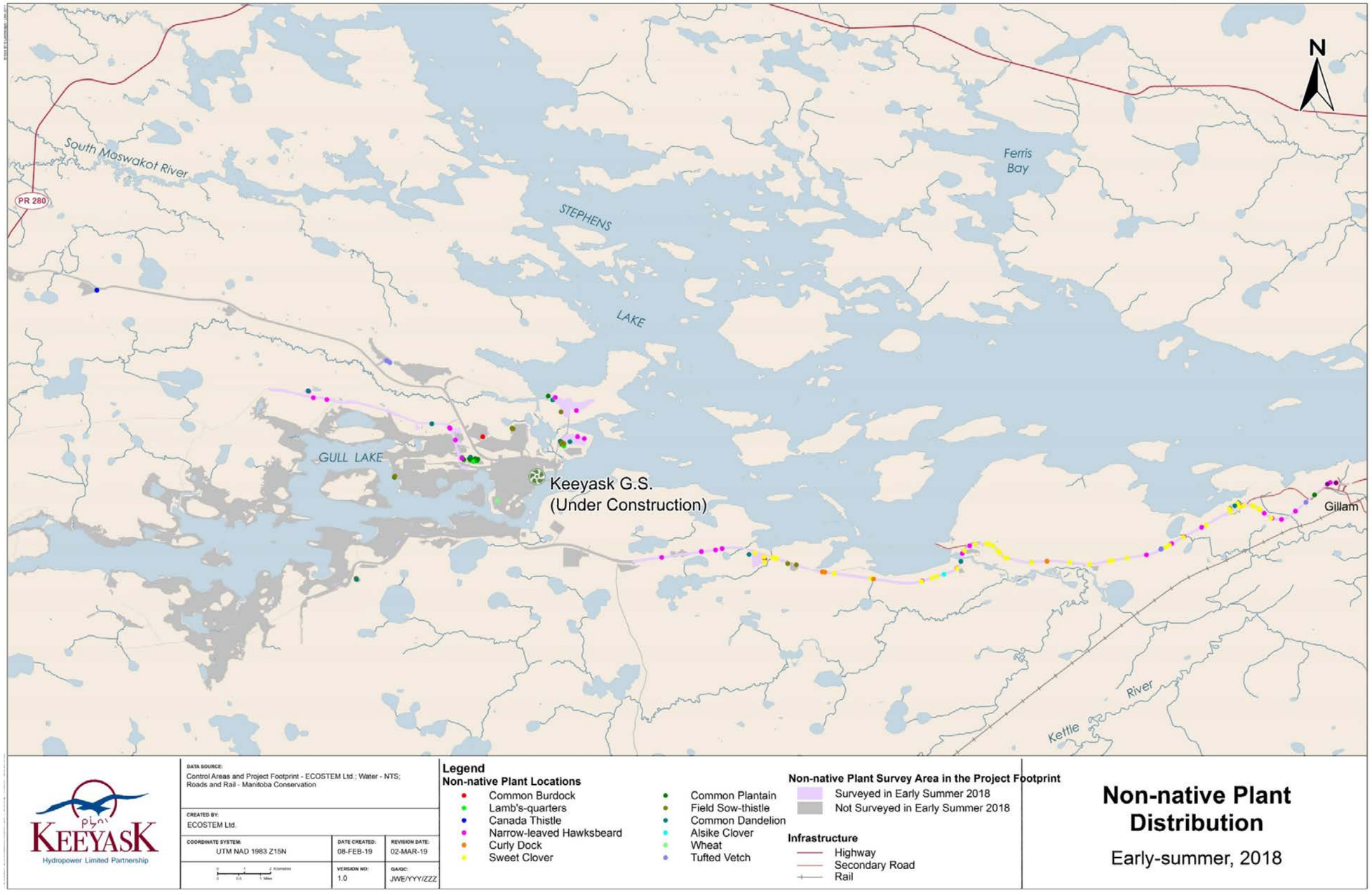
Construction activity along the SAR during summer 2018 was concentrated in an approximately 3 km segment at the west end of the road. This included heavy haul truck activity between the South Dyke and Borrow Areas S-2a and Q-1. Due to heavy haul truck and construction activity, these areas were not accessible for ground surveys. Since late summer 2017, non-native plant cover increased by more than 200% along the SAR west of the Butnau Marina (Map 3-5). The distribution and cover of plants remained higher around the current Sigfusson Northern/Voltage Camp and offices (formerly the SAR Camp), as well as in Borrow Area Q-9. A camp had been established in a portion of Borrow Area B-2 just east of Borrow Area S-2b and the E-1 access corridor. A few non-native plants were found growing near buildings there.

Most of the non-native plant cover along the SAR occurred in the ditches east of the Butnau Marina, where the ROW was either in close proximity to or overlapped the old Butnau Road (Map 3-5). Non-native plant extent and cover continued to expand along this portion of the road

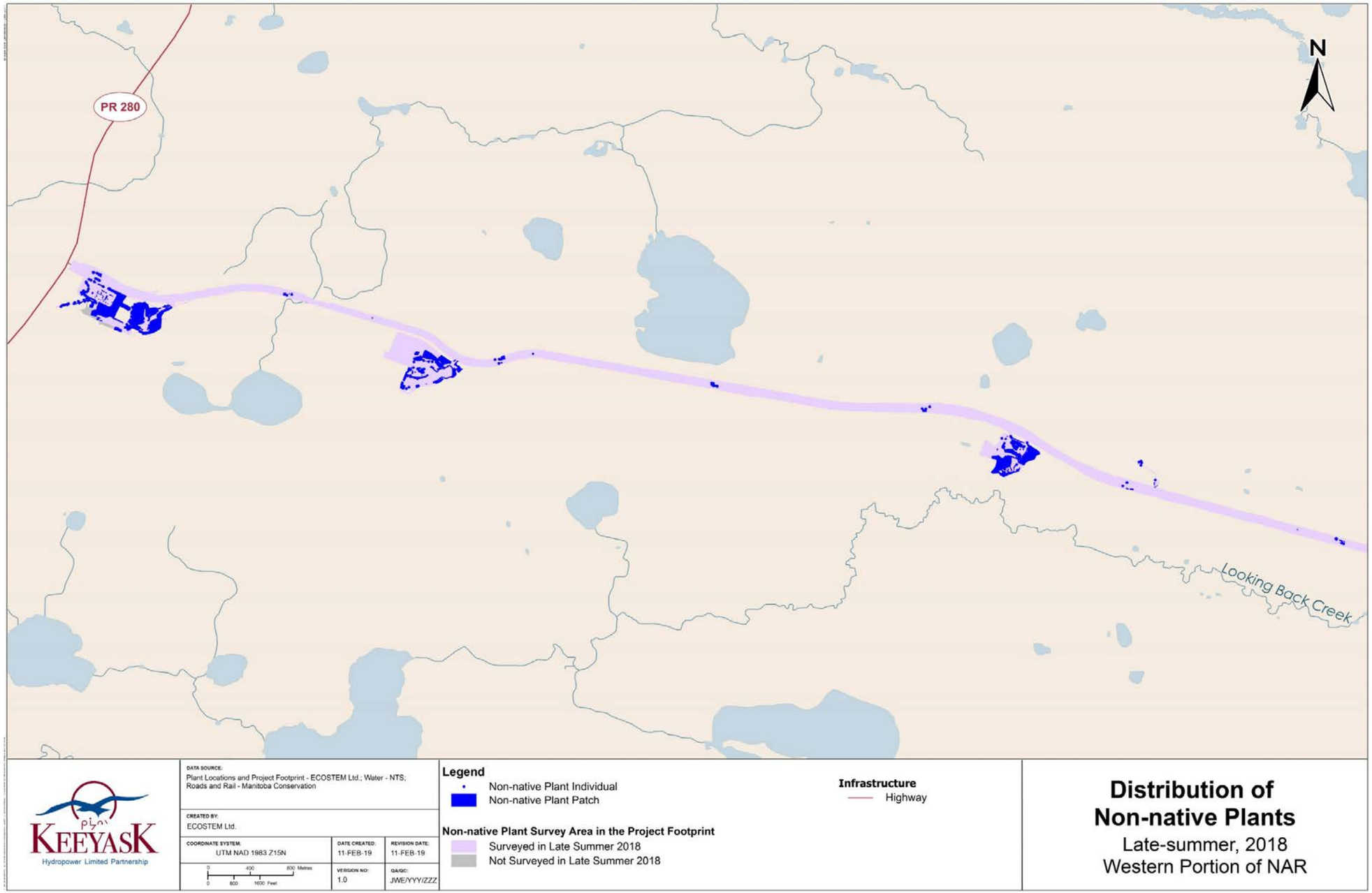
since 2017, as well as in the west and east sections of Borrow Area B-6, and in Borrow Area B-8.

Non-native plant cover along the surveyed portions of the south dyke remained similar to that recorded in 2017 (Map 3-6). Plant cover remained low overall in late summer 2018, but there was a slight increase since the previous year. Cover had increased in Borrow Area S-17a, and new plants had established in several new locations along the dyke on exposed mineral substrates. Non-native plants were observed for the first time in Borrow Area S-18.

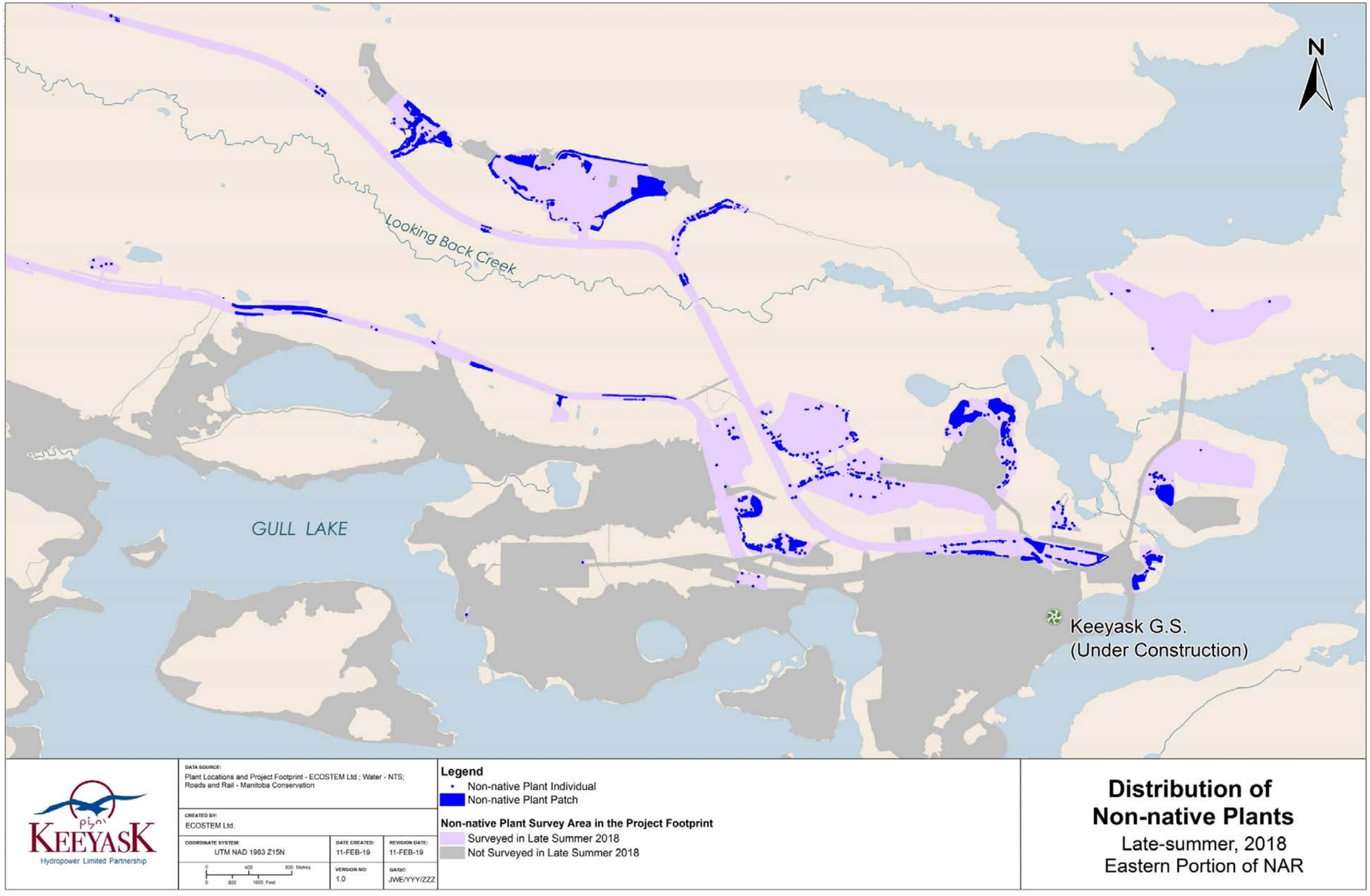
Ground searches were not possible in several locations for safety reasons. The eastern extent of Borrow Area G-1 was not surveyed due to bear activity. Locations not surveyed due to construction activity included portions of Work Area A (particularly around the rock crusher), in the generating station (GS) area, in portions of EMPA D12, Borrow Areas Q-1, S-2a and S-2b, the westernmost two SAR survey stops, and the easternmost NAR survey stop. Based on previous results (ECOSTEM 2017; WRCS and ECOSTEM 2017), it is unlikely that many non-native plants would have established in these areas due to the high volume of construction activity, including excavation, material stockpiling and vehicle traffic.



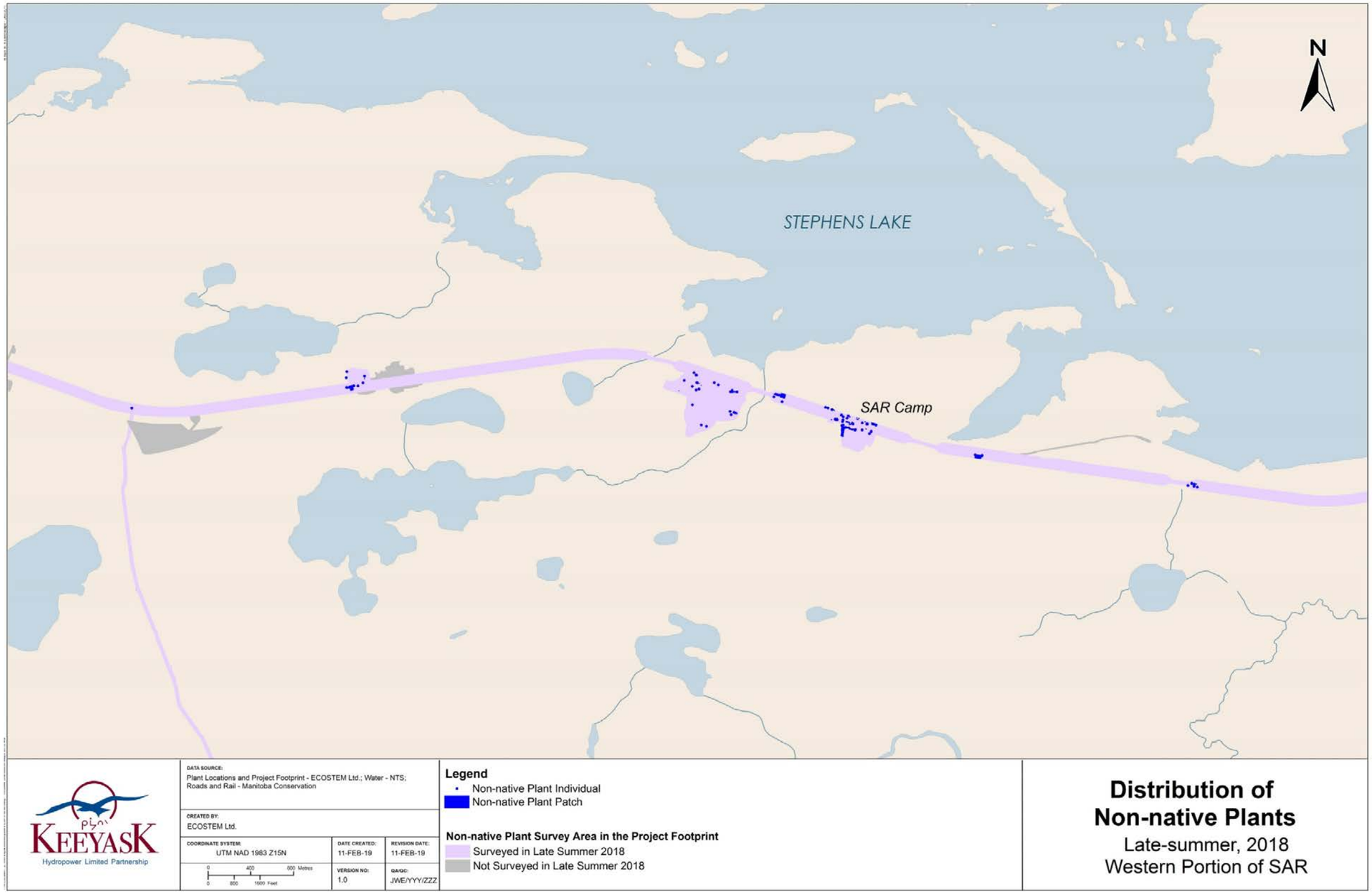
Map 3-1: Distribution of non-native plants within the Project footprint during early summer, 2018



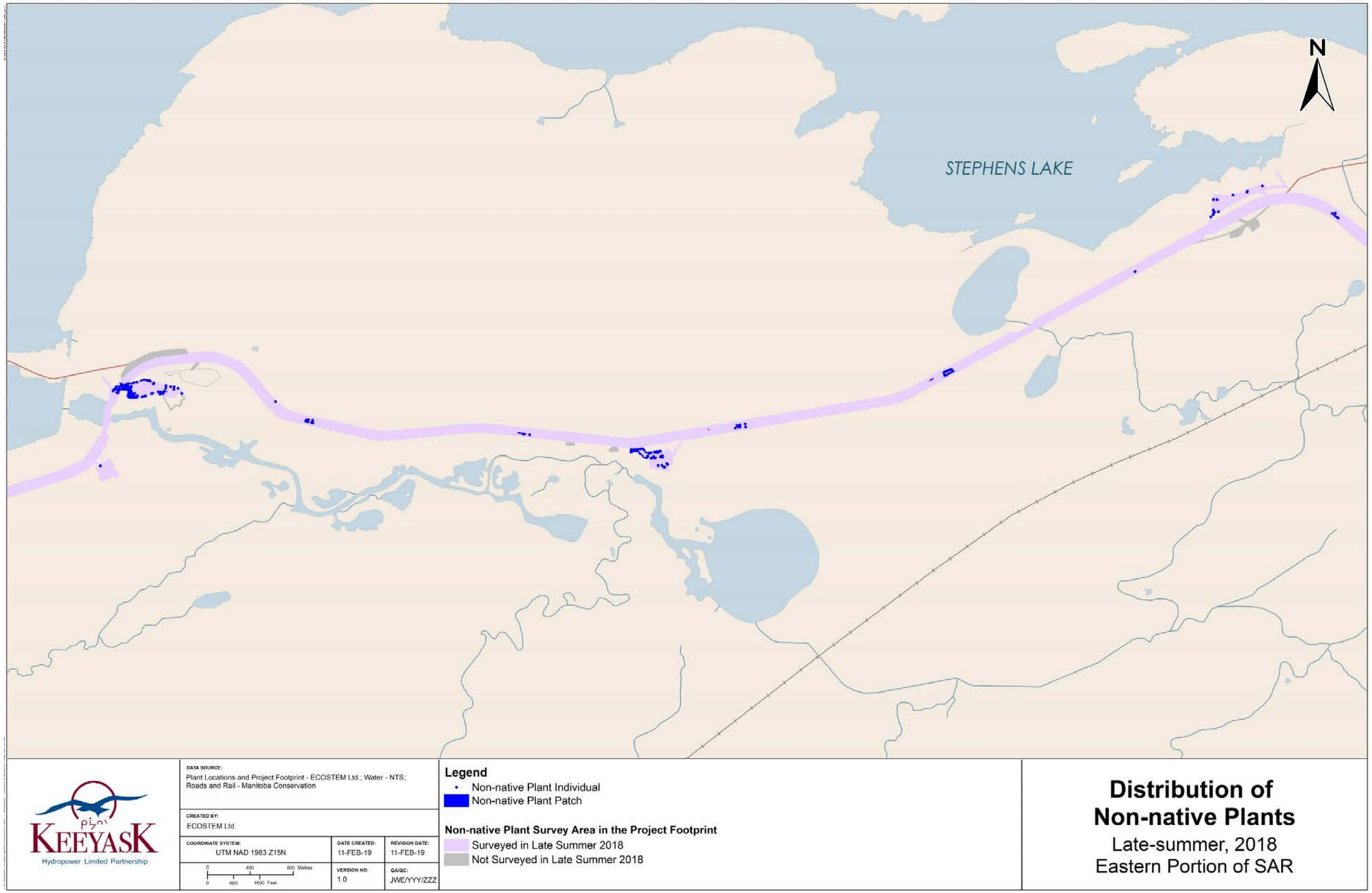
Map 3-2: Distribution of non-native plants during late summer 2018, in the Project footprint along the western portion of the North Access Road



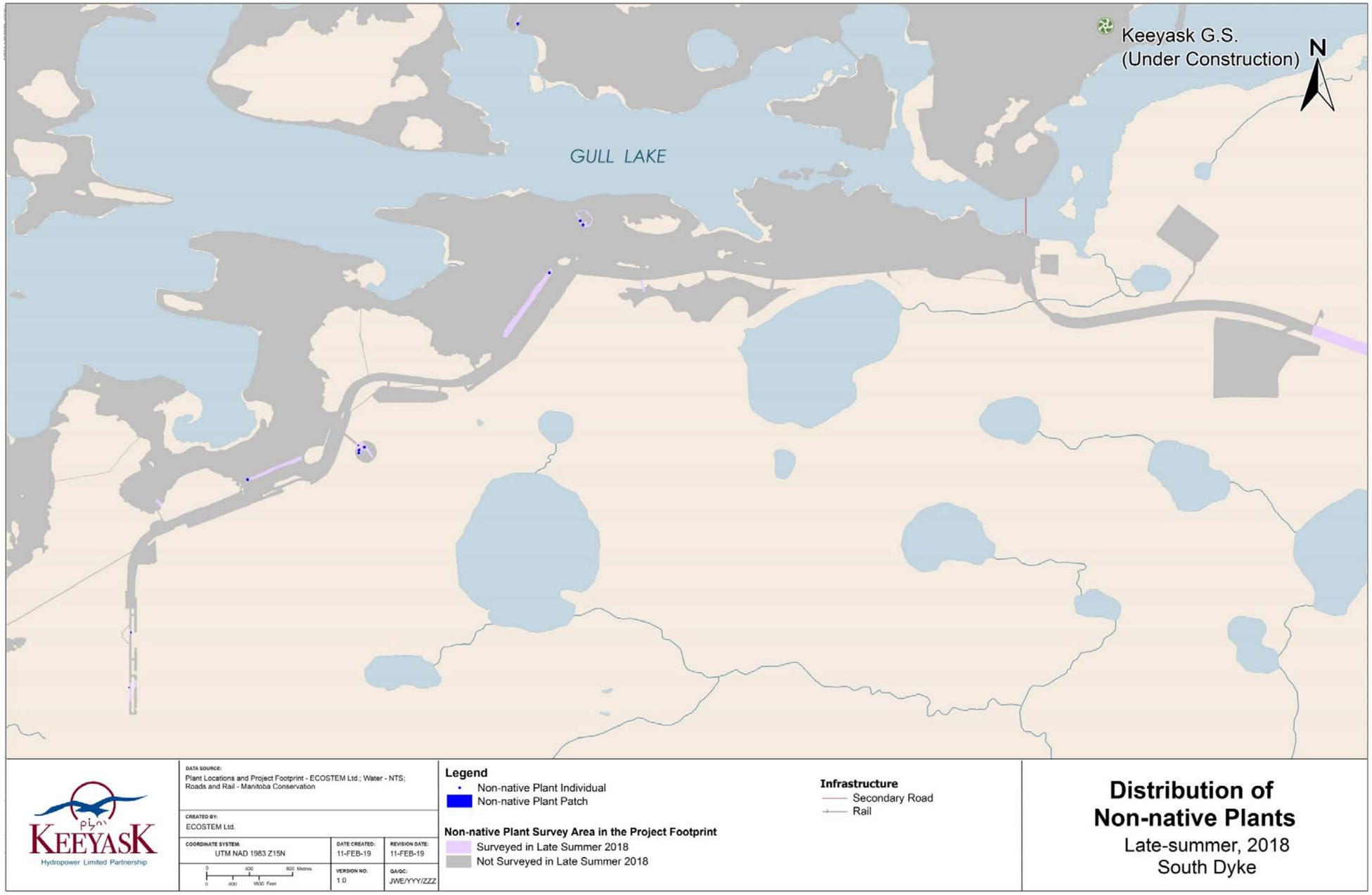
Map 3-3: Distribution of non-native plants during late summer 2018, in the Project footprint along the eastern portion of North Access Road



Map 3-4: Distribution of non-native plants during late summer 2018, in the Project footprint along the western portion of the South Access Road



Map 3-5: Distribution of non-native plants during late summer 2018, in the Project footprint along the eastern portion of the South Access Road



Map 3-6: Distribution of non-native plants during late summer 2018, in the Project footprint along the South Dyke

3.4 CHANGES TO SPECIES DISTRIBUTION AND ABUNDANCE

Based on data from non-native plant monitoring and incidental observations, a total of 22 non-native plant species were observed in 2018 (Appendix 4, Table 7-6). This was the same number of non-native species as observed in the previous year. The distribution and abundance of the five most abundant non-native species recorded in 2018 in Project footprints north and south of the Nelson River are shown in Map 7-1 to Map 7-20 in Appendix 3.

The four most abundant non-native species in 2018 (Table 3-5) accounted for 91% of all non-native plant cover (Table 3-6). These species were lamb's quarters (*Chenopodium album*), white sweet clover (*Melilotus albus*), narrow-leaved hawks-beard (*Crepis tectorum*) and common dandelion (*Taraxacum officinale*), each accounting for 34%, 20%, 19% and 18% of the total non-native cover in 2018, respectively (3-6). The next most abundant species was field sow-thistle (*Sonchus arvensis*) (4% of the total non-native cover), followed by five species at 1%.

All of the five most abundant species increased in cover since 2017. Total cover of narrow-leaved hawks-beard increased by more than eight times since late summer 2017. Both white sweet clover and common dandelion doubled in cover.

Common tansy (*Tanacetum vulgare*) was recorded for the first time in 2018. Species found during previous surveys but not recorded again in late summer 2018 (Table 3-5) included bird's-foot trefoil (*Lotus corniculatus*), black medick (*Medicago lupulina*), rye (*Secale cereal*) and white clover (*Trifolium repens*).

For rye, five individuals were found growing at three nearby locations beside the Start-up Camp in 2014. These plants were never found there again during subsequent surveys.

Cover for each of black medick, white clover and bird's-foot trefoil was extremely low in surveys from previous years. These plants may still be present in the Project footprint, but were not detected at the time of the 2018 surveys.

Table 3-5: Total approximate late summer non-native species cover (m^2) in the Project footprint, by year

Common Name[1,2]	Species	2014	2015	2016	2017	2018
Lamb's-quarters	*Chenopodium album*	2,903	8,844	6,342	15,229	19,812
White Sweet Clover	*Melilotus albus*	532	2,252	3,015	4,949	11,591
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	586	1,314	11,040
Common Dandelion	*Taraxacum officinale*	1,291	2,422	5,268	5,521	10,302
Field Sow-thistle	*Sonchus arvensis*	252	972	1,111	1,656	2,562
Alsike Clover	*Trifolium hybridum*	25	242	190	91	833
Common Plantain	*Plantago major*	80	121	268	246	741
Yellow Sweet Clover	*Melilotus officinalis*	0	2	109	254	543
Unidentified Sweet Clover	*Melilotus* spp.	72	-	1,838	67	307
Smooth Catchfly	*Silene csereii*	-	5	26	32	294
Tufted Vetch	*Vicia cracca*	-	-	0	38	170
Curly Dock	*Rumex crispus*	-	-	100	19	148
Alfalfa	*Medicago sativa*	124	11	14	40	98
Pineappleweed	*Matricaria discoidea*	-	18	29	325	74
Common Burdock	*Arctium minus*	-	-	0	-	5
Canada Thistle	*Cirsium arvense*	-	0	0	1	2
Wormwood	*Artemisia absinthium*	-	0	1	1	1
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0	0	1
Ox-eye Daisy	*Leucanthemum vulgare*	-	-	-	-	0
Common Timothy	*Phleum pratense*	-	-	0	0	0
Common Tansy	*Tanacetum vulgare*	-	-	-	-	0
Red Clover	*Trifolium pratense*	0	0	-	1	0
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0	0	-
Black Medick	*Medicago lupulina*	0	1	-	0	-
Rye	*Secale cereale*	0	-	-	-	-
White Clover	*Trifolium repens*	0	0	0	-	-
Wheat	*Triticum aestivum*	-	-	30	21	-
All species		*5,280*	*14,890*	*18,927*	*29,805*	*58,524*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Bolded species are Level 1 invasive concern (Table 2-4). Italicized species are Level 2 invasive concern. Underlined species are Level 3 invasive concern. Remaining species are non-native species that may become problematic in some locations and/or condition. [2] Species difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.

Table 3-6: Total approximate cover of a non-native species as a percentage of total cover for all non-native species, by year

Common Name[1,2]	Species	2014	2015	2016	2017	2018
Lamb's-quarters	*Chenopodium album*	55	59	34	51	34
White Sweet Clover	*Melilotus albus*	10	15	16	17	20
Narrow-leaved Hawks-beard	*Crepis tectorum*	-	-	3	4	19
Common Dandelion	*Taraxacum officinale*	24	16	28	19	18
Field Sow-thistle	*Sonchus arvensis*	5	7	6	6	4
Alsike Clover	*Trifolium hybridum*	0	2	1	0	1
Common Plantain	*Plantago major*	2	1	1	1	1
Yellow Sweet Clover	*Melilotus officinalis*	0	0	1	1	1
Unidentified Sweet Clover	*Melilotus* spp.	1	-	10	0	1
Smooth Catchfly	*Silene csereii*	-	0	0	0	1
Tufted Vetch	*Vicia cracca*	-	-	0	0	0
Curly Dock	*Rumex crispus*	-	-	1	0	0
Alfalfa	*Medicago sativa*	2	0	0	0	0
Pineappleweed	*Matricaria discoidea*	-	0	0	1	0
Common Burdock	*Arctium minus*	-	-	0	-	0
Canada Thistle	*Cirsium arvense*	-	0	0	0	0
Wormwood	*Artemisia absinthium*	-	0	0	0	0
Scentless chamomile	*Tripleurospermum inodorum*	-	0	0	0	0
Ox-eye Daisy	*Leucanthemum vulgare*	-	-	-	-	0
Common Timothy	*Phleum pratense*	0	0	-	0	0
Common Tansy	*Tanacetum vulgare*	-	-	-	-	0
Red Clover	*Trifolium pratense*	-	-	0	0	0
Bird's-foot Trefoil	*Lotus corniculatus*	-	-	0	0	-
Black Medick	*Medicago lupulina*	0	0	-	0	-
Rye	*Secale cereale*	0	-	-	-	-
White Clover	*Trifolium repens*	0	0	0	-	-
Wheat	*Triticum aestivum*	-	-	0	0	-
All species		*100*	*100*	*100*	*100*	*100*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Bolded species are Level 1 invasive concern (Table 2-4). Italicized species are Level 2 invasive concern. Underlined species are Level 3 invasive concern. Remaining species are non-native species that may become problematic in some locations and/or condition. [2] Similar species that are difficult to distinguish until they flower are combined into a broader taxon. *Melilotus* spp. includes *M. albus* and *M. officinalis*.

4.0 EFFORTS TO MANAGE INVASIVE PLANTS

Non-native species that were candidates for management measures included all of the species that were of the highest invasive concern for the Project footprint (i.e., Level 1 species; Section 2.4.3). Level 2 species were candidates for management measures if they were not already well-established in multiple locations. Level 3 and Level 4 species could be opportunistically included within locations where Level 1 or 2 species are treated.

Nine of the 22 non-native species recorded in 2018 (Appendix 4, Table 7-6) were classified as being Level 1 or 2 (Table 2-4), which are the levels of the highest invasive concern for the Project footprint. Of these, none were an ISCM Category 1 species, and none were a Tier 1 species in the *Noxious Weeds Act* of Manitoba.

Level 1 species (Table 2 4) included ox-eye daisy, scentless chamomile and common tansy. Level 2 species included Canada thistle, field sow-thistle, tufted vetch, common burdock, and white and yellow sweet clover.

Strategies employed to date to manage non-native plants include prevention, eradication and control. Prevention measures are included in the Environmental Protection Plans (e.g., washing equipment before transporting to site). Examples of other prevention measures are: monitoring staff clean their footwear before they leave a surveyed area; and site environmental staff have received non-native plant identification training and resources.

The two primary methods employed to date to eradicate or control Level 1 and 2 plants were rapid manual removal and herbicide treatments at key sites. Burying hay bales is an example of another method that has been employed. The following describes the eradication or control measures implemented to date.

4.1 RAPID MANUAL REMOVAL AND OTHER NON-CHEMICAL ACTIONS

The rapid manual removal strategy involved manually removing Level 1 plants shortly after finding them at sites with one to a few plants (see Section 2.4.3 for the removal methods).

4.1.1 LEVEL 1 NON-NATIVE SPECIES

The three Level 1 non-native species recorded in 2018 were ox-eye daisy, scentless chamomile and common tansy. All three species are an ISCM Category 2 species or a Tier 2 species in the

provincial *Noxious Weeds Act* (Table 2-4). Scentless chamomile and ox-eye daisy are also weed seed plants in the federal Weed Seeds Order.

To date, the rapid manual removal appears to have been effective for the Level 1 species (Section 5.3.2). The following describes the situations for individual species.

Ox-eye Daisy

Ox-eye daisy is an introduced ornamental perennial (Photo 4-1). It can quickly spread by both seed and rhizomes (ISCM 2018).

In August 2018, two ox-eye daisy plants were found growing at two locations in Borrow Area G-1, and at one location in the SAR camp (Photo 4-1; Appendix 3, Map 7-21). One plant at Borrow Area G-1, and the plant at the SAR camp were removed by ECOSTEM field staff after it was recorded. The second plant at Borrow Area G-1 was not removed because ECOSTEM staff had to leave the area in response to a weather alert. That location will be re-visited in early summer, 2019 to remove the plant if it is still present.

An ox-eye daisy plant had been found and removed near the Manitoba Hydro offices in Work Area B in early summer 2017 (ECOSTEM 2018). This site did not have any ox-eye daisy plants when it was revisited in 2018.

Scentless Chamomile

Scentless chamomile (Photo 4-2) is an annual to short-lived perennial. It is a fast-growing prolific seed producer that can form dense monocultures (LSSG 2010).

Field surveys identified one scentless chamomile plant in the Start-up Camp footprint (on the path to the well in 2015), in EMPA D17 in 2016, and in EMPA D16 in 2017 (Appendix 3, Map 7-22). Shortly after the 2015 and 2016 plants was found, it was recommended that Manitoba Hydro site staff remove and dispose of these plants using the preferred method. Manitoba Hydro site staff carried out the scentless chamomile plant removal shortly thereafter. ECOSTEM staff removed the plant found in 2017.

The locations where scentless chamomile plants had been removed in prior years were revisited. There were no scentless chamomile plants at these locations in 2018.

In August 2018, scentless chamomile was found growing at four new locations: one by the loading dock at the Start-up Camp, two in EMPA D16, and one in the ditch west of the BBE offices in Work Area B (Photo 4-2). All of these plants were immediately removed and disposed of by ECOSTEM field staff.

Common Tansy

Common tansy (Photo 4-3) is a perennial that spreads through seeds and its extensive root system. Seeds from this plant can germinate after being in the ground for up to 25 years (ISCM 2018).

Common tansy was found for the first time in 2018, growing at one location along the North Dyke (Appendix 3, Map 7-23). It appeared that the plant had not yet seeded. ECOSTEM field staff immediately removed and disposed of the plant.

Photo 4-1: Ox-eye daisy growing in Borrow Area G-1 on August 25, 2018

Photo 4-2: Scentless chamomile growing in Work Area B on August 26, 2018

Photo 4-3: Common tansy growing beside the North Dyke on August 23, 2018

4.1.2 LEVEL 2 NON-NATIVE SPECIES

Six Level 2 non-native species were recorded in 2018. Of these, the ISCM "other" species included Canada thistle, field sow-thistle, common burdock (*Arctium minus*), and tufted vetch. The first three of the preceding species are also Tier 3 species in the provincial *Noxious Weeds Act*. White *et al.* (1993) classify white sweet clover, yellow sweet clover and Canada thistle as moderately invasive in Canada. Canada thistle is also classified as a weed seed plant in the federal Weed Seeds Order (Table 2-4).

Manual removal has not been successful for Level 2 species in most cases. The following describes the situations for individual species.

Canada Thistle

Canada thistle is a perennial that has the capacity to proliferate from roots left in the ground after manual removal, and infestations can develop quickly (Saskatchewan Ministry of Agriculture 2008; Manitoba Agriculture 2019).

Canada thistle is the only Level 2 species that, in addition to meeting the criteria for inclusion in this level, is also a provincial Tier 3 noxious weed, a White *et al.* moderate invasive and a federal weed seed (Section 2.4.2).

Canada thistle was found at three locations during the 2015 and 2016 surveys (Appendix 3, Map 7-24). Plants were not observed again at one of the locations during surveys in subsequent years. The remaining two locations were included in the areas treated with herbicides (see Section 4.2).

Surveys in 2017 found two new locations with Canada thistle, one with two individuals near the south ditch surrounding the Start-up Camp, and one small patch at the eastern corner of Borrow Area KM-4. Because the patches were small, it was recommended that the plants be removed where feasible (Hutchinson 1992; Alberta Invasive Plant Council 2014). The preferred disposal method was the same as the one described above for scentless chamomile, with particular attention to removing the main root to the extent feasible). The plants at the latter location were removed and disposed of by ECOSTEM field staff in 2017. ECOSTEM field staff returned to the location at the Start-up Camp in 2017, and no new plants were found. However, plants at both locations had re-established in 2018, and were removed by ECOSTEM field staff in early and late summer. An incidental observation in September 2018 found that a larger patch of plants had re-established in Borrow Area KM-4.

Canada thistle was found at two new locations in 2018. One location was a small patch growing next to the North Dyke. These plants were removed by ECOSTEM staff. The second location was a more extensive patch in the ditch along the NAR (Appendix 3, Map 7-24). This patch was too extensive and interspersed among other plants to be removed by hand.

Canada thistle is known to have the capacity to proliferate from roots left in the ground after manual removal, and infestations can develop quickly (Saskatchewan Ministry of Agriculture

2008; Manitoba Agriculture 2019). As plants have reappeared after more than one removal, it is apparent that root systems have become established.

The overall management strategy for Canada thistle will be modified going forward as plants reappeared in the same location after several removals and manual removal can amplify vegetative spread. Canada thistle plants will no longer be removed at sites where the plants are mature or where they have reappeared after one removal of a plant. While manual removal will continue to include roots, there will be increased efforts to remove all of them at sites with one to a few plants.

Field Sow-Thistle

Field sow-thistle is a perennial that can spread both through seeds as well as through an extensive root system, and are capable of reducing the number of plant species in communities (ANHP 2011e; Manitoba Agriculture 2019).

Field sow-thistle was already sparsely but fairly widespread in the Project footprint, and in disturbed areas throughout the Keeyask region, prior to the Project. By 2015, field sow-thistle was already becoming well established in Project footprint components that were previously utilized by the KIP, particularly at the Start-up Camp, and in Borrow Area G-1 at KM-15. To limit further spread, ECOSTEM field staff implemented the rapid manual removal protocol at locations where only a small number of plants were present during the 2017 and 2018 surveys.

Of the locations containing field sow-thistle, the Start-up Camp, Work Area B and the SAR Camp were sprayed with herbicides in late July 2018 (see Section 4.2). Where one to a few plants were found during the 2018 surveys, these plants were removed and disposed of by ECOSTEM field staff. Monitoring in 2019 will assess the effectiveness of herbicide treatment and manual removal on controlling this species at these locations.

In 2017, a few field sow-thistle plants were found growing in the SAR Camp. These plants were manually removed during the early summer surveys, and again in the late summer.

By the time of the 2018 early summer survey, plants had re-established at all of the locations that were treated in previous years. Results from the late summer survey indicated that field sow-thistle cover continued to expand in all locations that it was already established, and had expanded into some new locations. The new locations were around the buildings in Borrow Area N-21, at the upstream boat launch, along the NAR, Work Area A, Borrow Area G-3, and the camp in Borrow Area B-2. Plants at all of these locations except Borrow Area N-21 were removed immediately by ECOSTEM field staff. The patch in Borrow Area N-21 was too large and interspersed with dense vegetation for manual removal at the time of the survey.

The best form of control for field sow-thistle is removing or killing the plants before the extensive root system develops (Manitoba Agriculture 2019). Like Canada thistle, this should be done before the root system has developed because field sow-thistle infestations can develop quickly from roots left in the ground after manual removal. The overall management strategy for field sow-thistle will be the same as described above for Canada thistle.

Common Burdock

Common burdock is a biennial plant forming a rosette in the first year, and a tall flowering stem in the second year (AISC 2014). The plant proliferates by seed, and the large basal leaves can shade out other herbaceous plants favouring its own species (ANHP 2010; AISC 2014).

In 2016, a single common burdock plant was found growing near the Main Camp.

The plant's remains, along with its attached burrs, were removed by ECOSTEM staff in early summer 2017. No new plants were found in 2017. However, by early summer 2018, a patch with many small plants was found growing at that location (Appendix 3, Map 7-25). None of the plants had flowered by late summer 2018. The location was recommended for herbicide treatment shortly after being found.

While this patch was included in the high priority key sites given to the contractor for herbicide treatment, it was missed. None of the plants appeared to have flowered by late August 2018. It is recommended that the patch be herbicided early in the 2019 growing season to control further spread.

Tufted Vetch

Tufted vetch is a trailing perennial that can spread by seed as well as rhizomes, and can overgrow surrounding vegetation and alter soil chemistry (ANHP 2011a; ISCM 2018).

Tufted vetch plants were found at 13 new locations during the 2018 surveys (Appendix 3, Map 7-26). Three of the new locations were in Borrow Area G-1, one was in the Start-up Camp, while the remaining locations were along the SAR. Two additional patches of tufted vetch in Borrow Area G-1 were also present in 2017.

Tufted vetch plants were most widespread along the SAR east of the Butnau Marina, where larger patches were recorded at three locations in the ditch. Previous surveys indicated that tufted vetch was already well established in this location and in nearby areas, particularly along the old Butnau Road and in the Town of Gillam.

ECOSTEM field staff implemented the rapid manual removal protocol for three of the five tufted vetch plants found in Borrow Area G-1 since there were few plants in that part of the Project footprint. The removal of these plants proved to be difficult and time-consuming due to their extensive rhizomes. Monitoring in 2019 will assess the effectiveness of manual removal on controlling this species.

Attempts were not made to manually remove the tufted vetch plants at the other two locations in the Borrow Area G-1 because they were interspersed within denser vegetation. While these locations had been included among those recommended for herbicide application in 2018, they were missed by the herbicide applicator. The tufted vetch patch in the Start-up Camp was growing in a gravel pad, and would have been too time consuming for survey staff to remove by hand.

The remaining nine tufted vetch locations were along the SAR and in an adjacent borrow area east of the Butnau Marina. In these cases, rapid manual removal was not employed (and not recommended) since the plants were well established at these locations and in areas adjacent to or near the Project footprint. These locations are among those being considered for herbicide treatment in 2019 (Section 5.3.2).

White and Yellow Sweet Clover

White and yellow sweet clover are biennial plants that spread prolifically by seed, and rapidly invade open areas, shading out other vegetation (ANHP 2011f).

White and yellow sweet clover plants have continued to expand rapidly in both extent and cover. As of August 2018, total cover was more than twice that recorded in August 2017. Extent and/or cover increased in all but one of the footprints where it was previously present, with the exception of the Cemetery site. The species continued to spread to new areas along the SAR and adjacent borrow areas west of the Butnau Marina.

The rapid manual removal protocol was not applied for white and yellow sweet clover. White sweet clover was already fairly widespread in the Project footprint, and in disturbed areas throughout the Keeyask region, prior to the Project. This species has expanded considerably in extent and/or cover from 2014 to 2018, and has become the second most abundant non-native species. White and yellow sweet clover are commonly found in disturbed areas throughout the Province, particularly along roadsides, making it difficult to prevent them from spreading.

White and yellow sweet clover were present in some of the key sites treated with herbicides in 2018 (Section 4.2).

4.1.3 LEVEL 3 NON-NATIVE SPECIES

Six of the non-native species recorded in the Project footprint were Level 3 invasive concern. All are considered to be noxious weeds, weed seed species and/or minor invasives in Canada (Table 2-4). Level 3 species recorded in 2018 included lamb's quarters, narrow-leaved hawk's-beard, common dandelion, curly dock, alfalfa (*Medicago sativa*) and wormwood (*Artemisia absinthium*).

Lamb's Quarters

Lamb's quarters is an annual that spreads by seeds, which can remain viable in the soil for up to 40 years (ANHP 2011c; Manitoba Agriculture 2019).

Lamb's quarters has been the most abundant of the Level 3 species in every year of Project monitoring (Table 3-6). Results from the 2016 surveys suggested that lamb's quarters cover was possibly beginning to decline (ECOSTEM 2017). However, by late summer 2017 lamb's-quarters extent and cover had increased substantially to its highest level since construction began (ECOSTEM 2018). Plant cover continued to increase by late summer 2018, although the

increase was not as large as it was in 2017. Plant cover and/or extent increased in all footprints where the plant was already present. In 2018, lamb's quarters also became established along the North Dyke, as well as continuing to spread along the SAR and adjacent borrow areas west of the Butnau Marina.

Narrow-leaved Hawks-beard

Narrow-leaved hawks-beard is an annual that reproduces by seed, and can rapidly colonize areas delaying the establishment of other plants (ANHP 2011d; Manitoba Agriculture 2019).

By late summer 2018, narrow-leaved hawks-beard extent and cover had increased substantially, with total cover becoming more than eight times higher than in 2017. This species has spread throughout the Project footprint, increasing in cover where it was previously present, and establishing in new locations, particularly along the North Dyke. Overall cover was highest along the North Dyke, in the camps and work areas north of the Nelson River, and in borrow areas utilized by both the KIP and the Project (Appendix 3, Map 7-18).

Common Dandelion

Common dandelion is a perennial that spreads prolifically by seed, as well as by shoots from root crowns (ANHP 2011b; Manitoba Agriculture 2019). Common dandelion is an early colonizer, and can also establish in existing vegetation and compete for resources and pollinators (ANHP 2011).

Common dandelion cover has also rapidly expanded since 2017, nearly doubling by late summer 2018. By 2018, common dandelion cover had increased in most footprints where it was already established, particularly in the areas used by both the KIP and the Project. Plants established in a few new locations, including along the North Dyke and in adjacent EMPAs, as well as in Borrow Areas G-3, N-5 and Q-9.

Total cover for the remaining species at Level 3 invasive concern was relatively low.

4.1.4 LEVEL 4 NON-NATIVE SPECIES

The remaining seven non-native species recorded in the Project footprint were Level 4, or the lowest level of invasive concern, for the Project footprint.

Wheat

Volunteer wheat is an annual that produces by seeds that can remain viable in the soil for one to three years (Manitoba Agriculture 2019).

Surveys in 2016 reported the presence of healthy volunteer wheat plants growing from straw being stored in the Spillway Laydown Area (ECOSTEM 2017). These straw bales were brought to site for erosion control. It was thought that the straw bales contained viable wheat seeds. Given the developmental stage of the plants at the time of the 2016 surveys, it appeared

unlikely that they could produce viable seed before a fall frost would kill the plants. By early summer 2017, the bales had been moved to Borrow Area G-3. A substantial amount of wheat was growing out of the remnants of straw left on the ground in the Spillway Laydown Area, as well as from straw that was spread in Borrow Area G-3 and in EMPA D16.

By late summer 2018, no new wheat plants were growing from the remnants of the straw at any location, except for a few plants growing directly from the stockpiled bales in Borrow Area G-3. Manitoba Hydro environmental staff indicated that the remaining bales would be buried in Borrow Area G-3. The status of these bales will be checked in summer 2019.

Other Species

While the remaining Level 4 non-native species were fairly common in disturbed areas surrounding the Project, few of these species appeared to be spreading at the same rate as the lamb's quarters had. The only other species that appeared to be expanding rapidly in both extent and/or cover was alsike clover (*Trifolium hybridum*), common plantain (*Plantago major*) and smooth catchfly (*Silene csereii*), but overall cover of these species was relatively low.

4.2 HERBICIDE TREATMENTS AT KEY SITES

4.2.1 TREATMENTS

Herbicide application at key sites was the second management strategy employed to date for the control of invasive plant species. The key sites were selected based on a combination of which invasive species were present, where these species were most prolific, accessibility, and which sites had the highest potential for providing seed that could be spread to other Project areas (i.e., due to vehicles or footwear picking up seeds and carrying them elsewhere).

The first herbicide treatment (ECOSTEM 2016) was recommended for five key sites located in the Start-up Camp, Borrow Area KM-1, Borrow Area G-1, Work Area B and the SAR Camp. The treatments were implemented on August 25, 2016 in four of the five sites (Map 4-1). The SAR Camp was not treated. The herbicide mixture was 5.0 liters Vantage, 0.5 liters Milestone and 0.375 liters Esplanade applied at a rate of 700 liters per hectare.

A second herbicide treatment was recommended for 14 sites in 2018, including seven high priority sites, and seven lower priority sites (Map 4-2). Herbicide treatments were applied during the last week of July, 2018 in four of the seven high priority sites. The treated sites were in the Start-up Camp, the Main Camp, Work Area B, and the SAR Camp. The boat launch area in Work Area C was not sprayed because it was considered to be too close to the water. The NAR Gate staging area was not treated. It is assumed that Borrow Area G-1 was not treated as there was no obvious plant mortality (Figure 4-1). As described below, the omission of Borrow Area

G-1 had a substantial effect on the observed efficacy of the herbiciding as this site contained about a considerable proportion of the total cover of the target species.

In 2018, the herbicide mixture used in the sites along the NAR was Clearview (230 g./ha), Esplanade (0.3 L/ha) and Roundup HC (5 L/ha). The herbicide mixture used at the SAR Camp was 2,4-D Ester 700 (2 L/ha), Blue Dye WSP40 (1 package/ha), Clearview (230 g./ha), Esplanade (0.375 L/ha) and Roundup HC (5 L/ha).

4.2.2 EFFICACY OF TREATMENTS

The overall effectiveness of the herbicide treatments is uncertain at this stage. Despite promising initial results, the 2016 treatment was later found to be ineffective, likely due to the late timing of application. While initial results were good for the 2018 treatment, the degree to which invasive plants have been eliminated will not be known until the 2019 monitoring is conducted. The following provides details.

For the 2016 treatment, monitoring surveys conducted in 2017 suggested that there had been a high rate of initial plant mortality based on the nature of the dead plant remains (ECOSTEM 2018). However, the treatment ultimately was not effective because invasive and other non-native plant cover appeared to have returned to or exceeded pre-herbiciding levels by the following year. Additionally, the herbiciding had slowed the expansion of plants at only one of these sites (the Start-up Camp). The herbiciding was ultimately ineffective, likely because it occurred in late August. By this point in the growing season, the plants had already produced seed. Another possibly reason that this treatment was ineffective is that the roots of some biennial or perennial plants were not killed.

In 2018, the herbicide treatments reduced overall non-native plant cover by approximately 84% within the four treated sites. This percentage was slightly lower than that for the total non-native plant cover that was apparently contacted by herbicide (i.e., approximately 87%). Monitoring in 2019 will assess how effectively this treatment slowed the spread or reduced non-native plant cover in the treated areas.

Based on the total cover of live and deceased non-native plants, total non-native plant cover over all of the sites prior to treatment was approximately 5,280 m^2 in late July, 2018 (Table 4-2). Total non-native plant cover was highest in Work Area B, followed by the Start-up Camp.

A total of 13 non-native species were identified within the sites that were treated. Common dandelion was the most abundant species by far in the treated sites, making up more than half of the total non-native plant cover, followed by white and yellow sweet clover. Species at Levels 1 and 2 invasive concern included ox-eye daisy, field sow-thistle, common burdock, and white and yellow sweet clover. Of these, field sow-thistle had the highest cover in the treated areas.

Foliage mortality was used as an indicator for the approximate boundaries for where herbicides were actually applied in the treated sites. Surveys were conducted soon enough after application (less than one month) that the plant remains should still have been present and

identifiable to species. This indicator assumed that some degree of mortality would occur on any plants that were contacted by the herbicides. Some treated plants may occur outside of the mapped treated area due to factors such as variability in application rates or a particular species' tolerance to the chemicals used.

Herbicide coverage varied among treatment sites (Appendix 4, Table 7-9), with the planned sites in Work Area B and the Start-up Camp having the highest portion of its area apparently receiving herbicides (93% and 87%, respectively). The Main Camp had the lowest treated area, with less than one percent of the non-native plant cover treated. It appeared that targeted applications of herbicide in this site did not treat all of the recommended patches (Figure 4-2). In other sites, it appeared the "blanket" applications were performed.

With respect to individual species, eight of the 13 non-native species in the treated sites were impacted (Appendix 4, Table 7-10) because the herbiciding was selectively applied within the entire key site. Based on foliage mortality, treatment coverage for these species ranged from 59% to 91% of their total cover. The five species that were not impacted had low cover, and appeared to be missed by the targeted herbicide applications. Of the species at the highest two levels of invasive concern (Table 2-4), white and yellow sweet clover and field sow-thistle were treated.

Within treated patches, plant mortality ranged from 30% to 100%, with an overall average of 93% mortality. Figure 4-2 to Figure 4-4 provide examples of the effect of the treatment in the different areas. Living foliage among the treated patches was generally in very poor condition regardless of the mortality rate for the entire patch. At the time of the surveys, which was approximately three to four weeks after the herbicide treatment, there was no apparent plant re-growth in the treated areas.

When considering all non-native plant cover in the sites receiving herbicides, including patches not treated and foliage that survived treatment, overall live non-native plant cover in the treated sites was reduced by 84%, to 845 m^2 (Table 4-1). The largest overall cover reductions were in Work Area B, where 91% of the non-native plant cover was killed, followed by the Start-up Camp with 71% (Table 4-2). Common dandelion and common plantain had the highest overall reductions in cover following treatment (89% each), while the lowest was alsike clover (53%). When considering only the treated patches, mortality was similarly high for all species (Appendix 4, Table 7-11), with overall percent live cover reduction ranging from 89% (field sow-thistle) to 100% (narrow-leaved hawks-beard, common plantain and smooth catchfly).

The species specifically targeted for herbicide treatment in the treated areas included ox-eye daisy, common burdock, field sow-thistle and tufted vetch. The priority treatment areas were also selected based on the total abundance of all species at Levels 1 and 2 invasive concern.

While herbicide application was highly effective in the treated sites, it had a small effect on total non-native plant cover in the overall Project footprint. Following treatment, live non-native plant cover was reduced from 5.9 ha to 5.5 ha, or from 0.88% to 0.83% of the total area surveyed. The overall proportion of the most highly affected non-native plant species did not substantially change in the footprint as a whole. The relatively small reduction was expected because the

treatments were focused over a small portion of the Project footprint where species of higher concern were present, and there was a high potential for spread.

When considering only the species specifically targeted for herbicide treatment in the treated areas, the overall live plant cover for the all of the areas of the Project footprint that were surveyed was reduced from 2,737 m^2 to 2,693 m^2 (a 1.6% reduction), or from 0.041% to 0.040% of the total area surveyed (Appendix 4, Table 7-12). When considering only the species at Levels 1 and 2 invasive concern that were present in the treated areas, the overall live plant cover was reduced from 1.5 ha to 1.4 ha (a 10% reduction), or from 0.23% to 0.20% of the total area surveyed (Appendix 4, Table 7-13).

The cover reduction for the targeted species from the herbicide treatments was much lower than expected because the priority 1 treatment area in Borrow Area G-1 at KM-15 was missed by the applicators. This area contained about half of the total field sow-thistle cover in the surveyed Project footprint, and about one fifth of the total white and yellow sweet clover cover. Had it been treated, there would have been a more substantial overall reduction of total cover for the target species, and for species of higher concern.

Table 4-1: Non-native species cover in herbicide-treated sites before and after treatment in 2018

Common Name	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change
Common Burdock	5	5	0
Wormwood	0	0	0
Lamb's-quarters	1	1	0
Narrow-leaved Hawks-beard	148	33	-78
Ox-eye Daisy	0	0	0
White and Yellow Sweet Clover	1,862	342	-82
Common Plantain	70	8	-89
Curly Dock	11	11	0
Smooth Catchfly	12	2	-84
Field Sow-thistle	62	19	-70
Common Dandelion	2,891	323	-89
Alsike Clover	216	102	-53
All non-native species	*5,278*	*845*	*-84*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".[1] Percent change; A negative sign means that cover decreased.

Table 4-2: Non-native species cover in herbicide-treated sites before and after treatment in 2018, by treatment site

Common Name	Start-up Camp			Main Camp			Work Area B			SAR Camp		
	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change
Common Burdock	-	-	-	5	5	0	-	-	-	-	-	-
Wormwood	-	-	-	0	0	0	-	-	-	-	-	-
Lamb's-quarters	-	-	-	0	0	0	1	1	0	0	0	0
Narrow-leaved Hawks-beard	-	-	-	30	30	0	118	3	-98	0	0	0
Ox-eye Daisy	-	-	-	-	-	-	-	-	-	0	0	0
White and yellow sweet clover	373	68	-82	8	8	0	1,177	108	-91	304	158	-48
Common Plantain	-	-	-	2	2	0	65	6	-91	4	0	-93
Curly Dock	-	-	-	11	11	0	-	-	-	-	-	-
Smooth Catchfly	11	1	-95	1	1	0	-	-	-	-	-	-
Field Sow-thistle	40	7	-82	11	10	-2	7	1	-90	4	-	-100
Common Dandelion	225	83	-63	5	5	0	2,661	236	-91	-	-	-
Alsike Clover	127	13	-90	89	89	0	-	-	-	-	-	-
All non-native species	*777*	*171*	*-78*	*162*	*162*	*0*	*4,028*	*354*	*-91*	*312*	*158*	*-49*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".[1] Percent change; A negative sign means that cover decreased.

A

Borrow Area G-1 on July 5, 2018

Borrow Area G-1 on August 25, 2018

B

NAR Gate Staging Area on July 5, 2018

NAR Gate Staging Area on August 28, 2018

Figure 4-1: High priority sites in Borrow Area G-1 (A) and the NAR Gate staging area (B) recommended for herbicide treatment in 2018 that were not treated.

A

Main Camp ditch on July 5, 2018

Main Camp ditch on August 28, 2018

B

Main Camp common burdock patch on July 5, 2018

Main Camp common burdock patch on August 28, 2018

Figure 4-2: Recommended patches that were treated (A) and untreated (B) by herbicide in the Main Camp in 2018.

A

Start-up Camp on July 5, 2018

Start-up Camp on August 18, 2018

B

Work Area B on July 5, 2018

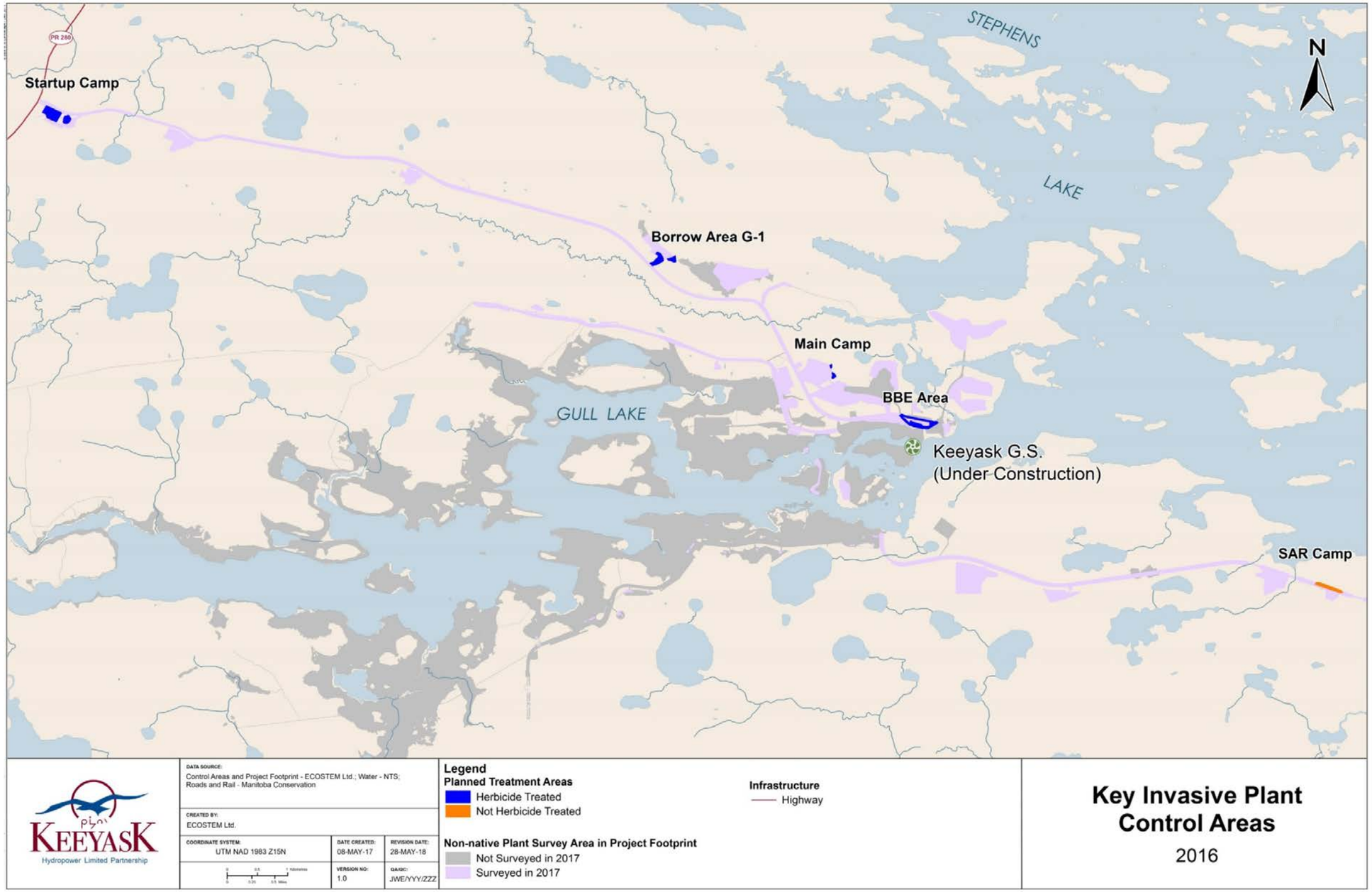
Work Area B on August 26, 2018

Figure 4-3: Recommended patches that were treated by herbicide in the Start-up Camp (A) and Work Area B (B) in 2018.

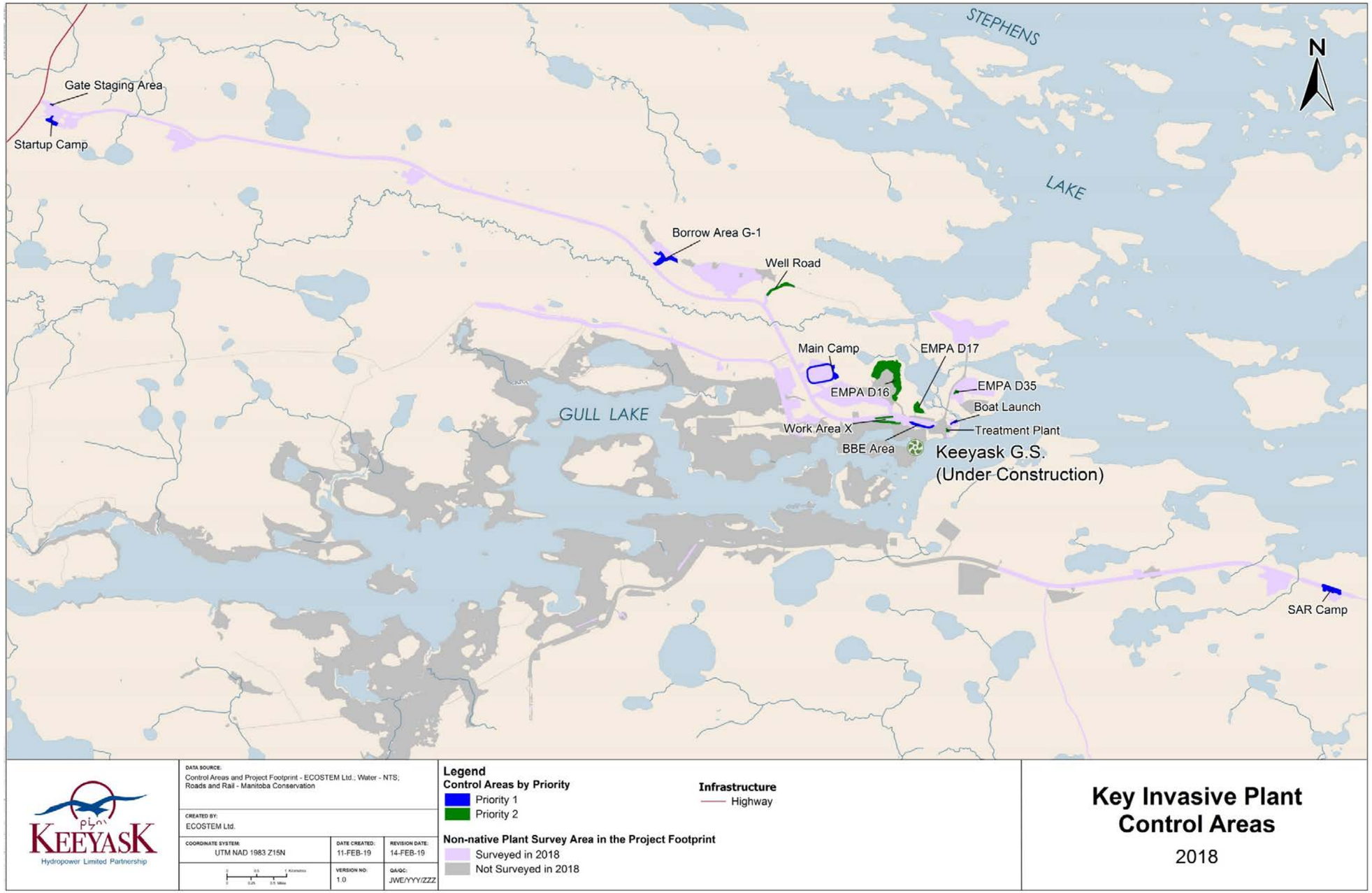
SAR Camp on July 8, 2018

SAR Camp on August 29, 2018

Figure 4-4: Recommended patches that were treated by herbicide in the SAR Camp in 2018



Map 4-1: Key areas selected for invasive plant herbicide control in 2016



Map 4-2: Key areas (Priority 1 areas) selected for invasive plant herbicide control in 2018

5.0 DISCUSSION

5.1 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

Total non-native plant cover was still very low (0.9% of the total area surveyed) five years into construction. This was not surprising given that much of the Project footprint was only recently disturbed, active construction was continuing to severely disturb some areas, and some eradication and control efforts had been undertaken (Section 4.0).

Even though total non-native plant cover was still low in 2018, increasing cover or extent would be of concern as small patches of non-native plants can quickly become broad infestations if not managed. This concern was enhanced by the fact that non-native plants were recorded in almost 10% of the surveyed area (note that this is an overestimate of non-native plant distribution within the entire Project footprint; see Section 2.2).

Both overall non-native plant extent and cover approximately doubled between the 2017 and 2018 surveys. These increases were primarily attributed to human activities introducing or spreading seeds within the Project areas, construction activities creating suitable germination conditions for seeds in the seed bank and/or construction activities transporting seeds to other sites. Natural factors such as dispersal of seeds from other areas by wind or birds were expected to have introduced some seeds as well. Compounding these factors were the higher amount of construction activity and the increasing amount of time since construction activity first began.

Another natural factor possibly contributing to the increasing non-native plant extent and cover was the 2013 wildfire, which affected much of the planned Project footprint north of the Nelson River. This wildfire created several changes that favored invasive plants. First, it burned off the surface organic layer in scattered locations, exposing mineral substrates, which is a preferred seedbed for many invasive plants. Second, it removed much of the taller foliage in the area, which may have otherwise served to limit the transport of wind-dispersed seeds into the Project footprint. Third, it removed shading, which inhibits many invasive plants.

Wind-dispersed species (e.g., common dandelion, field sow-thistle, narrow-leaved hawk's-beard) have not established, or have been slow to establish around the perimeters of Borrow Areas G-3 and N-5, where there is little construction activity. This was despite having several years of frequent vehicle traffic that could transport seeds into these areas. Both of these borrow areas were surrounded by taller trees because they were not burned in 2013. However, further evidence is required to confirm this factor as these borrow areas are also on islands and likely experienced less human activity before Project construction began.

Non-native plant cover and extent increased in several Project footprint components where construction activity had recently decreased or stopped over the past one or two years. The North Dyke was the most notable example, with other examples including the perimeter of Borrow Area G-1 and EMPA D16. The higher rate of non-native plant expansion in these areas occurred despite no ongoing excavation or construction activity, no newly exposed mineral substrates and close proximity to seed sources. In the case of the North Dyke, there had been little to no construction activity except minor traffic for more than a year, which would provide an opportunity for seeds to disperse into the area and for plants to establish without being disturbed. In contrast, non-native plant cover remained very low in Borrow Areas G-3 and N-5, which exhibited a combination of having been excavated more recently, having nearly all of its area in bare ground (which creates a large area of favorable seedbed with no competition from other plants), being distant from other footprint components, having less through traffic and being surrounded by trees (can inhibit wind dispersal).

A potential trend emerging in 2018 was an apparent decrease in non-native plant cover in monitored footprint components that were primarily utilized for the KIP but not for the current Project (e.g., most of Borrow Areas KM-4 and KM-9). While non-native plant extent remained the highest in the KIP areas, overall extent and plant cover decreased by 21% and 50%, respectively, since 2018. If this decrease is an actual trend rather than a single year anomaly, possible reasons for it are reduced traffic and increasing competition with regenerating native plants whose cover has been increasing in these areas. Monitoring in 2019 will help determine of this is an actual trend.

5.2 CHANGES IN SPECIES DISTRIBUTION AND ABUNDANCE

While the total number of non-native plant species recorded during the 2018 surveys (22) was the same as in 2017, there were large changes in the relative abundances of some species. The total cover of each of the four most abundant species (lamb's-quarters, white sweet clover, narrow-leaved hawks-beard and common dandelion) has increased over each of the past three years. In combination, these four species accounted for 91% of total non-native plant cover by the time of the 2018 surveys. The reasons for this were described in the previous section.

Another noteworthy trend by the fifth year of construction (i.e., in 2018) was that three species with more than 100 m^2 of cover (i.e., narrow-leaved hawks-beard, tufted vetch, curly dock) were first recorded in the third year of construction. The possible reasons why these species did not appear during the first two years of construction, like most of the other species with non-trivial cover, included their method of dispersal, the time required for germination and/or the rate of spread.

Narrow-leaved hawks-beard became the third most abundant species over a period of only three years. This species was first recorded during the 2016 surveys, and had relatively low

cover. Cover increased rapidly up to 2018 in areas that were utilized by both the Project and KIP. The plant first became established in newer areas that were utilized only by the Project a year later in 2017, then expanded very rapidly by 2018. Conversely, while cover increased annually in areas that were used only by KIP, overall cover was substantially lower in these areas in 2018 compared to the more active or newer footprint components. This pattern could indicate that this species can rapidly colonize more recently disturbed areas after it has had an opportunity to establish, particularly because it is a prolific producer of wind-dispersed seeds. The slower increase in cover in the regenerating footprints that were used only by KIP could be due to competition from other regenerating native plants. A deeper evaluation of the possible explanations for the changes will be undertaken by the construction synthesis report, which is when more data will be available to examine multivariate hypotheses.

Tufted vetch has a very different dispersal strategy than narrow-leaved hawksbeard. This species spreads vegetatively via underground roots, and also by seeds, which can remain viable in the soil for several years (ANHP 2011). It is likely that this species did not establish in the footprint until several years into construction because it was not present in the seedbank and required time for the seeds to be dispersed into the area, for seeds to germinate and for root systems to develop. A deeper evaluation of the possible explanations for the changes will be undertaken by the construction synthesis report.

5.3 EFFORTS TO MANAGE INVASIVE PLANTS

While overall non-native plant cover was still quite low in 2018 (0.9% of the total area surveyed), the large increase from 2017, combined with overall plant extent (9.6% of the total area surveyed), merited an evaluation of management efforts undertaken to date.

To date, the rapid manual removal appears to have been effective for the Level 1 species. Manual removal has not been successful for Level 2 species in most cases, likely because root systems were already well-established, seeds from the seed bank germinated and/or some plants in the area had already produced seed.

The overall effectiveness of the herbicide treatments was uncertain. The 2016 treatment was completely ineffective ostensibly because the herbiciding occurred in late August, which was after the plants produced seed, and possibly because the roots of some plants were not also killed. While the 2018 herbiciding considerably reduced total non-native plant cover over all of the treated areas (i.e., approximately 84%), the cover reduction for the target species was much lower (i.e., 1.6%) because the applicators missed treating the priority areas with largest amounts of the target species.

The following provides some general considerations for future efforts to control invasive plants in the Project footprint. Specific control recommendations are being developed for the 2019 growing season based on the monitoring results to date.

5.3.1 PREVENTION

It is difficult to prevent vehicles and people from inadvertently spreading non-native plant species into the Project footprint (Section 2.4.1). Therefore, recommendations in addition to the standard measures included in the EIS and EnvPPs focus on the plant species of highest invasive concern and on the situations where there are practical ways to eradicate these species or to prevent them from spreading further.

Of the non-native plant species recorded during monitoring, several of Levels 1 and 2 invasive concern were known to be present prior to the Project (KHLP 2009; KHLP 2012b). At least two such species (white sweet clover, ox-eye daisy) were likely already established in the Start-up Camp and Main Camp areas before KIP construction began (ECOSTEM 2014). Additionally, some Level 2 species (i.e., white and yellow sweet clover, Canada thistle, field sow-thistle) were found along PR 280 prior to development of the KIP (KHLP 2009; KHLP 2012b).

One strategy to prevent or reduce the spreading of invasive plants beyond their current locations is for equipment, machinery, vehicles and people to avoid or minimize travel through infested areas. A related strategy is to restrict travel to those periods when the spreading of seed or propagules is least likely (e.g., prior to seed development). Possible implementation of these strategies has become more feasible because the number of new construction areas have declined as the Project is approaching completion, and substantial additional Project clearing is not anticipated (Manitoba Hydro pers. comm. 2019).

Promoting native plant regeneration is another strategy to prevent invasive plants from establishing. This can be accomplished in two way: first, by implementing the already planned site regeneration as soon as feasible after a construction area will no longer be used; and second, by limiting traffic and other activity on sites where desired vegetation has established or is establishing.

5.3.2 ERADICATION AND CONTROL

The only situation for which an eradication strategy for Level 1 and 2 plant species is both feasible and likely to succeed is within those footprint components where these species occur as small patches in one to a few locations.

For sites with only one to a few plants, rapid manual removal has been effective to date for the Level 1 species (Section 4.1.1). Continued high vigilance is needed for these species because they are difficult to control (ISCM 2019). In addition, ISCM (2019) states that scentless chamomile and ox-eye daisy are common along fence lines, roadways and fields in Manitoba, so continued introductions by Project vehicles entering from outside of the Project footprint are quite possible. Monitoring surveys in 2019 will determine if rapid manual removal continues to be effective for controlling these species, as well as common tansy.

Rapid manual removal has only been partially effective where it was applied to small patches of Level 2 species in 2016 (efficacy of the 2018 manual removals to be determined after 2019 surveys). As described in Section 4.1.2, the manual removal method will be modified for this type of situation.

Rapid manual removal by monitoring field staff will continue to be employed for newly found sites with Level 1 and 2 species. For previously recorded sites, rapid manual removal will not be implemented for species that reproduce prolifically by rhizomes and where either the plants are mature or it appears the plants have already developed a root system (see Section 4.1.2). Herbicide application is being considered for these sites.

Additional herbicide applications are recommended to control or eradicate invasive plants at key sites. Key sites will be identified for treatment in summer 2019 using the same criteria as in previous years.

Site environmental staff will be provided with an updated invasive species list and photo guide.

A general strategy to eradicate or control invasive plants involves promoting native plant regeneration. This can be accomplished in the same ways as described for prevention (Section 5.3.1).

6.0 SUMMARY AND CONCLUSIONS

While the late summer cover and extent of all non-native plants combined increased between the 2017 to the 2018 surveys, non-native plants still covered less than 1% of the surveyed area. As was the case in 2017, most of the non-native plant cover was within cleared areas that were either there before the Project (e.g., cutlines, borrow areas and ditches along Butnau Road portion of the South Access Road) or were created by the Keeyask Infrastructure Project (KIP), and are now being used by the Project.

A total of 22 non-native plant species were found during the 2018 surveys. While this was the same total number of species as in 2017, some of the species were different. One new species (common tansy) was recorded in 2018, two previously recorded species (bird's-foot trefoil and black medick) were not observed, and one species (common burdock) that was recorded in 2016 but not 2017 was recorded again in 2018.

The 2018 monitoring found locations with plants for each of three species at the highest level of invasive concern for the Project area. These species were ox-eye daisy, scentless chamomile, and common tansy. Common tansy was found for the first time in the Project footprint in 2018.

Manitoba Hydro site staff or ECOSTEM field staff have been manually removing invasive plants of higher concern, immediately after discovery, at sites with one to a few plants. Monitoring surveys in 2018 found that manual removal of plants from the species of highest concern was generally effective, as new plants have not returned to those locations. This control method will be continued for these species in 2019.

The 2018 monitoring also found that rapid manual removal has only been partially effective where it was applied to small patches of Level 2 species in 2016. Two of three species involved have the ability to proliferate from roots left in the ground after manual removal. For these and other species that can proliferate from roots, plants will not be removed at sites where either the plants are already mature or they have reappeared after one removal of a small patch or two removals of one to a few plants. Also, for sites where manual removal is applied, there will be increased efforts to remove all of the roots. Other control measures, such has herbicide applications, are being considered for sites such as these.

Four key sites in the Project footprint were treated with herbicides in July 2018. These sites were selected based on where then non-native species of high invasive concern were most prolific and had the highest potential for being spread to other Project areas due to vehicles or footwear picking up seeds and carrying them elsewhere. Monitoring surveys in August 2018 found that the herbicide treatments reduced living non-native plant cover in the treated areas by approximately 84%. Surveys in 2019 will determine if the herbicide treatment is expected to continue to reduce or slow the spread of invasive plant cover in these sites.

6.1 NEXT STEPS

Additional invasive plant control recommendations are being developed for the 2019 growing season based on the monitoring results to date. Monitoring fieldwork for invasive and other non-native plants will continue in 2019.

7.0 LITERATURE CITED

Alaska Natural Heritage Program (ANHP). 2010. Common burdock, *Arctium minus* (Hill) Bernh. [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alaska Natural Heritage Program (ANHP). 2011a. Bird vetch, *Vicia cracca* L. [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alaska Natural Heritage Program (ANHP). 2011b. Common dandelion, *Taraxacum officinale* F.H. Wigg. ssp. *officinale* [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alaska Natural Heritage Program (ANHP). 2011c. Lambsquarters, *Chenopodium album* L. [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alaska Natural Heritage Program (ANHP). 2011d. Narrowleaf hawksbeard, *Crepis tectorum* L. [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alaska Natural Heritage Program (ANHP). 2011e. Perennial sowthistle, *Sonchus arvensis* ssp. *uliginosus* (Bieb.) Nyman [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alaska Natural Heritage Program (ANHP). 2011f. White sweetclover, *Melilotus alba* L. [Online] https://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list/ [Accessed April 2, 2019]

Alberta Invasive Plant Council. 2014. Fact sheet: Canada thistle - *Cirsium arvense (aka creeping thistle*). 2 pp.

Brodersen, C., Lavergne, S. and J. Molofsky. 2008. Genetic variation in photosynthetic characteristics among invasive and native populations of reed canarygrass (Phalaris arundinacea). Biol Invasions 10: 1317–1325.

Calsbeek, B., Lavergne, S., Patel, M. and J. Molofsky. 2011. Comparing the genetic architecture and potential response to selection of invasive and native populations of reed canarygrass. Evolutionary Applications 4: 726–735.

Canadian Food Inspection Agency. 2008. Invasive Alien Plants in Canada. CFIA. Ottawa, ON. 72 pp.

Canadian Weed Science Society. 2019a. Biology of Canadian Weeds Series. [Online] https://weedscience.ca/resources/biology-of-canadian-weeds/ [Accessed February 8, 2019]

Canadian Weed Science Society. 2019b. The Biology of Invasive Alien Plants in Canada Series. [Online] https://weedscience.ca/resources/biology-of-invasive-alien-plants/ [Accessed February 8, 2019]

Carlson, M. L., Lapina, I. V., Shephard, M., Conn, J. S., Densmore, R., Spencer, P., Heys, J., Riley, J., Nielsen, J. 2008. Invasiveness Ranking System for Non-Native Plants of Alaska. 217 pp.

Clark, J. 2003. Invasive plant prevention guidelines. Centre for Invasive Plant Management. September, 2003. 15 pp.

Coastal Invasive Species Committee. 2016. Control invasive plants. [Online] http://www.coastalisc.com/how-to-control-invasive-plants [Accessed January 24, 2017]

ECOSTEM 2014. Keeyask Infrastructure Project: Terrestrial habitat, ecosystem and plant monitoring during construction: Annual report 2013 - 2014. Monitoring Program Report #13-01.

ECOSTEM 2015. Keeyask Infrastructure Project: Terrestrial plant, habitat and ecosystem monitoring during construction: Annual report 2014 - 2015.

ECOSTEM Ltd. 2016. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2016-01: Terrestrial Plant, Habitat, and Ecosystem Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2016.

ECOSTEM Ltd. 2017. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2017-05: Invasive Plant Spread and Control Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2017.

ECOSTEM Ltd. 2018. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2018-05: Invasive Plant Spread and Control Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2018.

ECOSTEM Ltd. 2019. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2019-01: Habitat Loss and Disturbance Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2019.

Government of Canada. 2016. Weed Seeds Order, 2016. Minister of Justice, Government of Canada [Online] http://laws-lois.justice.gc.ca.

Government of Manitoba. 2017a. The *Noxious Weeds Act.* Government of Manitoba, C.C.S.M. c. N110.

Government of Manitoba. 2017b. The *Noxious Weeds Act*. Government of Manitoba: Noxious Weeds Regulation, C.C.S.M. c. N110.

Hayley, A. 2012. Invasive Reed Canary Grass (Phalaris arundinacea subsp. arundinacea) Best Management Practices in Ontario. Ontario Invasive Plant Council, Peterborough, ON.

Hellmann, J., Byers, J., Bierwagen, B., and Dukes, J.. 2008. Five Potential Consequences of Climate Change for Invasive Species. Conservation Biology. 22(3): 534-543.

Hutchison, M. 1992. Vegetation management guideline: Canada thistle (*Cirsium arvense* (L.) Scop.). Natural Areas Journal 12: 160-161.

ISCM (Invasive Species Council of Manitoba). 2018. Invasive plants & animals in Manitoba. [Online] http://www.invasivespeciesmanitoba.com/site/index.php. [accessed March 21, 2018].

ISCM (Invasive Species Council of Manitoba). 2019. Reed canarygrass (Phalaris arundinacea). Online: https://invasivespeciesmanitoba.com/site/index.php?page=reed-canary-grass [accessed: January 25, 2019]

Jakubowski, A.R., Casler, M.D. and R.D. Jackson. 2012. Genetic evidence suggests a widespread distribution of native North American populations of reed canarygrass. Biol Invasions. DOI 10.1007/s10530-012-0300-3.

Keeyask Hydropower Limited Partnership (KHLP). 2009. Keeyask Infrastructure Project Environmental Assessment Report, Winnipeg, Manitoba. July 2009.

Keeyask Hydropower Limited Partnership (KHLP). 2012a. Keeyask Generation Project Environmental Impact Statement: Response to EIS Guidelines, Winnipeg, Manitoba. June 2012.

Keeyask Hydropower Limited Partnership (KHLP). 2012b. Keeyask Generation Project Environmental Impact Statement: Terrestrial Environment Supporting Volume, Winnipeg, Manitoba. June 2012.

Keeyask Hydropower Limited Partnership (KHLP). 2015. Keeyask Generation Project Terrestrial Effects Monitoring Plan. Winnipeg, Manitoba. December 2015.

Lavergne, S. and J. Molofsky. 2004. Reed canarygrass (Phalaris arundinacea) as a biological model in the study of plant invasions. Critical Reviews in Plant Sciences 23(5): 415–429.

Lavergne, S. and J. Molofsky. 2007. Increased genetic variation and evolutionary potential drive the success of an invasive grass. PNAS 104(10): 3883–3888.

Leafy Spurge Stakeholders Group (LSSG). 2010. Best Management Practices for Industry: Top invasive Plant Concerns for Rights-of-Way. Brandon, Mb.

Manitoba Agriculture. 2019. Manitoba Agriculture crop weed web pages. [Online] https://www.gov.mb.ca/agriculture/crops/weeds/index.html [Accessed January, 2019.]

Maurer, D. A., Lindig-Cisneros, R., Werner, K.J., Kercher, S., Miller, R. and J. B. Zedler. 2003. The replacement of wetland vegetation by reed canrygrass (*Phalaris arundinacea*). Ecological Restoration 21(2): 116–119.

Ministry of Transportation and Infrastructure, Ministry of Environment (BC Parks and Protected Areas), Ministry of Forests, Lands, and Natural Resource Operations and Ministry of Agriculture. 2011. Pest Management Plan for Invasive Alien Plant and Noxious Weed

Control on Provincial Crown Lands within the South Coastal Mainland of British Columbia. 60 pp.

Morse, L. E., Randall, J. M., Benton, N., Hiebert, R. and Lu, S. 2004. An Invasive Species Assessment Protocol: Evaluating Non-Native Plants for Their Impact on Biodiversity. Version 1. NatureServe, Arlington, Virginia. 40 pp.

Saskatchewan Ministry of Agriculture. 2008. Fact Sheet: Canada Thistle and its Control. Saskatchewan Agriculture Knowledge Centre. 6 pp.

White, D.J., Haber, E., and Keddy, C. 1993. Invasive plants of natural habitats in Canada: an integrated review of wetland and upland species and legislation governing their control. Canadian Wildlife Service, Ottawa, Canada. 121pp.

Wikeem, B. 2007. Evaluation of Ranking Procedures for Invasive Plants: Application to British Columbia. Solterra Resource Inc. 56 pp.

Wildlife Resource Consulting Services MB Inc. (WRCS) and ECOSTEM Ltd. 2017. Pointe Du Bois Spillway Replacement Project Terrestrial Effects Monitoring Plan Construction Synthesis Report 2012 – 2016. A report prepared for Manitoba Sustainable Development on behalf of Manitoba Hydro by Wildlife Resource Consulting Services MB Inc. and ECOSTEM Ltd., March 2017.

Williams, P. A., and Newfield, M. 2002. A weed risk assessment system for new conservation weeds in New Zealand.

APPENDIX 1:
NON-NATIVE PLANT INDIVIDUAL AREAS

Table 7-1: Estimated radius and derived area for individual plant species

Species	Estimated Radius (cm)	Derived Area (m^2)
Arctium minus	25	0.196
Artemisia absinthium	25	0.196
Avena sativa	4	0.005
Capsella bursa-pastoris	5	0.008
Chenopodium album	10	0.031
Leucanthemum vulgare	10	0.031
Cirsium arvense	10	0.031
Cirsium vulgare	15	0.071
Crepis tectorum	8	0.020
Descurainia sophoides	15	0.071
Helianthus annuus	20	0.126
Hordeum jubatum	4	0.005
Lotus corniculatus	25	0.196
Matricaria discoidea	7.5	0.018
Medicago lupulina	10	0.031
Medicago sativa	25	0.196
Melilotus albus	25	0.196
Melilotus officinalis	25	0.196
Oenothera biennis	20	0.126
Phalaris arundinacea	15	0.071
Phleum pratense	3	0.003
Plantago major	10	0.031
Secale cereale	4	0.005
Silene csereii	10	0.031
Sonchus arvensis	10	0.031
Tanacetum vulgare	25	0.196
Taraxacum officinale	10	0.031
Trifolium hybridum	20	0.126
Trifolium pratense	20	0.126
Trifolium repens	20	0.126
Tripleurospermum inodorum	5	0.008
Triticum aestivum	4	0.005
Verbascum thapsus	20	0.126
Vicia cracca	20	0.126

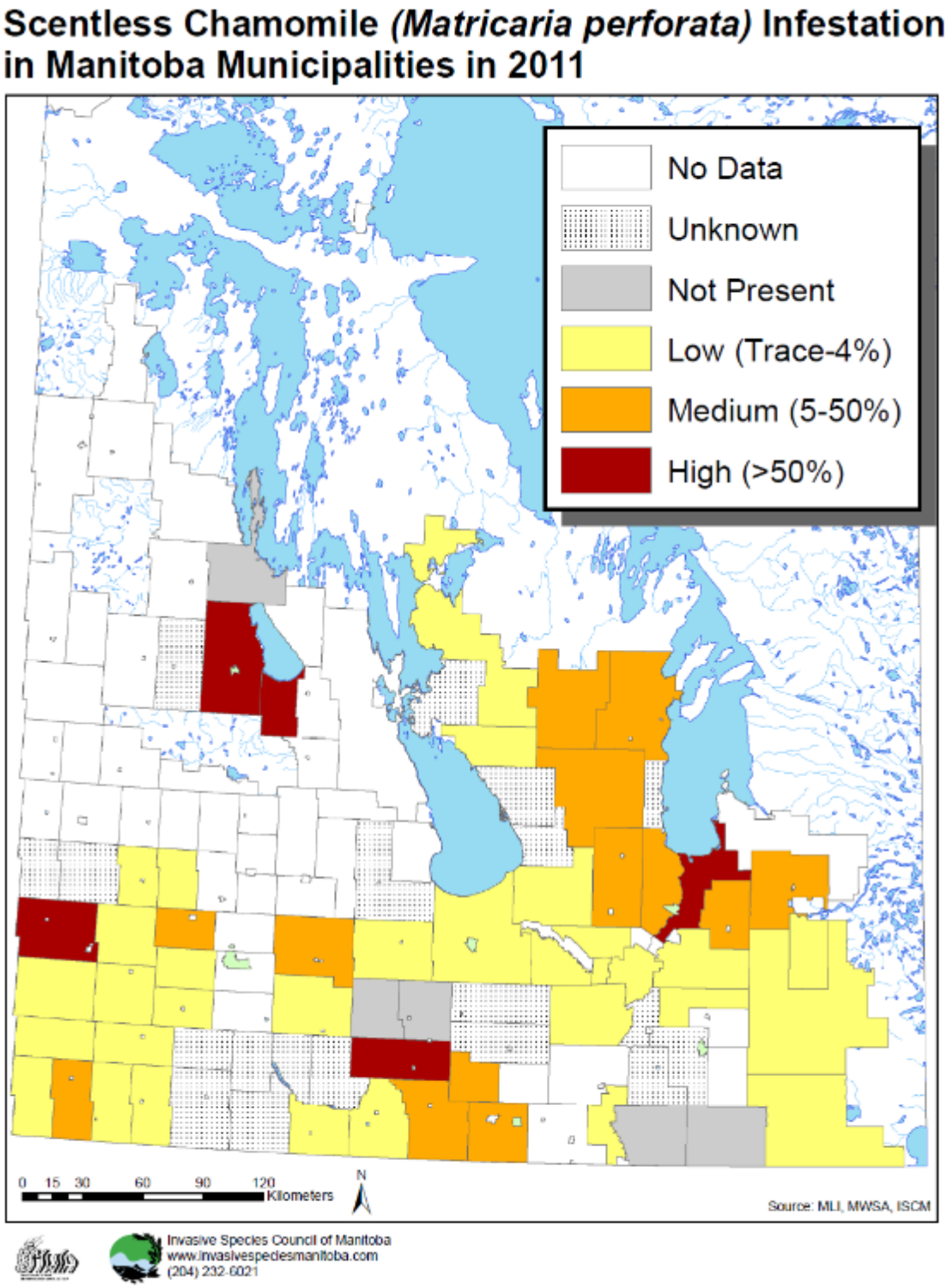
APPENDIX 2:
INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES

7.1.1 BACKGROUND

This monitoring study provides additional control or eradication recommendations during construction monitoring. The following describes the approach taken to make recommendations regarding which non-native species to prioritize for management, and the types of locations that management efforts will focus on.

It is widely recognized that it is not practical to attempt to eradicate or even control all non-native plant species (e.g., White *et al.* 1993; Morse *et al.* 2004; Ministry of Transportation and Infrastructure *et al.* 2011). For example, some species are already too widespread and well-established to implement an approach that removes plants at a faster rate than they reappear in the same locations and establish in new locations.

Many of the non-native species recorded during Project monitoring are commonly found in disturbed areas throughout the Province (e.g., field sow-thistle, white clover), particularly along roadsides, making it difficult to prevent them from being spread by human or natural sources. Maps produced by the Invasive Species Council of Manitoba (ISCM) demonstrate the widespread distribution of noxious weeds in southern Manitoba. For example, Figure 7-1 provides a general impression of how widespread scentless chamomile (a highly invasive species) was in southern Manitoba in 2011. However, this map considerably understates scentless chamomile distribution and abundance as data are missing for a high proportion of municipalities.



Source: Invasive Species Council of Manitoba.

Figure 7-1. Scentless Chamomile infestation in Manitoba municipalities in 2011

As noted above, it is not practical to eradicate or even control all non-native plant species. For this reason, numerous ranking systems have been developed to prioritize which non-native plant species to target, which types of locations should be focused on and/or the preferred management strategies. Examples of publications that review some of these systems include Williams and Newfield (2002), Wikeem (2007) and Carlson *et al.* (2008).

Three themes which frequently appear in systems that prioritize and/or determine which non-native plant species to actively manage (e.g., White *et al.* 1993; Morse *et al.* 2004; Ministry of Transportation and Infrastructure *et al.* 2011) are:

1. The potential for the species to cause major harm to ecosystems, conservation values or human health;
2. The species' current and expected future distribution and abundance; and,
3. The likelihood that management efforts can achieve their objectives over the long-term.

This monitoring study uses the preceding three themes to prioritize and develop management recommendations for non-native plants in the Project area. Management recommendations focus on the plant species of highest invasive concern (first and second themes) and the situations where there are practical ways to reduce these species or prevent further spreading (third theme).

For this monitoring, the primary sources used to classify the potential for a non-native plant species to have substantial adverse effects on ecosystems or biodiversity in the Project area were the ISCM (2018), White *et al.* (1993), the Provincial *Noxious Weeds Act* (Government of Manitoba 2017a) and the Federal Weed Seeds Order (Government of Canada 2016). While the federal *Plant Protection Act* was also relevant from the regulatory perspective, few of the species currently on its list occur in Manitoba, and those that do are limited to a few locations in the southern portion of the province.

The primary additional sources of information that assisted with evaluating potential invasiveness in the Project area, and with developing management recommendations, included the Biology of Canadian Weeds Series (Canadian Weed Science Society. 2019a), the Biology of Invasive Alien Plants in Canada (Canadian Weed Science Society. 2019b), Manitoba Agriculture (2019) and results from EIS or monitoring studies for this and other projects in northern Manitoba. The last of these sources also provided some information regarding patterns of distribution and abundance in the Project region.

A limitation for some of the sources used to determine a plant's degree of invasiveness was that they did not include data from the Keeyask region. The observed degree of invasiveness for the species included in these sources was generally obtained in regions subject to much different climates than that occurring in the Project region. Local invasiveness can differ greatly from that observed in other regions (Carlson *et al.* 2008).

Of the sources used for ranking a species' degree of invasiveness listed above, ISCM (2018) and White *et al.* (1993) were considered the most relevant ones because their focus is on impacts to ecosystems and biodiversity. The Provincial *Noxious Weeds Act* and the Federal

Weed Seeds Order were developed to address impacts on the agricultural economy or the viability of the agricultural operations. An upshot of this agricultural focus is that these regulations do not list some species known to be of concern for impacts on native ecosystems and biodiversity (e.g., purple loosestrife). Conversely, these regulations also list some native boreal plant species (e.g., foxtail barley) as weeds since they can be problematic for agriculture. Native boreal species appearing on these lists were not considered to be invasive for the Project area.

An additional reason for including the *Noxious Weeds Act* of Manitoba is that it includes some management obligations for species encountered during construction activities. This Act creates a general duty to destroy species it identifies as noxious weeds because they are a significant threat to Manitoba's agricultural economy or to the viability of the agricultural operations. The Act states that: “Each occupant of land, or, if the land is unoccupied, the owner thereof, or the agent of the owner, and each person, firm, or corporation who or which is in control of, or in possession of, or in charge of, land, shall destroy all noxious weeds and noxious weed seeds growing or located on the land as often as may be necessary to prevent the growth, ripening and scattering of weeds or weed seeds.”

The degree of management response required by the Act depends on the species’ threat to agricultural crops. Species are categorized into one of three degrees of threat, which are Tier 1, 2 or 3. The Act requires that a landowner, occupier or contractor:

a) destroy all tier 1 noxious weeds that are on land that the person owns or occupies;
b) destroy all tier 2 noxious weeds that are on land that the person owns or occupies if the area colonized by the weeds is less than five acres [2.023 ha];
c) control all tier 2 noxious weeds that are on land that the person owns or occupies if the area colonized by the weeds is five acres [2.023 ha] or more; and
d) control a tier 3 noxious weed that is on land that the person owns or occupies if the weed's uncontrolled growth or spread is likely to negatively affect an aspect of Manitoba's economy or environment in the area of the land or the well-being of residents in proximity to the land.

The Act defines control as curtailing the weed’s growth and preventing its spread beyond its current location.

It is noted that, as there are no agriculture crops near the Project, weeds in the Project site do not pose a local threat to agricultural operations. Equipment or vehicles moving from the site to other regions could transport weed propagules into agricultural areas.

7.1.2 INVASIVE CONCERN CLASSIFICATION

As noted above, ISCM and White *et al.* (1993) were the primary sources for ranking a species’ degree of invasiveness. To provide background for this study’s invasive concern classification, the criteria used in the ISCM and White *et al.* (1993) classifications are first presented.

Table 7-2 provides the ISCM invasive plant categories, criteria for inclusion in a category and the minimum management criteria. Category 1 and 2 species are the species considered to pose the greatest threats, and have a management response that includes eradication if feasible. The essential differences between these categories is that Category 1 includes species not yet known to be present in natural areas and species declared to be noxious weeds. Species that ISCM lists as "other" are not on the early detection and rapid response list.

White *et al.* (1993) classify alien plants in Canada as being either a principal, moderate or minor invasive. Principal Invasive Aliens are the species considered to pose the greatest threat to natural areas. Moderate Invasive Aliens are the species considered to pose an intermediate level of threat to natural areas. Minor Invasive Aliens are the species considered to be only minor problems.

Table 7-2. ISCM invasive plant categories, criteria for inclusion and minimum management criteria

Categories and Criteria for Inclusion	Minimum Management Criteria
Category 1 Species	
• These invasive plants are not present in Manitoba, but may be present in cultivation[1] but not yet known to have escaped, and/or • If listed as a Manitoba Noxious Weed, and/or • If on the List of Pests Regulated in Canada and • Capable of establishing in Manitoba based upon climate variables • A pathway of introduction exists • Easily identifiable with available resources.	• Eradication is first option if detected and if feasible. • A lead agency should be identified and a management committee formed to develop an eradication strategy. • An education and awareness program is required. • Provincial ban on sale and trade. • Species may be moved to next category if found in Manitoba.
Category 2 Species	
• These invasive plants are present in Manitoba and • Capable of further spread and • Pathways for spread are present and • Easily identifiable with available resources.	• Eradication is first option, when feasible. • Containment and control programs are second option. • Education and awareness programs to foster prevention. • A response plan is available or under development.
Other Species	
• Other terrestrial invasive plants	• Not specified in the ISCM website.

Source: ISCM (2018).

Notes: [1] Cultivated as a garden plant, for ornamental horticulture, water ponds or gardens, for lawns; and is outside its natural range.

The non-native plant species recorded during monitoring to date were classified into one of four levels of invasive concern for the Project area (Table 2-3). Level 1 was the highest level of invasive concern for the Project. Level 1 species included ISCM Category 1 and 2 species.

The second highest level of invasive concern for the Project (Level 2 species) included ISCM "other" species of concern and/or the non-native species that White *et al.* (1993) classify as being principal or moderate invasives in Canada. These species also have the potential to crowd out native species in many of the conditions where non-native plants are found.

The third highest level of invasive concern (Level 3 species) included non-native species that White *et al.* (1993) classify as minor invasives in Canada and/or the species that government sources classify as noxious weeds or weed seed species.

The fourth and lowest level of invasive concern (Level 4 species) included all of the non-native plant species not already included in another level. Species at the third and fourth levels may become problematic in some locations and/or conditions (*e.g.*, changed climate). They will also be a consideration when developing revegetation plans for areas being rehabilitated to native habitat types.

Table 2-4 shows how the invasive concern classification was applied to the non-native plant species recorded in the Project footprint to date.

Table 7-3 classifies non-native species that have not been recorded to date but could potentially occur in the Project footprint. These included species that are known to be present in Manitoba, and are listed as Tier 2 or 3 noxious weeds in Manitoba (Government of Manitoba 2017b), or are listed as Category 2 or Other invasive plants by the ISCM (2018).

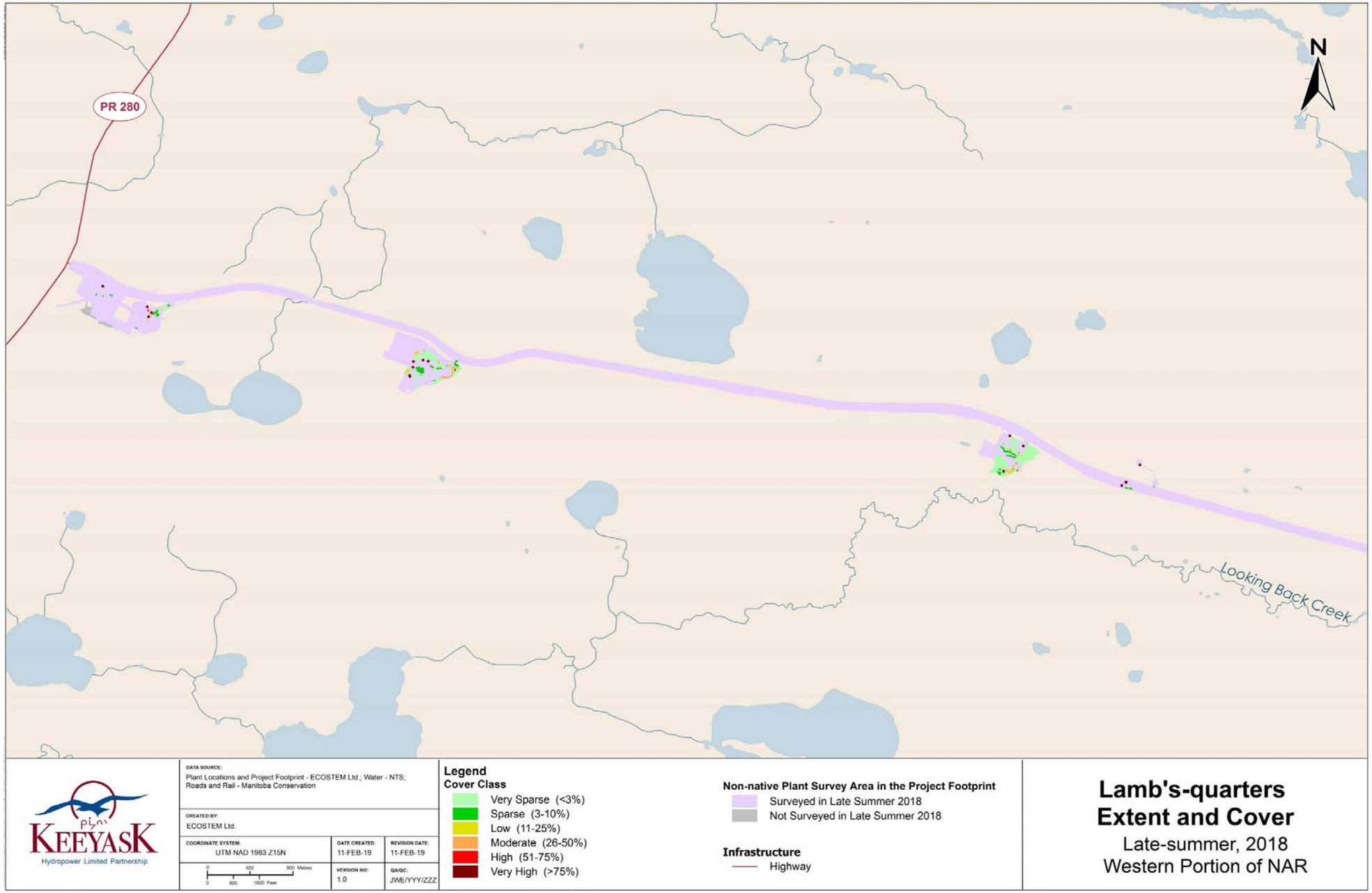
Table 7-3: Invasive concern classifications for non-native plant species that could potentially occur in the Project footprint

Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White *et al.* Category[4]	Noxious weed[5]	Weed Seed[6]
Level 1	Hoary alyssum	*Berteroa incana*	Other		Tier 2	
	Japanese brome	*Bromus japonicus*	Category 2		Tier 2	
	Downy brome	*Bromus tectorum*	Category 2		Tier 2	
	Flowering Rush	*Butomus umbellatus*	Category 2	Principal		
	Thistle, nodding	*Carduus nutans*	Category 2	Minor	Tier 2	Prohibited
	Blueweed	*Echium vulgare*	Category 2			
	Spurge, leafy	*Euphorbia virgata*	Category 2	Principal	Tier 2	Prohibited
	Baby's-breath	*Gypsophila paniculata*	Other		Tier 2	
	St. John's-wort	*Hypericum perforatum*	Category 2	Moderate	Tier 2	
	Large Touch-me-not	*Impatiens glandulifera*	Category 2			
	Scabious, field	*Knautia arvensis*	Category 2		Tier 2	
	Toadflax, Dalmatian	*Linaria dalmatica*	Category 2		Tier 2	Primary
	Toadflax, yellow	*Linaria vulgaris*	Category 2		Tier 3	Primary
	Purple Loosestrife	*Lythrum salicaria*	Category 2	Principal		Primary
	Bartsia, red	*Odontites vulgaris*	Category 2		Tier 2	Prohibited
	Common reed, invasive	*Phragmites australis* ssp. *australis*	Category 2		Tier 2	
	Buckthorn, European	*Rhamnus cathartica*	Category 2	Principal	Tier 3	
	Bouncingbet	*Saponaria officinalis*	Category 2		Tier 2	
Level 2	Garlic Mustard	*Alliaria petiolata*	Other	Principal		
	Bellflower, creeping	*Campanula rapunculoides*	Other		Tier 3	
	Thistle, bull	*Cirsium vulgare*	Other		Tier 3	
	Field Bindweed	*Convolvulus arvensis*	Other			Primary
	Common Hound's Tongue	*Cynoglossum officinale*	Other			

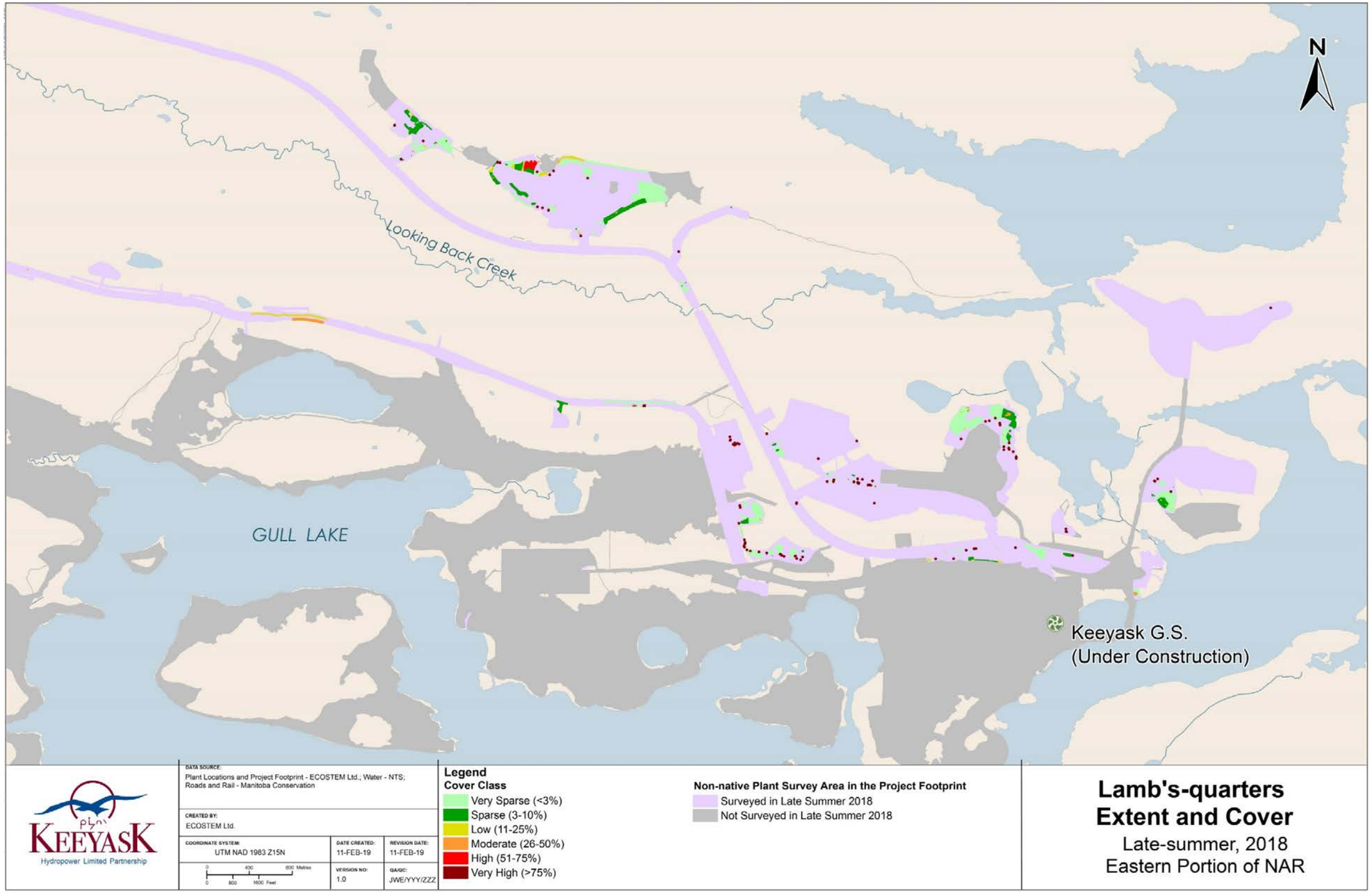
Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White *et al.* Category[4]	Noxious weed[5]	Weed Seed[6]
	Japanese Knotweed	*Fallopia japonica*	Other			
	Giant hogweed	*Heracleum mantegazzianam*	Other			
	Dame's-rocket	*Hesperis matronalis*	Other	Minor		
	Tansy Ragwort	*Jacobaea vulgaris*	Other			Primary
	Scotch Thistle	*Onopordum acanthium*	Other			
	Orange Hawkweed	*Pilosella aurantiaca*	Other			
	Common Buttercup	*Ranunculus acris*	Other			
	Cockle, white	*Silene latifolia*	Other		Tier 3	Primary
	Puncture Vine	*Tribulus terrestris*	Other			
	Cow-cockle	*Vaccaria hispanica*	Other			Secondary

Notes: [1] See Table 2-3 for the invasive concern classification. [2] In decreasing order of concern for the Project area. [3] Invasive Species Council of Manitoba (2018). [4] White *et al.* (1993). [5] Government of Manitoba (2017b). Number in column is the Tier in the Act (see text). [6] Government of Canada (2016).

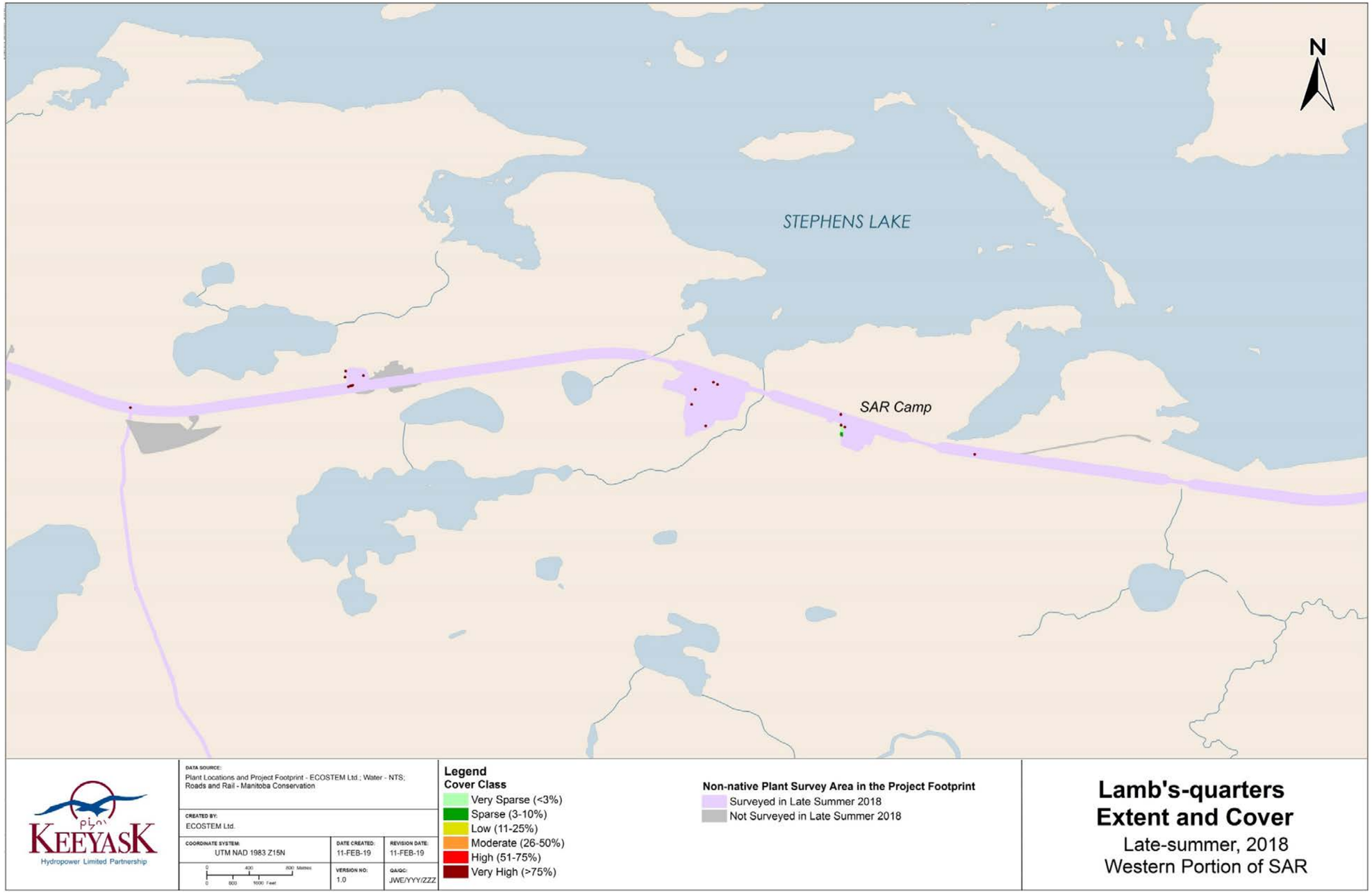
APPENDIX 3:
NON-NATIVE PLANT DISTRIBUTION MAPS



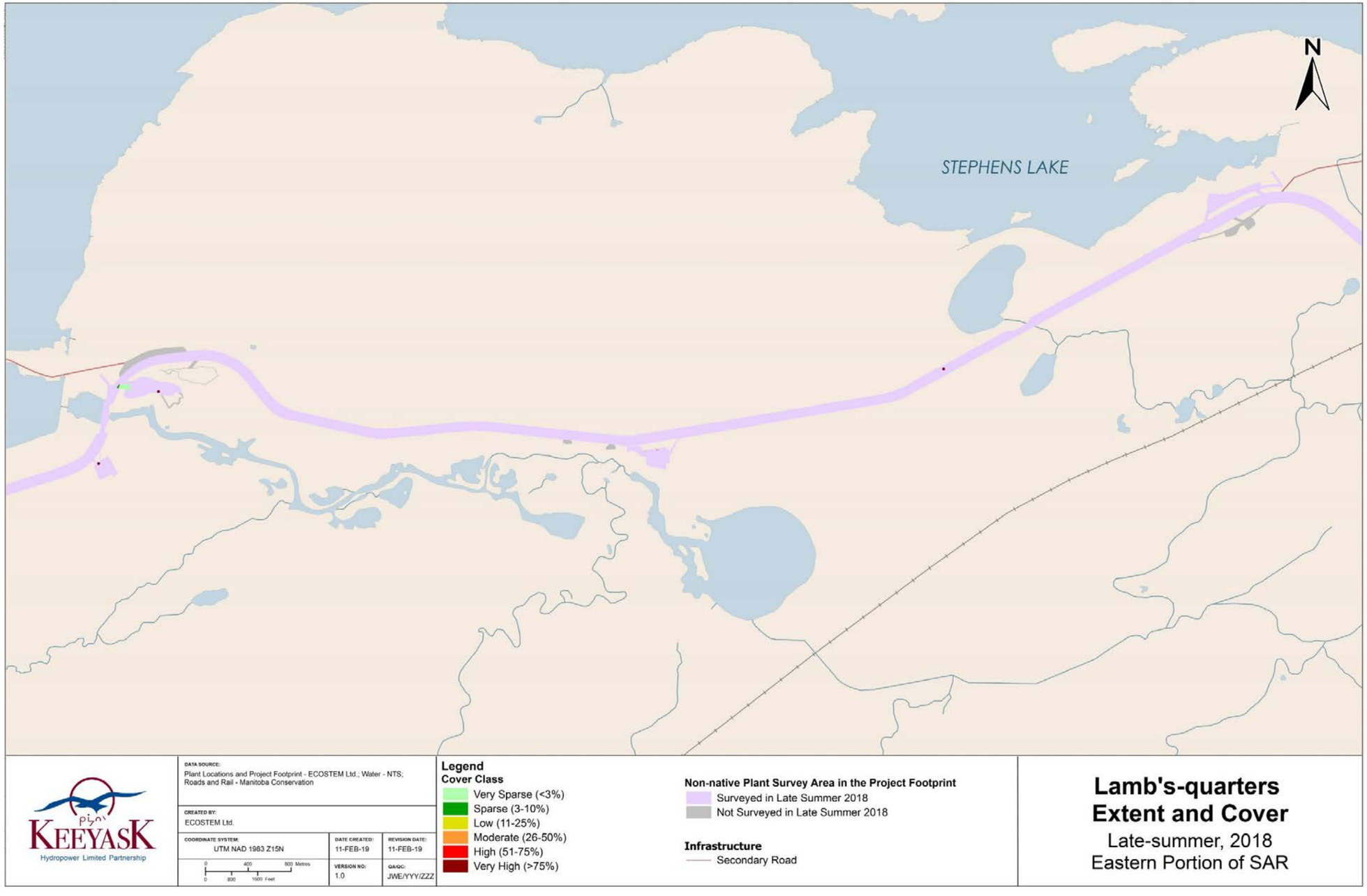
Map 7-1: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the western portion of the North Access Road in late summer, 2018



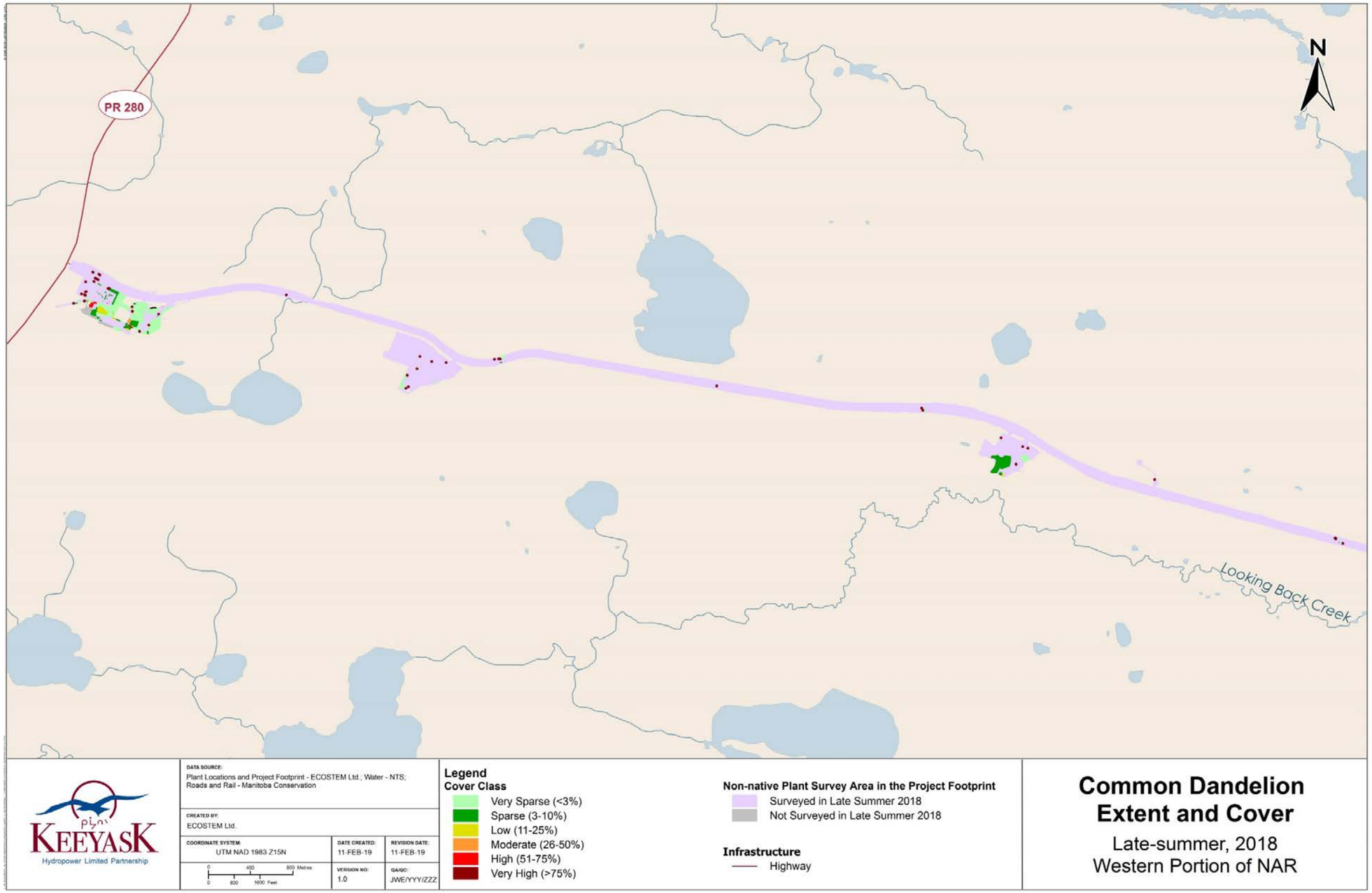
Map 7-2: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the eastern portion of the North Access Road in late summer, 2018



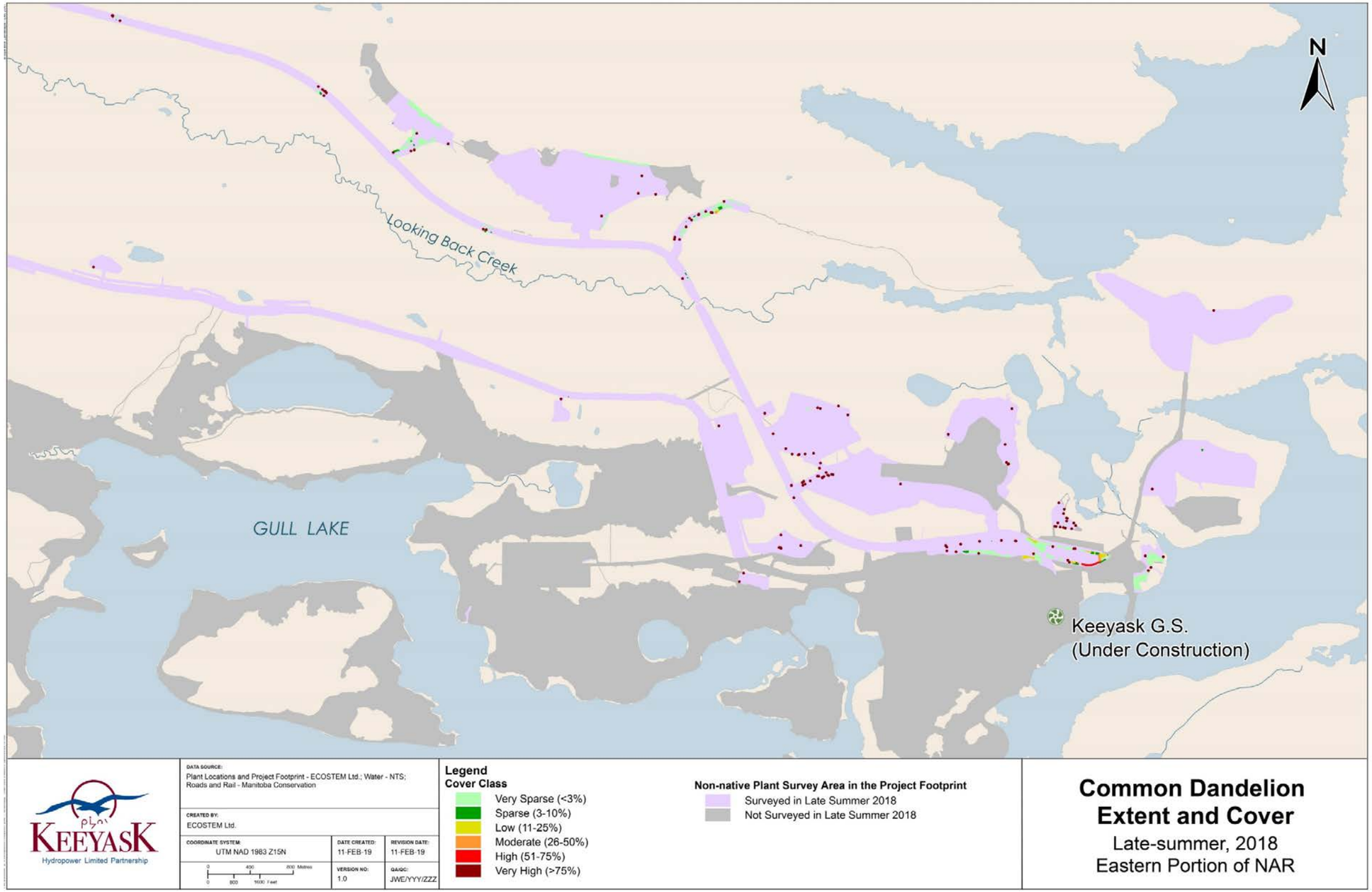
Map 7-3: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the western portion of the South Access Road in late summer, 2018



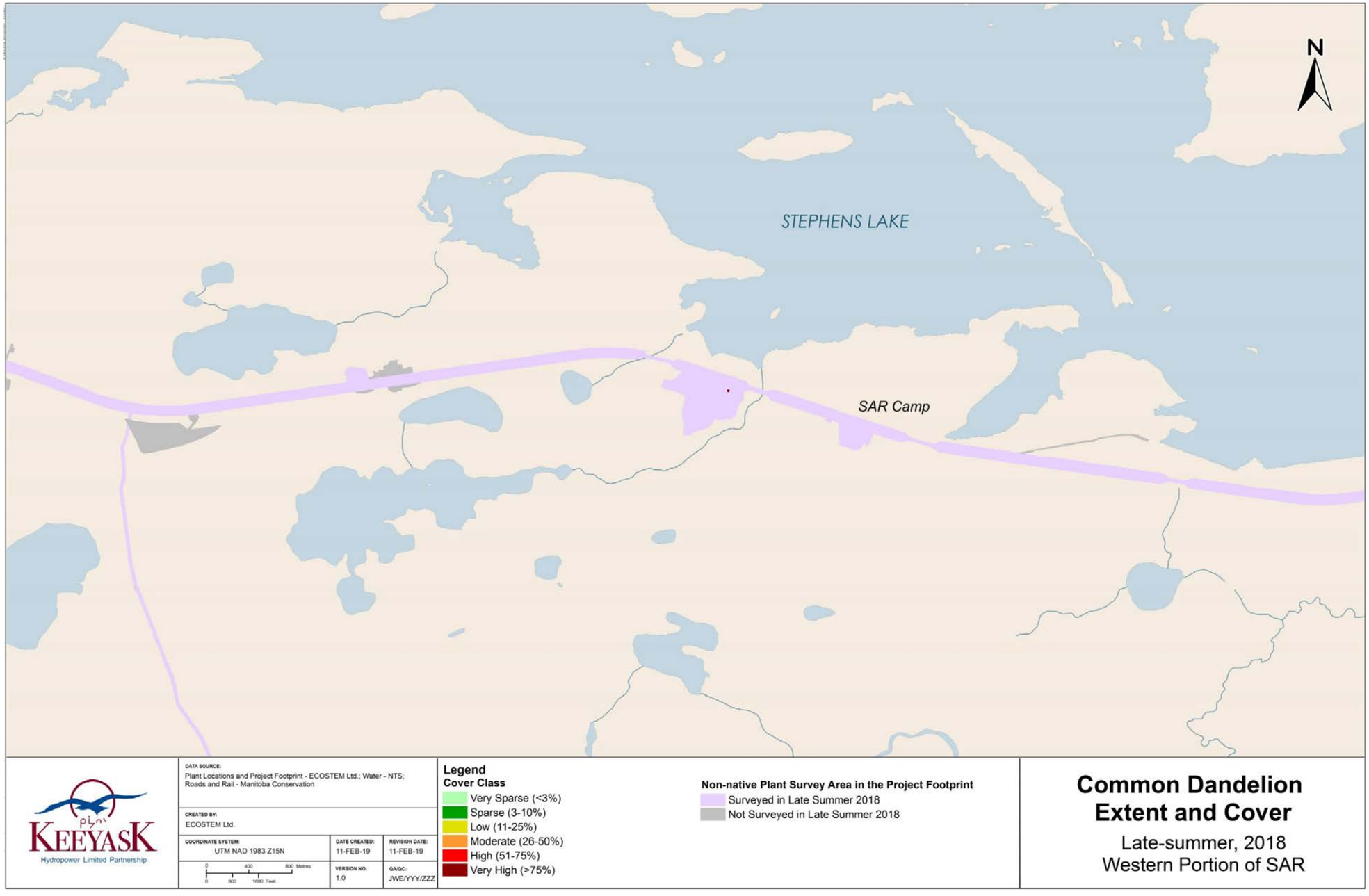
Map 7-4: The distribution and abundance (cover class) of lamb's quarters in the Project footprint along the eastern portion of the South Access Road in late summer, 2018



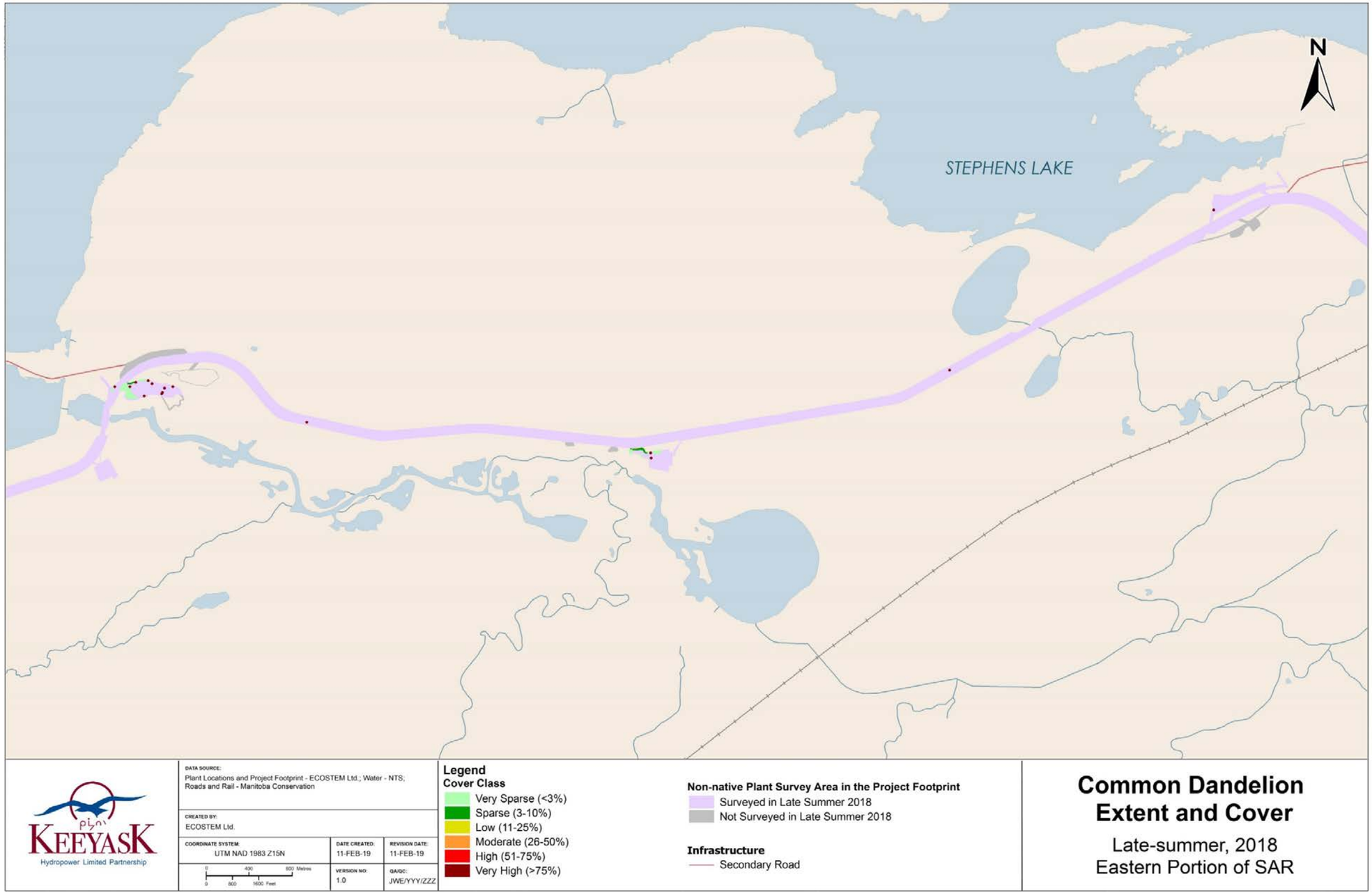
Map 7-5: The distribution and abundance (cover class) of common dandelion in the Project footprint along the western portion of the North Access Road in late summer, 2018



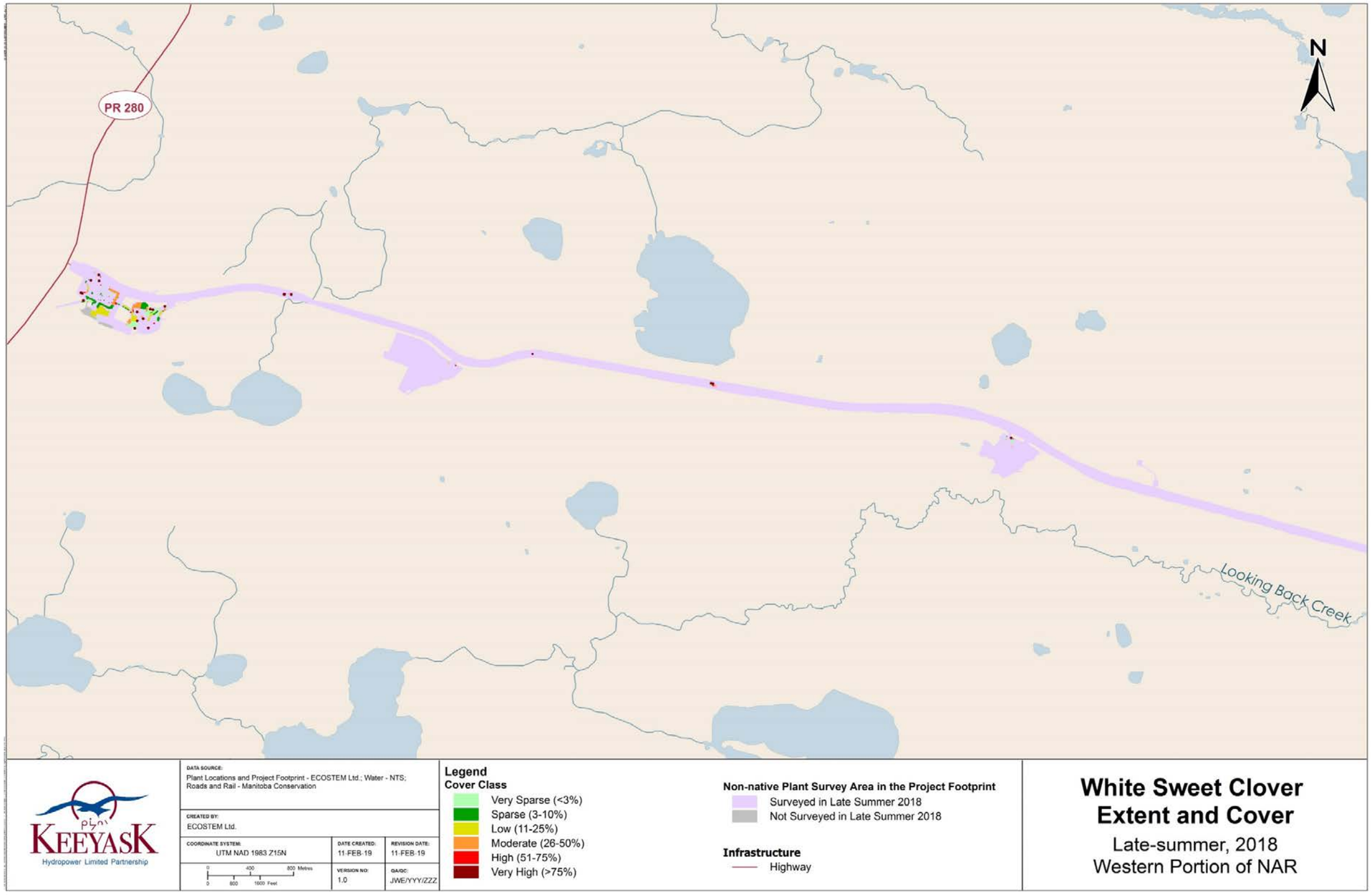
Map 7-6: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the North Access Road in late summer, 2018



Map 7-7: The distribution and abundance (cover class) of common dandelion in the Project footprint along the western portion of the South Access Road in late summer, 2018

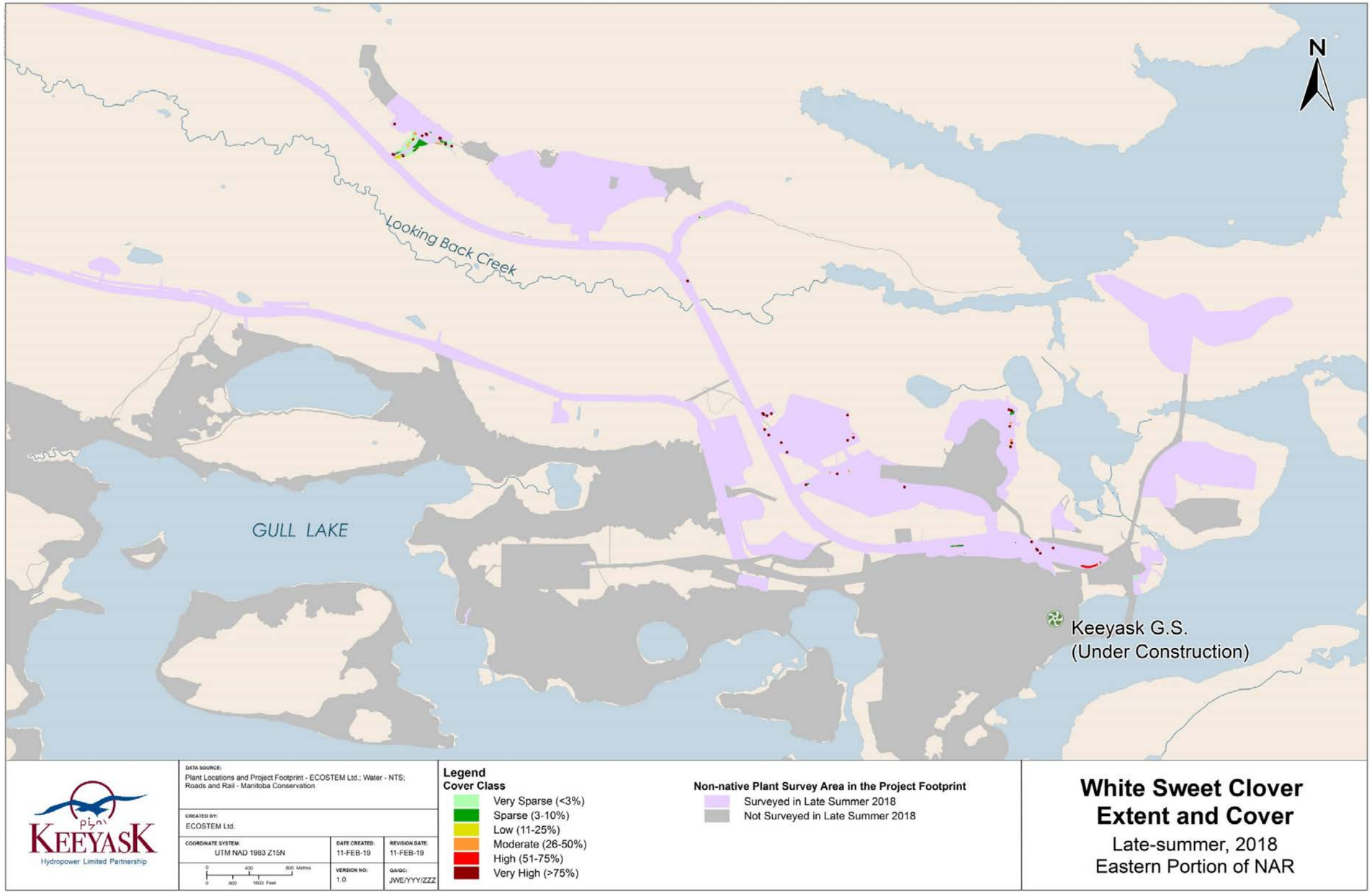


Map 7-8: The distribution and abundance (cover class) of common dandelion in the Project footprint along the eastern portion of the South Access Road in late summer, 2018



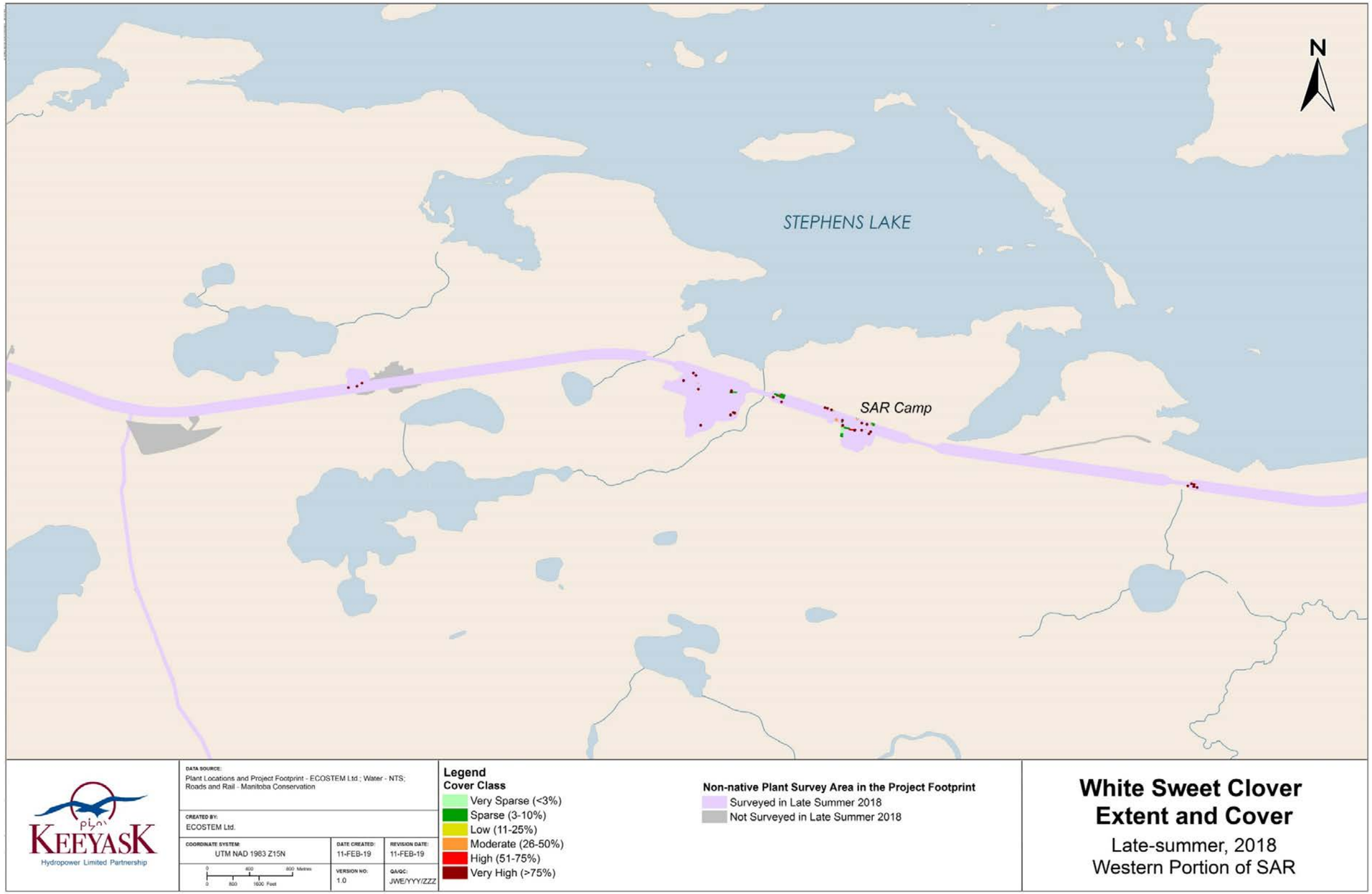
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 7-9: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the western portion of the North Access Road in late summer, 2018



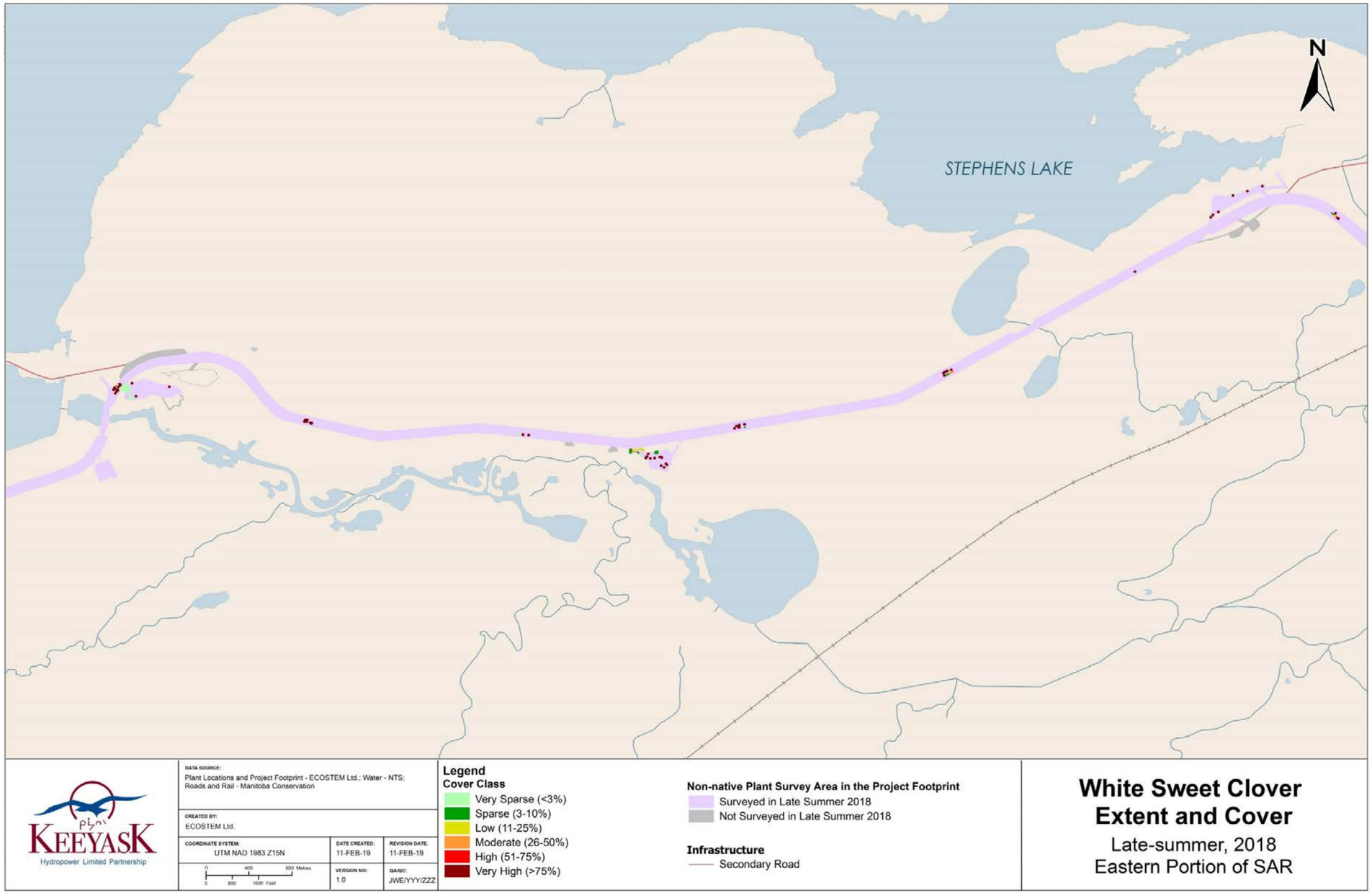
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 7-10: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the eastern portion of the North Access Road in late summer, 2018



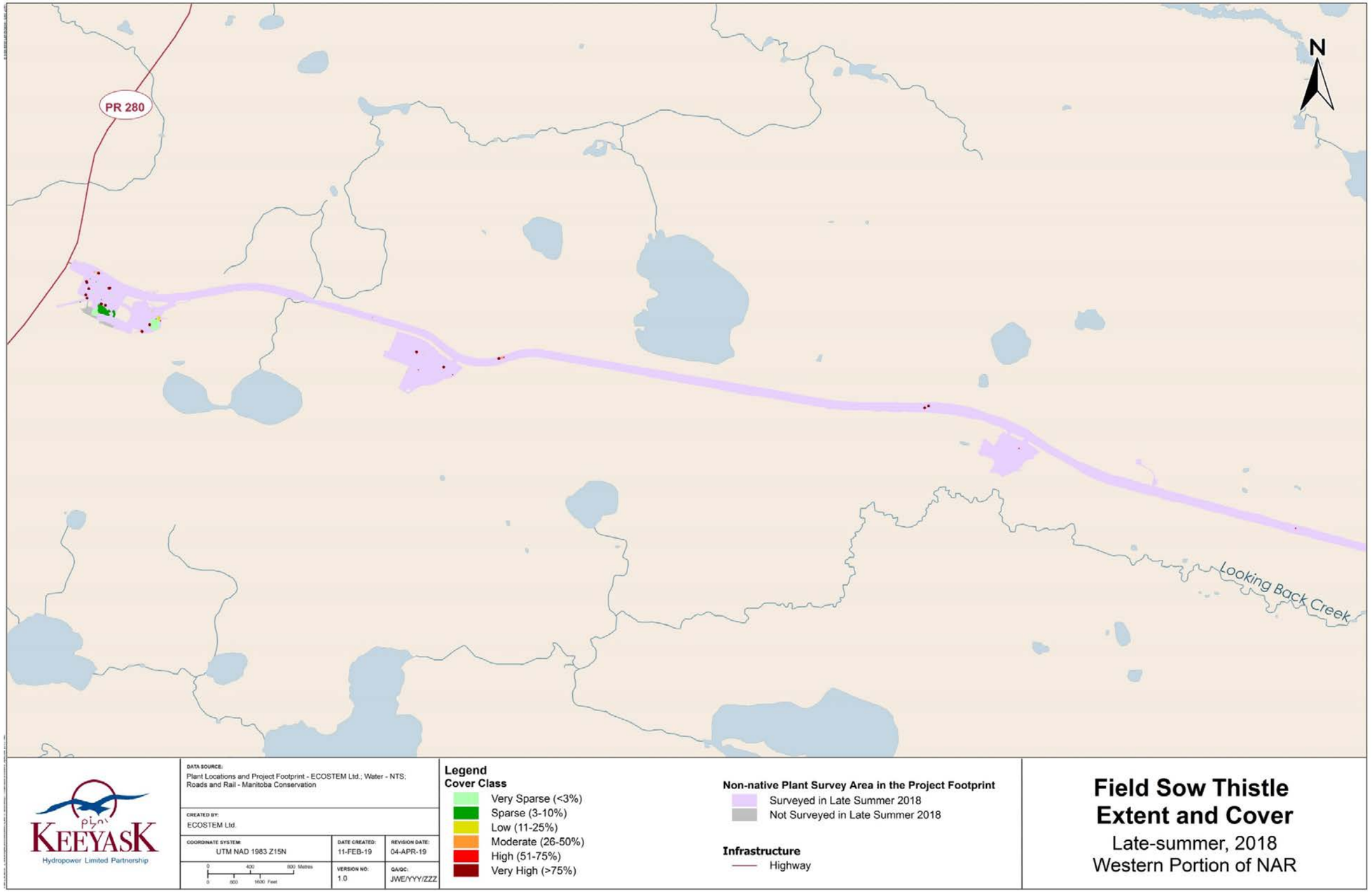
[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

Map 7-11: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the western portion of the South Access Road in late summer, 2018

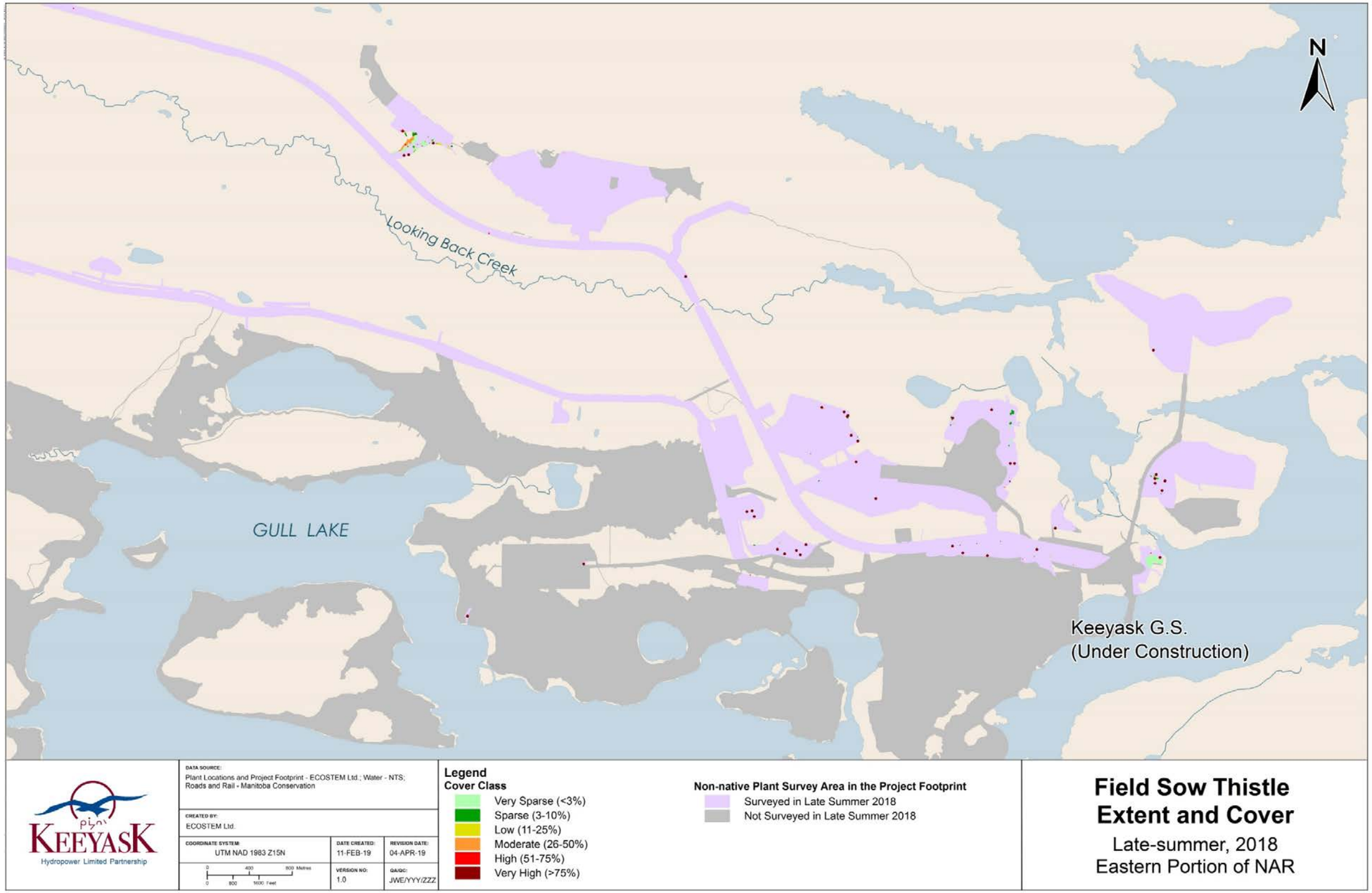


[1] Includes locations with unidentified white or yellow sweet clover due to lack of flowers.

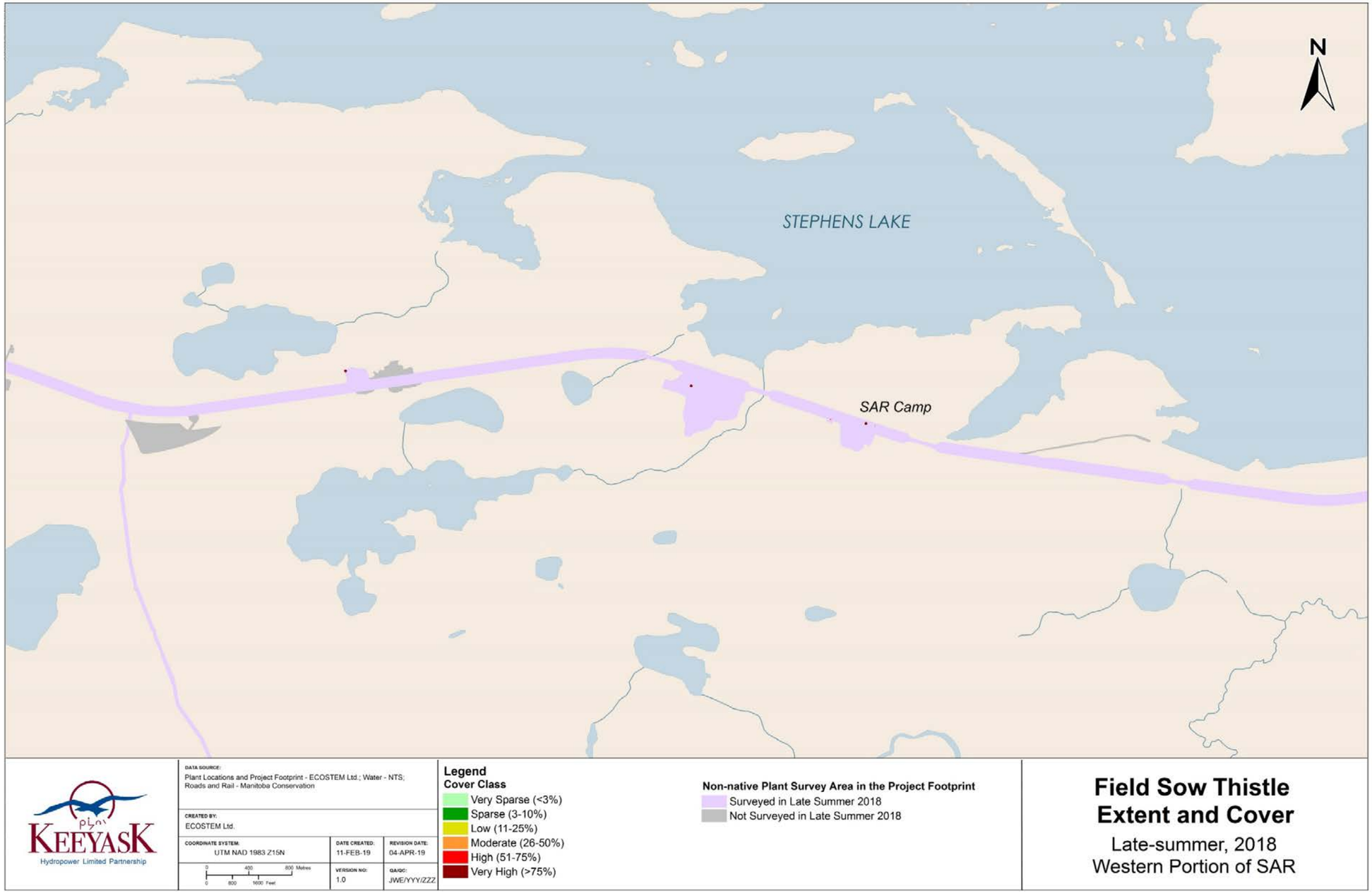
Map 7-12: The distribution and abundance (cover class) of white sweet clover[1] in the Project footprint along the eastern portion of the South Access Road in late summer, 2018



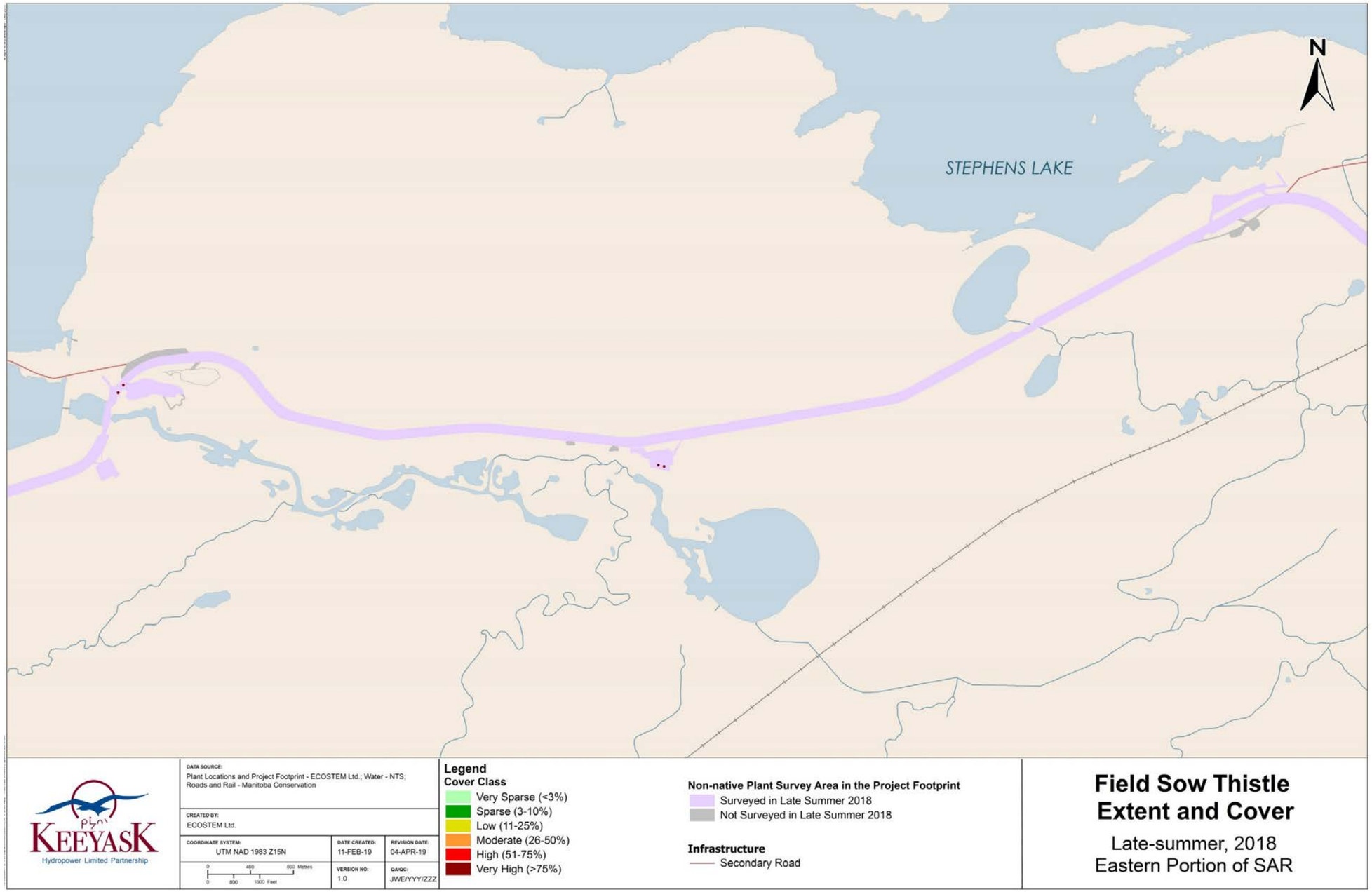
Map 7-13: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the North Access Road in late summer, 2018



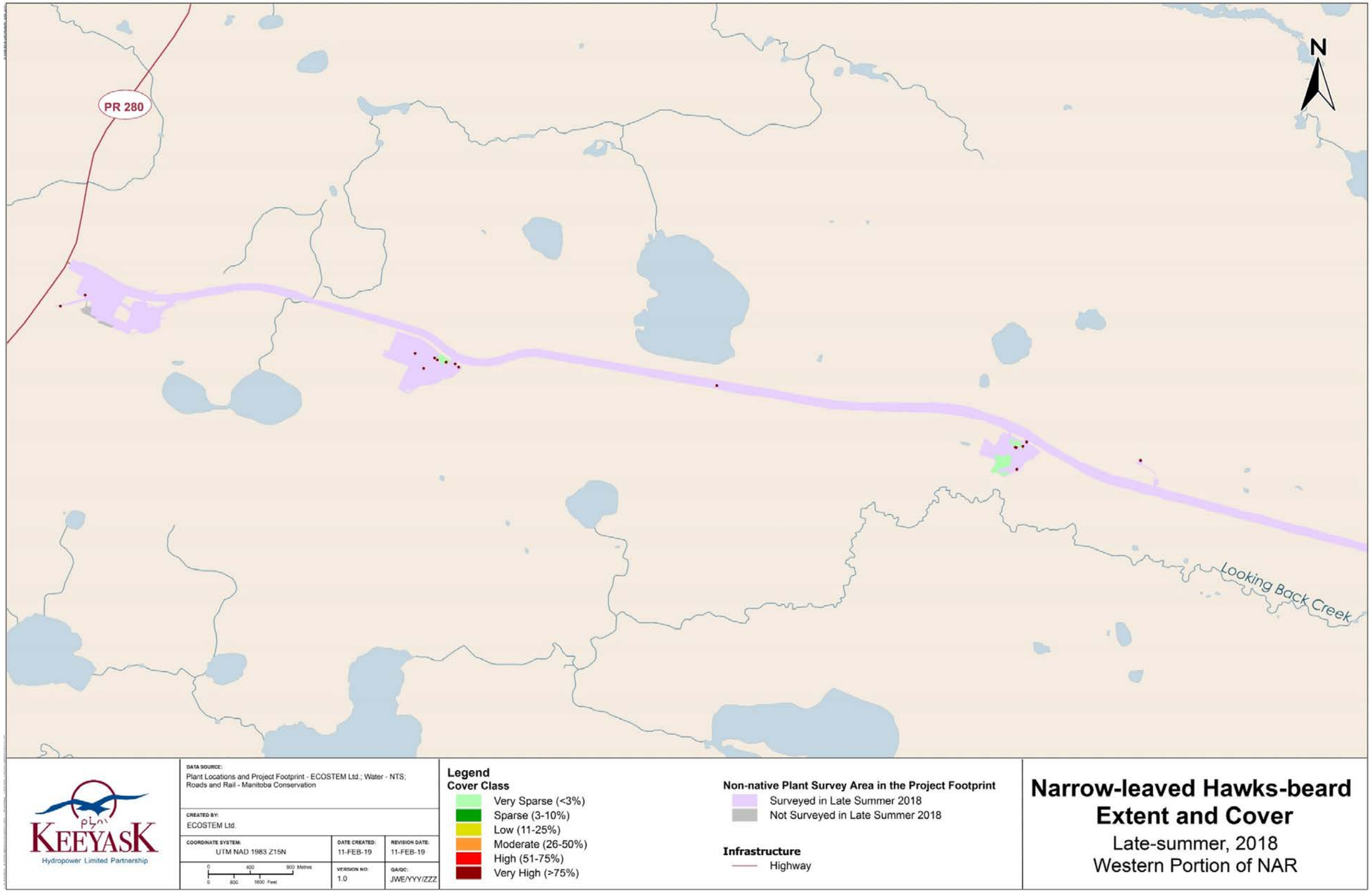
Map 7-14: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the North Access Road in late summer, 2018



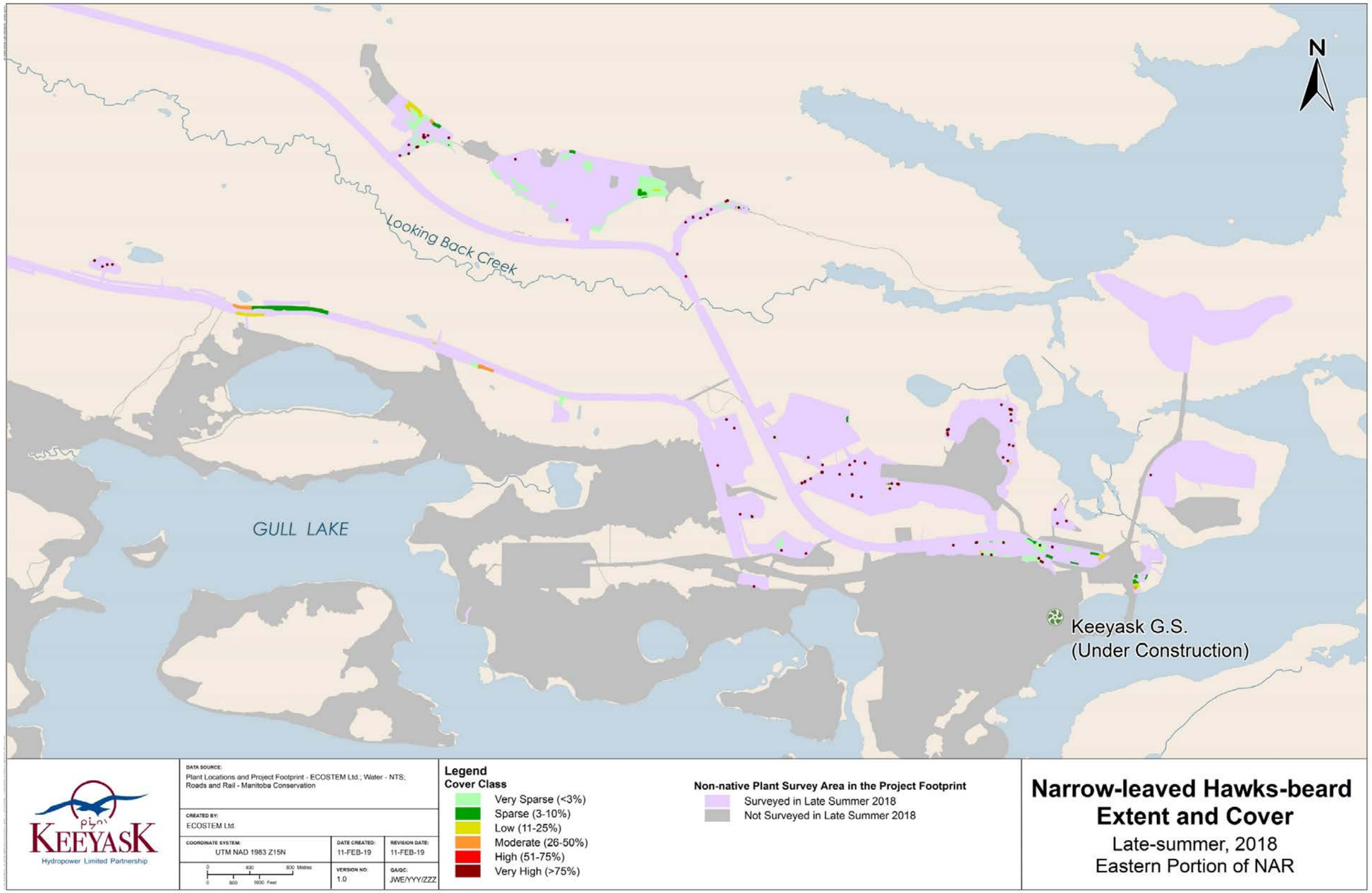
Map 7-15: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the South Access Road in late summer, 2018



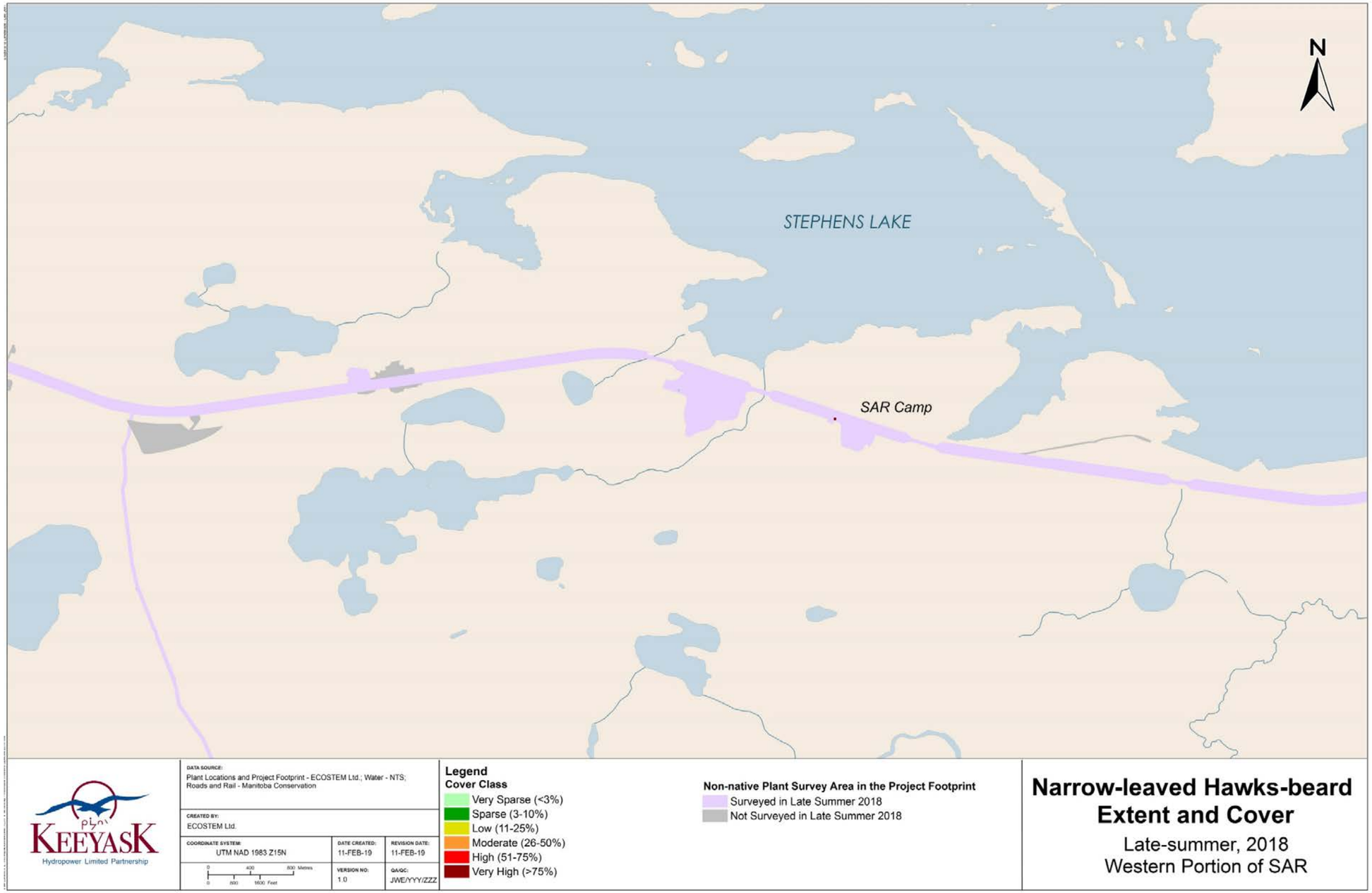
Map 7-16: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the South Access Road in late summer, 2018



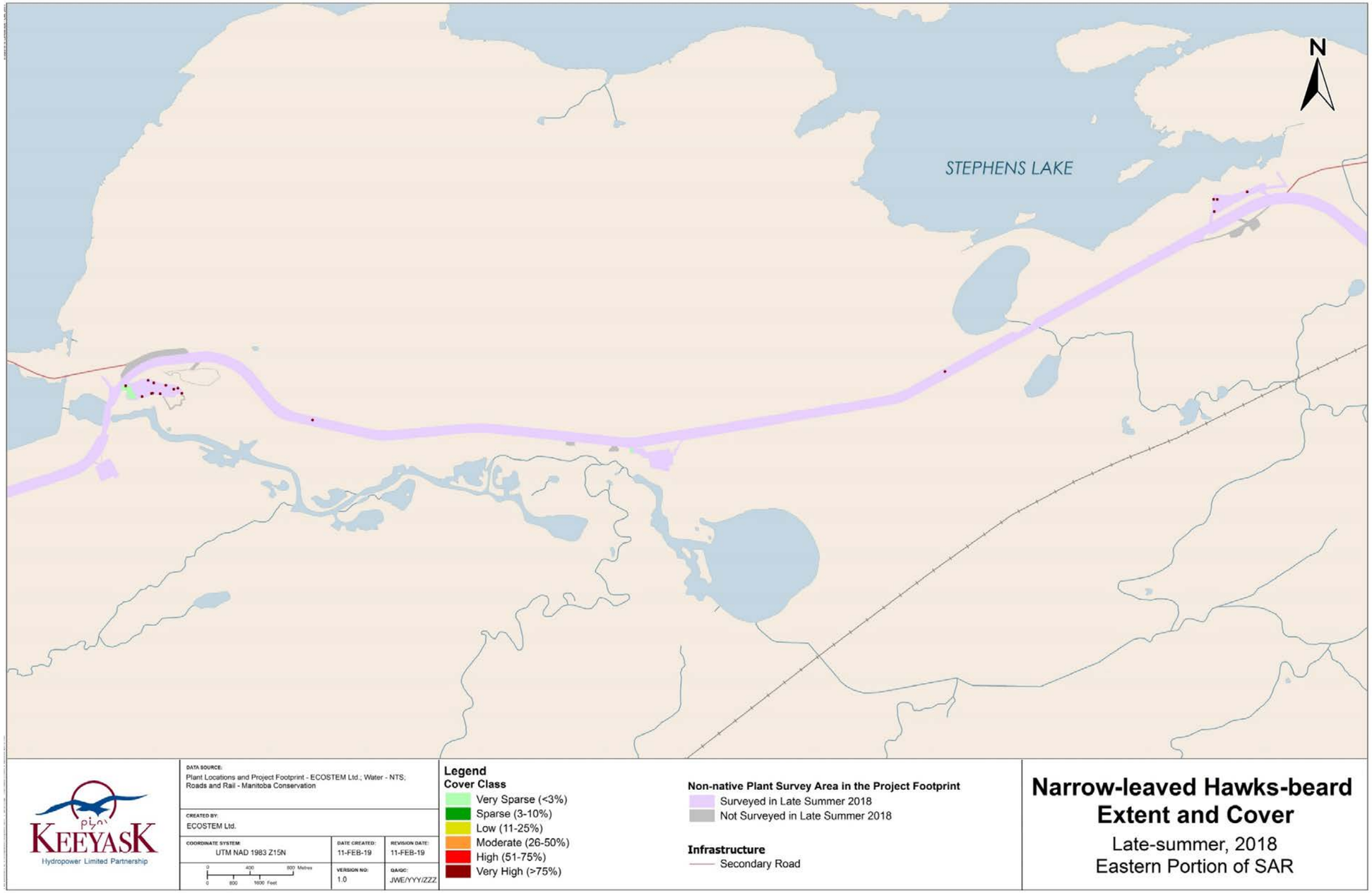
Map 7-17: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the western portion of the North Access Road in late summer, 2018



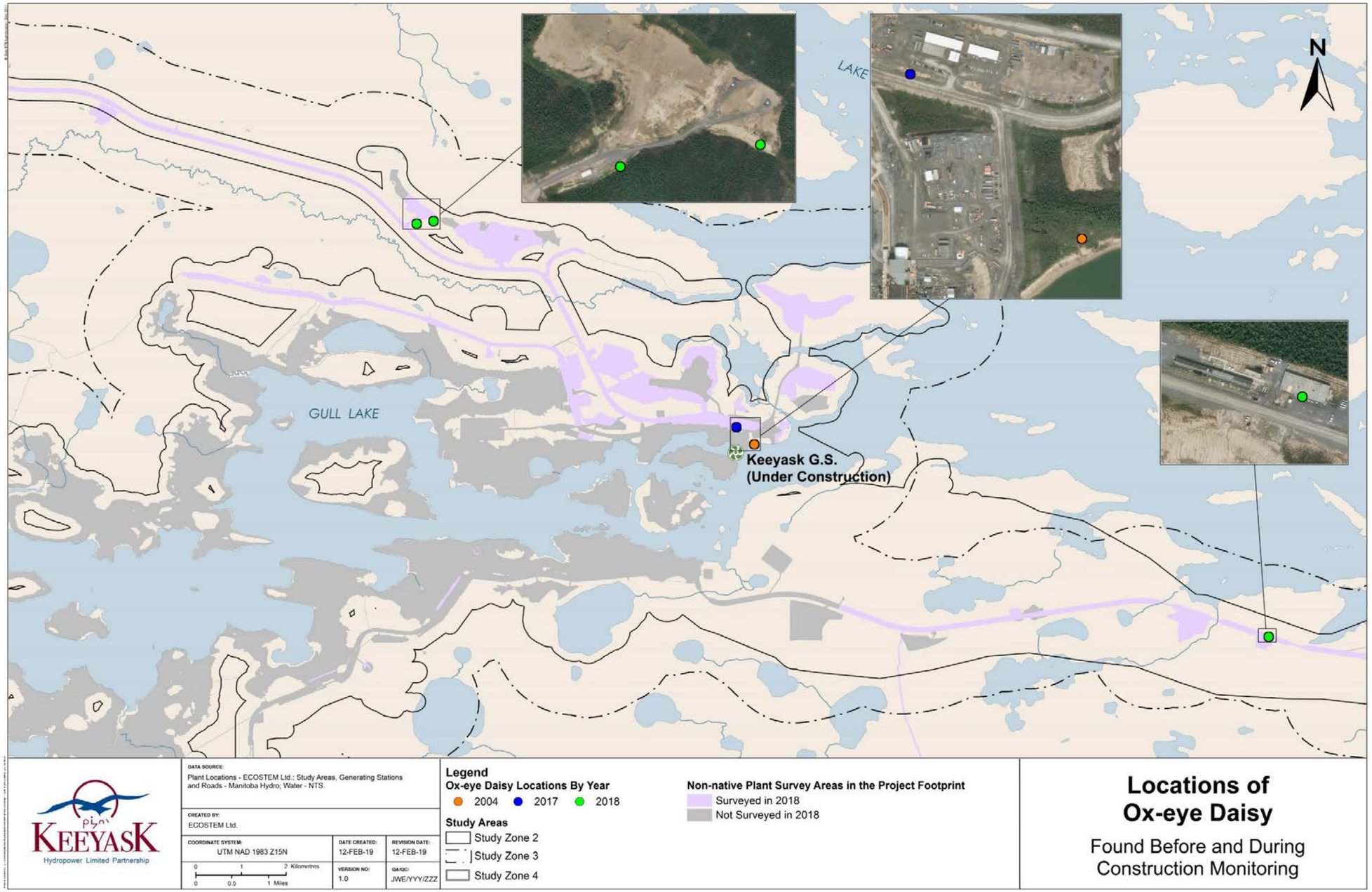
Map 7-18: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the eastern portion of the North Access Road in late summer, 2018



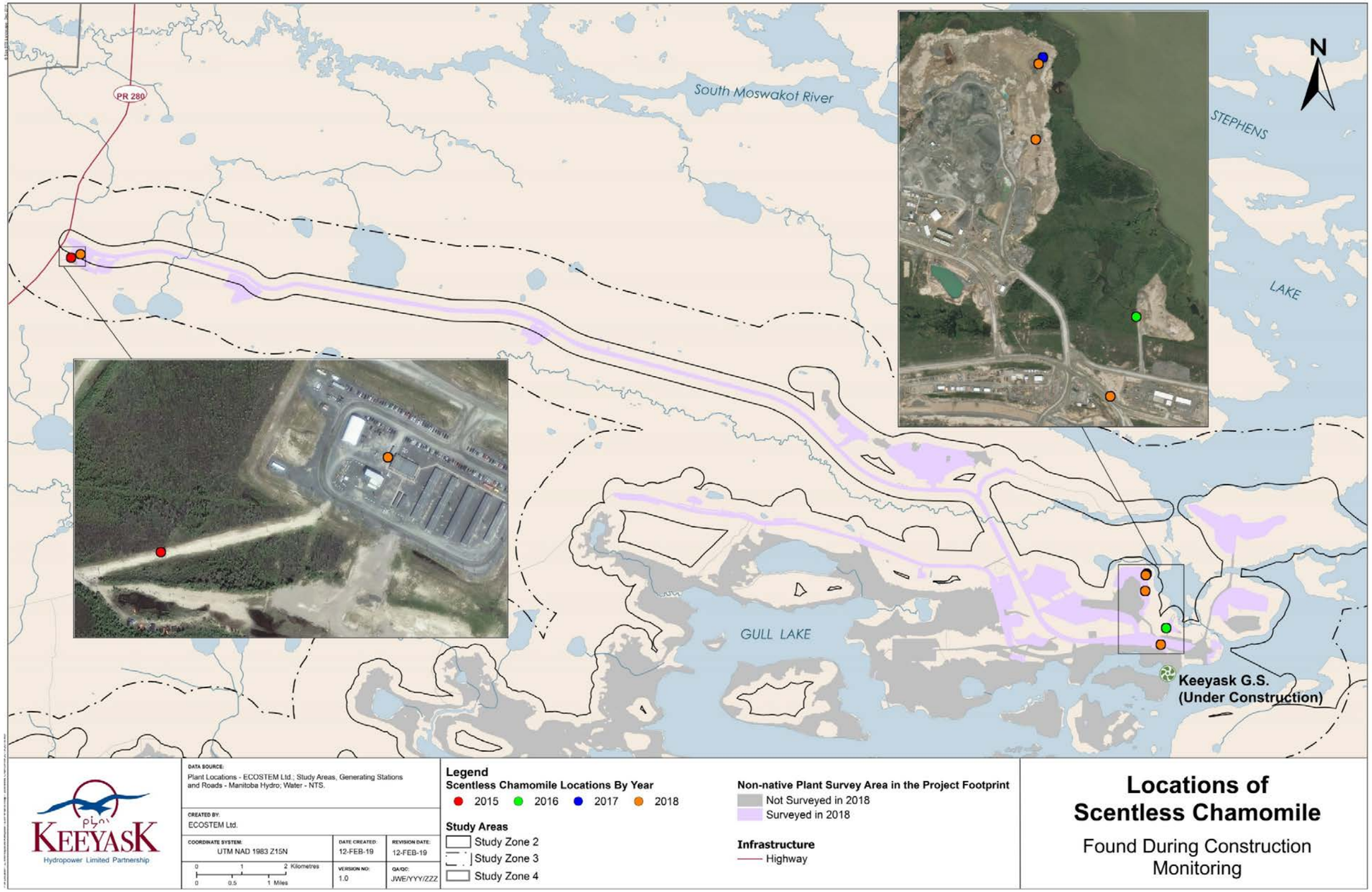
Map 7-19: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the western portion of the South Access Road in late summer, 2018



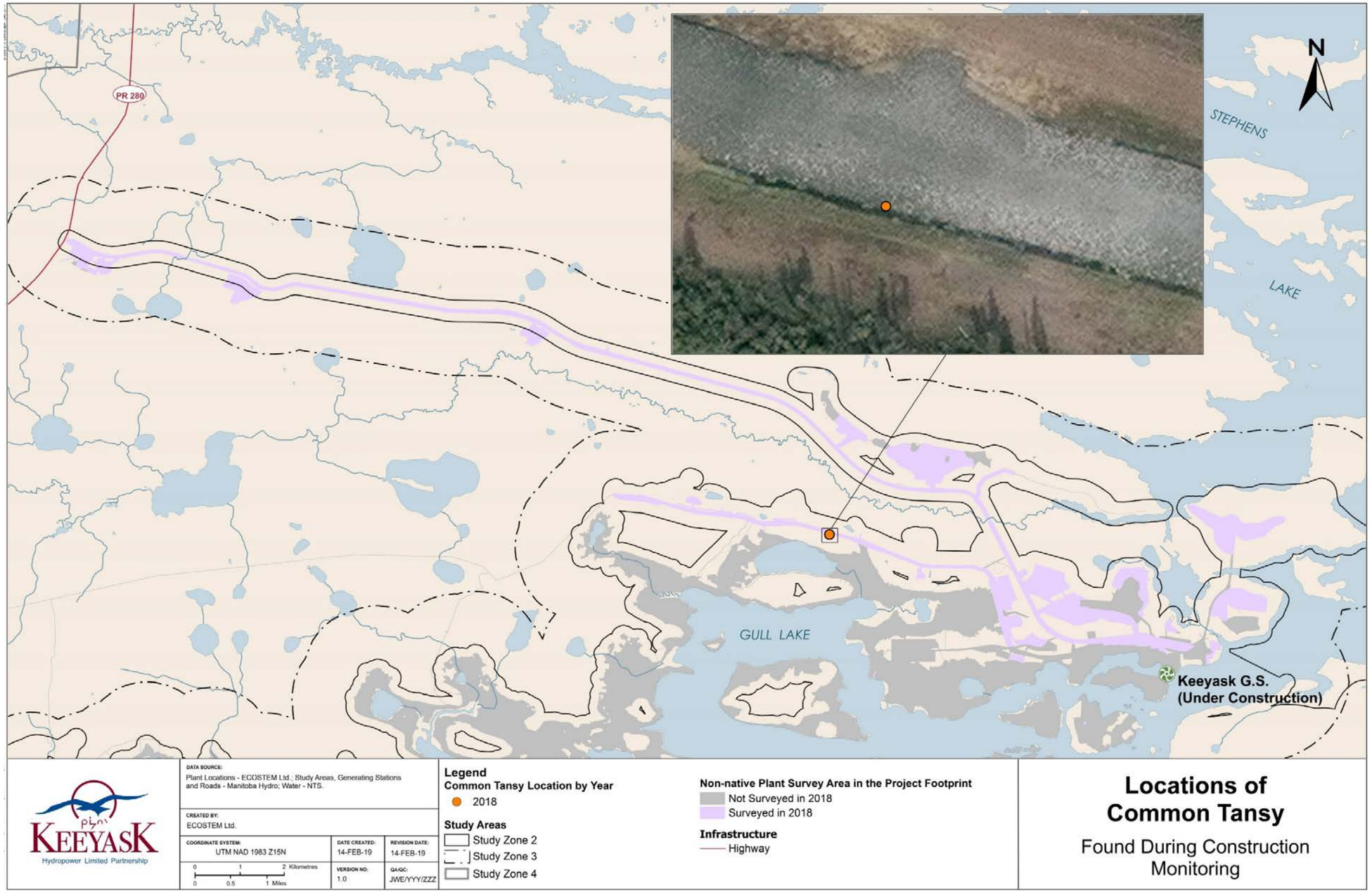
Map 7-20: The distribution and abundance (cover class) of narrow-leaved hawks-beard in the Project footprint along the eastern portion of the South Access Road in late summer, 2018



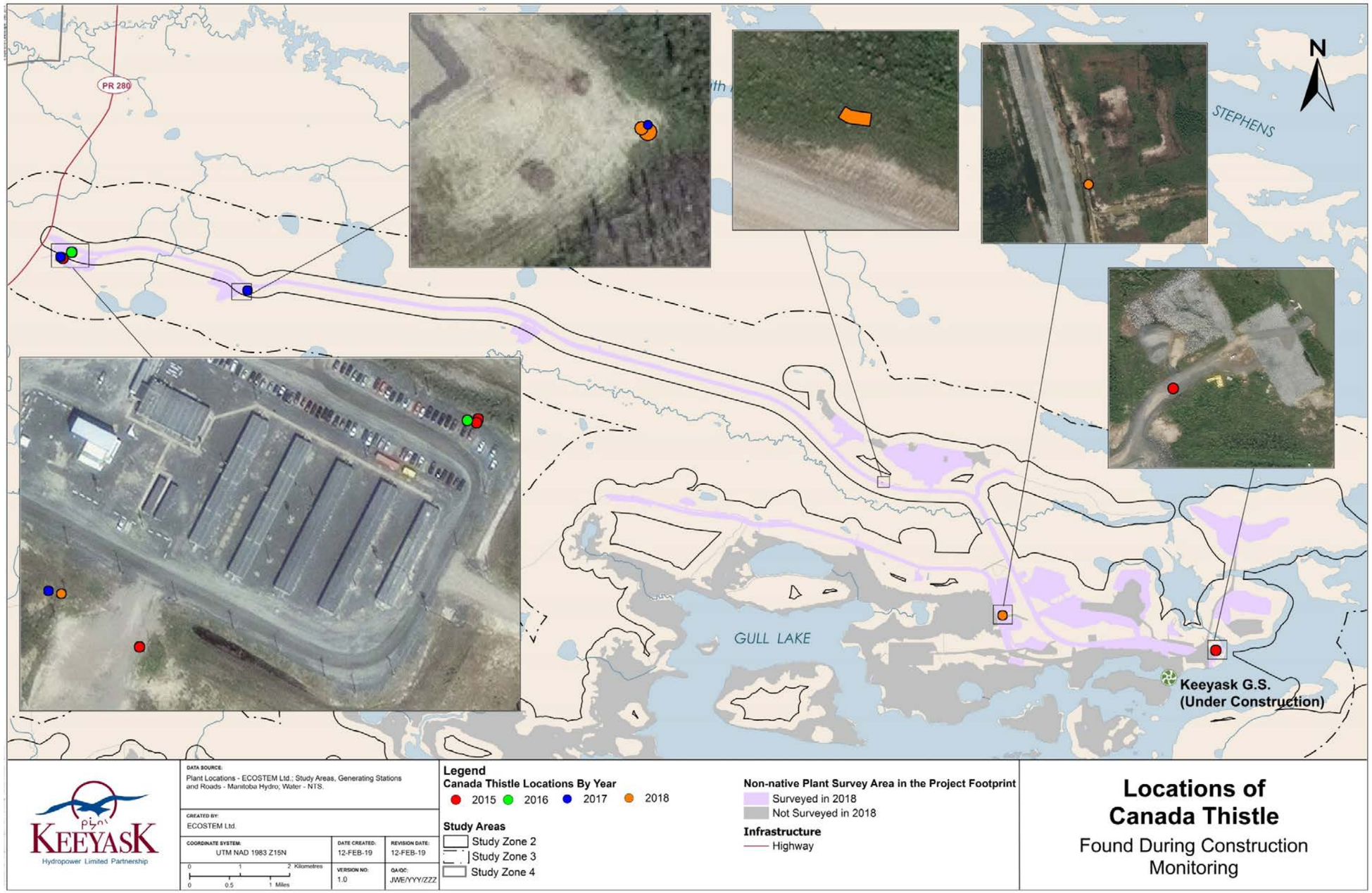
Map 7-21: Locations of ox-eye daisy found before and during Project construction monitoring



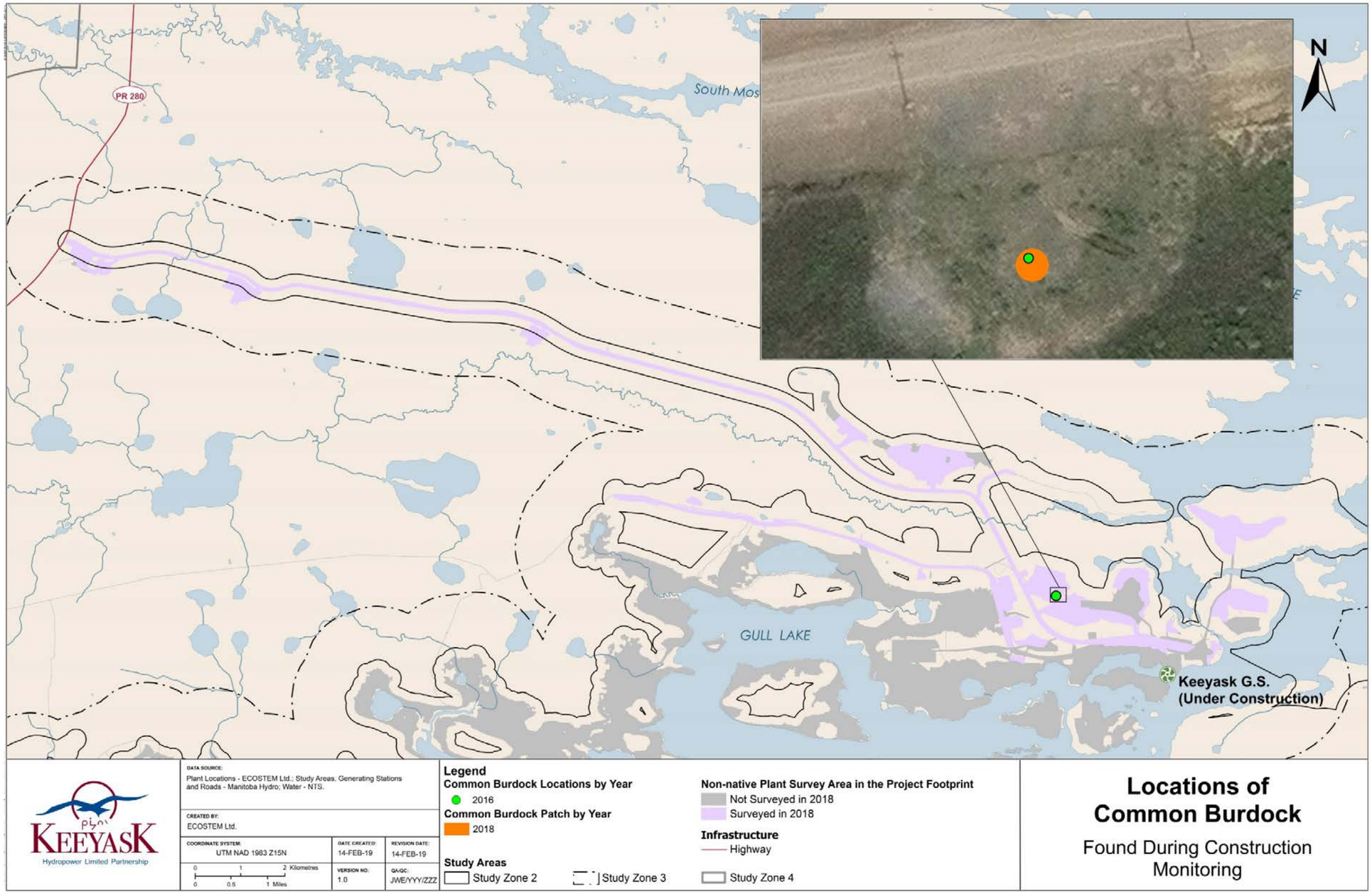
Map 7-22: Locations of scentless chamomile identified during Project construction monitoring



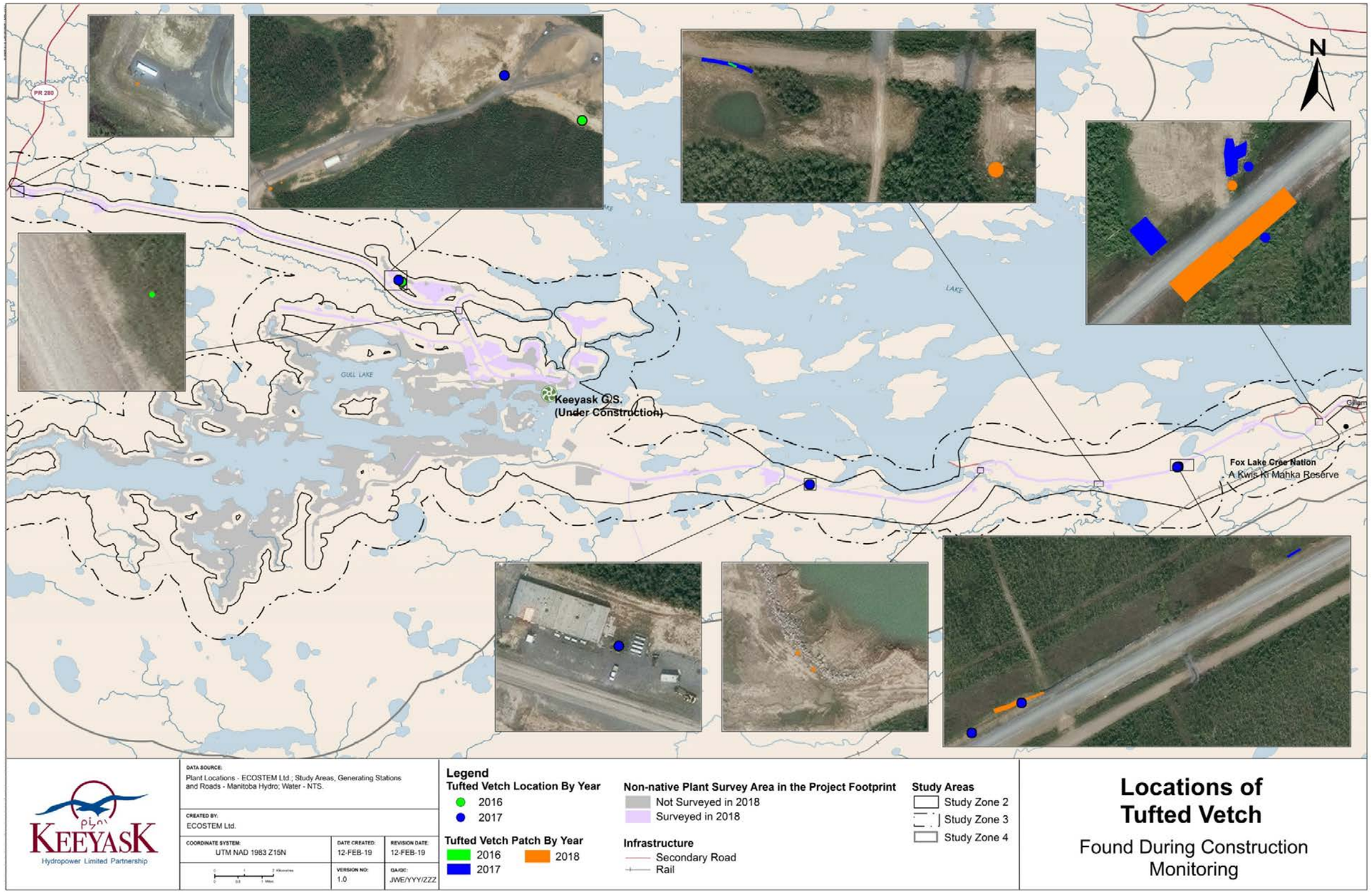
Map 7-23: Location of common tansy identified during Project construction monitoring



Map 7-24: Canada thistle locations identified during Project construction monitoring



Map 7-25: Common burdock locations identified during Project construction monitoring



Map 7-26: Tufted vetch locations identified during Project construction monitoring

APPENDIX 4:
ADDITIONAL NON-NATIVE PLANT RESULTS

Table 7-4: Total early and late summer non-native plant extent as a percentage of total area surveyed by year and Project component

Project Component	2014		2015		2016		2017[2]	2018[2]
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer	Late Summer	Late Summer
North Access Road	0.00	0.32	0.32	0.89	0.01	3.5	4.4	7.6
South Access Road	-	-	-	-	-	0.2	2.8	7.9
Camp & Work Areas	0.56	3.24	3.59	4.66	1.26	4.0	5.9	12.8
Borrow Area	0.02	0.33	0.64	3.09	0.85	2.1	5.1	8.9
North Dyke	-	-	-	-	-	0.1	0.3	7.6
South Dyke[1]	-	-	-	-	0.00	0.0	0.1	0.2
Generating Station Area	-	-	-	-	-	0.5	0.2	-
Reservoir Clearing Area	-	-	-	-	-	-	-	-
All	0.30	1.83	1.98	3.70	0.72	2.4	4.3	9.6
Total non-native plant extent (ha)	*0.7*	*4.9*	*4.7*	*9.3*	*4.8*	*14.8*	*28.9*	*64.0*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*	*671*	*668*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Proportion of non-native cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.
[2] Full early summer survey not undertaken in 2017 and 2018.

Table 7-5: Total early and late summer non-native plant cover as a percentage of total area surveyed by year and Project component

Project Component	2014		2015		2016		2017[2]	2018[2]
	Early Summer	Late Summer	Early Summer	Late Summer	Early Summer	Late Summer	Late Summer	Late Summer
North Access Road	0.00	0.01	0.02	0.07	0.00	0.25	0.38	0.62
South Access Road	-	-	-	-	-	0.01	0.36	1.21
Camp & Work Areas	0.06	0.34	0.46	0.77	0.18	0.58	0.73	1.20
Borrow Area	0.00	0.05	0.05	0.48	0.04	0.24	0.46	0.74
North Dyke	-	-	-	-	-	0.00	0.01	0.79
South Dyke1	-	-	-	-	0.00	0.00	0.02	0.02
Generating Station Area	-	-	-	-	-	0.03	0.00	-
Reservoir Clearing Area	-	-	-	-	-	-	-	-
All	0.03	0.20	0.24	0.59	0.06	0.31	0.44	0.88
Total non-native plant cover (ha)	*0.08*	*0.53*	*0.57*	*1.49*	*0.43*	*1.89*	*2.98*	*5.85*
Total area surveyed (ha)	*247*	*269*	*237*	*251*	*669*	*620*	*671*	*668*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Proportion of non-native cover in south dyke area is likely an overestimate of the proportion for entire footprint. See Section 2.1.
[2] Full early summer survey not undertaken in 2017 and 2018.

Table 7-6: Total approximate non-native species cover (m^2) and number of species in the Project footprint, by year and season

Common Name	2014		2015		2016		2017		2018	
	ES	LS	ES	LS	ES	LS	ES1	LS	ES1	LS
Common Burdock	-	-	-	-	-	0	-	-	2	5
Wormwood	-	-	0	0	0	1	0	1	-	1
Lamb's-quarters	89	2,903	1,115	8,844	990	6,342	131	15,229	-	19,709
Canada Thistle	-	-	0	0	-	0	-	1	1	2
Narrow-leaved Hawks-beard	-	-	-	-	-	586	191	1,314	-	11,040
Ox-eye Daisy	-	-	-	-	-	-	0	-	-	0
Bird's-foot Trefoil	-	-	-	-	0	0	-	0	-	-
Pineappleweed	-	-	7	18	0	29	-	325	-	74
Black Medick	-	0	-	1	-	-	-	0	-	-
Alfalfa	119	124	0	11	4	14	4	40	-	98
White Sweet Clover	-	532	1,742	2,252	900	3,015	11	4,949	-	11,508
Yellow Sweet Clover	-	0	-	2	7	109	-	254	-	543
Unidentified Sweet Clover	387	72	-	-	565	1,838	1,372	67	-	307
Common Timothy	-	-	-	-	-	0	101	0	-	0
Common Plantain	27	80	56	121	68	268	97	246	-	741
Curly Dock	-	-	-	-	-	100	19	19	-	148
Rye	-	0	-	-	-	-	-	-	-	-
Smooth Catchfly	-	-	0	5	16	26	1	32	-	294
Field Sow-thistle	38	252	301	972	52	1,111	420	1,656	14	2,543
Common Tansy	-	-	-	-	-	-	-	-	-	0
Common Dandelion	143	1,291	2,316	2,422	1,654	5,268	1,465	5,521	-	10,199
Alsike Clover	-	25	145	242	43	190	2	91	-	833
Red Clover	-	0	-	0	-	-	0	1	-	0
White Clover	-	0	-	0	0	0	-	-	-	-
Scentless chamomile	-	-	-	0	-	0	-	0	-	1
Wheat	-	-	-	-	-	30	-	21	0	-
Tufted Vetch	-	-	-	-	0	0	2	38	2	170
Number of non-native species	7	12	11	16	13	21	16	21	5	21

Notes: Numbers that round to zero shown as "0"; absences shown as "-". ES="Early Summer"; LS="Late Summer".
[1] Full early summer survey not undertaken in 2017 and 2018. Cover only includes patches mapped using full method.
[2] Species difficult to distinguish until they flower are combined into a broader taxon. Unidentified sweet clover includes white sweet clover and yellow sweet clover.

Table 7-7: Total late summer non-native plant extent by project and year as a percentage of area surveyed

Footprint Use	2014	2015	2016	2017	2018
Keeyask Infrastructure Project	0.5	3.7	7.5	29.4	23.2
Both Keeyask Infrastructure and Keeyask Generation Projects	2.4	3.7	4.2	6.9	15.1
Keeyask Generation Project	-	-	0.3	0.4	4.1

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

Table 7-8: Total late summer non-native plant cover by project and year as a percentage of area surveyed

Footprint Use	2014	2015	2016	2017	2018
Keeyask Infrastructure Project	0.1	0.6	1.1	2.3	1.1
Both Keeyask Infrastructure and Keeyask Generation Projects	0.2	0.6	0.5	0.8	1.5
Keeyask Generation Project	-	-	0.06	0.03	0.4

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

Table 7-9: Percentage of total non-native plant cover with mortality by treatment area

Treatment area	Total cover (m^2)	Percent of Cover Treated[1]
Start-up Camp	777	87
Main Camp	162	0
Work Area B	4,029	93
Sigfusson Northern/Voltage Camp	312	52
All areas	*5,280*	*87*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Patches with mortality characteristic of herbicide application.

Table 7-10: Percentage of total non-native plant cover with mortality by species

Common Name	Total cover (m^2)	Percent of Cover Treated[1]
Common Burdock	5	0
Wormwood	0	0
Lamb's-quarters	1	0
Narrow-leaved Hawks-beard	148	78
Ox-eye Daisy	0	0
White and yellow sweet clover	1,862	85
Common Plantain	70	90
Curly Dock	11	0
Smooth Catchfly	12	84
Field Sow-thistle	62	78
Common Dandelion	2,891	91
Alsike Clover	216	59
All species	*5,278*	*87*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Patches with mortality characteristic of herbicide application.

Table 7-11: Non-native species cover in herbicide-treated patches before and after treatment in 2018

Common Name	Pre-treatment cover (m^2)	Post-treatment cover (m^2)	Percent change
Narrow-leaved Hawks-beard	115	-	-100
White and yellow sweet clover	1,584	64	-96
Common Plantain	63	0	-100
Smooth Catchfly	10	-	-100
Field Sow-thistle	48	5	-89
Common Dandelion	2,623	55	-98
Alsike Clover	127	12	-90
All Species	*4,570*	*137*	*-97*

Notes: Numbers that round to zero shown as "0"; absences shown as "-".

[1] Percent change; A negative sign means that cover decreased.

Table 7-12: Changes in the overall cover[1] of the species specifically targeted for herbicide treatment that were in the treatment areas before and after treatment in 2018

Common Name	Overall Live Cover Before Herbicide Treatment (m^2)	Overall Live Cover After Herbicide Treatment (m^2)	Percent Change[2]
Ox-eye Daisy	0.1	0.1	-
Common Burdock	4.7	4.7	-
Field Sow-thistle	2,562.4	2,517.9	-1.7
Tufted Vetch	170.2	170.2	-
All targeted species	2,737.4	2,693.0	-1.6
Percent of total area surveyed	*0.041*	*0.040*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Overall cover includes treated and untreated surveyed areas.
[2] Percent change; A negative sign means that cover decreased.

Table 7-13: Changes in the overall cover[1] of the species at Levels 1 and 2 of invasive concern that were in the treatment areas before and after treatment in 2018

Common Name	Overall Live Cover Before Herbicide Treatment (m2)	Overall Live Cover After Herbicide Treatment (m2)	Percent Change2
Ox-eye Daisy	0.1	0.1	-
Common Burdock	4.7	4.7	-
Field Sow-thistle	2,562.4	2,517.9	-1.7
White and yellow sweet clover	12,441.1	10,939.4	-12.1
Tufted Vetch	170.2	170.2	-
All Level 1 and 2 species	15,178.6	13,632.4	-10.2
Percent of total area surveyed	*0.23*	*0.20*	

Notes: Numbers that round to zero shown as "0"; absences shown as "-".
[1] Overall cover includes treated and untreated surveyed areas.
[2] Percent change; A negative sign means that cover decreased.

APPENDIX 5:
REED CANARYGRASS RESULTS

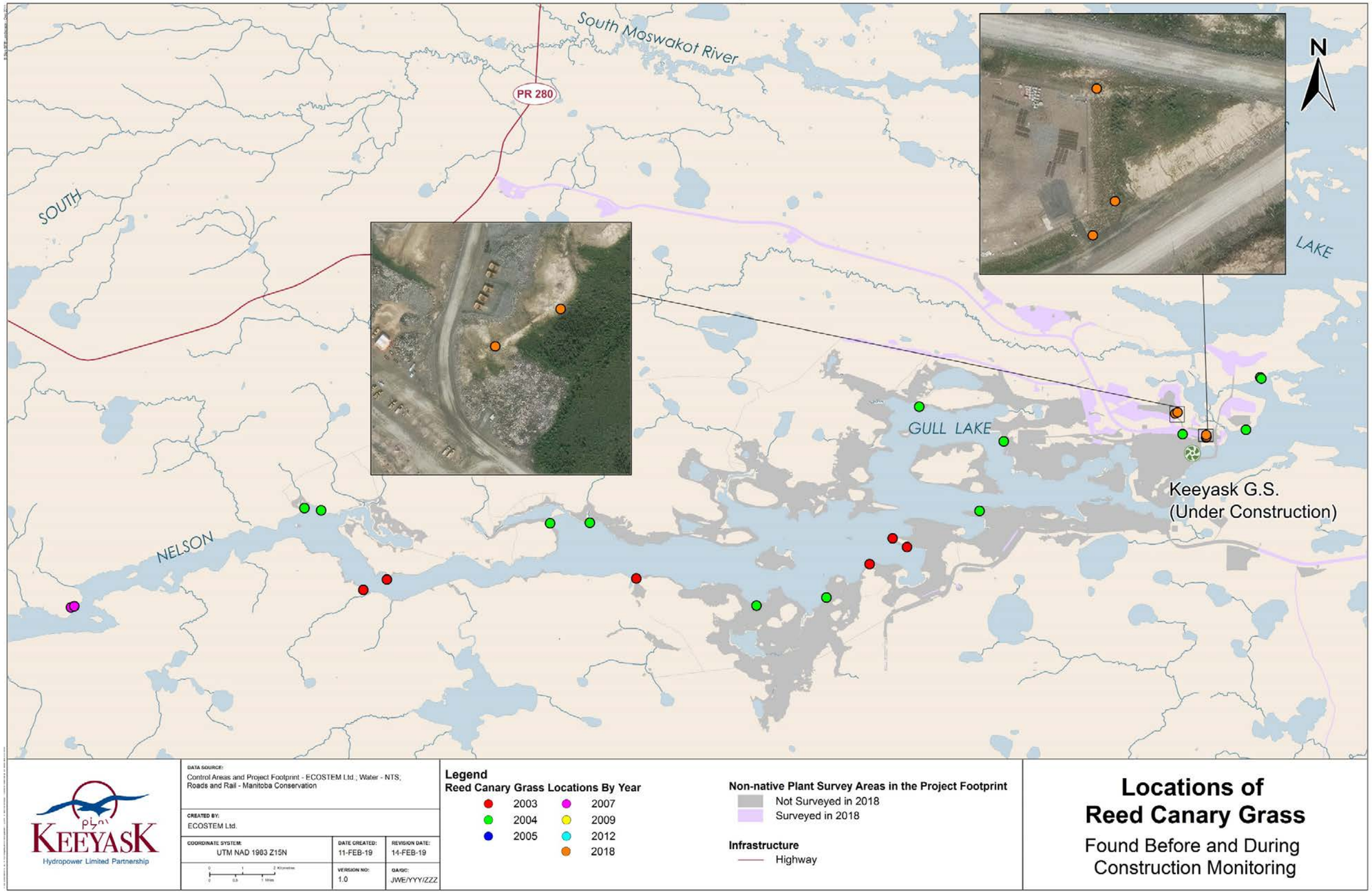
Reed Canarygrass

Reed canarygrass (*Phalaris arundinacea*) was recorded in the Project footprint for the first time in 2018 at five locations (Photo 7-1; Map 7-27). Three patches were found just outside the fence at the east end of the Manitoba Hydro yard in Work Area B, and two patches were growing at the southeast corner of EMPA D16. These plants were not removed at the time of the survey because the species was not yet confirmed, and the plants had already seeded.

The plant has previously been found at 21 locations near and along the Nelson River shoreline between Clark and Stephens Lakes during plant surveys in 2003, 2004 and 2007. The nearest previously recorded location was within approximately 700m of the locations found in 2018. It is uncertain whether the plant was introduced by Project construction activity, or if it spread to this location from a pre-existing population outside of the Project footprint.

Due to the reasons stated in Section 2.4, reed canarygrass found during the monitoring is not being included as a non-native species. Manual removal will continue at sites with one to a few plants. Recorded plant locations will be monitored, however, and mitigation options will be considered in the future if the plant appears to become invasive.

Photo 7-1: Reed canarygrass growing in Work Area B on August 26, 2018



Map 7-27: Reed canarygrass locations identified before and during Project construction monitoring