Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Invasive Plant Spread and Control Monitoring Report

TEMP-2023-06

KEEYASK

Manitoba Environment and Climate Client File 5550.00
Manitoba Environment Act Licence No. 3107

2022 - 2023

KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2023-06

INVASIVE PLANT SPREAD AND CONTROL MONITORING
YEAR 1 OPERATION
2022

A Report Prepared for

Manitoba Hydro

By

ECOSTEM Ltd.

June 2023

This report should be cited as follows:

ECOSTEM Ltd. 2023. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2023-06: Invasive Plant Spread and Control Monitoring, Year 1 Operation, 2022. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2023.

SUMMARY

Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. The vast majority of construction activities were completed by fall 2021, and the generating station was fully operational by March of 2022, with all seven units in service.

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 non-native plant species that can out-compete or even replace native plants.

Non-native plants can be introduced or spread in the Keeyask area by seeds that are brought into the Project site on vehicles, construction equipment, and footwear. There are measures in place under the Project's Environmental Protection Plan to help minimize this. For example, washing any construction equipment that is coming to the Project site from areas outside the Keeyask region is a preventative measure.

This report describes the results of invasive and other non-native plant monitoring conducted during 2022, the first summer of operation monitoring for the terrestrial monitoring studies.

Common tansy, an invasive plant found at the Keeyask site during construction and operation

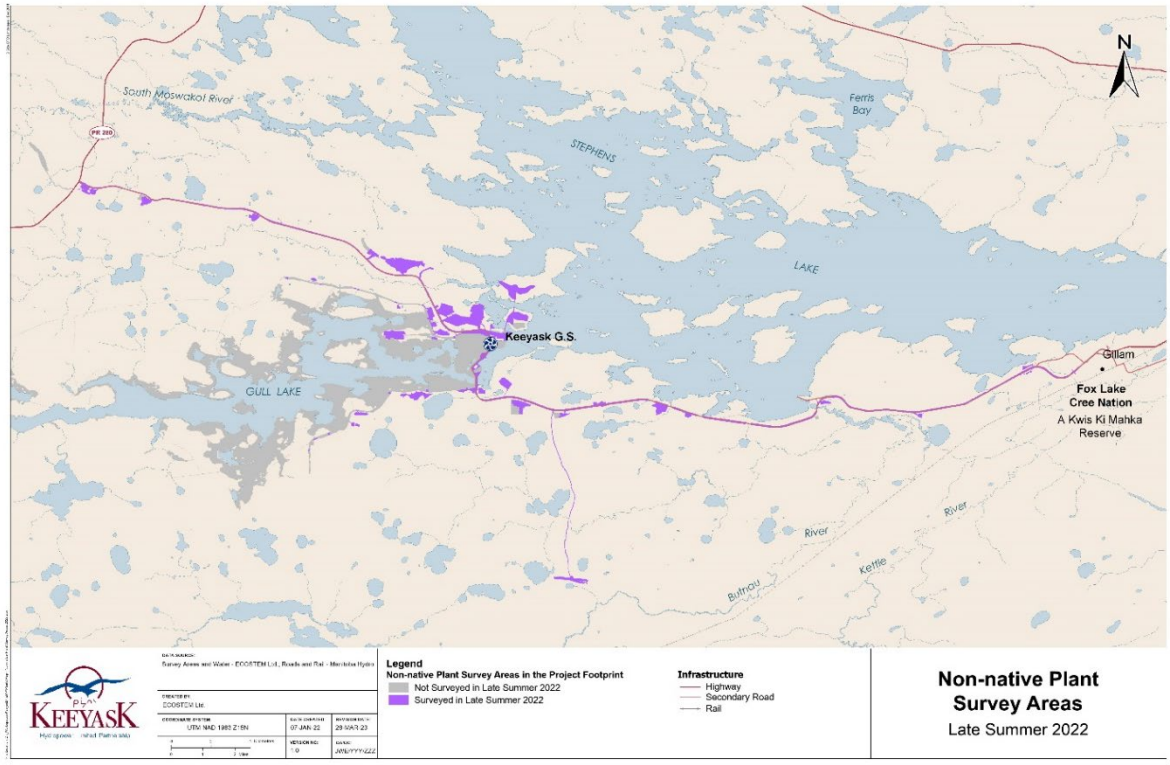
Why is the study being done?

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 environmental conditions at a site. Non-native plants are also a concern because they could interfere with the Project's efforts to restore native habitat in sites that are no longer being used by the Project.

Surveys are being done to determine how Project development is affecting which non-native plants are present, where these plants are found, and to help decide where to carry out measures to control the plants that might become an issue at the Project site.

What was done?

In 2022, non-native plant surveys were carried out within most of the cleared Project areas (see map below). These surveys occurred between August 19 and 31.



What was found?

Non-native plants covered 0.7% of the area surveyed in late summer 2022, which was lower than at the same time in 2021.

Non-native plant cover was highest (2.6%) within older temporary Project areas that had been previously developed as part of the Keeyask Infrastructure Project. In permanent Project areas, cover was highest (1.8%) along the North and South Access Roads.

A total of 28 non-native plant species were found during the 2022 surveys. One of these, smooth brome was recorded for the first time in the Project footprint.

The most abundant (had the highest total cover) non-native plant species were dandelion followed by Lamb's-quarters.

Three of the seven most abundant species increased in cover in the area surveyed in 2021 and 2022 (alsike clover, field sow-thistle, and smooth catchfly). Lamb's-quarters, white and yellow sweet clover and narrow-leaved hawk's-beard, the other most abundant species, decreased in cover.

Of the 28 non-native plant species found in 2022, scentless chamomile, ox-eye daisy and common tansy are the ones of highest invasive concern for the Project site. Each of these species were found at several sites.

The species of highest invasive concern are being controlled by manually removing the plants as soon as they are found during the surveys. For the most part, scentless chamomile, ox-eye daisy and common tansy were not found in 2022 at the sites where they had been removed in previous years.

Six of the 28 non-native plant species found in 2022 are of moderate invasive concern for the Project site. To minimize further spreading of these six species, herbicides were applied in a limited number of Project areas in mid-August 2022.

Grasses were seeded in various locations for erosion control and/or to assist with vegetation rehabilitation. One non-invasive, non-native grass species (diploid annual ryegrass) was intentionally seeded in EMPAs D16 and D17 for erosion control purposes. The food value of this species for mammals in the region is expected to be low. As seeds are obtained from plants growing in fields, two other non-native species were present in the seed mix. However, the number of those seeds in the seed mix was very low and less than the maximum allowed. Also, neither of these were found during monitoring surveys.

What does it mean?

While some non-native plant species present during Project construction are spreading further during the first year of Project operation, there was an overall decrease in cover. Decreases in portions of the Project footprint appear to be following a trend observed in multiple areas during Project construction: a large increase in plant cover after construction activity stopped was followed by a gradual decline in cover for some species (e.g., lamb's quarters). If this trend is repeated into operation, it is expected that overall cover of non-native plants will continue to decrease as time passes after temporary footprint decommissioning. Additionally, ongoing vegetation rehabilitation efforts should contribute to crowding out some non-native plants.

Given their potential to spread rapidly, the monitoring continued to make recommendations for practical ways to reduce invasive and other non-native plant species in the Project footprint, and/or to prevent them from spreading further. Many of these species are commonly found in

other 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 up to 2022 showed that immediate manual removal is generally an effective way to control the species of highest invasive concern and the species that do not resprout from roots left in the ground after removal. Staff conducting the monitoring surveys will continue to manually remove plants at sites where there are one to a few plants present.

The 2021 herbicide treatment appeared to reduce the cover of target species at locations where the herbicide was effectively applied. As the 2022 herbicide treatment occurred just before the subsequent monitoring surveys, and it was too soon to assess how effective it was, this will be evaluated in 2023. Monitoring in 2023 will also determine if herbicide and/or mowing treatment is expected to continue to reduce or slow the spread of invasive plant cover in these sites.

What will be done next?

Additional invasive plant control recommendations will be developed for the 2023 growing season based on the monitoring results to date. Monitoring fieldwork for invasive and other non-native plants will continue in 2023. 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 Martial Lemoine, James Teskey and Jodi Ross for their support and assistance in planning field activities and providing 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 and Shari Fournier, for their guidance, logistical support and other resources that made these studies possible.

Custom Helicopters is gratefully acknowledged for providing transportation during fieldwork and Aaron Johnson and Claire Brueckner for coordinating the logistics.

STUDY TEAM

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

Fieldwork in 2022 was conducted by Ryan Sheffield, Karine Grotte, Sofia Sparby, Owen Romanchuk and Alanna Sutton of ECOSTEM Ltd.

Data analysis and report writing in 2022 were completed by Sofia Sparby, Alanna Sutton and Brock Epp. Report review was completed by Brock Epp and James Ehnes. GIS analysis was completed by Brock Epp, Sofia Sparby and Alex Snitowski. Alex Snitowski completed the cartography.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOS

LIST OF APPENDICES

1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt hydroelectric generating station (GS) and the associated facilities. The Project is located at the former Gull Rapids on the lower Nelson River in northern Manitoba where Gull Lake flows into Stephens Lake, 35 km upstream of the existing Kettle GS. Project construction began in July 2014 and the vast majority of construction activities had been completed by fall 2021. The reservoir was first brought to full supply level in September 2020 and the final generating unit went into service on March 9, 2022.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project (KHLP 2012a). Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TE SV; KHLP 2012b). The *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 not only because they can crowd out other plant species, but, in extreme cases can 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 non-native plants, and to evaluate the effectiveness of invasive plant 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 report details the temporal and spatial patterns of non-native plants during Project construction from 2014 to 2021 (ECOSTEM 2022). This report presents the non-native plant monitoring conducted in 2022, during the first year of operation for the terrestrial monitoring studies.

2.0 METHODS

Section 3.3.2 of the TEMP details the methods for this study. The following summarizes the activities conducted in 2022.

2.1 PROJECT COMPONENTS

During construction monitoring, Project footprint components were grouped based on the general type of activity occurring there and the time since construction activity occurred. This approach was used as ongoing construction activities such as excavation either largely prevented or influenced non-native plant distribution and abundance. These groupings are described in a previous report (ECOSTEM 2022).

Based on the overall trends observed during Project construction (see ECOSTEM 2022 for information on the generalized non-native plant extent pathways), Project components for operation were grouped based on their permanence and planned rehabilitation (Table 2-1). At the beginning of Project operation, most of the components that were not required for Project operation (i.e., the temporary Project areas) had been or were in the process of being decommissioned. Additionally, a portion of the permanent and temporary Project areas have undergone various amounts of rehabilitation. Consequently, ongoing use (in areas with permanent infrastructure) and ongoing rehabilitation activities, in combination with time since rehabilitation are two of the major drivers determining non-native plant spread in those areas.

In the permanent Project footprint, vehicle and foot traffic will continue to contribute to spreading of non-native plants. There are two types of areas in the temporary Project footprint. In areas that still require site preparation for revegetation (e.g., grading, discing), heavy construction activity will continue to affect vegetation cover. In areas that have already been revegetated, foot and vehicle traffic will have mostly ceased, and impediments to vegetation regeneration will be reduced. An important factor is that invasive plant mitigation options will be limited in areas where rehabilitation is completed, as it will be unlikely that chemical measures could be used without affecting planted vegetation.

It should be noted that because the subdivision of the Project footprint into activity types (Table 2-1) is generalized for an entire footprint component, there may be small areas within a specific footprint that are from a different activity type. Manitoba Hydro is currently determining which areas within the Construction Footprint will be required for Project operation, and the categorization will be refined once the data becomes available. Nevertheless, this categorization aids in the interpretation of broad patterns and trends across the Project site.

Map 2-1 shows the locations of the Project components as well as some of their constituent features.

Table 2-1: General component categories and their activity during Project operation

Project Footprint Component		Description	Activity
Permanent	Project Infrastructure	Permanent infrastructure and work areas that will be used for Project operation	Light vehicle and foot traffic, Manitoba Hydro personnel
	Access Roads	North and south access roads, which will become a highway operated by the province	Public use, frequent heavy to light vehicle traffic.
Temporary	Not yet rehabilitated	Temporary areas planned for rehabilitation, but have not been to date	Will be subject to heavy construction activity for site preparation in most locations
	Recently rehabilitated	Temporary areas that have been rehabilitated between 2020 and 2022	Very little to no foot traffic
	Older rehabilitated	Temporary areas that were rehabilitated in 2016	Very little to no foot traffic

2.2 DATA COLLECTION

Non-native plant surveys have been conducted annually since the start of Project construction. Survey methods evolved as the Project footprint developed from 2014 (beginning of KGP construction; only KIP footprints surveyed) to 2022. A detailed description of how the methods evolved throughout Project construction, along with a detailed description of the current survey methods are provided in a previous annual report (ECOSTEM 2022). These methods, and specific additions or deviations for 2022 are summarized below.

With the exceptions of the North and South Access Roads and Dikes, surveys were not conducted in areas where non-native plants were expected to be completely or virtually absent based on results from previous years or from similar types of areas. This included the portions of the Project footprint that have only had tall vegetation cleared and were not further disturbed by the Project. Also, areas that were not safe to access due to construction or wildlife activity were not surveyed.

Surveys were conducted from August 18 to 30, 2022 at the locations shown in Map 2-2.

In 2022, non-native plant cover was recorded and mapped in the field using a combination of electronic tablets and the manual data recording method. ECOSTEM (2022) details how data were recorded for each of these methods.

Surveys were conducted by foot and truck in the portions of the Project Footprint areas meeting the safety and activity criteria described above. There were no active construction areas in 2022, therefore there were no areas avoided for safety reasons.

Three approaches were employed to surveying the Project Footprint depending on the nature of the locations, which were the same approaches used in 2021:

1. A combination of mobile truck-based surveys and systematic foot surveys. Truck-based surveys occurred along the entire lengths of the North and South Access Roads, as well as the North and South Dikes. Foot surveys were conducted at every 2 km.
2. A low-altitude helicopter survey, combined with spot surveys on foot was used for the Ellis Esker (Borrow Area E-1) access corridor.
3. Meandering foot surveys were conducted in the remaining Project areas.

Non-native plant spatial extent at a location was recorded either as a point with an associated number of individuals or as a patch of plants with an associated percent foliage cover class (Table 2-2).

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

Cover Class	Percent Cover Range
Trace	>0 - 0.1%
Very sparse	0.2 - 2%
Sparse	3 - 10%
Low	11 - 25%
Moderate	26 - 50%
High	51 - 75%
Very high	76 - 100%

2.3 AREAS SURVEYED

Borrow Area B-5 was not surveyed because it was fully covered by ponded water and Borrow Area G-5 was not accessible due to a locked gate. The portion of the SAR right-of-way that made up the SAR Camp was not surveyed by foot in 2022 because it had been rehabilitated and was now considered part of the SAR.

Several areas that had not been surveyed in 2021 were surveyed in 2022. These included Borrow Areas Q-1, N-21 (not surveyed since 2019), S-2a (not surveyed since 2017), S-2b, B-6, the downstream areas of the dam and spillway, and the portion of Work Area A where the former batch plant was.

To reduce the influence of changing total area surveyed when making year-to-year comparisons, non-native plant cover is expressed as a percentage of the total area surveyed, rather than as an absolute area (see ECOSTEM 2022 for additional rationale).

Non-native plant surveys in 2022 covered approximately 898 ha, or 52%, of the cleared or disturbed Project footprint that was not inundated in 2022 (Table 2-3; Map 2-2). Excluding very large footprint components that were not surveyed in full (i.e., the North and South Access Roads and Dikes), the percentage of the Project footprint surveyed increased to 85%.

The total area surveyed in 2022 was 203 ha higher than in 2021 because no areas were omitted due to safety concerns.

Table 2-3: Total area surveyed in 2022 for non-native plants by Project component

Project Component		Area Surveyed (ha)	Percent of Total Component Area
Permanent	Project infrastructure	82	31
	Access roads	26	5
Temporary	Not yet rehabilitated	420	73
	Recently rehabilitated	320	93
	Older rehabilitated	51	91
Total surveyed area		898	52
Areas where only tall vegetation removed		102	
Areas along the dikes and access roads that were not surveyed by foot		671	
Other areas not surveyed		69	
Total footprint area [1]		*1,741*	*100*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Approximately 75 ha of KIP borrow areas not used by the Project are included in these totals.

2.4 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 methods for 2022 were the same as those described in detail in the 2021 monitoring annual report (ECOSTEM 2022), which are summarized below along with any deviations from the 2021 methods.

The analysis evaluated non-native plant distribution and abundance in the context of precise clearing and disturbance mapping produced for 2022 (see ECOSTEM 2023a). The primary focus of this report is on the patterns observed in 2022. A detailed comparison of non-native plant spread over all construction years will be produced at the end of Project construction in the TEMP construction synthesis report (ECOSTEM and Wildlife Resource Consulting Services MB, Inc. 2023, in draft).

Species cover data collected using the note-based method was converted into Geographic Information System (GIS) polygons and points. These data were merged with the point and polygon features produced in the field using the tablets.

In previous annual reports, 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 was the metric for species distribution. The other measure was the area covered by each species (approximate plant cover), which was the metric for species 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. In 2022, only the abundance data was included because it provides a more meaningful way to compare non-native plant abundance between years (ECOSTEM 2022). Spatial extent is illustrated visually by the non-native plant cover maps.

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.

2.5 INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES

2.5.1 BACKGROUND

The Project's 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 operation 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).

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. Appendix Section 6.1.1 details the sources of information used to assist in evaluating potential invasiveness in the Project area. 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. Of the sources used for ranking a species' degree of invasiveness listed above, ISCM (2022) and White *et al.* (1993) were considered the most relevant ones because their focus is on impacts to ecosystems and biodiversity.

Due to the fact that many of the sources used during this exercise have an agricultural focus, they do not list some species known to be of concern for impacts on native ecosystems and biodiversity (e.g., purple loosestrife). Conversely, these sources 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.

2.5.2 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 2-4). Level 1 was the highest level of invasive concern for the Project. Level 1 species included ISCM Category 1 and 2 species (see Appendix Table 6-2 for detailed category criteria).

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 remaining 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 2-5 shows how the invasive concern classification was applied to the non-native plant species recorded in the Project footprint to date.

Table 2-4: 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 species[1]
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 2-5: 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			
	Smooth brome	*Bromus inermis*		Moderate		
	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	
	Flixweed	*Descurainia sophia*			Tier 3	
	Curled dock	*Rumex crispus*				Secondary
Level 4	Canola	*Brassica napus*				
	Shepherd's-purse	*Capsella bursa-pastoris*				
	Wormseed mustard	*Erysimum cheiranthoides*				
	Pineapple-weed	*Matricaria discoidea*				
	Bird's-foot trefoil	*Lotus corniculatus*				
	Black medick	*Medicago lupulina*				
	Spotted lady's-thumb	*Persicaria maculosa*				
	Common plantain	*Plantago major*				
	Common timothy	*Phleum pratense*				
	Smooth catchfly	*Silene csereii*				
	Alsike clover	*Trifolium hybridum*				
	Red clover	*Trifolium pretense*				
	White clover	*Trifolium repens*				
	Wheat	*Triticum aestivum*				

Notes: [1] See Table 2-4 for the invasive concern classification. [2] In decreasing order of concern for the Project area. [3] Invasive Species Council of Manitoba (2022a). [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).

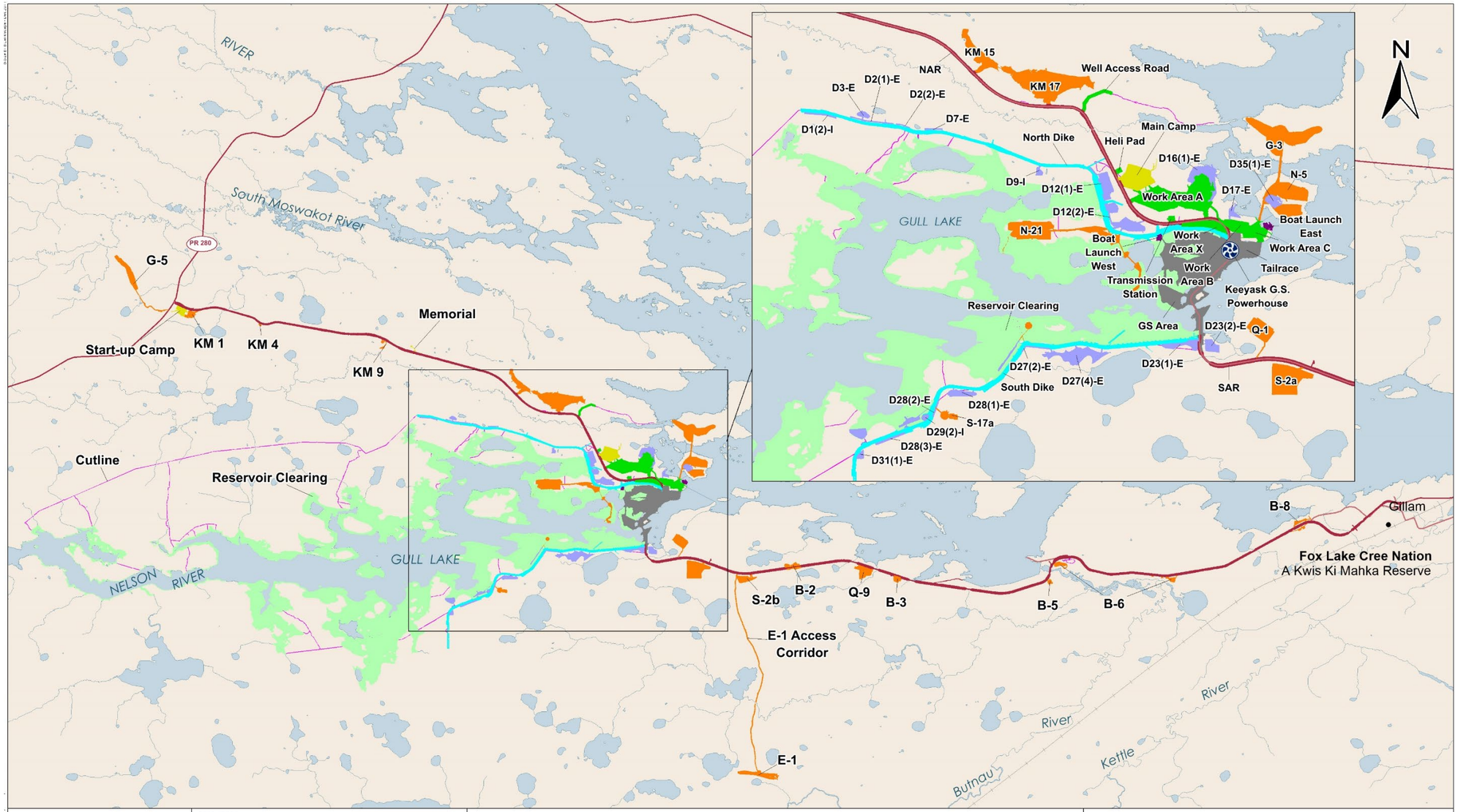
2.5.3 GENERAL APPROACH TO MANAGEMENT

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 2023).

For application, the overall approach for dealing with plants of higher concern (Levels 1 and 2) was the same in 2022 and in 2021. The rationale behind the development of the current approach is provided in greater detail in another annual report (ECOSTEM 2022). The approach is summarized below.

- Individual plants or small patches of Level 1 non-native species are removed manually as soon as they are discovered.
- Individual plants of Level 2 non-native species are removed manually as soon as they are discovered if they are isolated and there are no other plants or patches in the area.
- The remaining sites with Level 2 non-native species are identified for herbicide application if possible, or mowing if herbicide cannot be used at the site.

The efficacy of the treatments is assessed using the methods described in Section 2.5.4. Depending on the conditions at any given site, the management approach for Level 1 or Level 2 species may be modified if an alternate method would be more practical or efficient.



DATA SOURCE:
Components and Study Areas - ECOSTEM Ltd.; Water, Roads and Rail - Manitoba Hydro.

CREATED BY: ECOSTEM Ltd.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	21-MAR-23	27-MAR-23
0 2 4 Kilometres / 0 1 2 Miles	VERSION NO: 1.0	QA/QC: JWE/YYY/ZZZ

Legend

Project Components

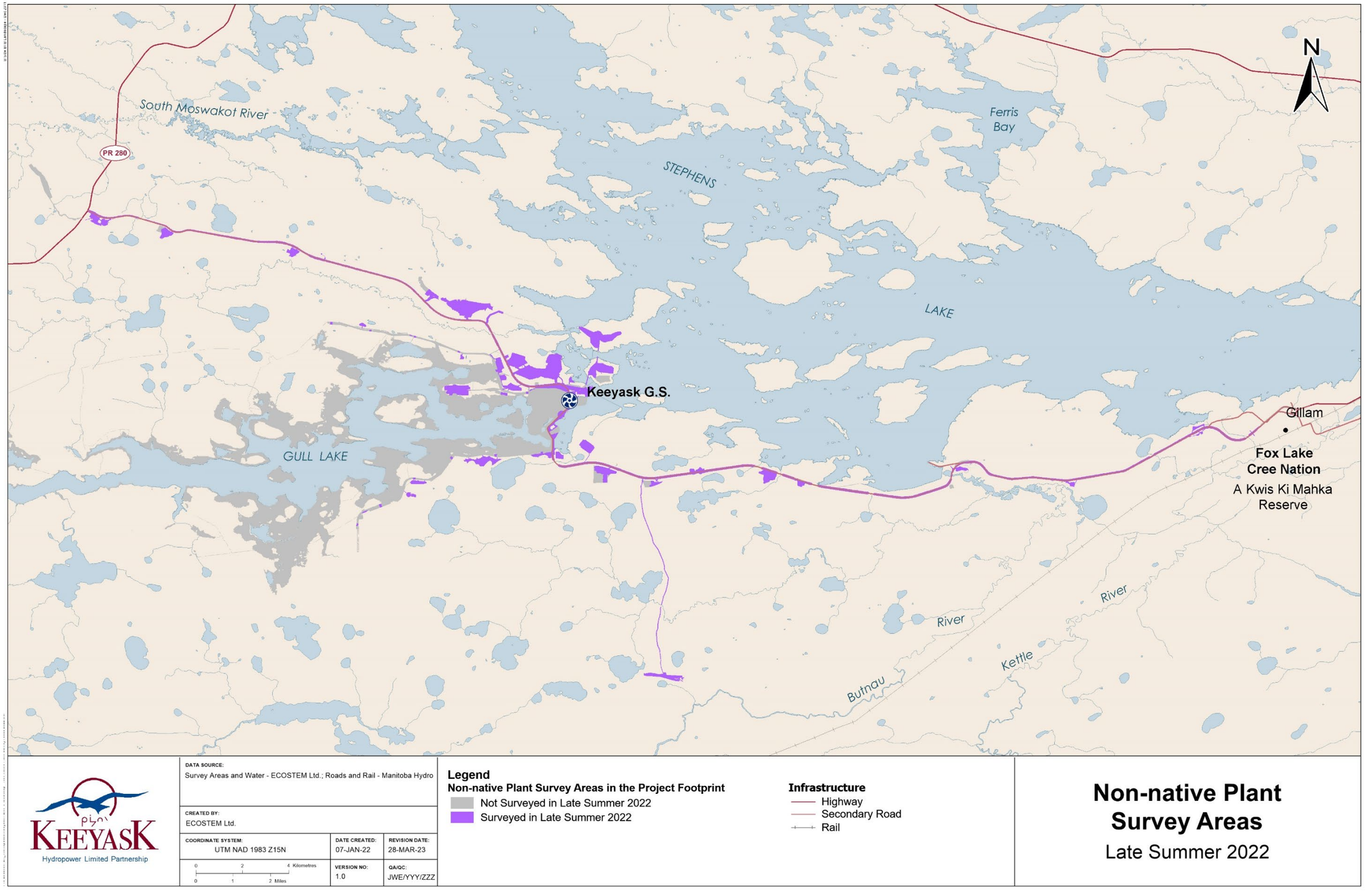
- Borrow Area
- Camp
- Cutline
- EMPA
- GS Area
- Access Road
- Dike
- Portage Route
- Work Area
- Reservoir Clearing

Infrastructure

- Highway
- Secondary Road
- Rail

Project Components

Map 2-1: Project components



Map 2-2: Late summer non-native plant survey areas in 2022

2.5.4 NON-NATIVE PLANT CONTROL

Several areas were recommended for herbicide application and mowing based on the 2021 monitoring results (see Section 3.3.2 for details). The areas were those which contained invasive species of high concern that had high potential to spread into other areas.

On July 5 to 8, 2022, a botanist visited the areas that were recommended for herbicide or mowing treatment. The botanist identified if the target species was present in these areas and marked areas to herbicide with pin flags. For areas where herbicide treatment was inappropriate, mowing was prescribed.

A contractor treated the herbicide-recommended areas with herbicide on August 17 and 18, 2022 (see Section 3.3 for details).

Treated areas were surveyed to evaluate the efficacy of the control treatments. A patch was considered treated with herbicide if there was evidence of herbicide damage on any of the vegetation in the patch. This may be different than the actual area sprayed because the effects of the herbicide can be systemic and may extend beyond the application area for rhizomatous species. Non-native plants in the treatment areas were recorded according to the standard survey methods. Where there was evidence of treatment, in addition to the standard data, the percent of dead foliage for each non-native species in the patch was also recorded and photos of the treated patches of plants were taken.

Longer-term effectiveness of non-native plant control measures may be assessed by comparing the cover of species targeted for control from the previous year (prior to treatment) to the current year. A reduction in overall cover of these species in footprint components where treatment was applied would be an indicator that the treatments were effective. Consideration of the overall success of the treatment application based on the assessment from the previous year's report (i.e., did herbicide application or mowing impact the target patches?) also informs the interpretation of this comparison.

2.6 SEED MIXTURES USED IN REHABILITATION EFFORTS

Habitat rehabilitation includes seeding some areas with a native grass mixture. The *Keeyask Generating Station Construction Environmental Protection Plan* (KHLP 2016) indicated this mixture is to only include native and/or non-invasive introduced plant species, and of low-quality food value for mammals. This monitoring study confirms which species were included in the seed mixtures.

Manitoba Hydro provided the seed certificates for mixtures used during construction. The list of species was reviewed.

3.0 RESULTS

3.1 OVERALL NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

Map 3-1 to Map 3-5 shows the distribution of non-native plant patches within the Construction Footprint. Non-native plants were present in all surveyed Project areas.

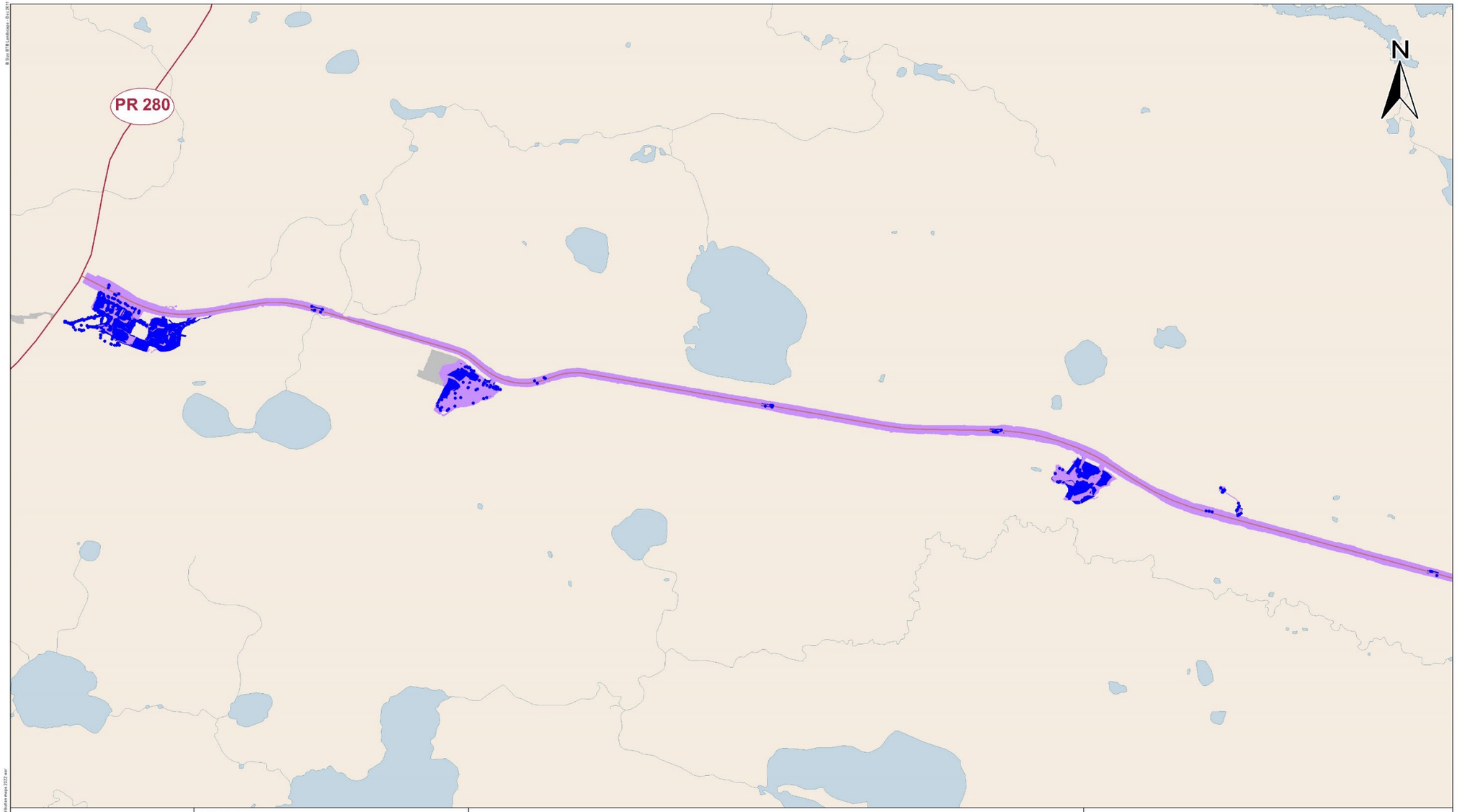
Total non-native plant cover was 6.1 ha by late summer, 2022, or 0.7% of the total surveyed area (Table 3-1). This was a decrease from 9.8 ha, or 1.4% of the area surveyed in 2021 (ECOSTEM 2022).

Table 3-1: Total late summer non-native plant cover in 2022 as a percentage of total area surveyed, by Project component

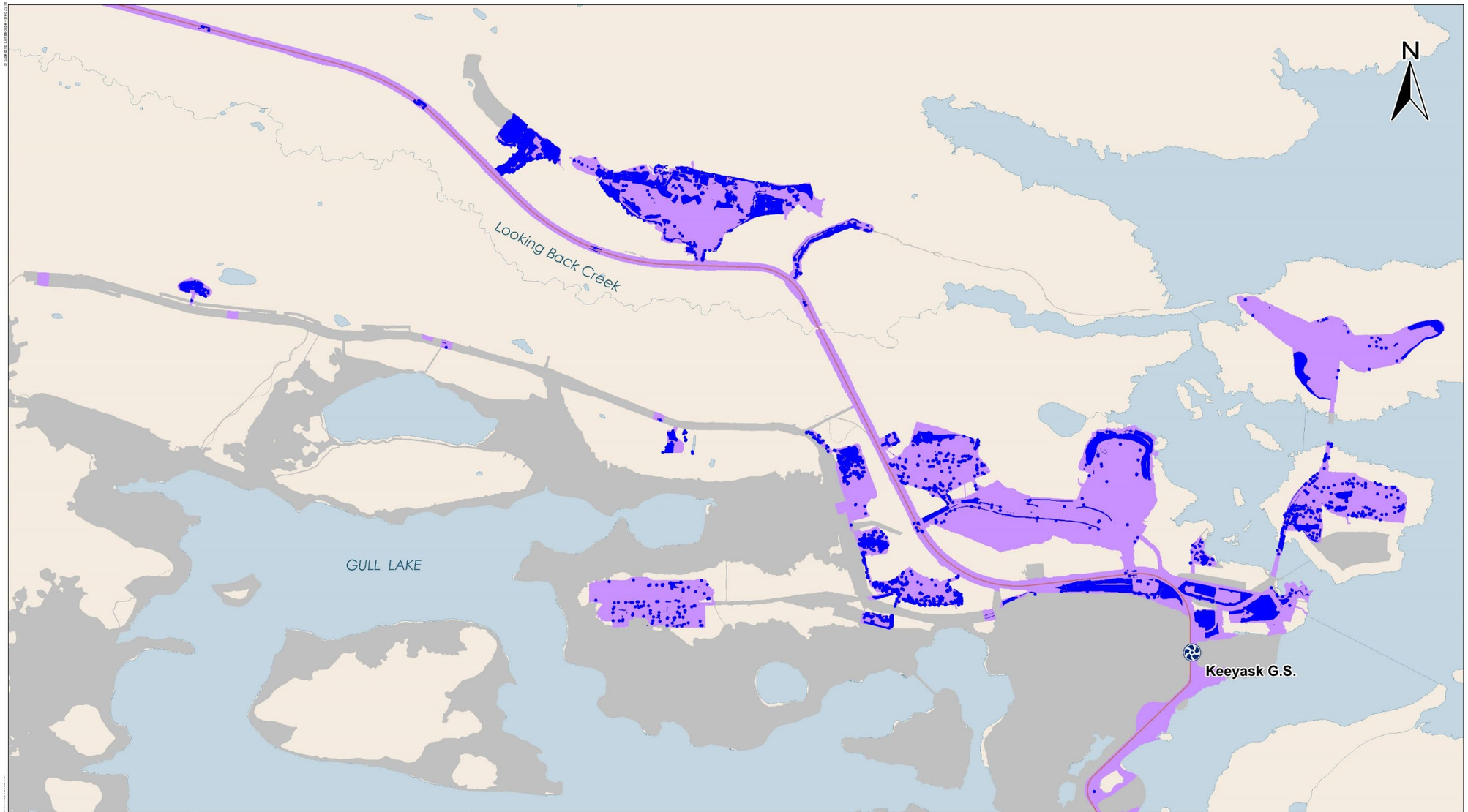
Project Component		Percent of Area Surveyed
Permanent	Project Infrastructure	0.48
	Access Roads	1.76
Temporary	Not yet rehabilitated	0.47
	Recently rehabilitated	0.60
	Older rehabilitated	2.58
All surveyed areas		0.68
Total non-native plant cover (ha)		*6.1*
Total area surveyed (ha)		*898*

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

As a percentage of surveyed area, temporary areas that had been rehabilitated earlier in the construction period had the highest non-native plant cover (2.6%), followed by the access road rights-of-way (1.8%). The lowest percentage cover was found in temporary areas where no rehabilitation has yet been carried out.



Map 3-1: Distribution of non-native plants during late summer 2022, in the Project footprint along the western portion of the North Access Road



KEEYASK Hydropower Limited Partnership

DATA SOURCE:
Plant Locations, Survey Areas and Water - ECOSTEM Ltd.; Roads and Rail - Manitoba Hydro

CREATED BY:
ECOSTEM Ltd.

COORDINATE SYSTEM:	DATE CREATED:	REVISION DATE:
UTM NAD 1983 Z15N	09-MAR-23	28-MAR-23
0 400 800 Metres / 0 800 1600 Feet	VERSION NO: 1.0	QA/QC: JWE/YYY/ZZZ

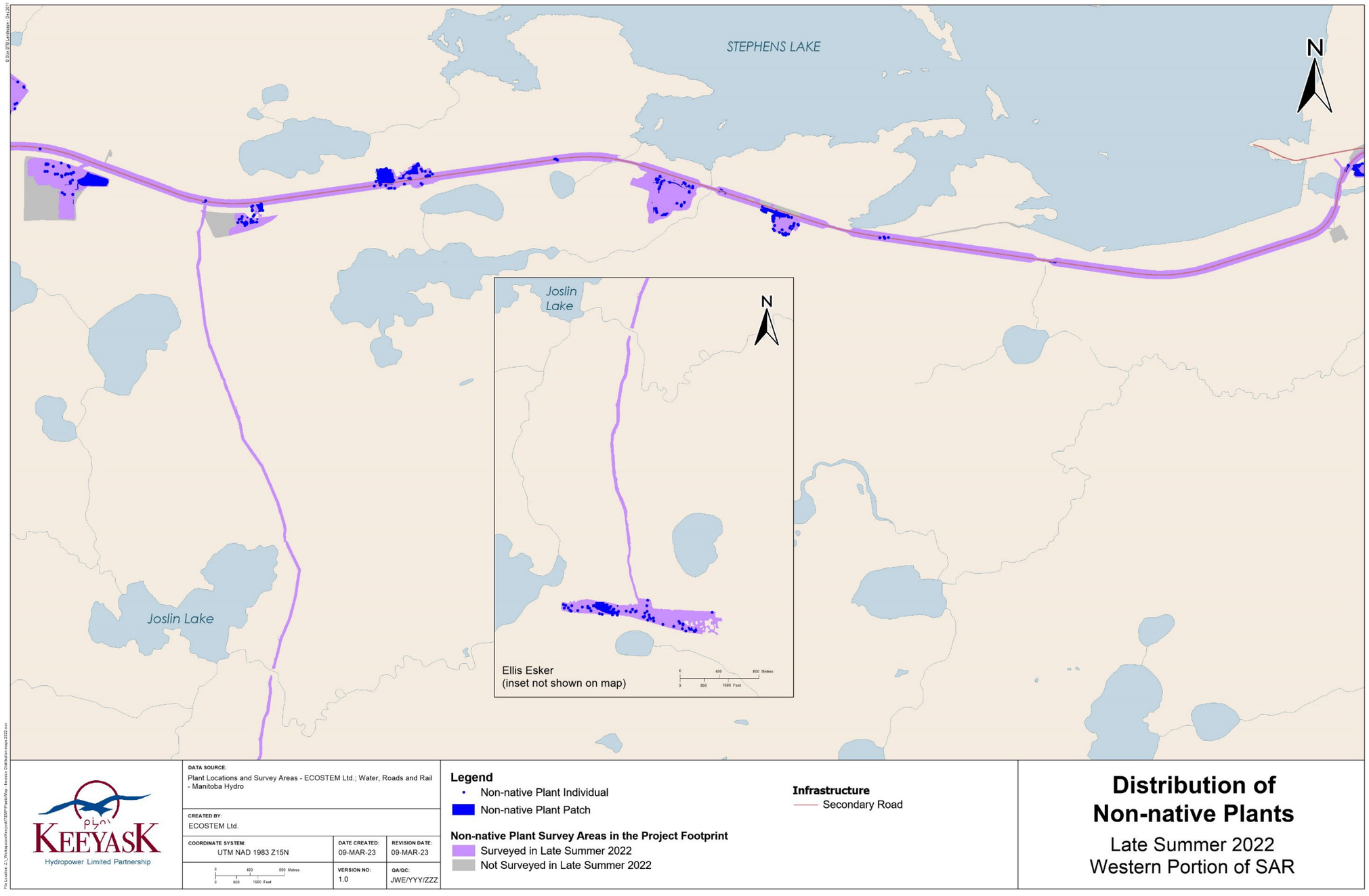
Legend
- Non-native Plant Individual
- Non-native Plant Patch

Non-native Plant Survey Areas in the Project Footprint
- Surveyed in Late Summer 2022
- Not Surveyed in Late Summer 2022

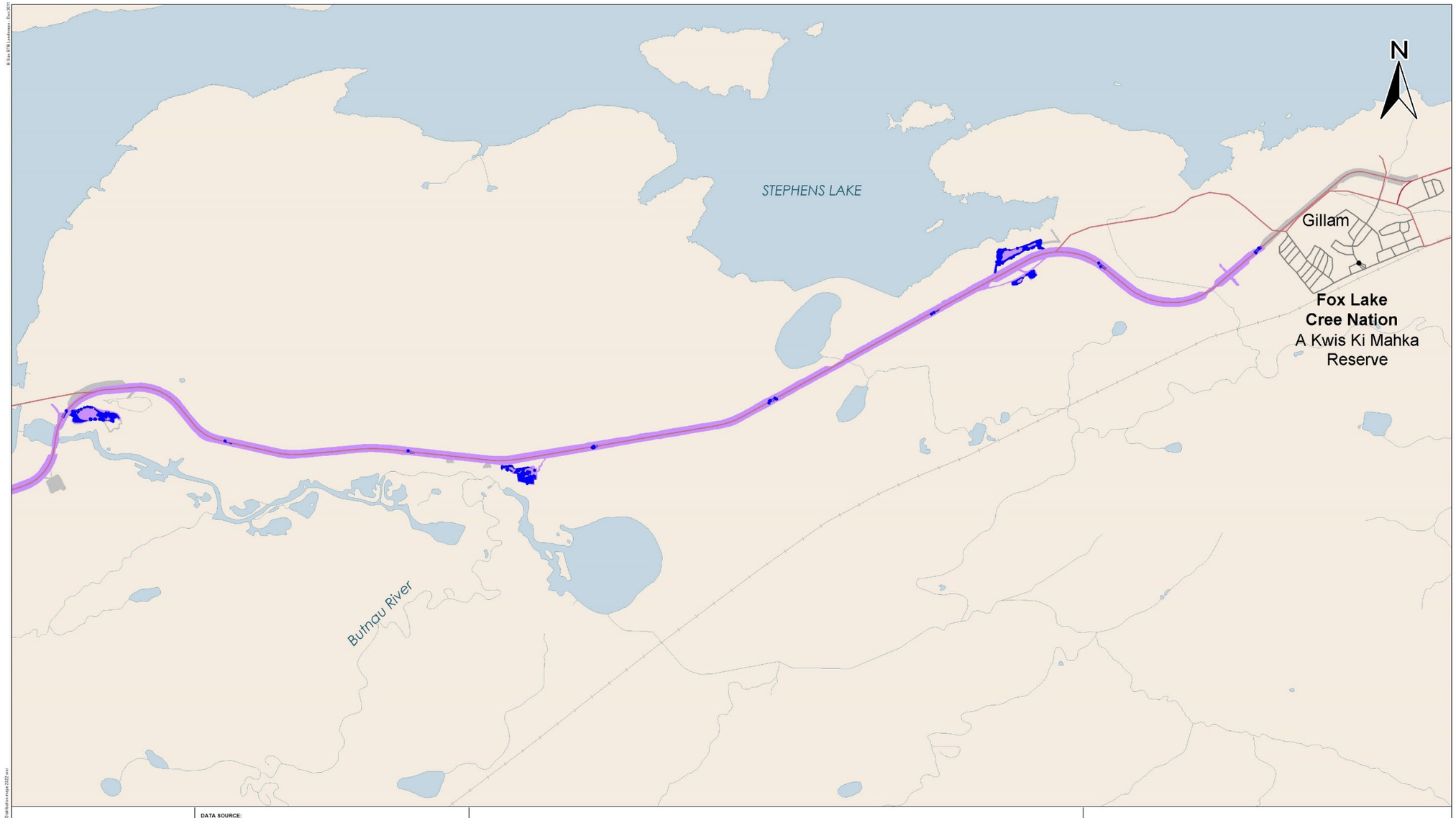
Infrastructure
- Secondary Road

Distribution of Non-native Plants
Late Summer 2022
Eastern Portion of NAR

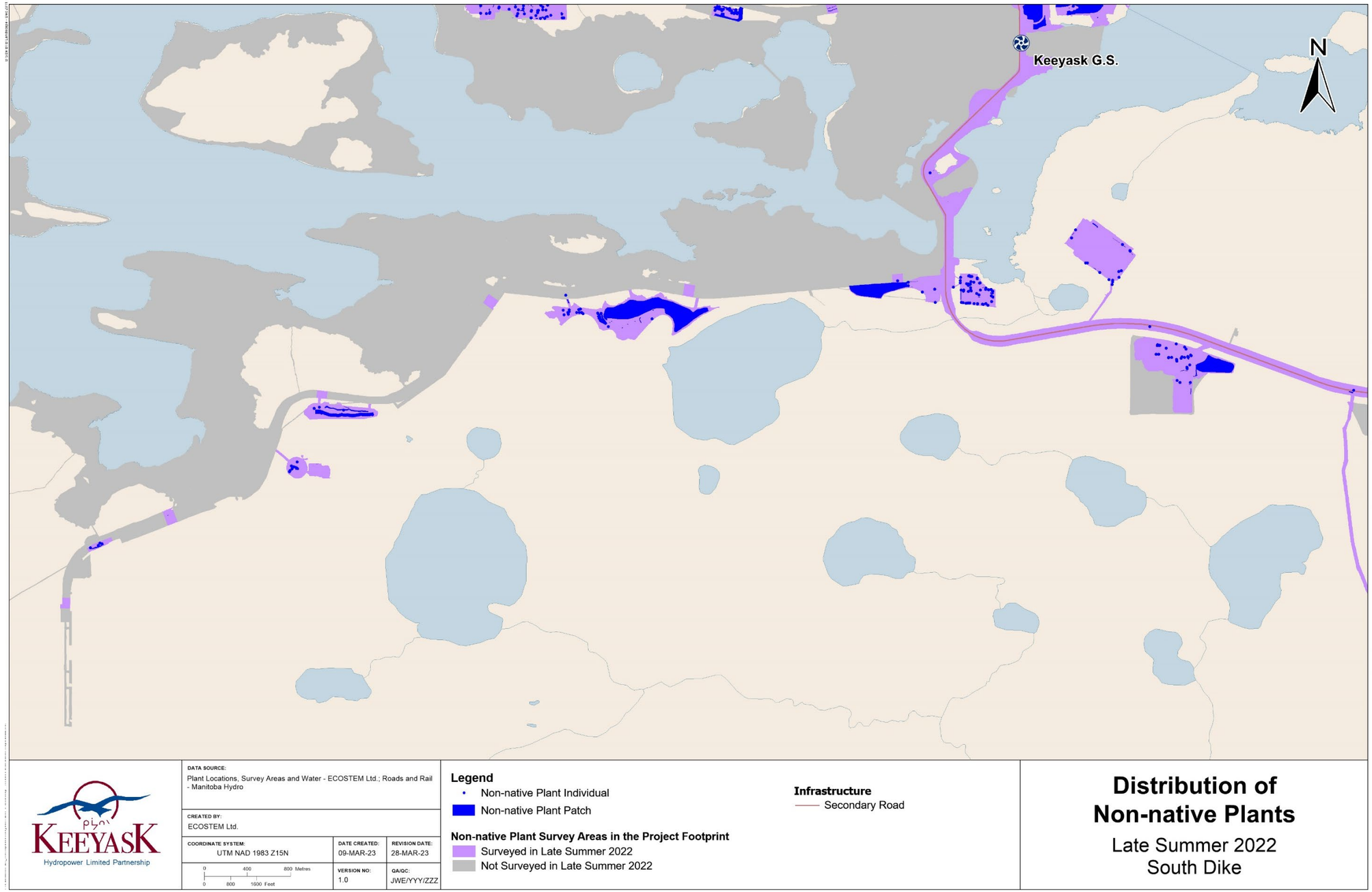
Map 3-2: Distribution of non-native plants during late summer 2022, in the Project footprint along the eastern portion of North Access Road



Map 3-3: Distribution of non-native plants during late summer 2022, in the Project footprint along the western portion of the South Access Road



Map 3-4: Distribution of non-native plants during late summer 2022, in the Project footprint along the eastern portion of the South Access Road



Map 3-5: Distribution of non-native plants during late summer 2022, in the Project footprint in the South Dike area

3.2 SPECIES DISTRIBUTION AND ABUNDANCE

A total of 28 non-native plant species were recorded in 2022 from the non-native plant monitoring and from incidental observations during other terrestrial monitoring studies (Table 3-2). One new species, smooth brome (*Bromus inermis*), was recorded for the first time in the Project footrprint.

All non-native species recorded in 2021 were also present in 2022.

Smooth brome was recorded at several locations in Borrow Areas KM-15 and KM-17 and in the Start-up Camp. Black medick (*Medicago lupulina*) and wheat (*Triticum aestivum*) were recorded in 2022 for the first time since 2020 and 2017, respectively. Black medick was recorded at three locations in the Main Camp and Helicopter Pad areas, as well as in Borrow Area B-2. Wheat was recorded at one location in Borrow Area B-3.

The five most abundant non-native species in 2022 (Table 3-2) accounted for 75% of all non-native plant cover, and the eight most abundant accounted for 92% (Table 3-3). In descending order of abundance, these species were common dandelion (*Taraxacum officinale*), white and yellow sweet clover, lamb's-quarters (*Chenopodium album*), field sow-thistle (*Sonchus arvensis*), alsike clover (*Trifolium hybridum*), narrow-leaved hawk's-beard (*Crepis tectorum*) and smooth catchfly (*Silene csereii*). Common dandelion was the most abundant species by far at 30% of the total non-native cover, followed by white and yellow sweet cover (*Melilotus albus* and *M. officinalis*, respectively) combined at 24%, and lamb's-quarters (*Chenopodium arvense*) at 15%.

As a percentage of surveyed area, three of the eight most abundant species increased in cover since 2021 (see last year's annual report (ECOSTEM 2022) for 2021 cover). These included field sow-thistle, smooth catchfly and alsike clover. The largest changes, however, were decreases in the cover of narrow-leaved hawk's-beard, lamb's-quarters, and white and yellow sweet clover, which decreased by 82%, 78%, and 54%, relative to the area surveyed, respectively.

Field sow-thistle cover increases were highest in Borrow Areas B-2, G-1 at KM-15, N-21, N-22 and along the NAR. Total cover decreased in many of the Keeyask Infrastructure Project (KIP) Borrow Areas, the Main Camp and Borrow Area B-3.

Narrow-leaved hawk's-beard cover declined from 2021 to become the sixth most abundant non-native species. The largest decreases in cover were in older footprint components, such as Borrow Area G-1 at KM-17 and KM-15, Borrow Area KM-9, Work Area C and in Borrow Area N-22.

Since 2021, lamb's-quarters cover decreased in Borrow Area N-21, EMPA D28(1)-E and EMPA D27(4)-E. Increases in lamb's-quarters cover occurred in EMPA D23(1)-E, Borrow Areas G-1 at KM-17 and S-2a, and some of the other areas where activity more recently ceased.

The largest total sweet clover decreases occurred in the Start-up Camp, NAR, Borrow areas B-3, B-6, KM-1 and G-1 at KM-15. Increases in sweet clover cover occurred in Borrow Areas N-22, B-2 and EMPA D16.

Sweet clover was recorded in Borrow Areas S-2a, G-3 and Q-1 for the first time in 2022 (Q-1 was not accessible in 2021). Sweet clover was also recorded in Borrow Area S-2b and EMPAs D28(1)-E and D12.

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

Common Name[1,2]	Species	2021	2022
Common Dandelion	*Taraxacum officinale*	18,189	18,408
Lamb's-quarters	*Chenopodium album*	32,493	9,303
White Sweet Clover	*Melilotus albus*	18,799	9,246
Field Sow-thistle	*Sonchus arvensis*	2,580	4,740
Alsike Clover	*Trifolium hybridum*	839	3,288
Narrow-leaved Hawks-beard	*Crepis tectorum*	12,548	3,002
Unidentified Sweet Clover	*Melilotus spp.*	1,537	2,849
Smooth Catchfly	*Silene csereii*	1,048	2,630
Yellow Sweet Clover	*Melilotus officinalis*	3,861	2,580
Spotted Lady's-thumb	*Persicaria maculosa*	2,529	1,504
Common Plantain	*Plantago major*	1,667	1,295
Pineappleweed	*Matricaria discoidea*	86	649
Alfalfa	*Medicago sativa*	319	426
Tufted Vetch	*Vicia cracca*	1,032	247
Wormseed Mustard	*Erysimum cheiranthoides*	81	170
Wormwood	*Artemisia absinthium*	3	153
Bird's-foot Trefoil	*Lotus corniculatus*	1	64
Curled Dock	*Rumex crispus*	97	60
White Clover	*Trifolium repens*	1	57
Smooth Brome	*Bromus inermis*	-	48
Wheat	*Triticum aestivum*	-	46
Scentless chamomile	*Tripleurospermum inodorum*	4	19
Shepherd's-Purse	*Capsella bursa-pastoris*	1	4
Red Clover	*Trifolium pratense*	14	3
Canada Thistle	*Cirsium arvense*	4	1
Common Timothy	*Phleum pratense*	12	0
Common Tansy	*Tanacetum vulgare*	4	0
Ox-eye Daisy	*Leucanthemum vulgare*	0	0
Black Medick	*Medicago lupulina*	-	0
All species		*97,749*	*60,794*
Total Area Surveyed		*6,953,280*	*9,183,977*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Bolded species are Level 1 invasive concern (Table 2-5). 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 sites 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 3-3: Total approximate cover of non-native species as a percentage of total cover for all non-native species, by year

Common Name[1,2]	Species	2021	2022
Common Dandelion	*Taraxacum officinale*	19	30
Lamb's-quarters	*Chenopodium album*	33	15
White Sweet Clover	*Melilotus albus*	19	15
Field Sow-thistle	*Sonchus arvensis*	3	8
Alsike Clover	*Trifolium hybridum*	1	5
Narrow-leaved Hawks-beard	*Crepis tectorum*	13	5
Unidentified Sweet Clover	*Melilotus spp.*	2	5
Smooth Catchfly	*Silene csereii*	1	4
Yellow Sweet Clover	*Melilotus officinalis*	4	4
Spotted Lady's-thumb	*Persicaria maculosa*	3	2
Common Plantain	*Plantago major*	2	2
Pineappleweed	*Matricaria discoidea*	0	1
Alfalfa	*Medicago sativa*	0	1
Tufted Vetch	*Vicia cracca*	1	0
Wormseed Mustard	*Erysimum cheiranthoides*	0	0
Wormwood	*Artemisia absinthium*	0	0
Bird's-foot Trefoil	*Lotus corniculatus*	0	0
Curled Dock	*Rumex crispus*	0	0
White Clover	*Trifolium repens*	0	0
Smooth Brome	*Bromus inermis*	0	0
Wheat	*Triticum aestivum*	0	0
Scentless chamomile	*Tripleurospermum inodorum*	0	0
Shepherd's-Purse	*Capsella bursa-pastoris*	0	0
Red Clover	*Trifolium pratense*	0	0
Canada Thistle	*Cirsium arvense*	0	0
Common Timothy	*Phleum pratense*	0	0
Common Tansy	*Tanacetum vulgare*	0	0
Ox-eye Daisy	*Leucanthemum vulgare*	0	0
Black Medick	*Medicago lupulina*	0	0
All species		*100*	*100*
Total Area Surveyed		*6,953,280*	*9,183,977*

Notes: Numbers that round to zero shown as "0"; absences shown as "-". [1] Bolded species are Level 1 invasive concern (Table 2-5). 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 sites 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*.

3.3 EFFORTS TO MANAGE INVASIVE PLANTS

The non-native species that were considered for management measures included all the Level 1 species (Section 2.5.2), which were the species of highest invasive concern for the Project footprint. Level 2 species were candidates for management measures if they were not already well-established in multiple locations. Level 3 and Level 4 species were opportunistically managed within locations where Level 1 or 2 species were treated.

Nine of the 28 non-native species recorded in 2022 were classified as being Level 1 or 2 (Table 2-5). None of these were an ISCM Category 1 species, and none were a Tier 1 species in the *Noxious Weeds Act* of Manitoba.

The Level 1 species (Table 2-5) found in 2022 were ox-eye daisy (*Leucanthemum vulgare*), scentless chamomile (*Tripleurospermum inodorum*) and common tansy (*Tanacetum vulgare*). Level 2 species included Canada thistle (*Cirsium arvense*), field sow-thistle, tufted vetch (*Vicia cracca*), white and yellow sweet clover, and smooth brome.

Strategies employed to date to manage non-native plants include prevention, eradication and control. Several prevention measures are included in the Project Environmental Protection Plans (e.g., washing equipment before transporting to site). Examples of prevention measures implemented in the monitoring are: that staff conducting the surveys clean their footwear before they leave a surveyed area; and, providing site environmental staff with non-native plant identification training and resources during the construction period.

The three primary eradication and control methods employed to date were rapid manual removal, herbicide treatments, and mowing at key sites. The following describes these measures.

3.3.1 RAPID MANUAL REMOVAL AND OTHER NON-CHEMICAL ACTIONS

The rapid manual removal (i.e., by hand) strategy was applied to Level 1 plants at sites with one to a few plants (see Section 2.5.3 for the removal methods). Such plants were immediately removed when they were found. The following provides results by degree of invasive concern.

3.3.1.1 LEVEL 1 NON-NATIVE SPECIES

The three Level 1 non-native species recorded in 2022 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 2-5). Scentless chamomile is also a weed seed plant in the federal Weed Seeds Order. All three of these species were found and monitored during Project

operation. The characteristics of these species are described in detail in a previous annual report (ECOSTEM 2022).

To date, the rapid manual removal appears to have been effective for the Level 1 species (Section 2.5.3; see ECOSTEM 2022). The following describes the situations for individual species in 2022.

In 2022, scentless chamomile was found growing at ten new sites in Borrow Area B-2 (Appendix 3, Map 6-1; Photo 3-1, and in one large new patch in Borrow Area N-5. All these plants were immediately removed and disposed of by ECOSTEM field staff (Photo 3-2).

Ox-eye daisy (Photo 3-3) was recorded at five sites in 2022, in Borrow Areas KM-15 and B-2 (Appendix 3, Map 6-2). Two of the sites in Borrow Area G1 at KM-15 were located near (within approximately 7 m) a site recorded in 2018. In total ten plants were recorded at the locations in G1. Two individuals were recorded at two separate sites in Borrow Area B-2. All plants found were removed by ECOSTEM staff.

Common tansy was found growing at two sites in 2022 (Appendix 3, Map 6-3). This included one location in EMPA D35(1)-E and one in Borrow Area B-2 approximately 17 m west of the sites recorded in 2021 (Photo 3-4). Single plants were found at both sites. All plants found were immediately removed by ECOSTEM staff.

Photo 3-1: Scentless chamomile patch growing in Borrow Area B-2 on August 28, 2022

Photo 3-2: ECOSTEM staff removing scentless chamomile plants growing in Borrow Area B-2 on August 28, 2022

Photo 3-3: Ox-eye daisy (white flowers) growing in Borrow Area G1 at KM-15 on August 24, 2022

Photo 3-4: Common tansy growing beside Borrow Area B-2 on August 28, 2022

3.3.1.2 LEVEL 2 NON-NATIVE SPECIES

Six Level 2 non-native species were recorded in 2022. Of these, the ISCM "other" species included Canada thistle, field sow-thistle and tufted vetch. The first two 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 2-5). The characteristics of these species are described in detail in a previous annual report (ECOSTEM 2022). All these species were previously found in the Project footprint during construction.

Smooth brome was found for the first time in the Project footprint in 2022. This species is classified as moderately invasive in Canada by White *et al.* (1993).

Manual removal has not been successful for Level 2 species in most cases. The following describes the situations for individual species in 2022.

Several sites containing field sow-thistle (Photo 3-5) in 2021 were selected for herbicide and/or mowing treatment in 2022 (see Section 3.3.2). Sites located in the Start-up and Main Camp areas, portions of Borrow Area G-1 at KM-15 and KM-17, along the North Dike, in Work Areas A, C and X and in areas along the NAR and SAR were marked for herbicide application. Large areas at the Downstream Boat Launch and near Borrow Area B-3 were marked for mowing.

Results from the 2022 late summer survey indicated that field sow-thistle cover persisted in all sites where it was already established and increased in a few new areas (Appendix 3, Map 6-4 to Map 6-8). Total cover increased between 2021 and 2022. Total cover increase was highest in Borrow Areas B-2, G-1 at KM-15, N-21, N-22 and along the NAR. Total cover decreased in many of the KIP Borrow Areas, the Main Camp and Borrow Area B-3.

Photo 3-5: Field sow-thistle growing in Borrow Area B-2, August 28, 2022

Some of the patches found in 2021 were targeted for herbicide and/or mowing treatment in 2022 (Section 3.3.2.1). These included sites in the east side of Borrow Area G-1 at KM-1, the ditch of the NAR and SAR.

Surveys in 2022 found two individuals of Canada thistle near a patch recorded in 2020 and 2021 in Borrow Area KM-4 (Appendix 3, Map 6-9). The patch in KM-4 appeared to have decreased in size between 2021 and 2022. Two individuals were found at one new site in EMPA D35(1)-E, and patches at four sites were found in Borrow Area B-2 (Photo 3-6), near the site where plants were found in 2020 and 2021. The plants in Borrow Area B-2 were not removed because they were established patches. Those sites will be targeted for treatment with herbicide in 2023 and re-visited during the late-summer surveys.

Photo 3-6: Canada thistle growing in Borrow Area B-2, August 28, 2022

Tufted vetch plants (Photo 3-7) were found in two new areas during the 2022 surveys (Appendix 3, Map 6-10 and Map 6-11). These included scattered individuals in Borrow Area B-2 and Borrow Area G-1 at KM-17. Tufted vetch continued to grow in or around most of the sites where it had previously occurred.

Rapid manual removal was not employed (and not recommended) at the remaining tufted vetch sites along the SAR and in adjacent borrow areas east of the Butnau Marina. In these cases, the plants were well established at these sites and in areas adjacent to or near the Project footprint.

Photo 3-7: Tufted vetch growing in Borrow Area G-1 at KM-15, August 24, 2022

Smooth brome (Photo 3-8) is a rhizomatous perennial that has a has the capacity to proliferate from roots left in the ground after manual removal and may be susceptible to frequent and timely cutting and particular herbicide treatments (Otfinowski et al. 2007). Small patches or individual plants may be mowed, burned or herbicided frequently and at particular times of the year, where feasible (Grilz and Romo 1995; Otfinowski et al. 2007).

Smooth brome was found at several locations in Borrow Area G-1 at KM-15 and KM-17, and at two sites in the Start-up Camp (Appendix 3, Map 6-12). Because the plants were established patches, they were not removed manually. They will be targeted for herbicide treatment and/or mowing in 2023.

Photo 3-8: Smooth brome growing in the Start-up Camp, August 21, 2022

The rapid manual removal protocol was not applied for white and yellow sweet clover. White sweet clover (Photo 3-9) was already widespread in the Project footprint, and in disturbed areas throughout the Keeyask region, prior to the Project. As of August 2022, the two species were collectively the second most abundant non-native species.

Photo 3-9: White sweet clover growing in the ditch of the NAR, August 25, 2022

3.3.1.3 LEVEL 3 AND 4 NON-NATIVE SPECIES

Six of the remaining 19 non-native species were Level 3 invasive concern, and 13 were Level 4. These species were not managed, unless they fell within areas treated chemically or by mowing for species of higher invasive concern (see Section 3.3.2).

While the Level 3 and 4 non-native species were fairly common in disturbed areas surrounding the Project, few of these species appeared to be spreading rapidly, and two species (lamb's-quarters and narrow-leaved hawk's-beard) were declining in many of the footprint components.

3.3.2 HERBICIDE TREATMENTS AND MOWING AT KEY SITES

3.3.2.1 TREATMENTS

Herbicide application at key sites, with follow-up mowing where required, was the second management strategy employed to date to control invasive plants. 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).

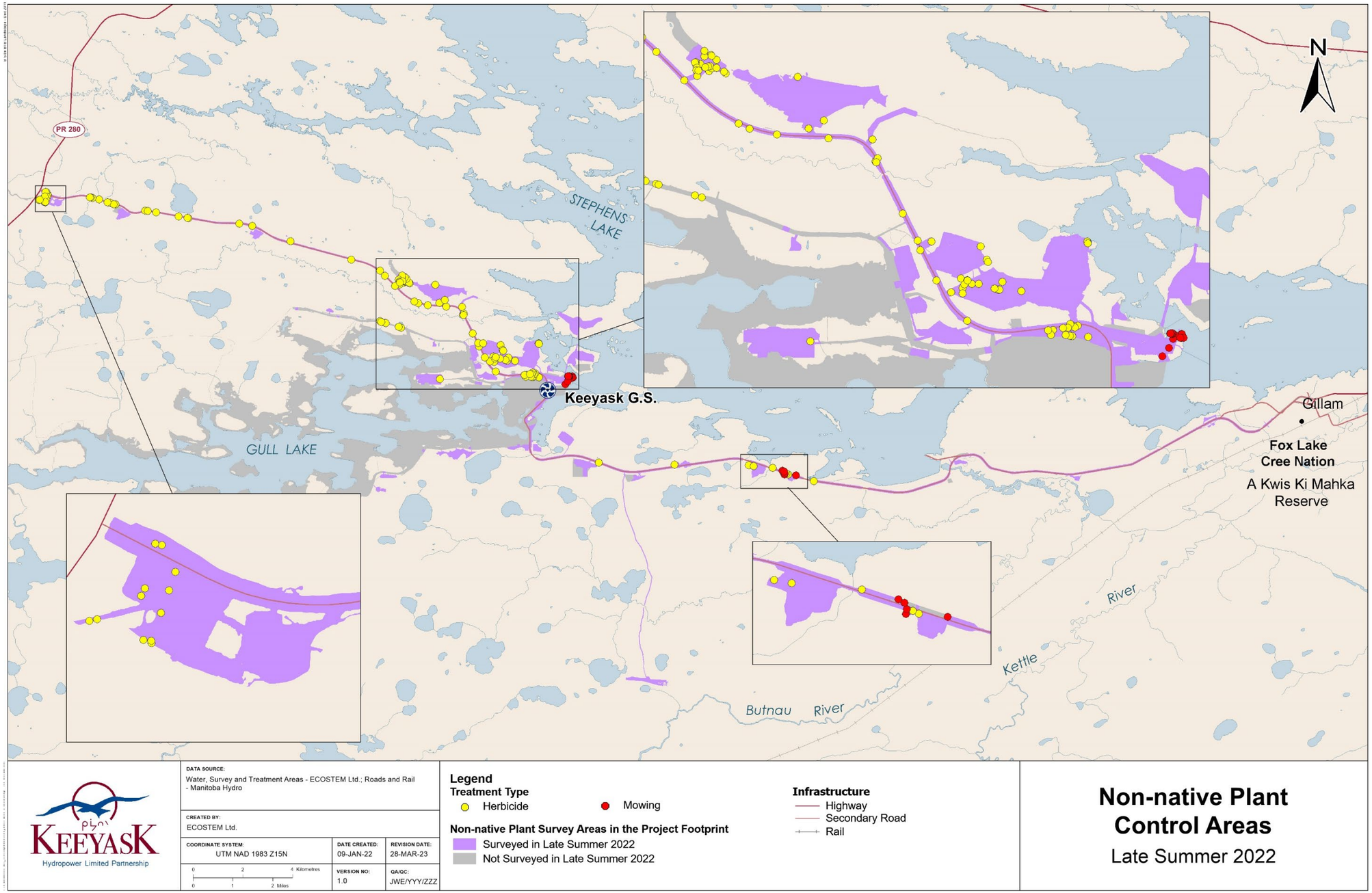
Herbicide treatment was used in 2022 in the areas shown in Map 3-6. Table 3-4 summarizes the dates, locations and herbicide mixture used for the treatments. Areas for herbicide treatment were visited by ECOSTEM staff in early July and marked with pin flags and wooden posts. Herbicide was applied August 17 and 18 to most of the areas marked for herbicide. Some areas in Work Area X were not accessible to the spray truck and some additional locations in that area had been excavated and disturbed during the installation of a culvert across the NAR.

One area near the downstream boat launch was marked for mowing in 2022, due to its proximity to Stephens Lake (Map 3-6).

Table 3-4: Herbicide treatments carried out at key sites during the last year of Project construction, and in 2022

Treatment Dates	Areas Treated[1]	Herbicide Mixture[2]
July 9, 2021	Start-up Camp and NAR gate staging area, North Dike, NAR, Borrow Area G-1 (KM-15), Main Camp, Work Area B, Borrow Areas B-2, B-3, Sigfusson Northern/Voltage Camp (SAR, decommissioned)	Garlon 4 (6.0 L), Roundup Weatherpro (2.5 L), Milestone (0.5 L), Onsite (1 L). Application rate = 1000L/ha
August 17 and 18, 2022	Start-up Camp and NAR gate staging area, North Dike, NAR, Borrow Area G-1 (KM-15), Main Camp, Work Area A, Borrow Areas Q-9, B-3, Sigfusson Northern/Voltage Camp (SAR, decommissioned), portions of Work Area X	Escort – 23005 (140 g/ha), Vanquish – 26980 (4 L/ha), Roundup – 33653 (5 L/ha).

Notes: [1] Herbicide was applied to target patches within the indicated areas. [2] "L/ha" = Litres per hectare; "g" = Grams; "g/ha" = Grams per hectare.



Map 3-6: Key areas selected for invasive plant herbicide control and mowing in 2022

3.3.2.2 EFFICACY OF TREATMENTS

3.3.2.2.1 AREAS TREATED IN 2021

In 2021, herbicide control and mowing were carried out at several locations. The locations and detailed results of the efficacy of the treatments are provided in last year's annual repot (ECOSTEM 2022). In 2021, herbicide applicators arrived on site before botanists were able to confirm and mark the target patches of plants. As a result, many of the target patches were missed.

The missed patches were marked when botanists were on site, and they were subsequently mowed instead in mid to late August, 2021. A single mowing was successfully carried out in nearly all the marked patches. Some touch-up mowing was also carried out at the Downstream Boat Launch and Main Camp sites on September 10, 2021.

Overall cover for all target species in footprint components where herbicide and/or mowing treatments were applied was 50% higher in 2022 than in 2021 (Table 3-5). For individual footprint components, target species cover was lower in 2022 in the Start-up Camp, Main Camp, and along the North Dike. For the remaining components, target species cover increased from 2021 to 2022. In Borrow Area G-1 at KM-15, target species cover increased by 123% from 2021 to 2022. In Work Area C, at the Downstream Boat Launch where only mowing was carried out, total cover of the target species (field sow-thistle) increased by 73%.

Table 3-5: Total cover of non-native species targeted[1] for control herbicide and/or mowing in treated footprint components in 2021 and 2022

Footprint Component	Total target species cover (m^2)		Percent difference
	2021	2022	
Start-up Camp	114	78	-31
Borrow Area G-1 (KM-15)	415	928	124
Borrow Area G-1 (KM-17)	44	43	-2
Main Camp	69	19	-73
North Access Road	190	191	1
North Dike	31	5	-85
Helicopter Pad	7	17	124
Work Area C (downstream boat launch)	120	208	73
All	989	1,536	50

Notes: [1] Species targeted in 2021 included field sow-thistle, Canada thistle, tufted vetch, scentless chamomile, and ox-eye daisy.

3.3.2.2.2 AREAS TREATED IN 2022

The overall effectiveness of the herbicide treatments in 2022 could not be evaluated for this report (see ECOSTEM 2022 for details on previous herbicide trials) as the 2022 non-native plant surveys

commenced one day after the application of the herbicide was completed. Because it may require several days for the effects of the herbicide to become apparent, the timing of the surveys was too soon to evaluate the effectiveness of the 2022 herbicide treatments. Some herbicide effects were observed in some of the treated areas that were surveyed two weeks after the treatment (Photo 3-10; Photo 3-11), but generally not to the extent expected for an effective treatment. It is unknown if this was due to low efficacy of treatment, or if insufficient time had passed since treatment. The results of the 2022 herbicide treatment will be evaluated in the next annual report.

Photo 3-10: Flagged site near Work Area X after herbicide treatment

Photo 3-11: Field sow-thistle after herbicide treatment

During invasive plant surveys in late August, it was observed that the areas around the Downstream Boat Launch that had been marked for mowing (because of their proximity to the water) had in fact been treated with herbicide (Photo 3-12). Most of the non-native high concern species present had already seeded while they were also showing the effects of the herbicide application.

Photo 3-12: Herbicide treatment in the mowing area near the downstream boat launch, August 30, 2022

3.4 SEED MIXTURES USED IN REHABILITATION EFFORTS

Rehabilitation efforts that included grass seeding are described in another monitoring report (ECOSTEM 2023b). Areas treated included the side slopes of the South Access Road (2016) and North Access Road (2020), portions of Borrow Areas B-3 and Q-9 under transmission lines (2020), and in EMPAs D16 and D17 for erosion control (2021). The grass species seed mixtures used are provided in Table 3-6.

All but one of the species included in the seed certificates were native to North America, and none of the species are listed as invasive in Manitoba or Canada. The exception was diploid annual grass (*Lolium multiflorum*), which was intentionally seeded into EMPA D16 and D17 for erosion control purposes (Table 3-6). This is a species native to Europe and is of low invasive concern (Level 4). The seed certificate also indicated that two other non-native seed species of Level 4 invasive concern (green foxtail (*Setaria viridis*) and barnyard grass (*Echinochloa crus-gali*)) were present in the seed in small amounts (2 seeds/25 grams and 6 seeds/25 grams, respectively, or 0.1% of total). Neither of these species have been recorded to date during invasive plant surveys.

Table 3-6: Species included in seed mix for seeded locations

Species	Common name	CDC S-Rank[1]	Invasive Rank	Areas Treated[2]
Koeleria macrantha	Prairie junegrass	S5	none	SAR; NAR; BA B-3 & Q-9
Festuca saximontana	Rocky mountain fescue	S4S5	none	BA B-3 & Q-9
Bromus anomalus	Nodding bromegrass	-	none	BA B-3 & Q-9
Elymus lanceolatus	Thick-spike wildrye	S3	none	SAR; NAR; BA B-3 & Q-9
Elymus canadensis	Canada wildrye	S4S5	none	NAR; BA B-3 & Q-9
Poa alpina	Alpine bluegrass	S4S5	none	BA B-3 & Q-9
Poa secunda	Sandberg bluegrass	SU	none	SAR
Elymus glaucus	Smooth wild rye	SU	none	SAR
Vicia americana	American purple vetch	S5	none	SAR
Agrostis scabra	Rough bentgrass	S5	none	SAR
Deschampsia caespitosa	Tufted hairgrass	S4S5	none	SAR; NAR
Bromus ciliatus	Fringed brome	S5	none	NAR
Pascopyrum smithii	Western wheatgrass	S3	none	NAR
Lolium multiflorum[3]	Diploid annual ryegrass	SNA	Level 4	EMPA D16 & D17

Notes: [1] Manitoba Conservation Data Centre 2023. [2] "SAR"="South Access Road"; "NAR"="North Access Road"; "BA" = "Borrow Area"; "EMPA"="Excavated Material Placement Area". [3] Seed mix where diploid annual ryegrass was used also contained green foxtail (*Setaria viridis*, 2 seeds/25 grams) and barnyard grass (*Echinochloa crus-galli*, 6 seeds/25 grams).

4.0 DISCUSSION

4.1 OVERALL CHANGES TO NON-NATIVE PLANT DISTRIBUTION AND ABUNDANCE

Total non-native plant cover as a percentage of the total area surveyed was only 0.7% in 2022, a decrease from 1.4% in 2021 (ECOSTEM 2022). This percentage was quite low after almost eight years of construction and one year of operation. This was especially true given that the total cover for the entire Project footprint was likely lower than for the area surveyed because unsurveyed areas generally had low non-native plant cover (see Section 2.3).

It is unlikely that the addition of areas surveyed in 2022 but not in 2021 artificially decreased non-native plant cover. The areas surveyed in 2022 but not in 2021 included excavated borrow areas that were previously inaccessible due to construction activity. These areas typically had a mineral substrate, and supported heavy construction traffic, both of which favour the establishment of non-native plants.

Even though total non-native plant cover in 2022 was quite low, the existing patches of non-native plants could still be a concern because these species can quickly become broad infestations if not managed. The end of Project construction changed the overall degree and type of activity in the Project footprint, which alters the factors influencing the subsequent spread of non-native plants. For example, decreased construction activity will reduce the spreading of non-native plants by foot and vehicle traffic in most of the footprint. However, the lack of active excavation and vegetation removal will allow vegetation, including non-native plants, to expand unimpeded.

There appeared to be differences in non-native plant cover between footprint components when evaluated based on ongoing activity type and time since rehabilitation. These differences reflected trends that were observed during construction monitoring (ECOSTEM 2022). Grouping the Project components based on permanence and time since rehabilitation will more effectively monitor trends in non-native plant cover for the operation period. This will help to anticipate non-native plant spread during operation and develop more effective management strategies.

4.2 CHANGES IN SPECIES DISTRIBUTION AND ABUNDANCE

The overall decline in non-native plant cover from 2021 to 2022 was due to large decreases in lamb's-quarters, white and yellow sweet clover, and narrow-leaved hawk's-beard cover. Several possible reasons for these decreases are outlined below.

Lamb's-quarters cover increased dramatically between 2020 and 2021. These increases were in areas that had recently been decommissioned (ECOSTEM 2022). This was followed by a large drop in lamb's-quarters cover between 2021 and 2022, from being the most abundant species in 2021 to the second most abundant in 2022.

Non-native plant monitoring during Project construction (ECOSTEM 2022), and for another project in northern Manitoba (ECOSTEM 2018) found that there was an apparent decline in non-native plant cover, largely driven by lamb's-quarters, beginning several years after construction activity ceased. A sharp increase in lamb's-quarters after decommissioning, followed by a rapid decline in subsequent years had been observed in many of the older areas of the Construction Footprint (ECOSTEM 2022). This trend may explain the decline between 2021 and 2022, because most of the site preparation occurred prior to 2021.

In 2022, lamb's-quarters was most abundant in temporary areas where more recent rehabilitation efforts have been carried out (0.16% of the surveyed area), which corresponds to the trend observed in multiple areas during construction (see above). If this trend is repeated during operation, it is expected that total lamb's quarters cover will continue to decrease as time passes after temporary footprint decommissioning, Additionally, vegetation rehabilitation efforts should contribute to crowding out some plants.

There are several possible explanations for the decrease in white and yellow sweet clover cover between 2021 and 2022. Construction monitoring found that the cover of this species fluctuated annually, regardless of the amount of construction activity where it was found (ECOSTEM 2022). Possible reasons for this were discussed in that report. In summary, these included species response to varying environmental conditions; periodicity in the species life cycle; and bias in detectability of the plant depending on the density of other vegetation. Sweet clover is an abundant plant in the ditches along Highway 280 (KHLP 2012b), suggesting that it is spread by vehicle traffic. If this is the case, then it is expected that traffic will continue to introduce sweet clover (and other non-native plants that occur along Highway 280) along the NAR and SAR once these roads become part of the provincial highway system.

Narrow-leaved hawk's-beard was among the most, or second most abundant non-native species at various times and places during construction (ECOSTEM 2022). By the late summer survey in 2022, it had decreased to the sixth most abundant species. The reason for the decline in 2022 is unknown, but overall cover peaked in the construction footprint in 2020, then there was a slight decrease between 2020 and 2021 (ECOSTEM 2022). One possible reason for the apparent decrease could be detectability of the plant. The plant is small and is highly visible for only a short time. Field observations indicate that it senesces quickly after it flowers, and then withers and becomes difficult to see, especially amongst other vegetation. This species may become increasingly difficult to detect as other vegetation cover increases in the temporary portions of the Project footprint.

Scentless chamomile (Level 1 invasive concern) was one of the few species that had a relatively substantial increase in total cover between 2021 and 2022. In 2022, scentless chamomile cover

was approximately 19 m^2. This was the first time that scented chamomile had more than 4 m^2 of recorded coverage in the Project area.

The largest patch of scentless chamomile was recorded in Borrow Area N-5, where it had not previously been recorded. Approximately 100 plants were found in that patch and manually removed (see Photo 3-2). The other location was in Borrow Area B-2, where it had previously been recorded and removed, including in 2020 and 2021. Although all the plants previously found had been removed, it is possible that a seed bank may have developed in those two locations. Those locations will be monitored closely for additional individuals of this species in coming years. It is recommended that traffic be limited or avoided at those locations to reduce opportunities for seed to be spread to other areas.

In 2022, common tansy and ox-eye daisy, the other two Level 1 species of concern, continued to be found in new locations. Common tansy and ox-eye daisy were found at five new sites each in 2022. Seeds may have been spread during roadwork or by vehicles from an unknown source, and/or by human foot traffic. All these plants were removed by ECOSTEM staff. Continued monitoring will determine if the plant continues to appear at new locations in the Project footprint.

4.3 EFFORTS TO MANAGE INVASIVE PLANTS

4.3.1 EVALUATION

4.3.1.1 EFFICACY

To date, the rapid manual removal (i.e., by hand) control strategy for invasive plants appears to have been effective for Level 1 species provided they are removed before they disperse seed. Manual removal has generally not been effective for Level 2 species. The most plausible possible explanations for the difference in success were that new plants were produced from already well-established root systems and/or seeds in the seed bank from other plants in the area.

One Level 1 species, scentless chamomile, that had been successfully controlled by manual removal previously, had returned in higher numbers to the same location in Borrow Area B-2 again in 2022. This suggests a seed bank had developed in that area, or that some individuals went undetected in 2021.

The efficacy of the 2022 herbicide treatments remains uncertain as the survey occurred too soon after the herbicide treatment. Surveys in 2021 suggested that herbicide treatment is effective where herbicide is correctly applied. In footprint components where the 2021 herbicide application impacted the target patches of plants (e.g., the Start-up Camp, North Dike), overall cover for those plants were lower in 2022 than in 2021.

The efficacy of mowing was uncertain. The cover of the target species increased in footprint components where only mowing was carried out in 2021. However, this may be due to several

factors, such as the timing of the mowing (in 2021 it occurred late in the season, after plants seeded), and/or the number of mowing treatments. In 2021, it was recommended that target patches be mowed twice, once early in July (before plants have seeded), and again in late August. Except for one location (the downstream boat launch), most patches were mowed for the first time in mid-August, after many plants would have seeded, and a second mowing was carried out at only a few locations.

4.3.1.2 RECOMMENDATIONS

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 sites.

Rapid manual removal has been effective to date for the Level 1 species that meet the preceding criteria (Section 3.3.1.1). Monitoring surveys in 2023 will determine if rapid manual removal continues to be effective for controlling these species, particularly after the increased number of scentless chamomile plants manually removed in 2022.

Rapid manual removal has only been partially effective where it was applied to small patches of Level 2 species in 2016. As described in Section 3.3.1.2, the manual removal method will only be implemented in certain situations.

Rapid manual removal by staff conducting the monitoring surveys will continue to be employed for newly found Level 1 and 2 species. For previously recorded sites, rapid manual removal will not be implemented for species that reproduce prolifically by rhizomes (e.g., Canada thistle) and where either the plants are mature or it appears the plants have already developed a root system (see Section 3.3.1.2). Herbicide application will be considered for these sites.

Additional herbicide applications are recommended to control or eradicate invasive plants at key sites where it remains feasible to do so. Where herbicide applications are not feasible, multiple mowing treatments are recommended. The first mowing treatment should be applied in early July, before plants have set seed, and a second mowing should occur in late August. Key sites will be identified for treatment in summer 2023 using the same criteria as in previous years.

4.3.2 PREVENTION

Preventing further invasive plant spread is becoming more important as more of the Construction Footprint is decommissioned and rehabilitated. Opportunities to use chemical control methods will become more limited over time because herbicides could damage desirable native vegetation after an area has been rehabilitated.

Several additional prevention strategies were described in the final construction annual report (ECOSTEM 2022). For areas where chemical control is not possible, preventative strategies include:

- Promote native plant regeneration;
- Avoid or minimize travel through areas infested with invasive plants; and,
- Avoid or limit traffic in areas that have been rehabilitated, and where desirable vegetation is establishing.

Site decommissioning and rehabilitation activities are currently underway, which addresses the strategy to promote native plant regeneration (see ECOSTEM 2023b for ongoing rehabilitation activities in the Project footprint). It is recommended that the remaining two strategies continue to be employed.

4.4 SEED MIXTURES USED IN REHABILITATION EFFORTS

The EIS and EnvPPs indicate that seed mixtures used for rehabilitation or erosion control will only contain native species and/or non-invasive introduced plant species (i.e., will not contain sweet clover or other invasive species). The EnvPPs add the additional requirement that the seed will be low quality food value for mammals.

All but one species included in the specified grass seed mix were native to Manitoba, or the western provinces of Canada. The exception was diploid annual ryegrass, which is a non-native, non-invasive species. It is a quick-growing non-native species commonly used in Manitoba as forage (Manitoba Agriculture 2023), and as a cover to reduce soil erosion. Diploid annual ryegrass food value for mammals in the Keeyask region is expected to be low (R. Berger, pers. comm.).

The seed certificate indicated that seed of two other non-native species of low invasive concern were present in small amounts in the seed mix. At eight seeds/25 grams, total weed seeds were below the maximum of 50 allowed for unintended weed species in Canada Certified No. 1 grade seed. Neither of these species were found in the seeded areas during invasive plant surveys in 2022.

Surveys in 2022 did not find any evidence that other non-native or invasive plants were introduced into rehabilitated areas through grass seeding.

Areas rehabilitated by grass seeding will continue to be monitored in 2023.

5.0 SUMMARY AND CONCLUSIONS

Non-native plant surveys in August 2022 covered 53% of the terrestrial portions of the Construction Footprint. This was the highest percentage to date due to the cessation or reduction of construction activity in many portions of the Project site.

Non-native plants in 2022 covered 0.7% of the surveyed Construction Footprint, which was a 50% decrease in overall cover from 2021.

Non-native plant cover was highest in the older temporary portions of the Construction Footprint, where rehabilitation was done in 2016. In the permanent Project areas, cover was highest along the North and South Access Road side slopes.

A total of 28 non-native plant species were found during the 2022 surveys. One new species (smooth brome) was recorded in 2022. Two species that had not been recorded in 2021 were observed again in 2022 (black medick and wheat). All species recorded in 2021 were also recorded in 2022.

Non-native plant cover decreased substantially in the Construction Footprint in 2022. The decreases were primarily due to large decreases in cover for four species, including narrow-leaved hawk's-beard, lamb's-quarters, and white and yellow sweet clover. Increases in cover since 2021 were observed for field sow-thistle, smooth catchfly and alsike clover.

The decrease of non-native plant cover in 2022 may have been caused by variability in growing conditions, natural life cycle patterns and/or natural population dynamics for different plant species. The decrease in lamb's-quarters cover appeared to follow trends observed during Project construction, as well as for another project in northern Manitoba.

Plants from three species of highest invasive concern for the Project area were found during the 2022 monitoring. Ox-eye daisy was found at a few locations in Borrow Areas G-1 at KM-15 and B-2, common tansy was found at two sites in Borrow Area B-2 and EMPA D35(1)-E, and scentless chamomile was found at 11 sites in Borrow Areas B-2 and N-5.

Immediate manual efforts to eradicate the species of highest invasive concern were implemented. ECOSTEM field staff removed all these plants by hand after they were found and documented.

Monitoring to date has indicated that manual removal of invasive plants of highest concern (i.e., scentless chamomile, common tansy, ox-eye daisy) was generally effective. It is recommended that manual removal of these species continue. Additional measures may be required for scentless chamomile, as cover increased substantially at two locations.

The monitoring found that total cover for target species in most areas where herbicide and/or mowing treatments were applied in 2021 was higher in 2022. This finding was attributed to issues with the timing or nature of the treatments. In the 2021 areas where herbicide was applied as per the prescription (e.g., the Start-up Camp), total cover of the target species in 2022 was lower than in 2021. A number of sites that were targeted for herbicide application in 2022 were treated in mid-August. Because the herbicide application was carried out only one day before the non-native

plant monitoring surveys in late August, the efficiency of the treatment will be evaluated after the 2023 surveys.

A small number of sites were also targeted for mowing. No evidence of mowing was observed at the time of the monitoring survey in late August. It was observed that the area near the downstream boat launch targeted for mowing was treated with herbicide instead.

Grasses were seeded in various locations for erosion control and/or to assist with vegetation rehabilitation. Review of the seed certificates for the grass seed mixtures used in seeded areas found one non-native grass species of low invasive concern (diploid annual ryegrass) that was intentionally seeded in EMPAs D16 and D17 for erosion control purposes. As seeds are obtained from plants growing in fields, two other non-native species were present in the seed mix. The seed mix contained fewer than 25 seeds/25 grams for both species combined. Neither of these were not found during monitoring surveys. The food value of diploid annual ryegrass for mammals in the region is expected to be low.

Additional invasive plant control recommendations are being developed for the 2023 growing season based on the monitoring results to date. Monitoring fieldwork for invasive and other non-native plants will continue in 2023.

6.0 LITERATURE CITED

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. 2023. Control invasive plants. [Online] http://www.coastalisc.com/how-to-control-invasive-plants [Accessed March 20, 2023]

ECOSTEM Ltd. 2018. Wuskwatim Generation Project: operation monitoring: invasive/non-native plant distribution and abundance. Report # 18-16. Prepared for Wuskwatim Power Limited Partnership. 94 pp.

ECOSTEM Ltd. 2022. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2022-05: Invasive Plant Spread and Control Monitoring. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2022.

ECOSTEM Ltd. 2023a. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2023-01: Habitat Loss and Disturbance Monitoring – Year 1 Operation, 2022. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2023.

ECOSTEM Ltd. 2023b. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2023-06: Habitat Rehabilitation Implementation and Success Monitoring Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd., June 2023.

ECOSTEM Ltd. and Wildlife Resource Consulting Services MB, Inc.. 2023. In Draft. Keeyask Generation Project Terrestrial Effects Monitoring Plan Report #TEMP-2023-17: Construction Phase Monitoring: Synthesis Report. A report prepared for Manitoba Hydro by ECOSTEM Ltd. and Wildlife Resource Consulting Services MB, Inc., June 2023.

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.

Grilz, P.L. and Romo, J.T. 1995. Management considerations for controlling smooth brome in fescue prairie. Natural Areas Journal. 15: 148-156.

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.

ISCM (Invasive Species Council of Manitoba). 2022. Invasive plants & animals in Manitoba. [Online] http://www.invasivespeciesmanitoba.com/site/index.php. [accessed January 3, 2022].

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 Generating Station Construction Environmental Protection Plan. Winnipeg, Manitoba. December 2015.

Keeyask Hydropower Limited Partnership (KHLP). 2016. Keeyask Generation Project Terrestrial Effects Monitoring Plan. Winnipeg, Manitoba. Revised December 2016.

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

Manitoba Agriculture. 2023. Manitoba Agriculture annual forage crops for Manitoba. [Online] https://gov.mb.ca/agriculture/crops/crop-management/forages/annual-forage-crops-for-manitoba.html [Accessed April, 2023.]

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.

Otfinowski, R., Kenkel, N.C. and Catling, P.M. 2007. The biology of Canadian weeds. 134. *Bromus inermis* Leyss. Can. J. Plant Sci. 87:183-198.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.

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 6-1: Estimated radius and derived area for individual non-native plant species in 2022

Species	Estimated Radius (cm)	Derived Area (m^2)
Arctium minus	25	0.196
Artemisia absinthium	25	0.196
Avena sativa	4	0.005
Brassica napus	10	0.031
Bromus inermis	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 sophia	15	0.071
Erysimum cheiranthoides	20	0.126
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
Persicaria maculosa	15	0.071
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

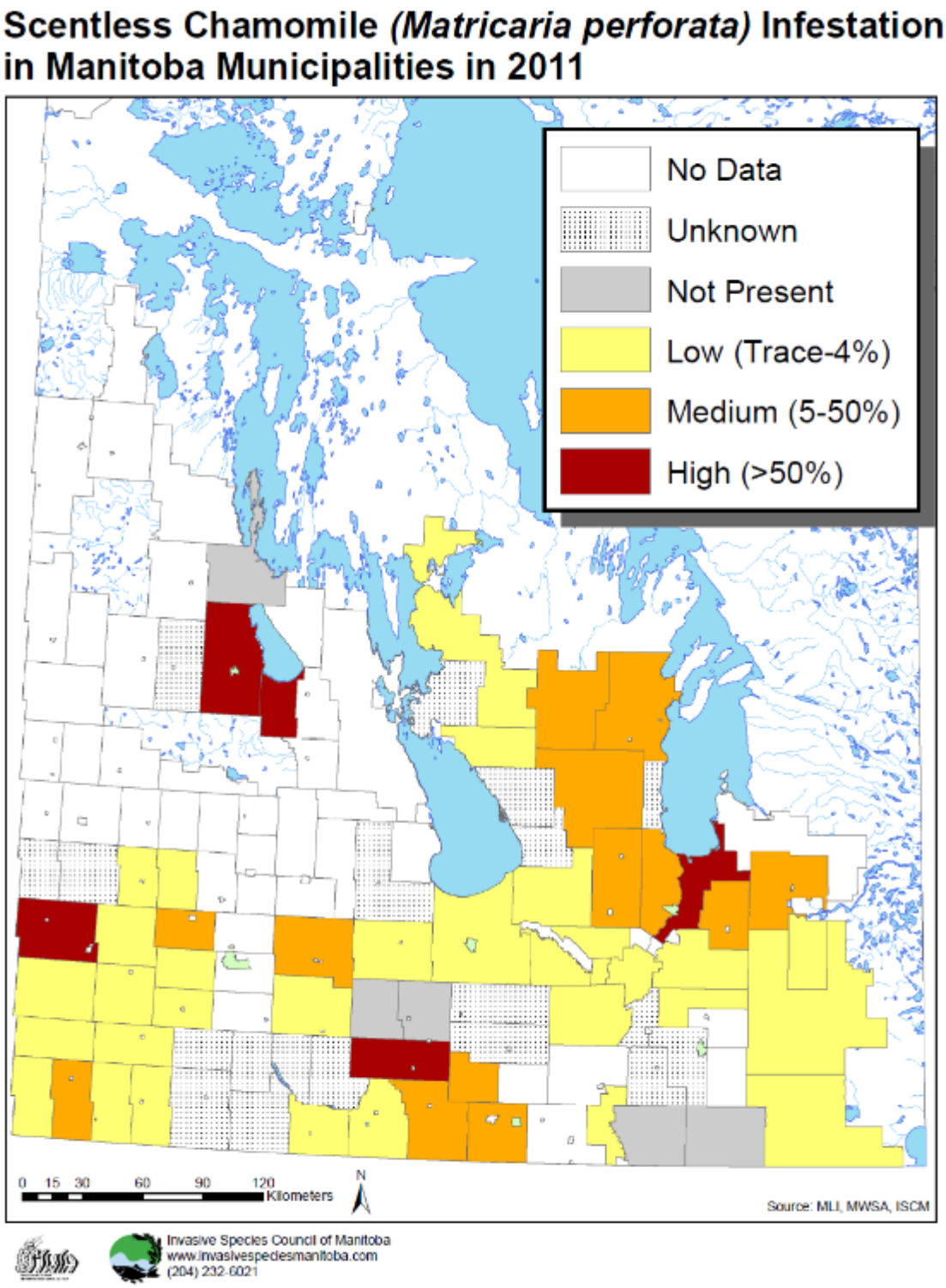
APPENDIX 2:
INVASIVENESS RANKINGS AND MANAGEMENT STRATEGIES

6.1.1 BACKGROUND

This monitoring study provides additional control or eradication recommendations during operation 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 sites and establish in new sites. Many of the non-native species recorded during Project monitoring are commonly found in disturbed areas throughout the Province (e.g., field sow-thistle (*Sonchus arvensis*) and white sweet clover (*Melilotus albus*)), 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 6-1 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: ISCM 2022.

Figure 6-1. 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 (2022), 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 (2022) 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.

6.1.2 INVASIVE CONCERN CLASSIFICATION

As noted above, ISCM (2022) 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 6-2 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 6-2. 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 (2022).

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 2-4). 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 2-5 shows how the invasive concern classification was applied to the non-native plant species recorded in the Project Footprint to date.

Table 6-3 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 (2022).

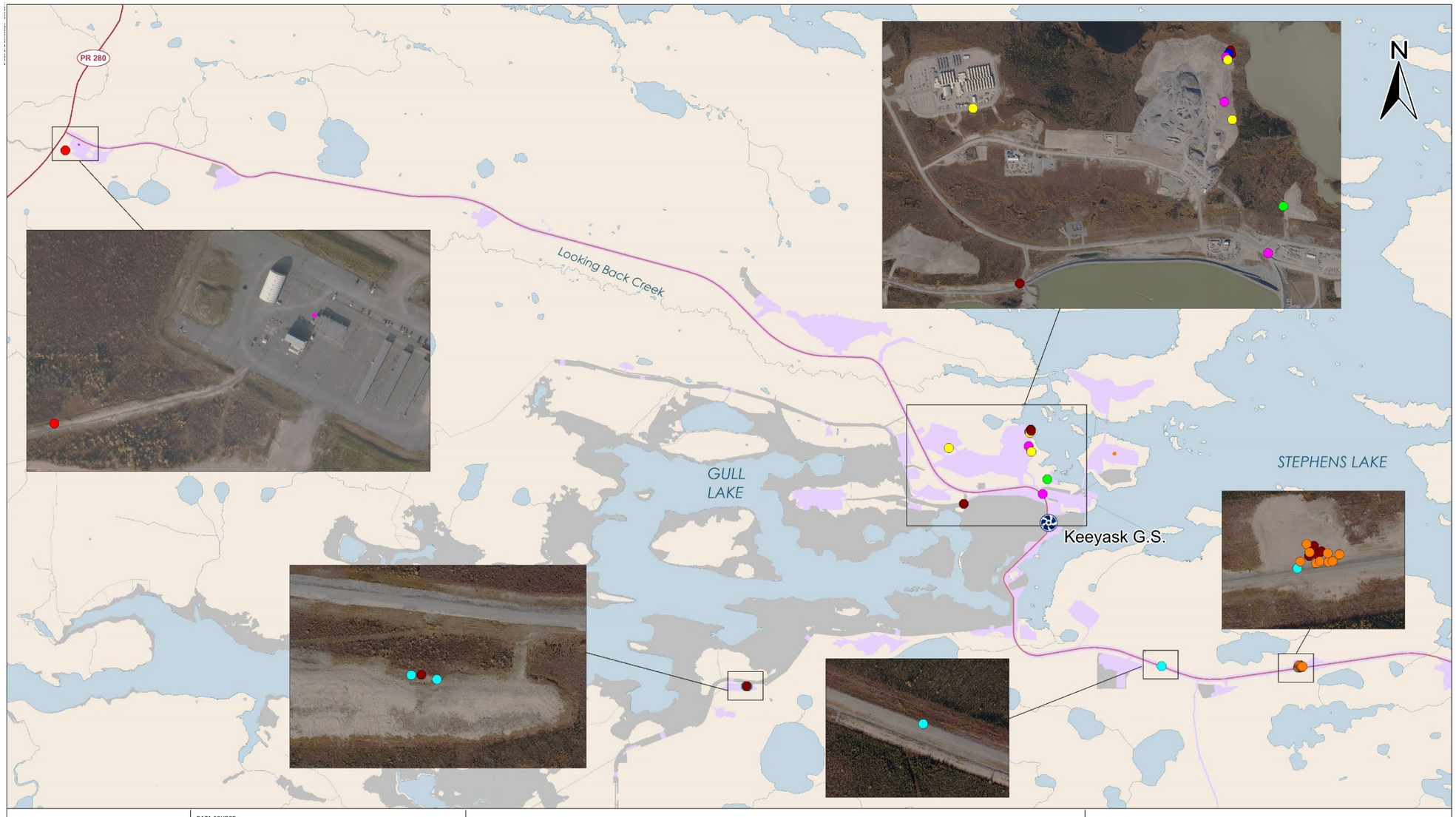
Table 6-3: Invasive concern classifications for non-native plant species that could potentially occur in the Project Footprint

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			

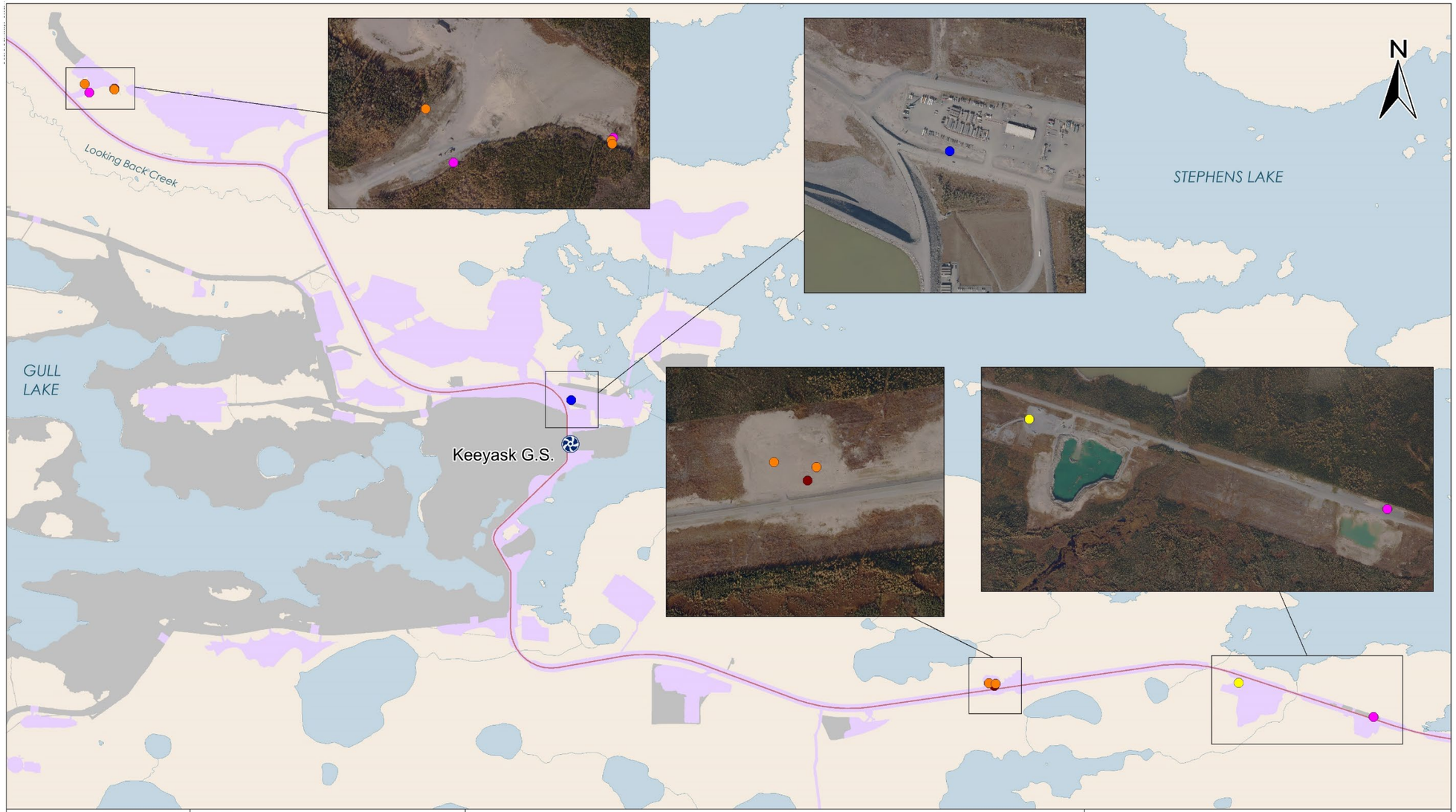
Invasive Concern[1]	Common Name[2]	Scientific Name	ISCM Category[3]	White *et al.* Category[4]	Noxious weed[5]	Weed Seed[6]
	Japanese Knotweed	*Fallopia japonica*	Other			
	Giant hogweed	*Heracleum mantegazzianam*	Other			
	Dame's-rocket	*Hesperis matronalis*	Other	Minor		
	Tansy Ragwort	*Jacobaea vulgaris*	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 2-4 for the invasive concern classification. [2] In decreasing order of concern for the Project area. [3] Invasive Species Council of Manitoba (2022). [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).

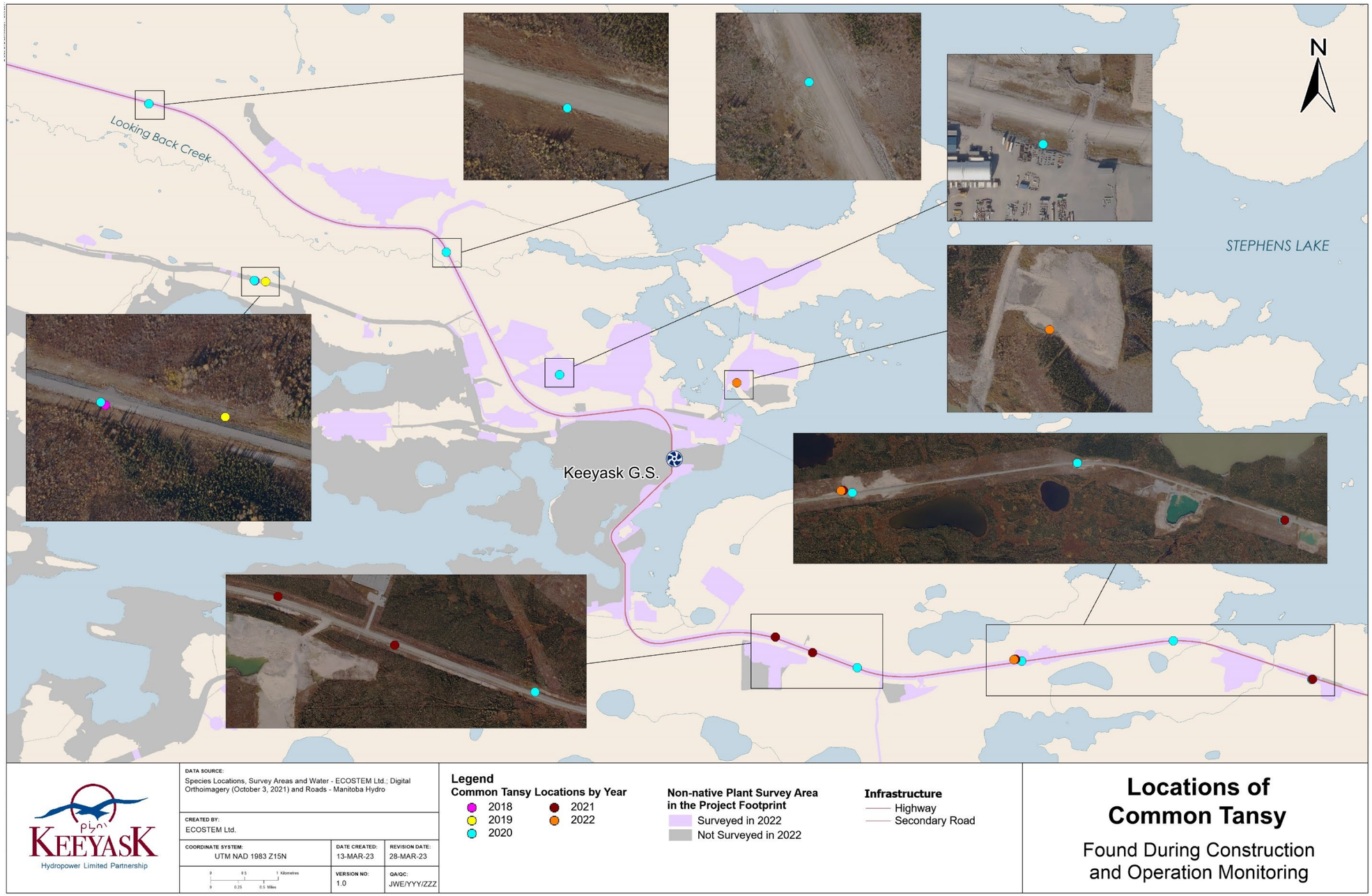
APPENDIX 3:
NON-NATIVE PLANT DISTRIBUTION MAPS



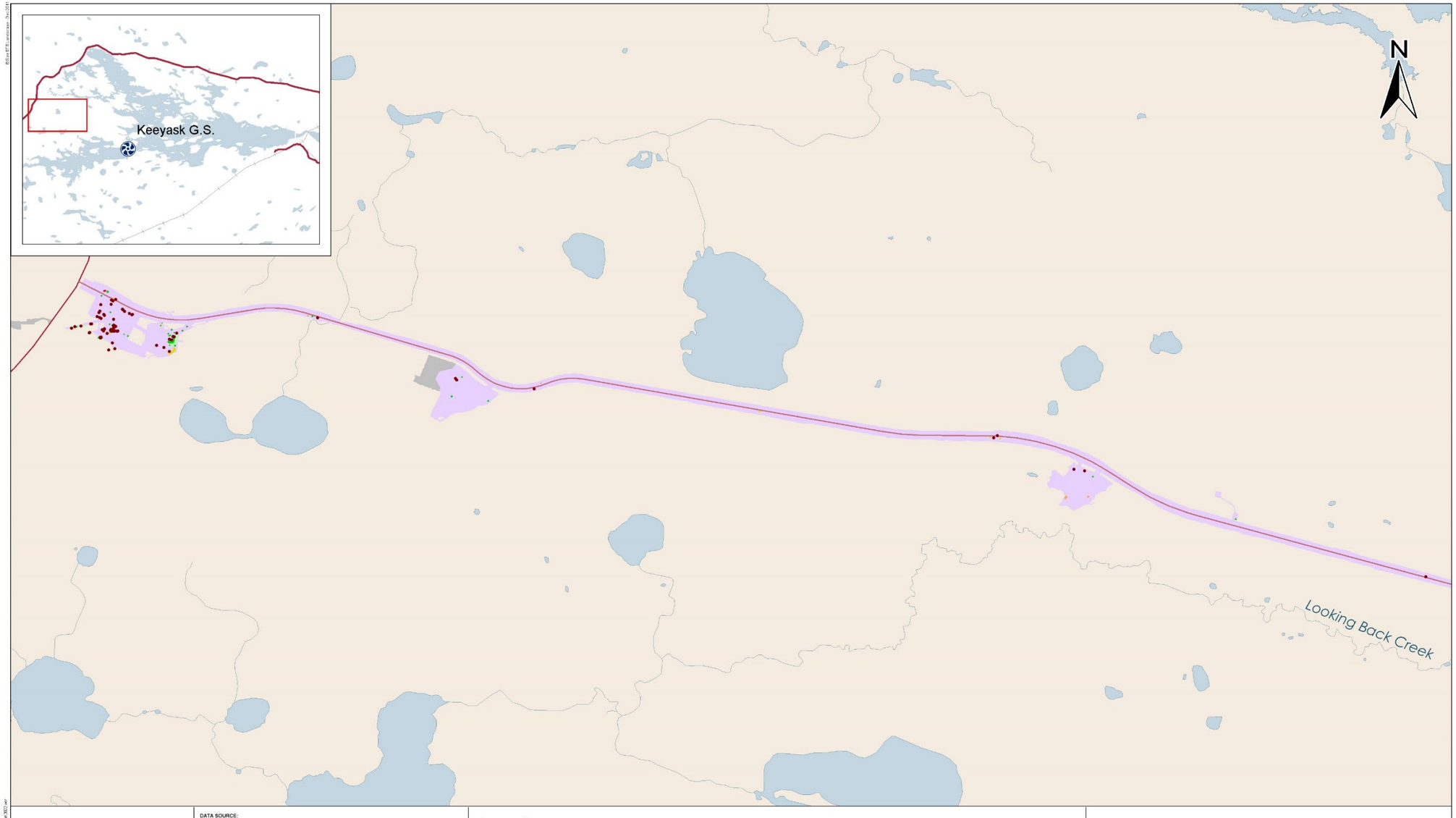
Map 6-1: Locations of scentless chamomile identified during Project construction and operation monitoring



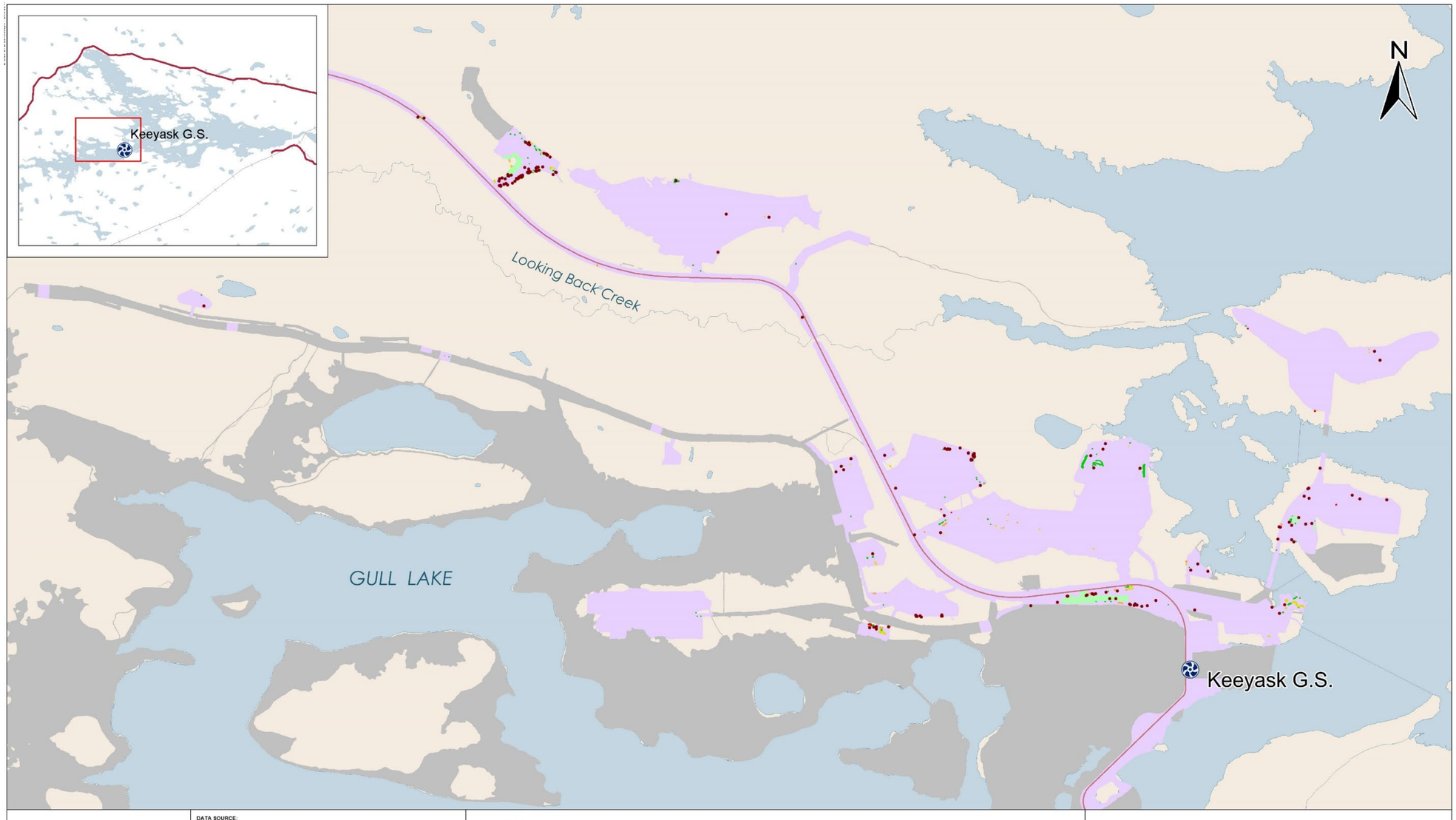
Map 6-2: Locations of ox-eye daisy identified during Project construction and operation monitoring



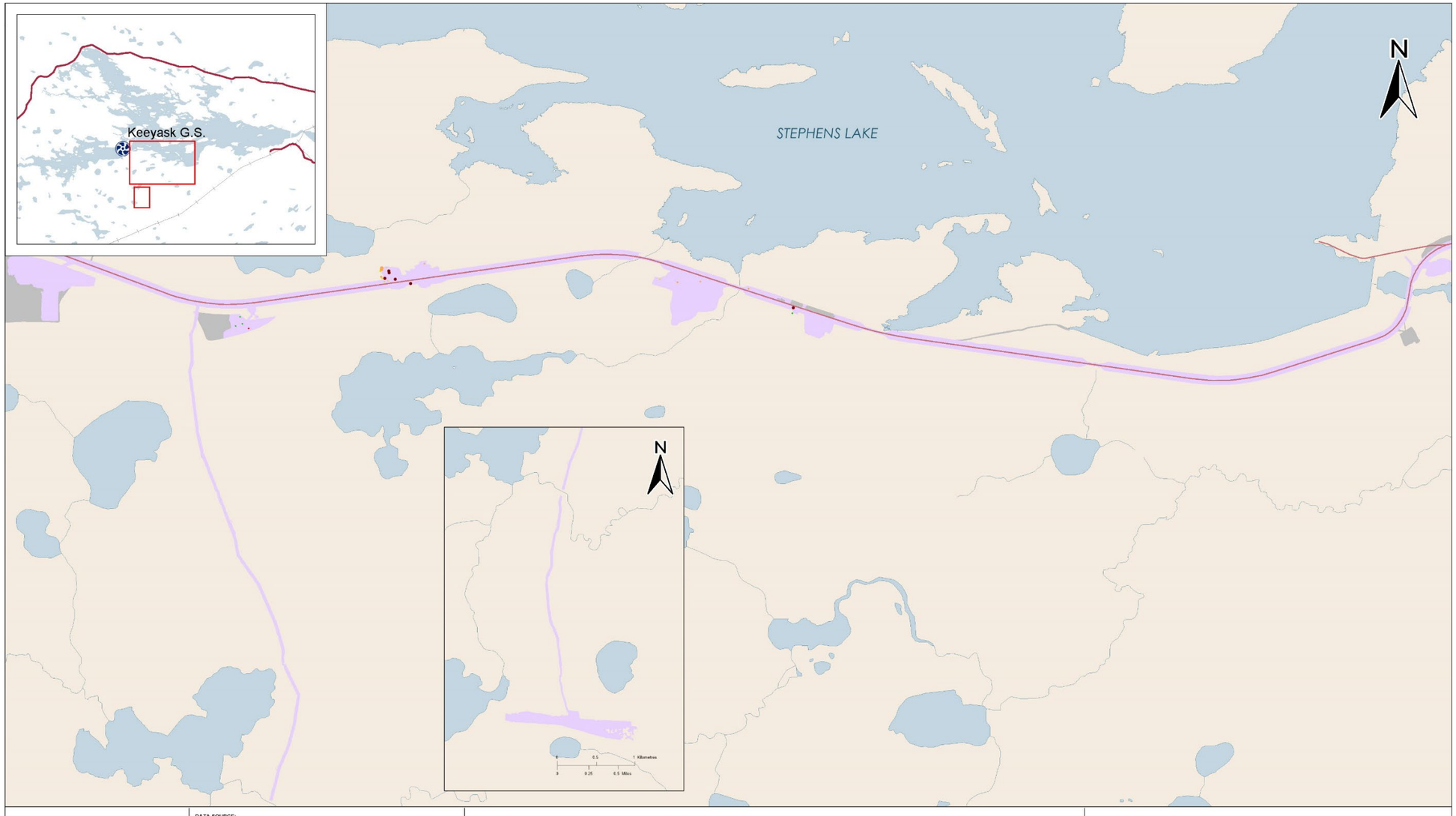
Map 6-3: Location of common tansy identified during Project construction and operation monitoring



Map 6-4: 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, 2022

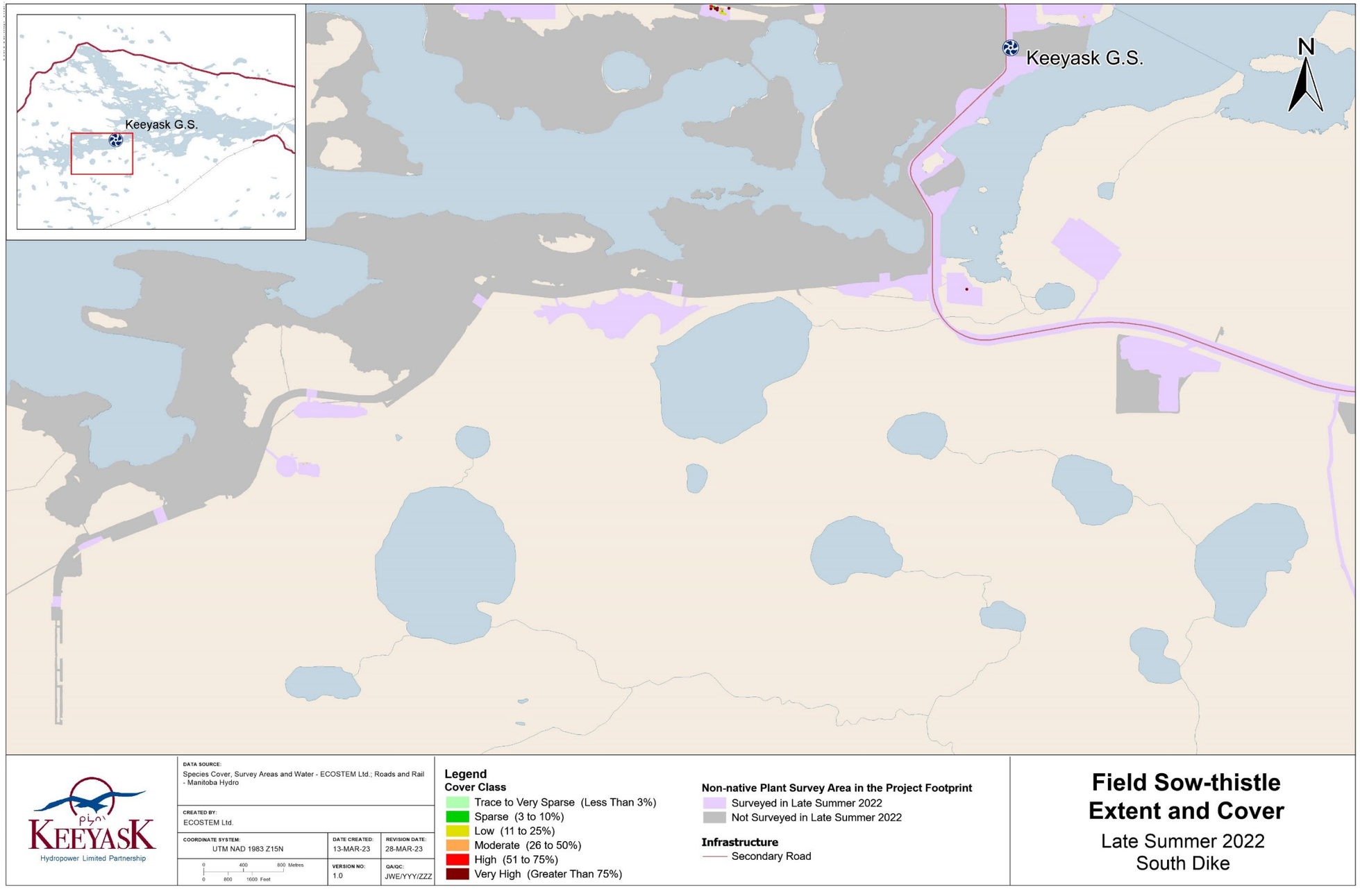


Map 6-5: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the eastern portion of the North Access Road in late summer, 2022

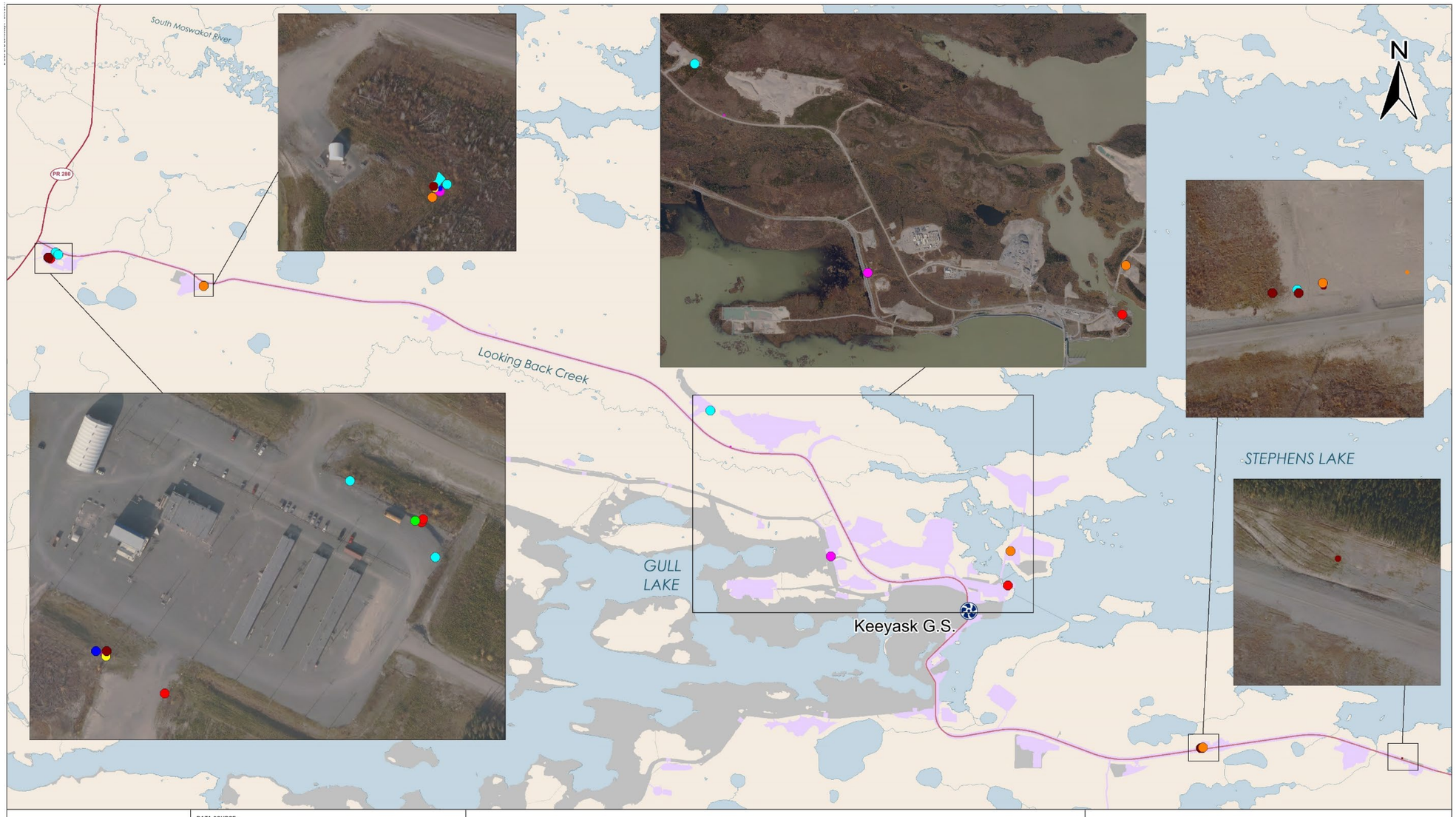


Map 6-6: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the western portion of the South Access Road in late summer, 2022

Map 6-7: 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, 2022

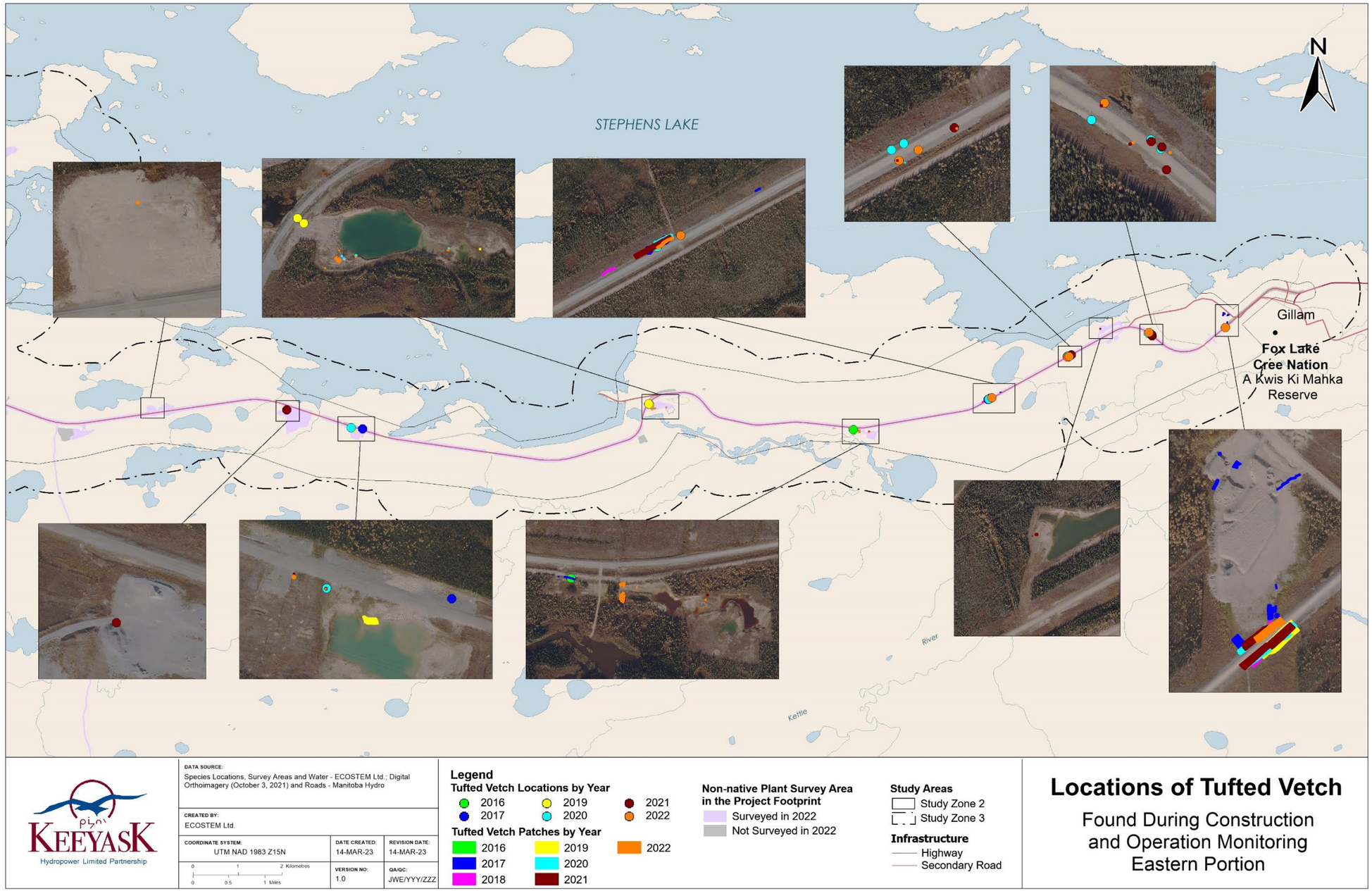


Map 6-8: The distribution and abundance (cover class) of field sow-thistle in the Project footprint along the South Dike in late summer, 2022

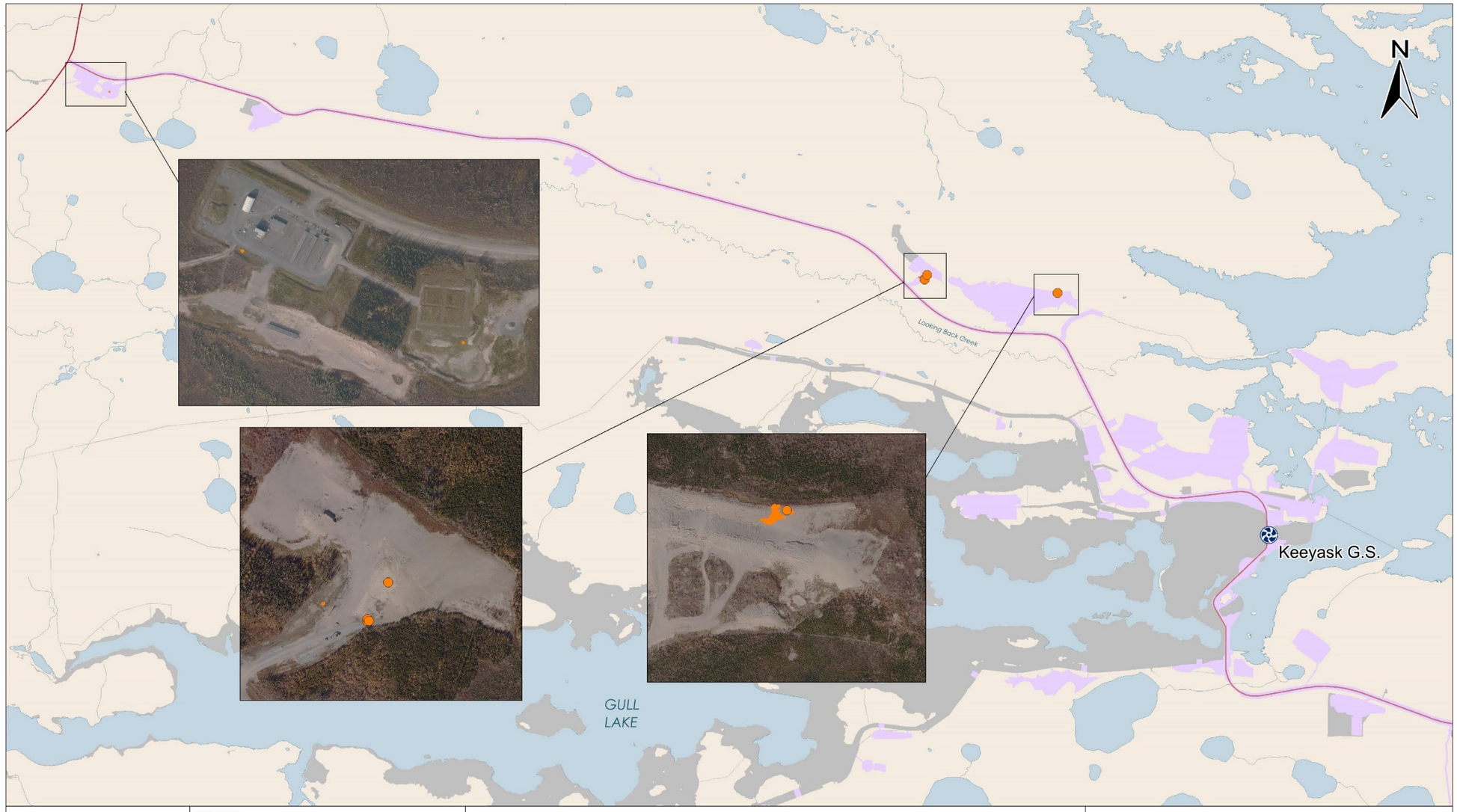


Map 6-9: Canada thistle locations identified during Project construction and operation monitoring

Map 6-10: Tufted vetch locations identified during Project construction and operation monitoring (western portion of Project footprint)



Map 6-11: Tufted vetch locations identified during Project construction and operation monitoring (eastern portion of Project footprint)



Map 6-12: Smooth brome locations identified in 2022