

# BIPOLE III TRANSMISSION PROJECT

## Permafrost Monitoring - Surface Temperature Change Detection Analysis

### 2014-2016

Prepared for :



Submitted by:



**Bipole III Transmission Project  
Permafrost Monitoring –  
Surface Temperature Change  
Detection Analysis 2014-2016**

Final Report



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November 14, 2016

## **Sign-off Sheet**

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**BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE  
DETECTION ANALYSIS 2014-2016**

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# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Introduction  
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## 1.0 INTRODUCTION

As a result of Bipole III Transmission Project's (the "Project") licence conditions imposed by Provincial regulatory authorities, Manitoba Hydro has requested that Stantec develop a permafrost and soil productivity monitoring program under its existing environmental monitoring framework agreement (Purchase Order No. 4500305162).

The following sections summarize the work conducted for the 2014 to 2016 monitoring period. The permafrost monitoring change detection analysis was developed for the northern sections of the Project, that is, Sections N1, N2, N3, the AC Collector Line and the Construction Power Line (**Map 1-1**).

## 1.1 BACKGROUND

Part of Manitoba Hydro's commitment to environmental protection included the development of a comprehensive Environmental Protection Program (EPP). This program included the development of a Project-Level Environmental Protection Plan (EnvPP) and Construction EnvPPs (CEnvPPs) specific to each major Project component.

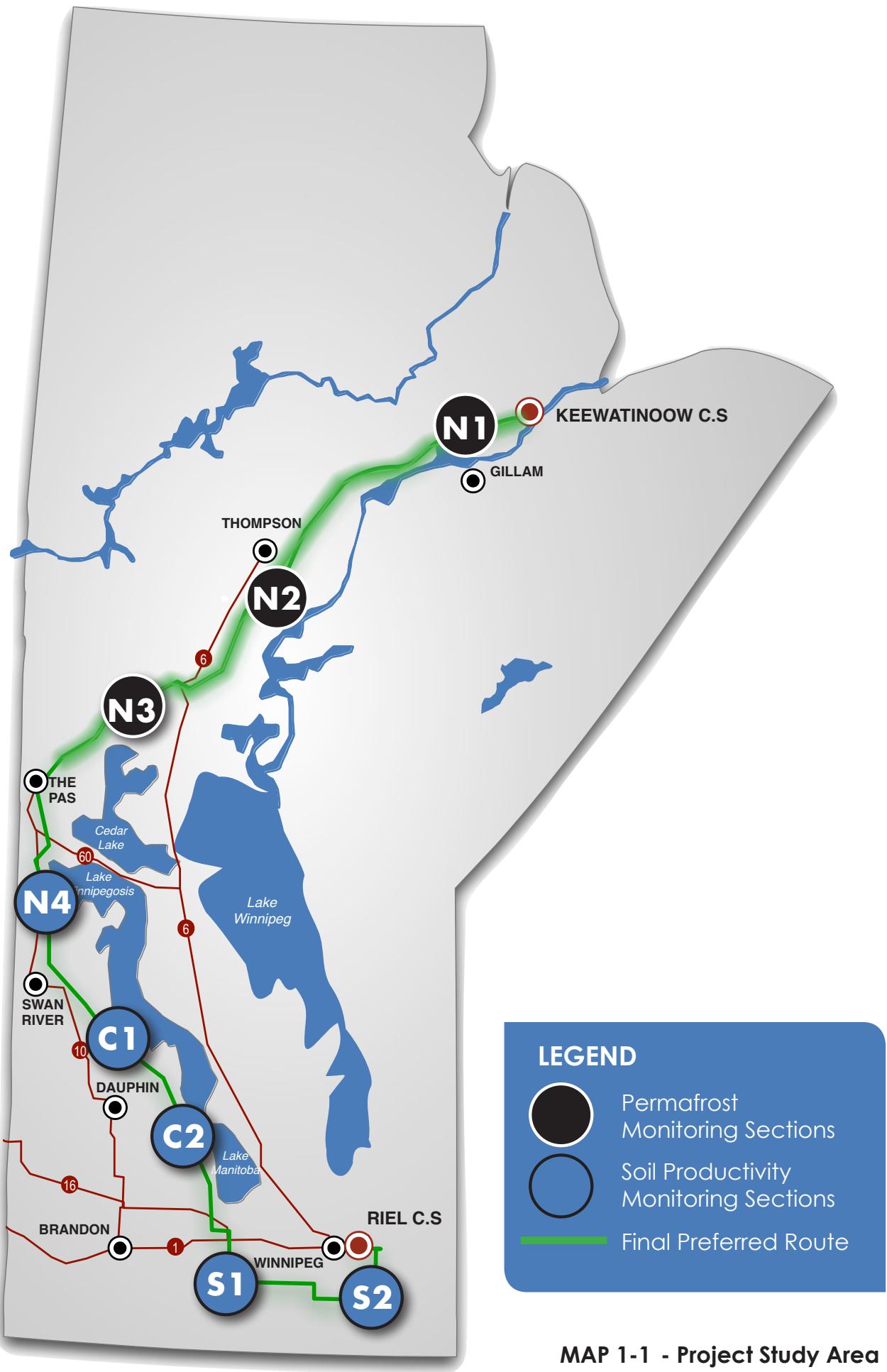
A number of Environmentally Sensitive Sites (ESS) have been identified around the various transmission components. ESS are locations, features, areas, activities or facilities that were identified in the Bipole III Transmission Project EIS to be ecologically, socially, economically or culturally important or sensitive to disturbance and require protection during construction of the project. The occurrence of permafrost in wetlands is an example of an ESS, as disturbance from anthropogenic activities has the potential to affect the stability of the permafrost.

### 1.1.1 Clearing Methods

Manitoba Hydro has implemented several clearing prescriptions for the construction of the transmission line rights-of-way. Various clearing methods have been used depending on specific site conditions initially identified in the CEnvPP (e.g., vegetation types, topography, distance from a wetland or from a riparian zone, permafrost occurrence, etc.). According to the Bipole III Transmission Project Annual Harvest Plan (Manitoba Hydro, Licensing and Environmental Assessment Department, Transmission Planning and Design Division, 2014), clearing methods include:

- Blading – using bull dozer equipment to pile biomass for disposal.
- Selective harvest – using low impact harvest techniques such as feller buncher, and hand clearing using brush and chainsaws as prescribed on ESS map sheets within the CEnvPP.





MAP 1-1 - Project Study Area

## BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Introduction  
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Disposal methods include:

- Burning – disposal of biomass by pile and burning between November 15 and March 31<sup>st</sup>.
- Salvage – disposal of merchantable timber to local milling operations or communities for firewood.

**Table 1-1** summarizes the various clearing types and methods used along the northern sections of the Project.

**Table 1-1 Vegetation Clearing Methods**

Clearing Type	Method(s) Used
General	<ul style="list-style-type: none"><li>• Shear blade (i.e., a bull dozer equipment to remove and pile biomass for disposal)</li><li>• Feller-buncher (i.e., a motorized vehicle used to grab, cut and gather trees)</li></ul>
Low Disturbance	<ul style="list-style-type: none"><li>• Shearblade ("Light-touch")</li><li>• Mulcher (i.e., a single motorized vehicle to cut and grind vegetation)</li></ul>
Selective	<ul style="list-style-type: none"><li>• Hand clear</li><li>• Feller-buncher</li></ul>

## 1.2 LANDSAT-8 THERMAL INFRARED SENSOR (TIRS)

Due to the shear length of the Bipole III transmission line, collecting permafrost data for the entire RoW would be too time consuming and costly. Stantec used Landsat-8 Thermal Infrared Sensor (TIRS) imagery to track surface temperature of the entire length of N1 to N3 and the construction power and collector lines. TIRS records the exposed surface temperature of objects within its instantaneous view of the Earth; it does not measure the ambient air temperature but rather the top of vegetation and top of soil surface temperature. TIRS cannot penetrate vegetation or ground surfaces and therefore cannot record sub-surface temperatures. Surface temperatures from Landsat-8 imagery in this investigation act as a surrogate measure for the temperature of sub-surface permafrost. Identifying surface temperature changes from clearing provides an understanding of areas that are at risk or are more likely to experience permafrost melting and ground subsidence.

Complete ROW coverage by Landsat-8 TIRS enabled all clearing practice types to be monitored for their effectiveness of retaining surface temperatures. TIRS data was collected for the entire northern RoW study area throughout the growing season. Landsat-8 has been continuously collecting thermal imagery since 2014 allowing for preconstruction thermal information of the entire RoW to be collected and analyzed for the effectiveness of each clearing practice type since 2014.



# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Image Processing  
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## 2.0 IMAGE PROCESSING

### 2.1 IMAGE ACQUISITION

Landsat-8 Thermal Infrared Sensor (TIRS) records surface temperature using two thermals channels, 10.8 µm and 12 µm, at 30-m resolution. The TIRS sensor is affected by atmospheric interference such as clouds, fog, rain or smoke and requires cloud free conditions to collect surface temperature information. The Landsat-8 satellite has a repeat coverage cycle of 16 days and has a 30% overlap swath width at mid-latitudes. Satellite image acquisition for the Bipole III RoW required multiple orbital paths due to the sheer size of the extent. Due to cloud cover, a long repeat coverage period and a high level of orbital overlap, each Landsat-8 image mosaic is unique in timing, orbital paths and number of images required to cover the RoW. Landsat-8 imagery was collected twice a year for 2014, 2015 and 2016 where cloud free data was available (**Table 2-1**).

**Table 2-1      Landsat-8 TIRS Image Acquisition for Six Time Periods and Dates**

<b>Summer 2014</b>	<b>Fall 2014</b>	<b>Summer 2015</b>	<b>Non-Peak 2015</b>	<b>Spring 2016</b>	<b>Summer 2016</b>
Jul 27, 2014	Aug 5, 2014	Jun 3, 2015	Jun 5, 2015	May 31, 2016	Aug 20, 2016
Jul 29, 2014	Aug 19, 2014	Jun 21, 2015	Sep 11, 2015	Jun 14, 2016	Aug 20, 2016
Jul 29, 2014	Sep 24, 2014	Jul 14, 2015	Oct 2, 2015	Jun 21, 2016	Aug 22, 2016
Aug 3, 2014	Oct 15, 2014	Jul 21, 2015	Oct 2, 2015	Jun 30, 2016	Aug 22, 2016
Aug 10, 2014		Aug 24, 2015		Jul 16, 2016	

### 2.2 ATMOSPHERIC CORRECTION

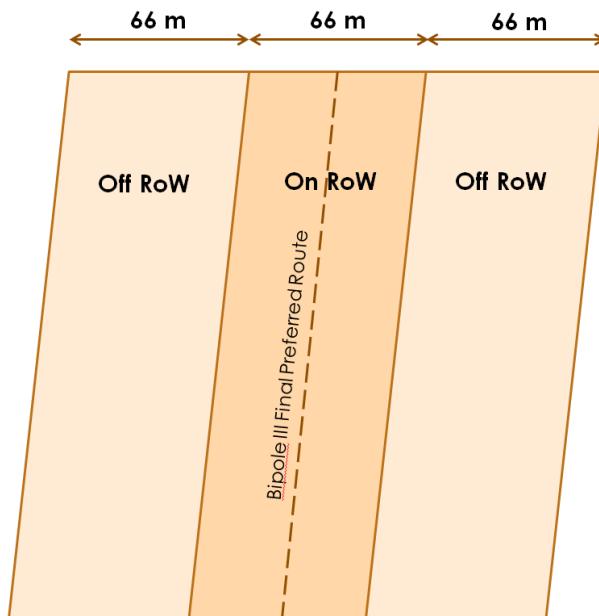
PCI Geomatica's ATCOR program was used to generate top of atmosphere (TOA) reflectance values used to convert pixel values to physical temperature measurements using the radiometric calibration coefficients for the TIRS thermal channels. Haze removal was performed as part of the atmospheric correction allowing for precise thermal measurements. ATCOR successfully normalized solar illumination conditions at different time periods allowing for accurate change detection analysis over multiple years. All imagery was converted to Celsius degree data resulting in six continuous coverages of Bipole III sections N1, N2, N3 and the AC construction power and collector lines.

# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Methodology  
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## 3.0 METHODOLOGY

The Bipole III final preferred route is 66 m in width and represents the area that will be affected by the Bipole III RoW. The 66-m-wide RoW was then buffered again by 66 m on both sides, resulting in three 66-m-width corridors – one ‘On the Row’ and two ‘Off the RoW’ (**Figure 3-1**). The same procedure was used for the AC collector lines but 132-m buffers were used.

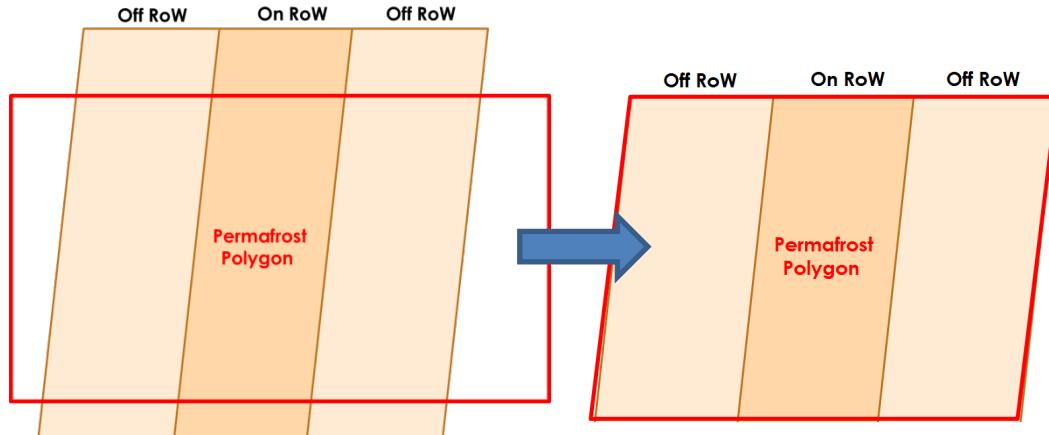


**Figure 3-1 Bipole III Final Preferred Route Buffered Creating Three Corridors – One On RoW and Two Off RoW**

The three corridors were then clipped by areas identified as environmentally sensitive permafrost sites in the Manitoba Hydro Construction Environmental Protection Plan (CEnvPP) (MB Hydro, 2013) to isolate permafrost areas (**Figure 3-2**).

# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Methodology  
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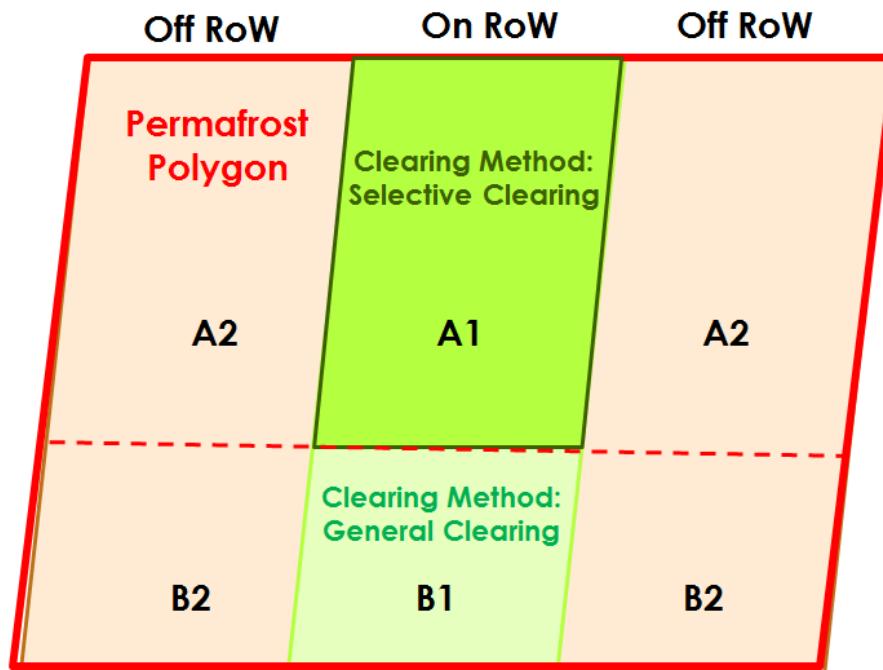
**Figure 3-2 The Three Bipole III RoW Corridors Clipped by Permafrost Polygons to Isolate Permafrost Areas**

## 3.1 CLEARING PRESCRIPTION COMPARISON

Permafrost polygons were then overlaid with the 2014-2016 surface temperature Landsat-8 TIRS coverages generating an average celsius value calculated for each polygon and for each time period. Permafrost areas were sub-sampled further to compare the effect of Manitoba Hydro's clearing prescription practices and to what extent the clearing method had an impact on derived surface temperature values (**Figure 3-3**).

# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Methodology  
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**Figure 3-3 Permafrost Areas (red) were Subdivided by Clearing Methods to Compare On RoW and Off RoW Surface Temperatures**

In the sample, Area A1 is compared against A2 areas to determine the surface temperature difference based on the Clearing Method – Selection Clearing (dark green). Area B1 is compared against B2 areas to determine the surface temperature difference based on the Clearing Method – General Clearing (light green).

Temperature readings of On ROW versus Off RoW polygons were compared to determine if there is a relative surface temperature difference between cleared and non-cleared areas. Surface temperature differences were also compared for each clearing method type (Table 3-1).

**Table 3-1 Clearing Prescription Methods used for Surface Temperature Analysis of Permafrost Polygons**

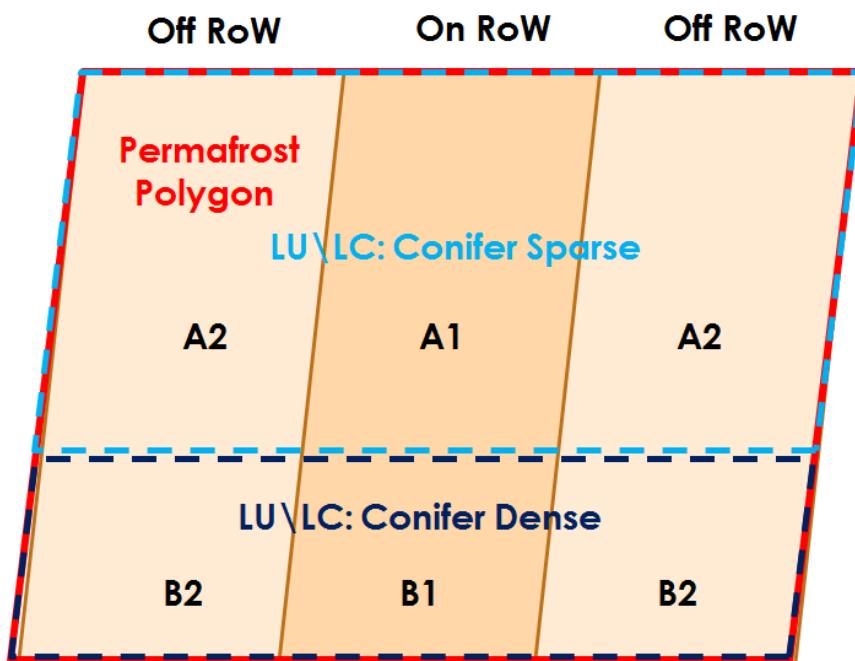
Clearing Type	Method(s) Used	Disturbance
General Clearing	Shearblade/Mulcer/Feller-buncher	Moderate-High
Low Disturbance Clearing	Shearblade (Light)/Mulcher	Low
Selective Clearing	Hand clear/Feller-buncher(saw mounted Pro Mac)	Low

# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

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## 3.2 LAND USE/LAND COVER COMPARISON

Permafrost areas were also sub-divided by land use/land cover (LU\LC) type by polygons. This task was done to ensure On/Off RoW polygon comparisons were relative as a permafrost polygon can have multiple LU/LC cover types with varying levels of surface temperature influences. The result was 524 permafrost polygons with matching On RoW and Off RoW land cover types to be used in the surface temperature relative change detection analysis (**Figure 3-4**).



**Figure 3-4** Permafrost Areas (red) were Subdivided by Land Use/Land Cover Class to Compare On RoW and Off RoW Surface Temperatures

In the sample, Area A1 is compared against A2 areas to determine the surface temperature difference based on the Conifer Sparse LU/LC class (light blue). Area B1 is compared against B2 areas to determine the surface temperature difference based on the Conifer Dense LU/LC class (dark blue).

# BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Results  
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## 4.0 RESULTS

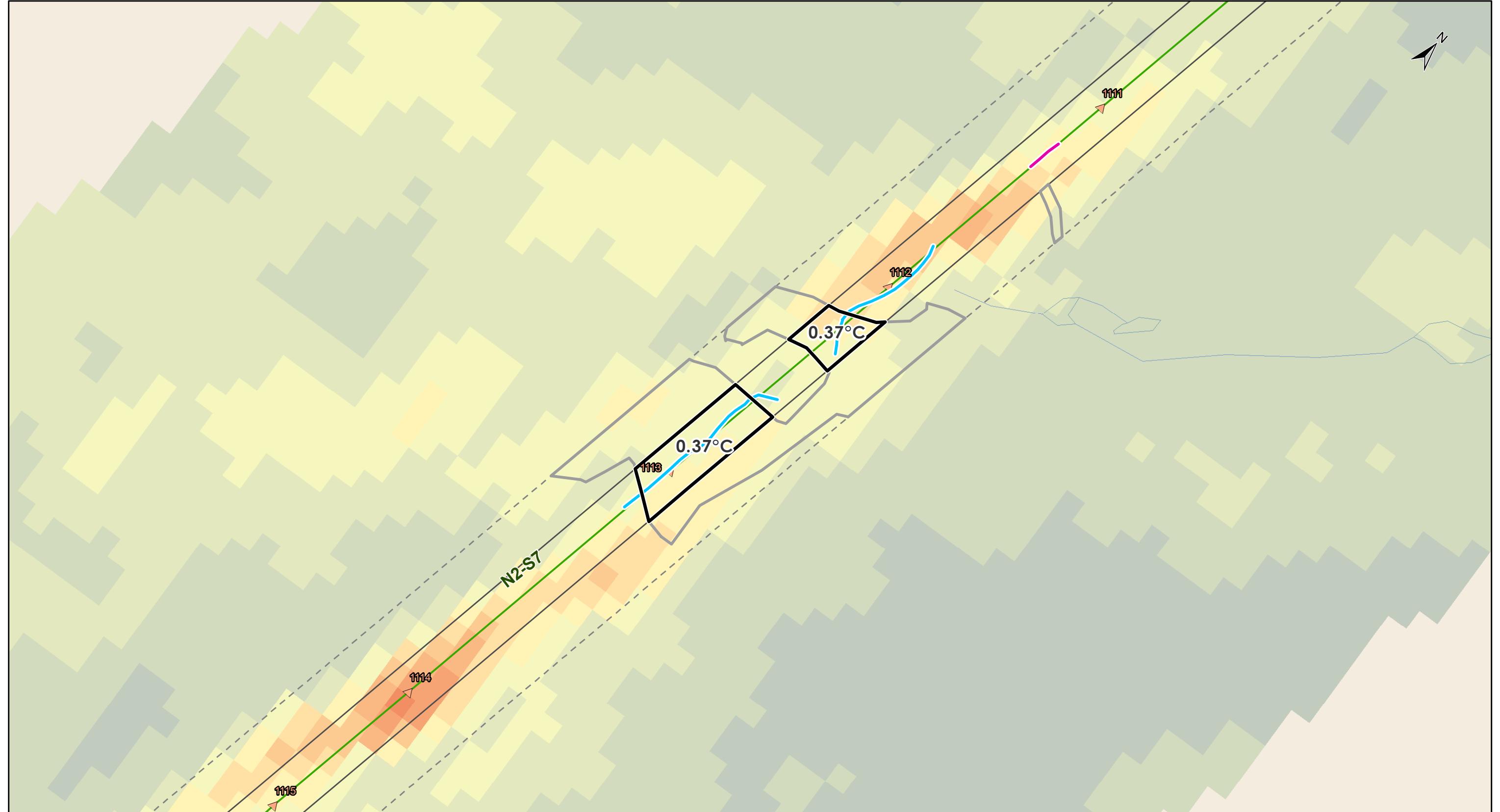
### 4.1 THERMAL CHANGE DETECTION ANALYSIS: CLEARING METHOD

All thermal data maps for the six TIRS coverages from 2014 to 2016 can be found in **Appendix A Map Series 4-100 to Map Series 4-300**. The relative surface temperature On/Off RoW change detection analysis by clearing method showed increases in surface temperature for all On RoW polygons (cleared) compared to Off RoW polygons (not cleared) (**Table 4-1**). This is likely due to vegetation removal (in one form or another) reducing the amount of cover shade increasing surface temperatures.

**Table 4-1 Relative On/Off RoW Surface Temperature Change in Degrees Celsius for the Six TIR Coverages by Clearing Practice**

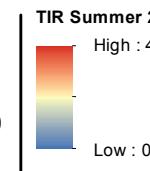
Clearing Practice	Summer 2014	Fall 2014	Spring 2015	Summer 2015	Spring 2016	Summer 2016
General Clearing	3.4	2.9	1.3	2.2	3.2	3.9
Low Disturbance Clearing	0.6	0.8	0.7	1.2	0.9	1.5
Selective Clearing	1.1	1.7	0.4	0.9	1.2	2.2

There were varying levels of surface temperature increases by clearing practice methods from 2014 to 2016 (**Figure 4-1**). Over the three year period, the General Clearing practice showed the highest relative On/Off RoW surface temperature change at 3.9°C in the summer of 2016 and had an average change over the three year period of 2.8°C. Low Disturbance Clearing had the lowest overall surface temperature change at 1.5°C in 2016 and an average change of 0.9°C. Selective Clearing had similar temperature increases of 2.2°C in 2016 and 1.2°C as a three year average. For comparison, representation of the correlation between each clearing method and temperatures for on and off RoW have been provided. For example, there is surface temperature warming for Low Disturbance and Selective Clearing (**Maps 4-1 and 4-2**) but not at the rate experienced by General Clearing methods (**Map 4-3**).



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 62.5 125 250  
Metres  
1:5,000



**TIR Change Detection Analysis**

- On ROW Polygons Used in Thermal Change Detection Analysis
- Off ROW Polygons Used in Thermal Change Detection Analysis

**ROW Clearing Methods**

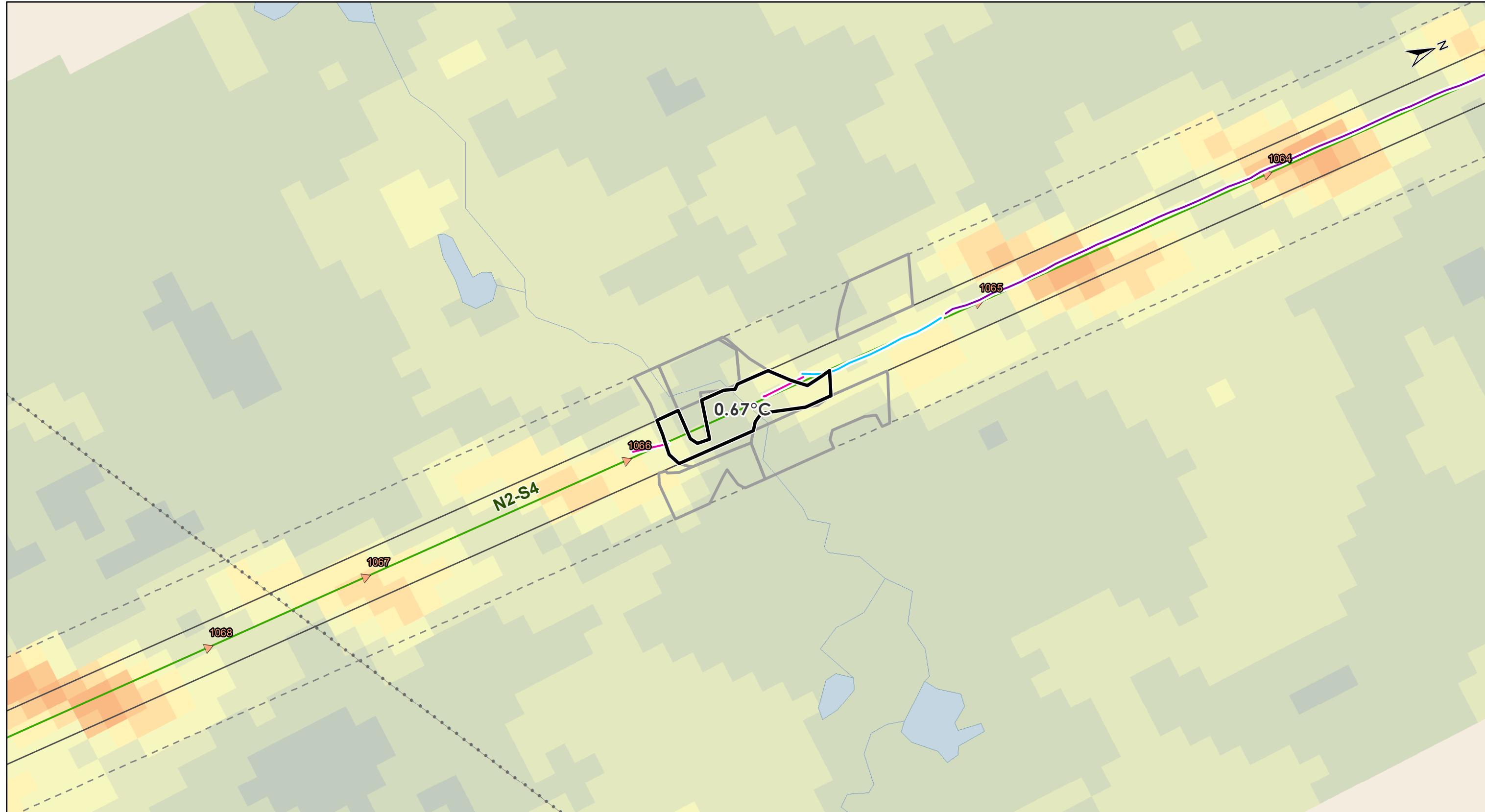
- Low Disturbance Clearing
- Selective Clearing

**Project Infrastructure**

## $^{\circ}\text{C}$	Temperature Change in $^{\circ}\text{C}$ Between On and Off ROW Polygons
Landbase	Watercourse

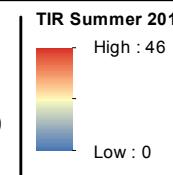
66m ROW  
66m Buffer of ROW  
Towers (Preliminary)

**Bipole III Transmission Project Permafrost Monitoring**  
**Thermal Change Detection Analysis**  
**N2-S7, Low Disturbance Clearing Method**  
**Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 62.5 125 250  
Metres  
1:5,000



**TIR Change Detection Analysis**

On ROW Polygons Used in Thermal Change Detection Analysis

Off ROW Polygons Used in Thermal Change Detection Analysis

**ROW Clearing Methods**

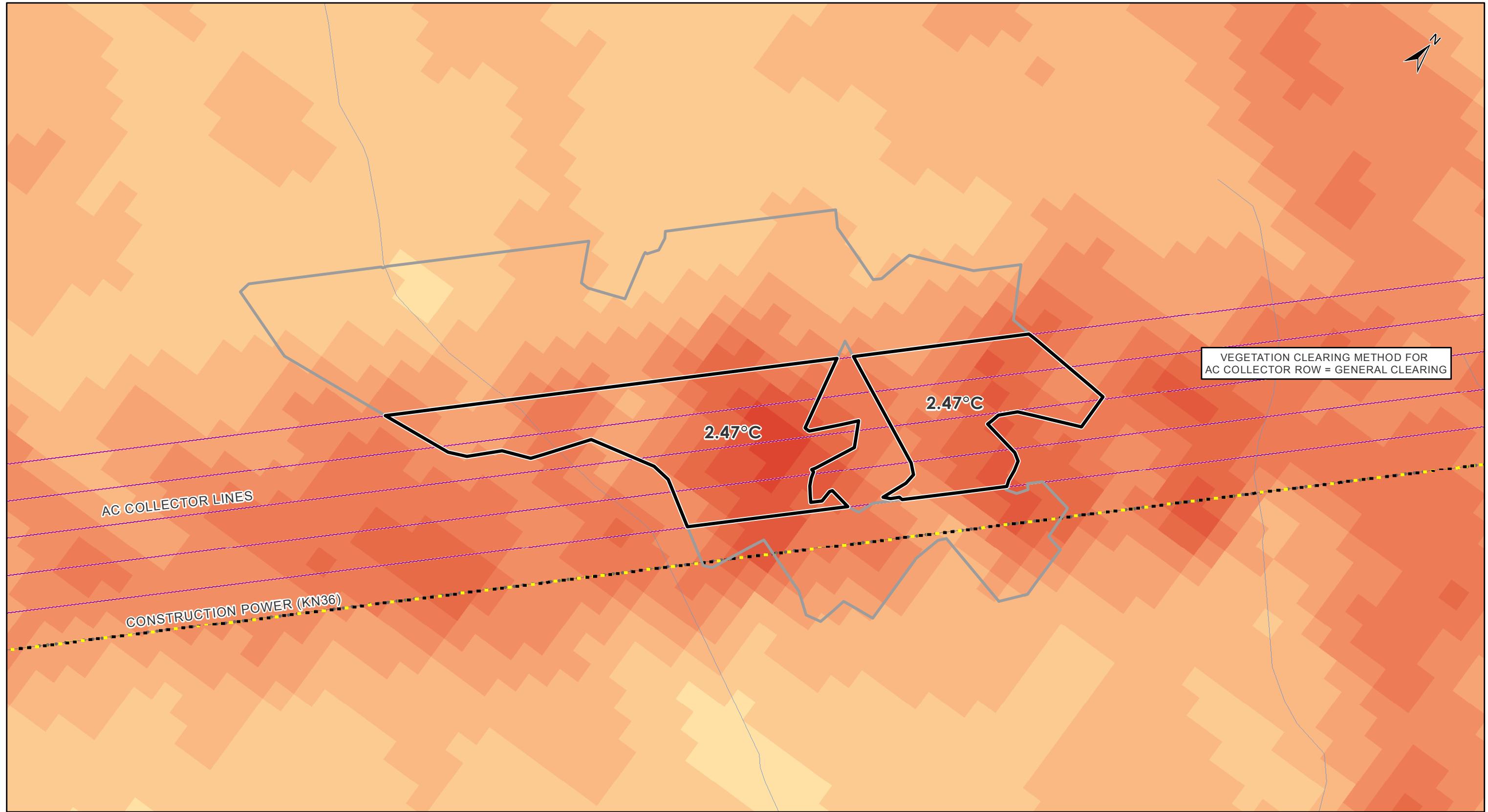
- General Clearing
- Low Disturbance Clearing
- Selective Clearing

## °C Temperature Change in °C Between On and Off ROW Polygons

Landbase

- Transmission Line
- Watercourse
- Waterbody

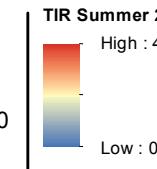
**Bipole III Transmission Project Permafrost Monitoring**  
**Thermal Change Detection Analysis N2-S4, Selective Clearing Method Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 62.5 125 250 Metres

1:5,000



**TIR Change Detection Analysis**

- On ROW Polygons Used in Thermal Change Detection Analysis
- Off ROW Polygons Used in Thermal Change Detection Analysis

## °C Temperature Change in °C Between On and Off ROW Polygons

**Project Infrastructure**

- Construction Power (KN36)
- AC Collector Line

**Landbase**

- Transmission Line
- Watercourse

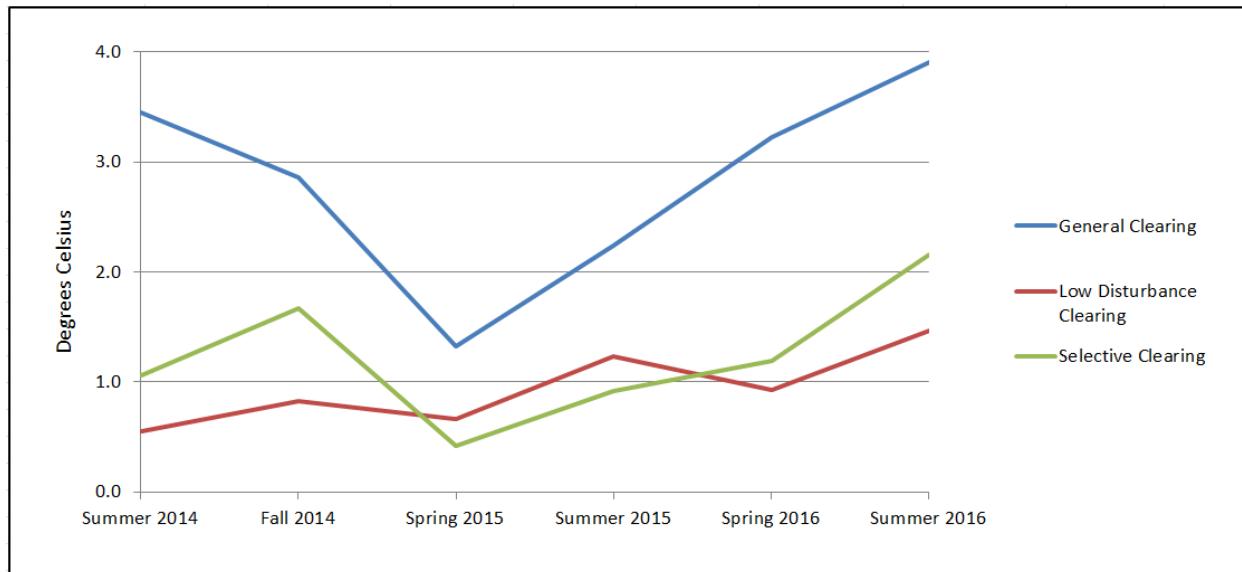
**Bipole III Transmission Project  
Permafrost Monitoring**  
**Thermal Change Detection Analysis  
AC Collector Line, General Vegetation Clearing Method  
Summer 2016**



## BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

### Results

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**Figure 4-1    Relative On/Off RoW Surface Temperature Change in Degrees Celsius from 2014 to 2016 by Clearing Practice**

## 4.2    THERMAL CHANGE DETECTION ANALYSIS: LU/LC CLASS

The relative surface temperature On/Off RoW change detection analysis by LU/LC class showed increases in temperature for all On RoW polygons (cleared) compared to Off RoW polygons (not cleared) over the three-year time period (**Table 4-2**). Each of the forested classes (Broadleaf, Mixedwood and Conifer Dense, Open and Sparse) shared similar surface temperature change ranging from 0.41°C (Broadleaf) to 0.74°C (Conifer Sparse) in the summer of 2016.

**Table 4-2    Relative Surface Temperature On/Off RoW Change Detection Analysis by LU/LC Class from 2014 to 2016 for Forested classes**

LU/LC Class	Summer 2014	Fall 2014	Spring 2015	Summer 2015	Spring 2016	Summer 2016
Broadleaf Dense	0.77	0.46	0.18	0.45	0.27	0.41
Mixedwood Dense	0.60	0.47	0.26	0.69	0.33	0.55
Coniferous Dense	0.62	0.44	0.18	0.54	0.49	0.57
Coniferous Open	0.95	0.49	0.39	0.54	0.66	0.65

## BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

Results

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**Table 4-2 Relative Surface Temperature On/Off RoW Change Detection Analysis by LU/LC Class from 2014 to 2016 for Forested classes**

LU/LC Class	Summer 2014	Fall 2014	Spring 2015	Summer 2015	Spring 2016	Summer 2016
Coniferous Sparse	0.99	0.52	0.28	0.43	0.78	0.74

The Treed Wetland and Herbaceous Wetland classes showed similar surface temperature increase at 0.11°C and 0.16°C respectively while the Shrub Wetland class increased 0.44°C in 2016 (**Table 4-3**). Grassland and Tall Shrub had nearly identical surface temperature results in 2016 at 0.26°C and 0.28°C respectively.

**Table 4-3 Relative Surface Temperature On/Off RoW Change Detection Analysis by LU/LC Class from 2014 to 2016 for all Remaining Classes**

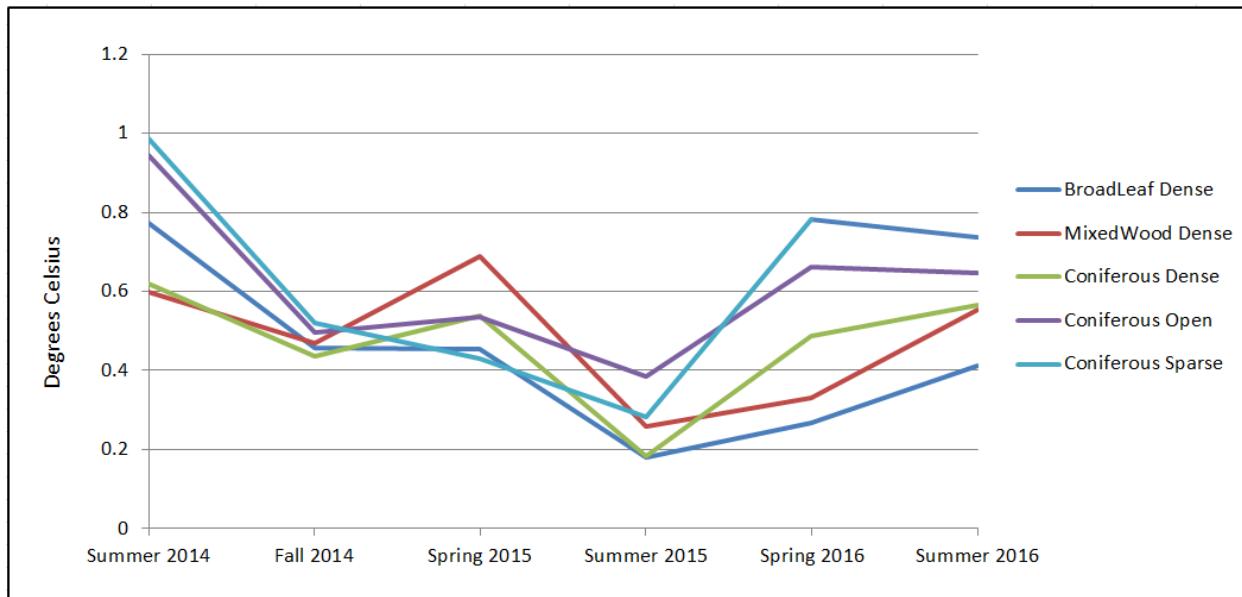
LU/LC Class	Summer 2014	Fall 2014	Spring 2015	Summer 2015	Spring 2016	Summer 2016
Grassland	0.36	0.03	0.58	0.35	0.22	0.26
Shrub Tall	0.17	0.16	0.11	0.26	0.37	0.28
Water	0.46	0.47	0.19	0.02	0.21	0.28
Wetland Herb	0.15	-0.01	0.23	0.23	0.11	0.16
Wetland Shrub	0.55	0.39	0.25	0.37	0.43	0.44
Wetland Treed	0.35	0.20	0.35	0.36	0.21	0.11

Each of the forest classes had a similar surface temperature increase signature over time the three-year period (**Figure 4-2**). Each forest class demonstrated a high degree of temperature change shortly after clearing in 2014 or 2015 followed by a reduction of increase, but then had a gradual surface temperature increase from summer 2015 to summer 2016.

## BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

### Results

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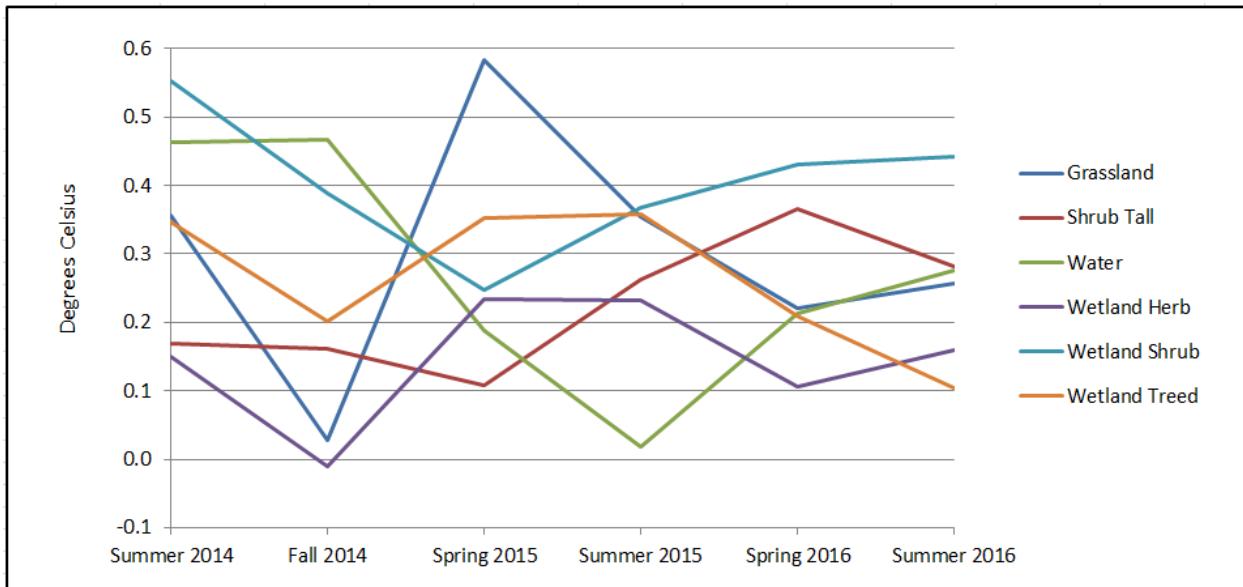
**Figure 4-2 Relative Surface Temperature On/Off RoW Change Detection Analysis by LU/LC Class from 2014 to 2016 for Forested Classes**

The wetland classes (Treed, Shrub and Herbaceous Wetlands) shared a similar surface temperature increase profile ranging from  $-0.01^{\circ}\text{C}$  in 2014 to  $0.44^{\circ}\text{C}$  in 2016. The wetland classes did not display an overall warming trend but were consistently warmer overall (**Figure 4-3**). The Shrub Tall class showed a marginal warming trend from  $0.17^{\circ}\text{C}$  to  $0.28^{\circ}\text{C}$  from 2014 to 2016. The Grassland class acted similar to the forest classes with an initial large increase in temperature change followed by a drop and a continual rise from spring 2015 to summer 2016.

## BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016

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**Figure 4-3 Relative Surface Temperature On/Off RoW Change Detection Analysis by LU/LC Class from 2014 to 2016 for all Remaining Classes**

## **BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016**

Conclusions  
November 14, 2016

### **5.0 CONCLUSIONS**

Any form of vegetation removal has resulted in a relative On/Off RoW surface temperature increase. The clearing practice trends identified would suggest permafrost thawing will occur more rapidly in areas that were cleared using the General Clearing methods than areas cleared by Low Disturbance or Selective Clearing methods. The Low Disturbance and Selective Clearing mitigation methods implemented by MB Hydro initially appear to have slowed surface temperature increases relative to General Clearing practices. Stantec will need to correlate in-ground permafrost instrument readings established in late 2016 with Landsat-8 TIR readings in subsequent project years to determine if satellite surface temperatures values can be used to predict permafrost temperature change in northern Manitoba.

Landsat-8 TIRS imagery from 2014-2016 found all LU/LC classes experienced an increase in a relative On/Off RoW surface temperature. Forested classes had the highest thermal changes and the wetland classes the lowest. Forest classes generally have the highest amount of vegetation biomass and shading to keep the ground temperature cooler than classes with less biomass such as grassland or shrubland. When trees are removed from the landscape the ground surface will experience the highest amount of sunlight exposure increase resulting in a higher surface temperature increase. This phenomenon was identified and delineated by thermal satellite imagery. The wetland classes had the lowest amount of surface temperature increase likely from TIRS sensing cooler water temperatures present both before and after clearing methods resulting in marginal surface temperature changes.



## **BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE DETECTION ANALYSIS 2014-2016**

References  
November 14, 2016

### **6.0 REFERENCES**

Manitoba Hydro, 2013. Bipole III Transmission Project, Construction Environmental Protection Plan, AC Collector Lines, Construction Power Line and Station, November 18, 2013.

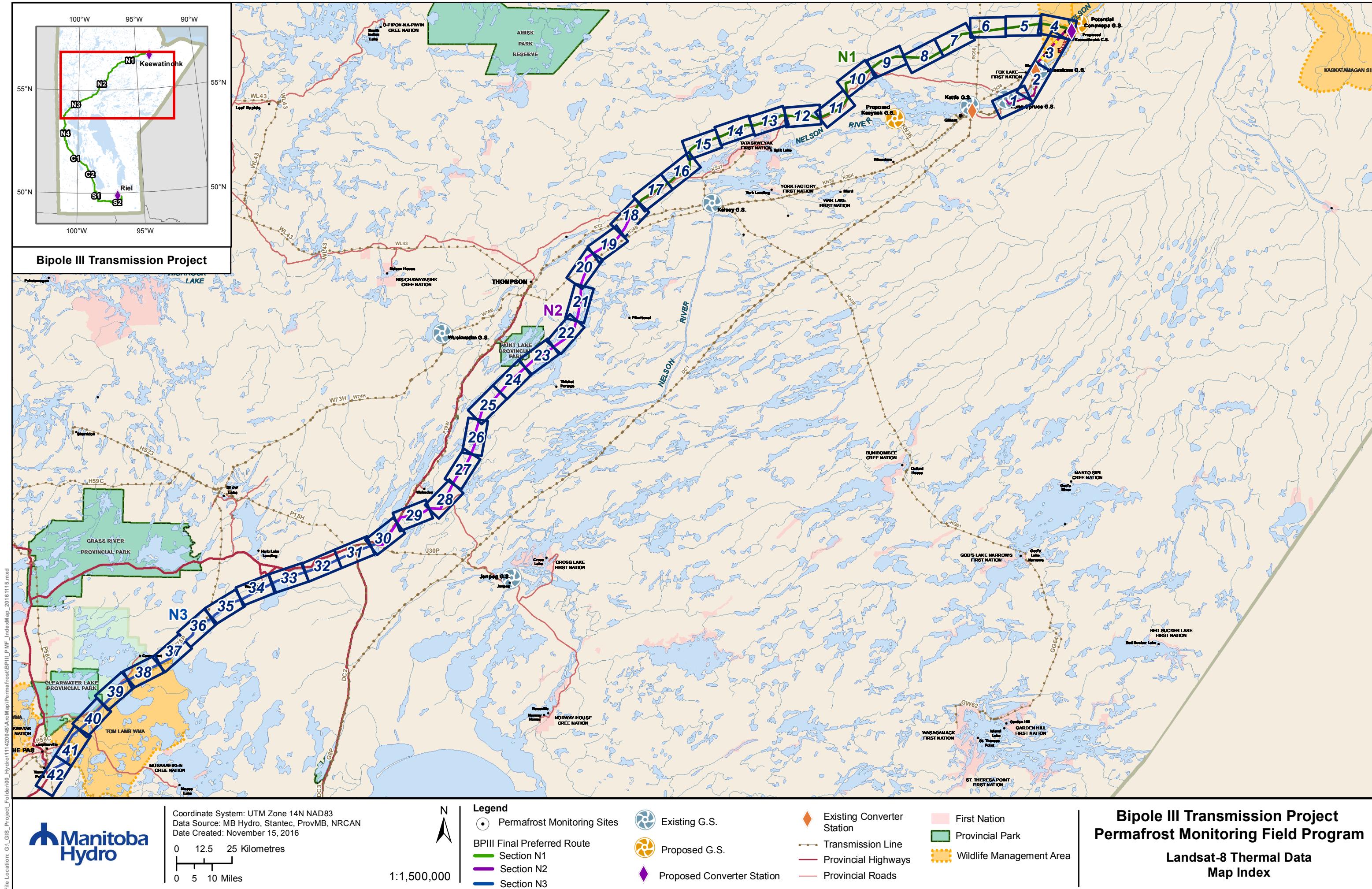
Manitoba Hydro, 2014. Bipole III Transmission Project Annual Harvest Plan N1,N2,N3 Bipole Transmission Line, AC Collector, Construction Power and Ground Electrode Transmission Lines

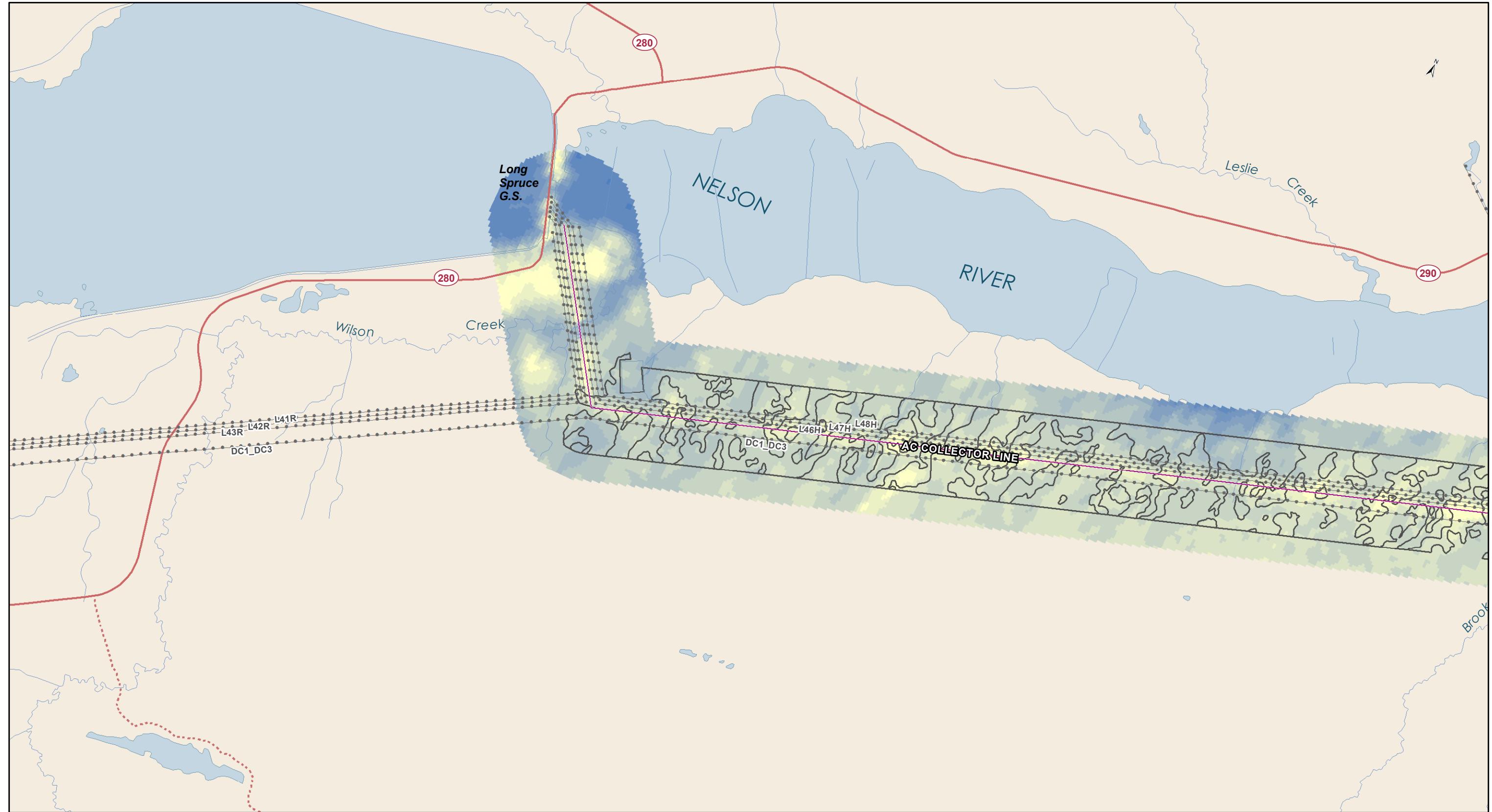
**BIPOLE III TRANSMISSION PROJECT PERMAFROST MONITORING – SURFACE TEMPERATURE CHANGE  
DETECTION ANALYSIS 2014-2016**

References  
November 14, 2016

**Appendix A MAPS**



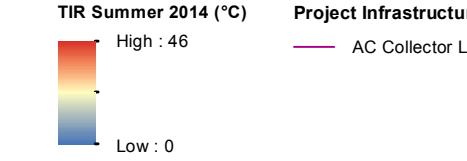




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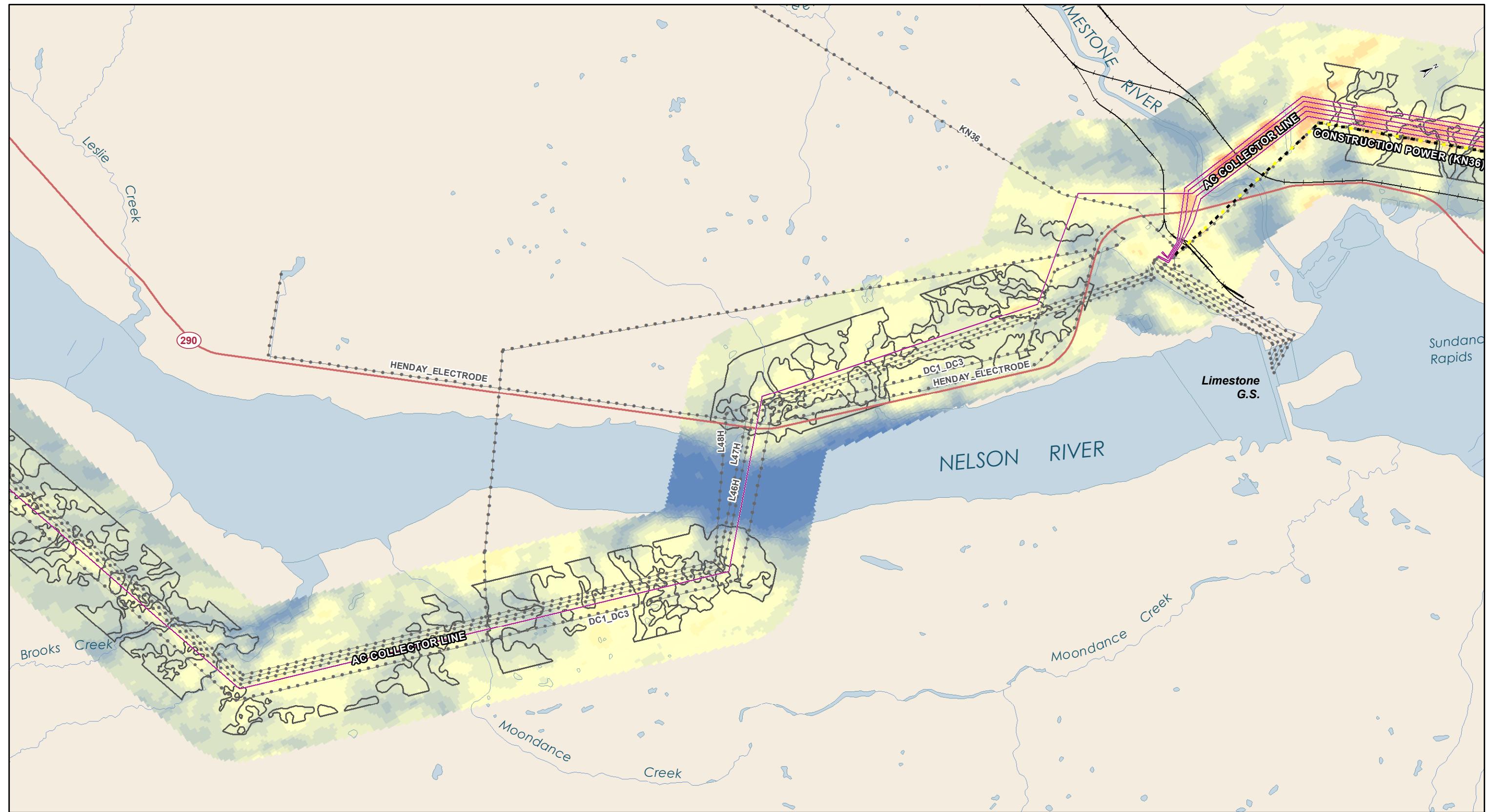
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**Project Infrastructure****AC Collector Line**

- Landbase**
- Provincial Road
  - Winter Road
  - Transmission Line
  - Watercourse
  - Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



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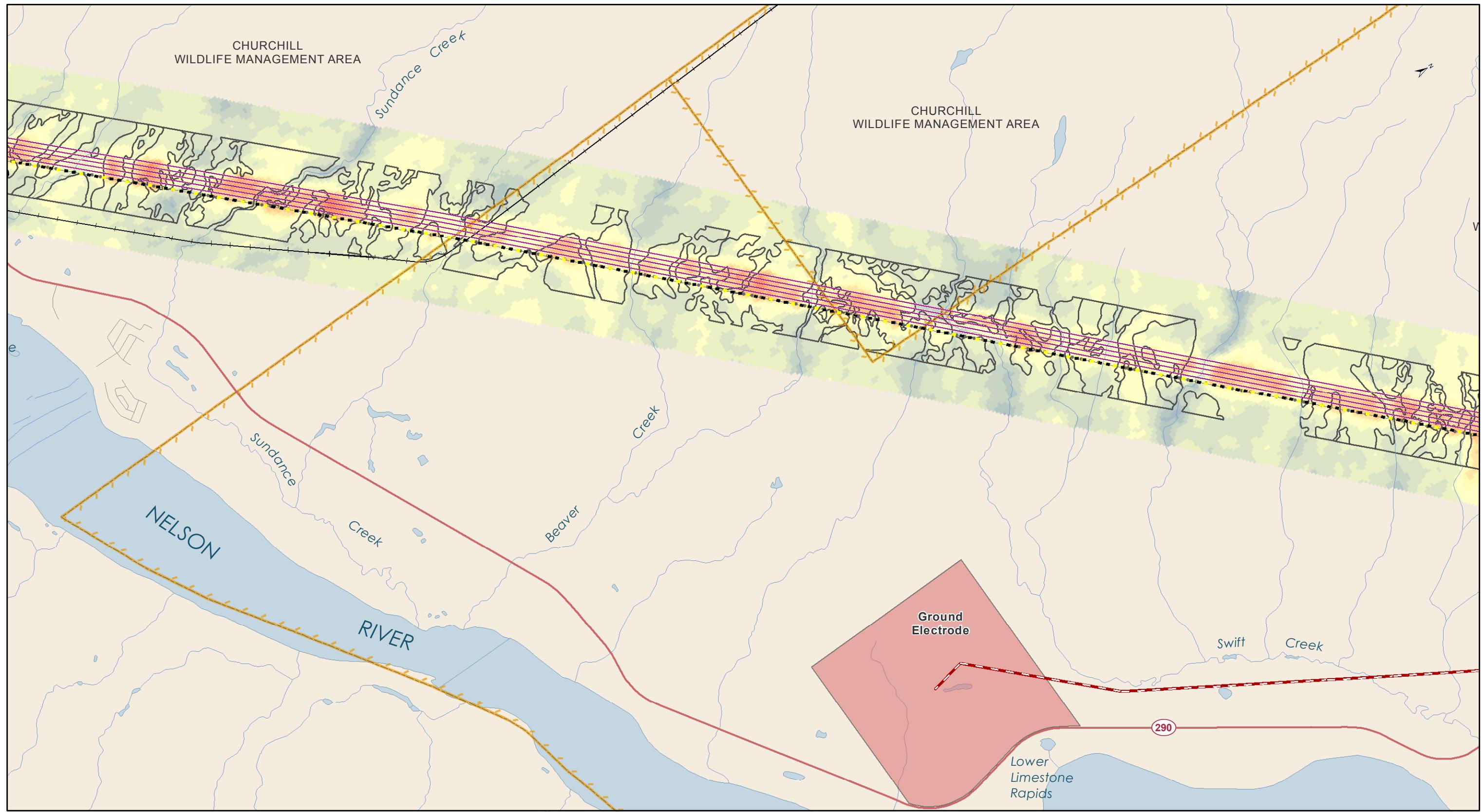
Base Data  
Permafrost

TIR Summer 2014 (°C)  
High : 46  
Low : 0

Project Infrastructure  
Construction Power (KN36)  
AC Collector Line

Landbase  
Provincial Road  
Railway (Operational)  
Transmission Line  
First Nation  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2014



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 15, 2016

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**Base Data**  
Permafrost

**TIR Summer 2014 (°C)**  
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Low : 0

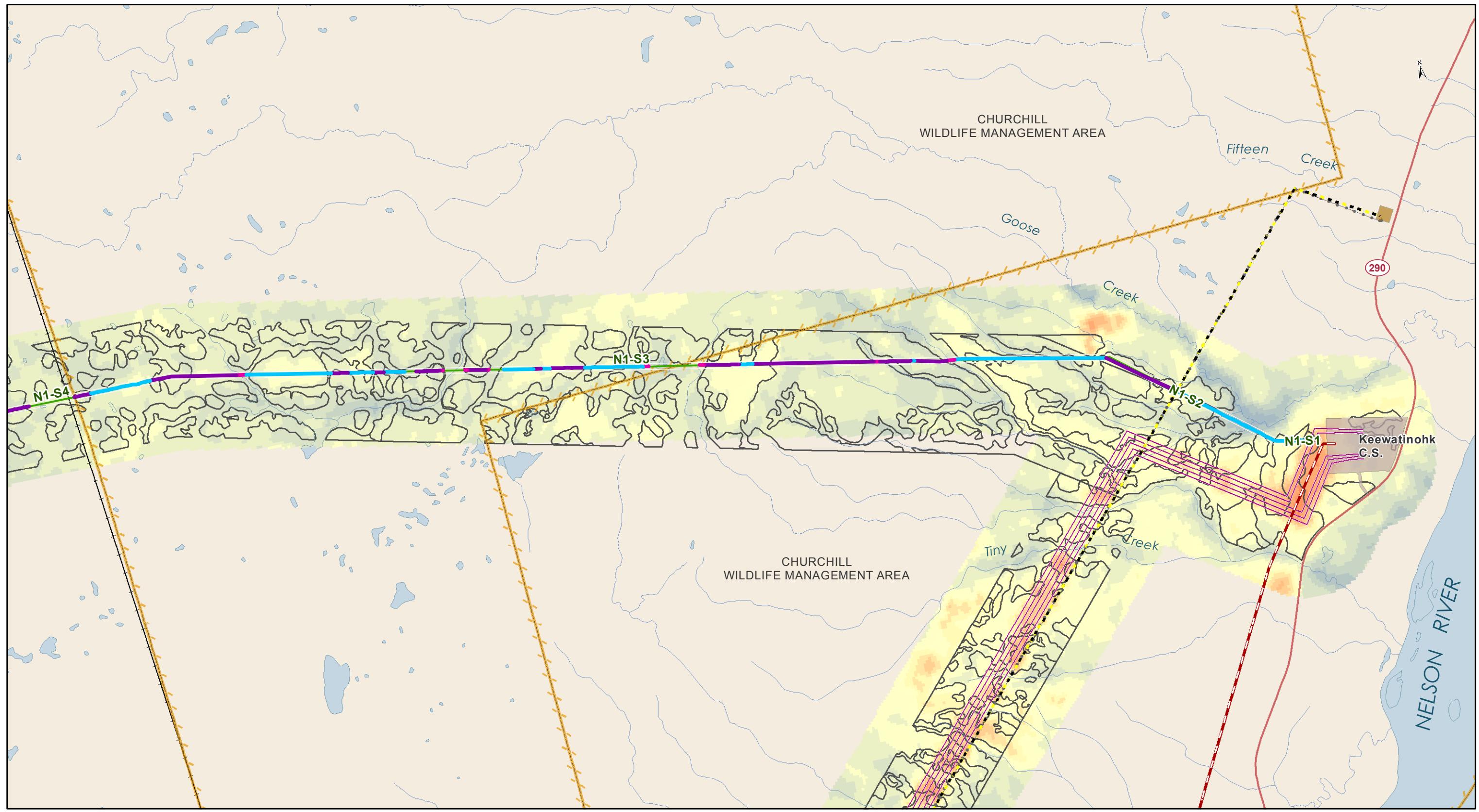
**Project Infrastructure**

- Construction Power (KN36)
- Ground Electrode Line
- AC Collector Line

**Landbase**

- Provincial Road
- Local Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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**Base Data**

- Permafrost
- ROW Clearing Methods
- General Clearing
- Low Disturbance Clearing
- AC Collector Line
- Selective Clearing

**TIR Summer 2014 (°C)**

High : 46  
Low : 0

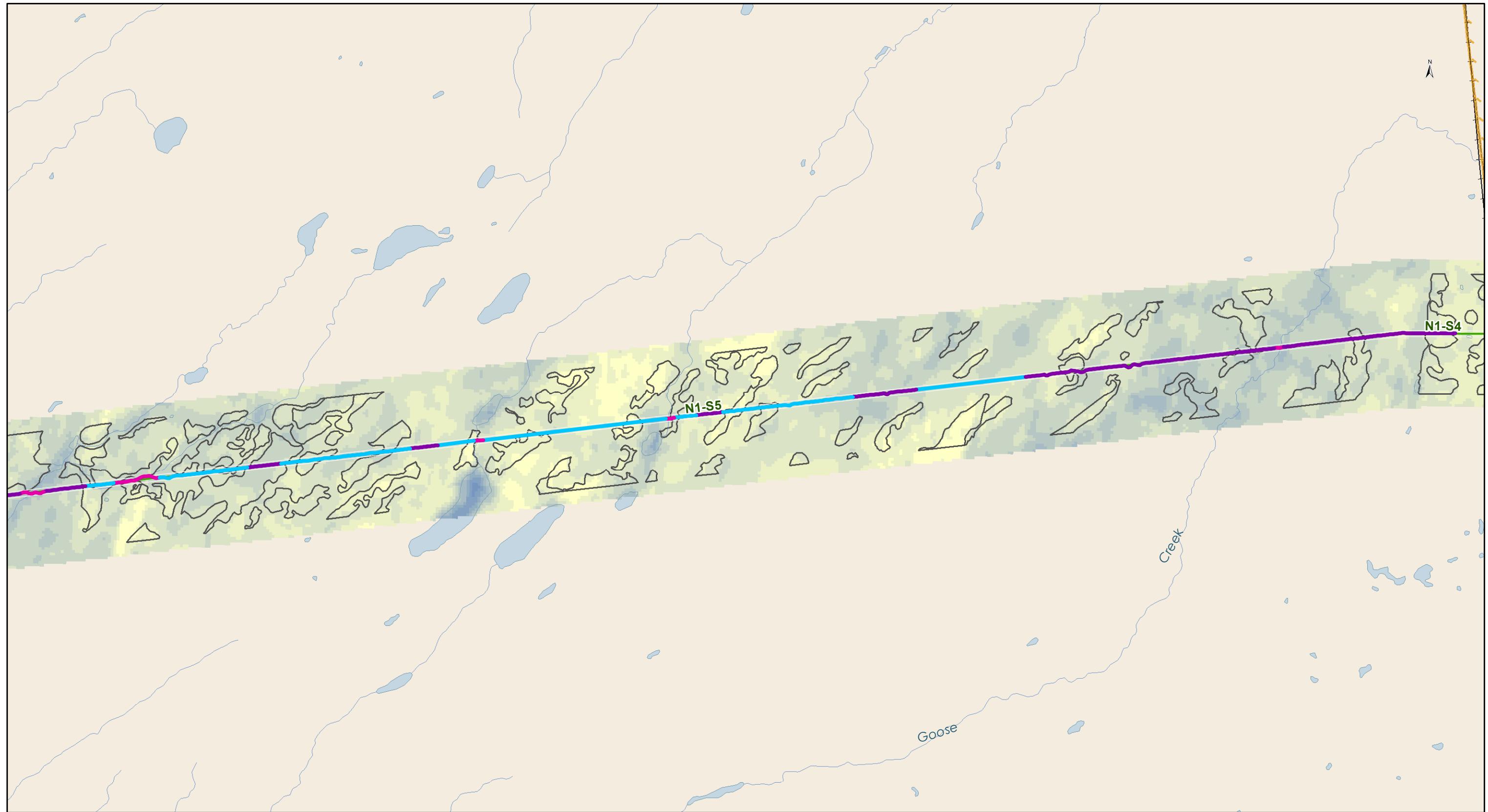
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW
- Construction Power (KN36)
- Ground Electrode Line
- AC Collector Line

**Landbase**

- Keewatinook Converter Station
- Construction Power Station
- Provincial Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**

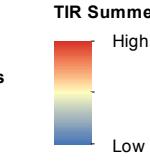


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Date Created: November 14, 2016

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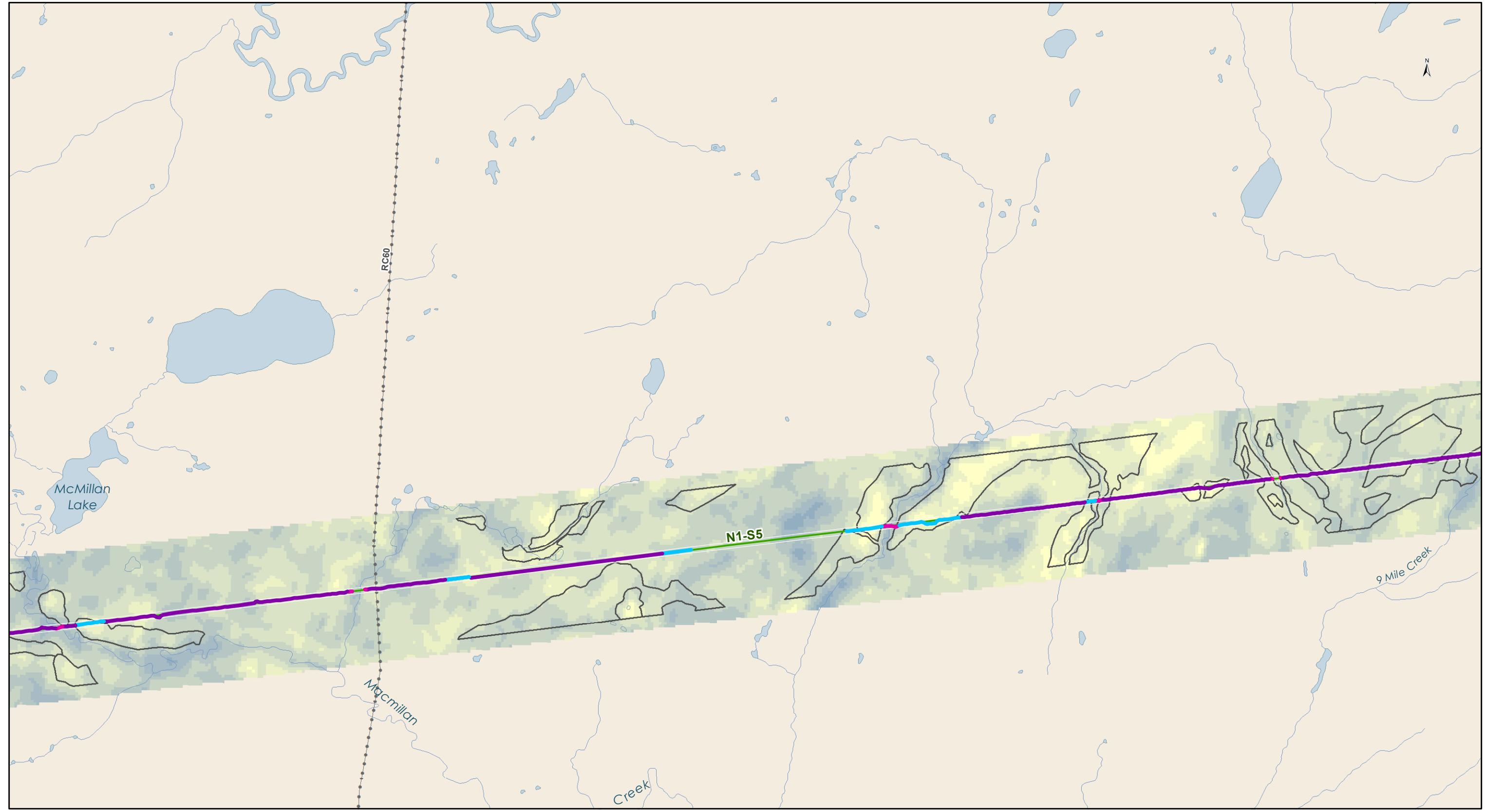
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



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Date Created: November 14, 2016

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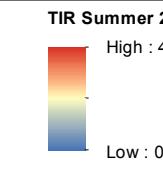
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



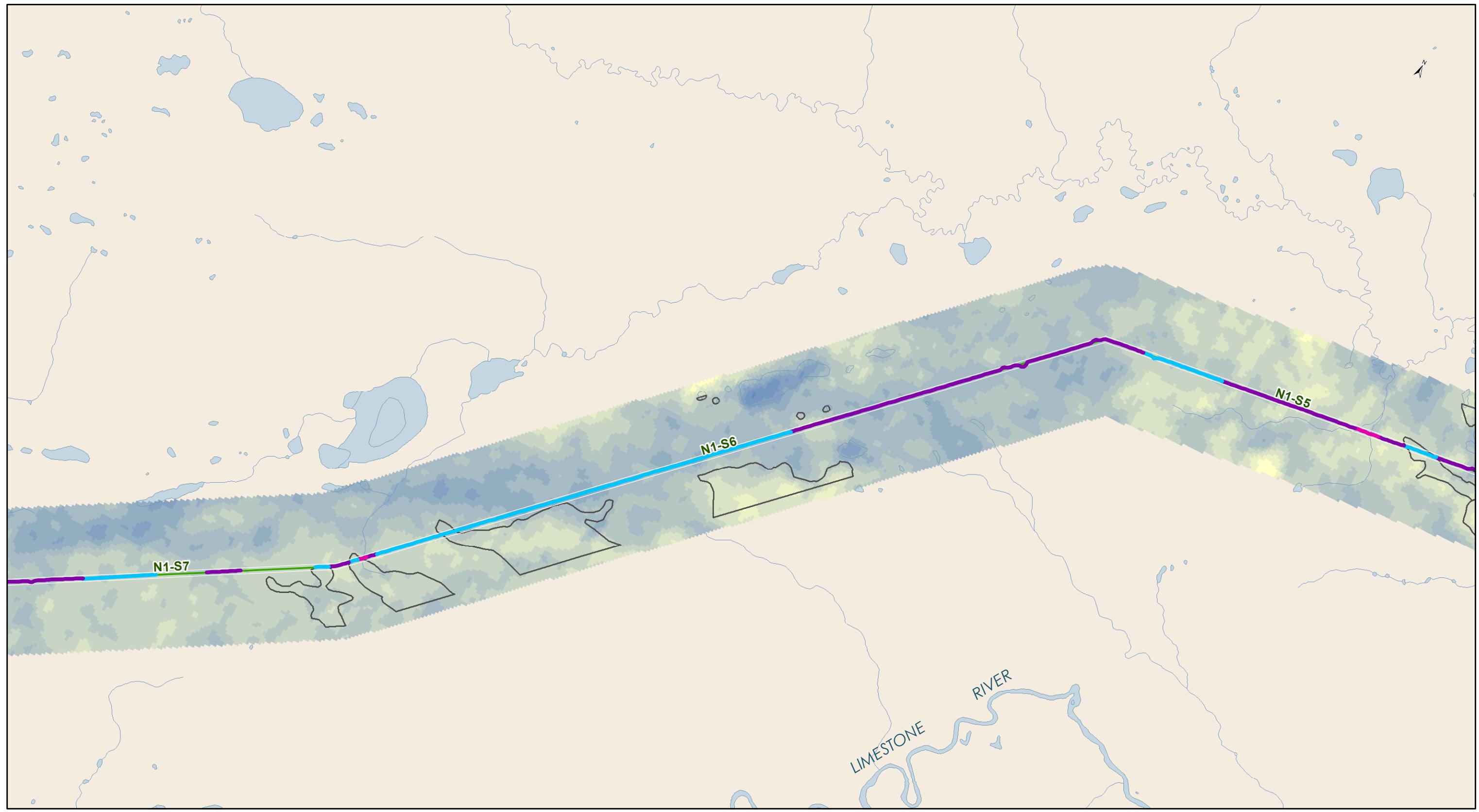
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



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Data Source: MB Hydro, ProvMB, NRCAN  
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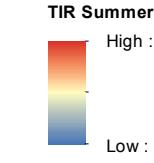
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



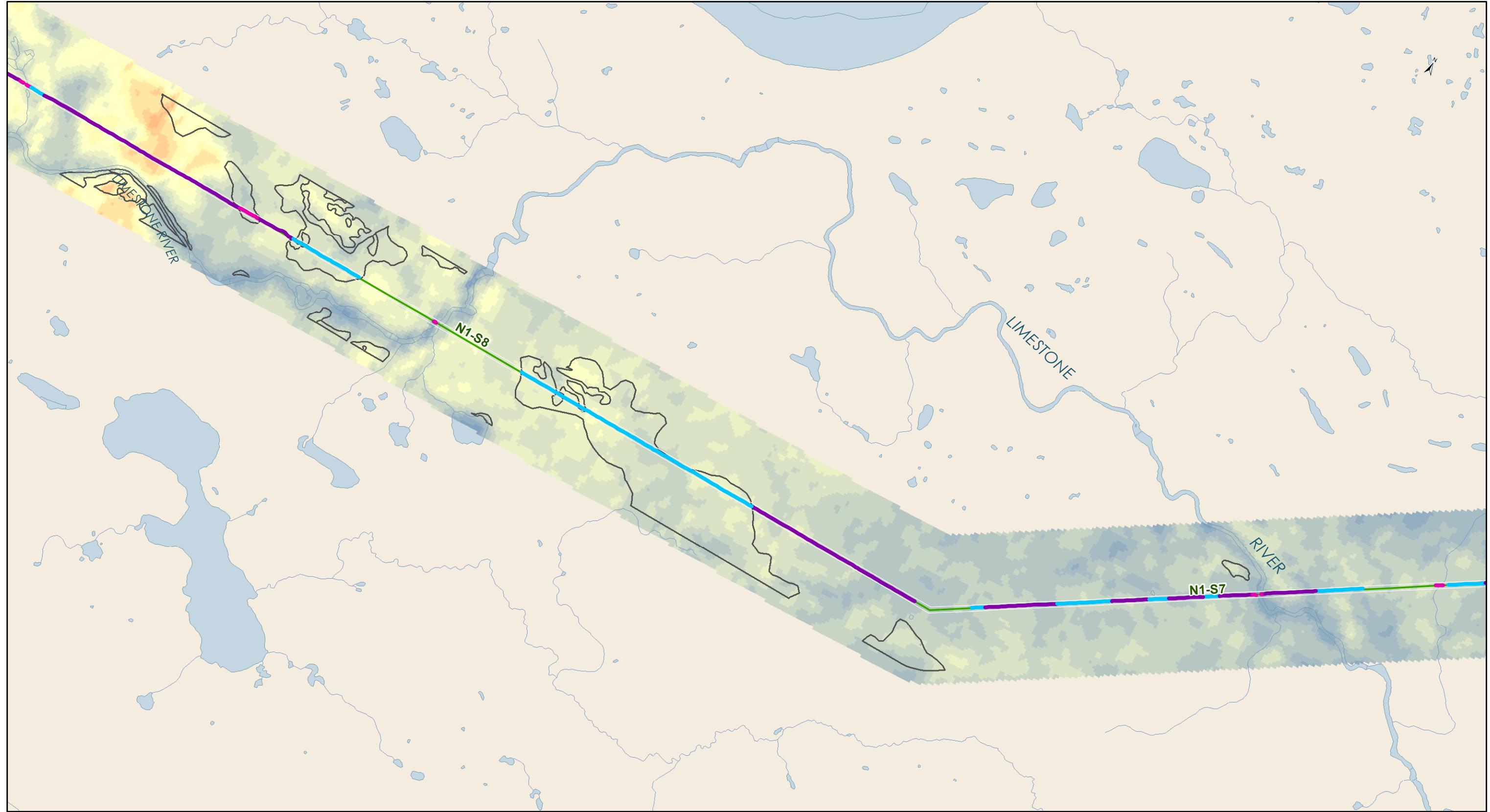
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2014**



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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

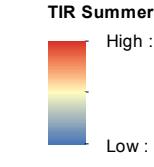
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



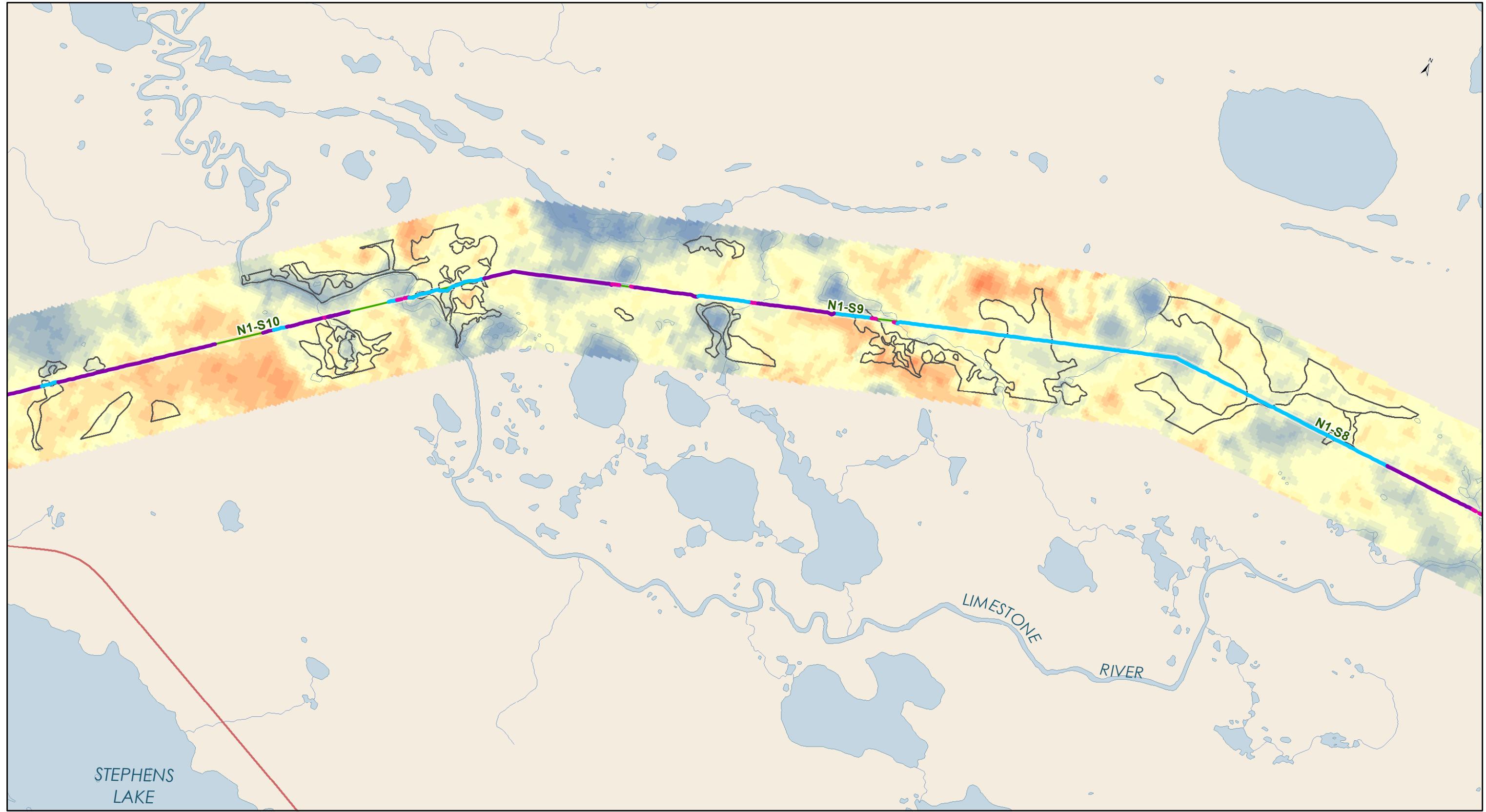
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



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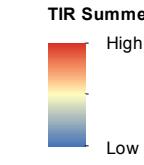
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**Base Data**  
Permafrost

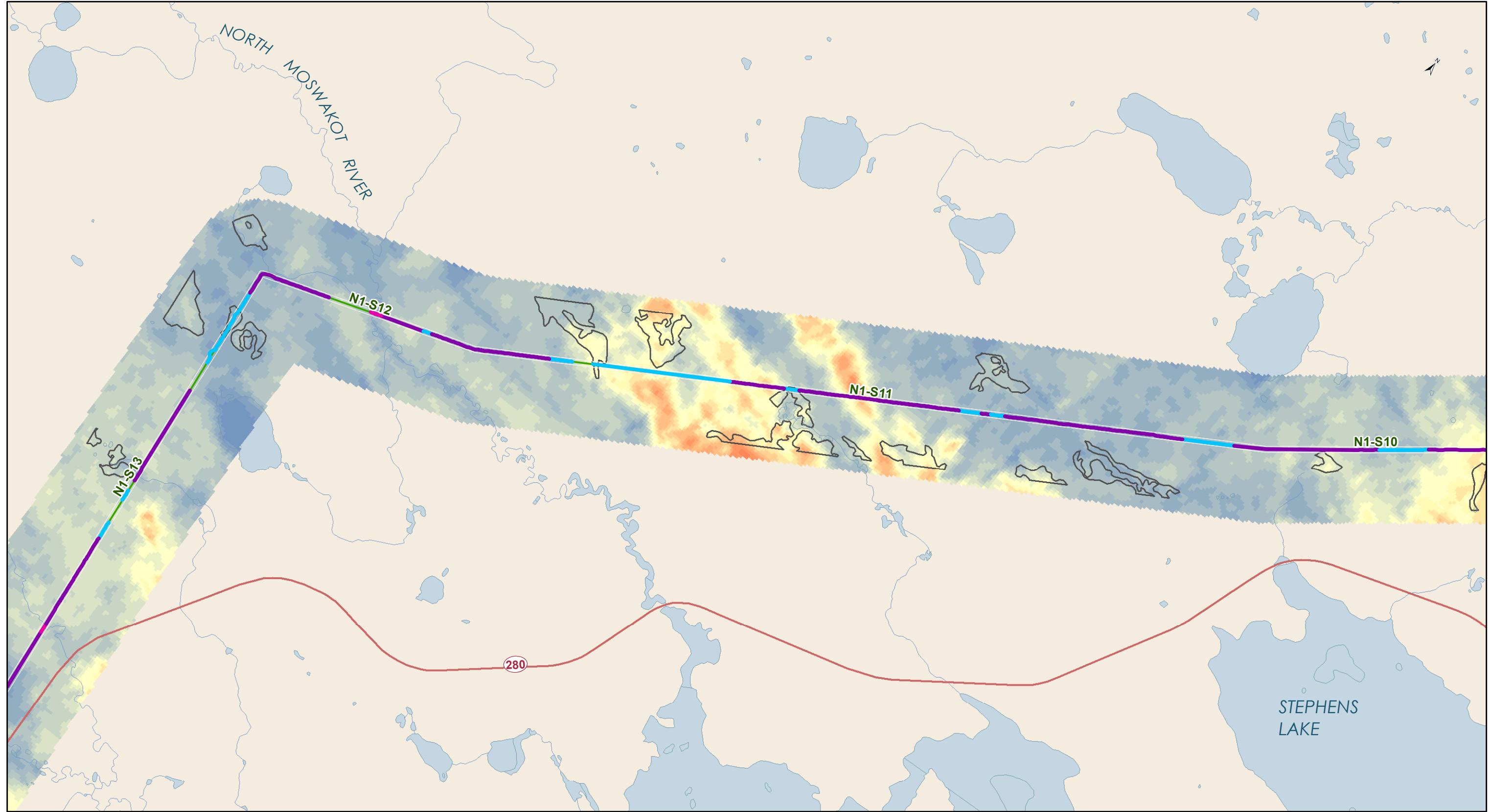
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing

**TIR Summer 2014 (°C)**

High : 46  
Medium : 10  
Low : 0

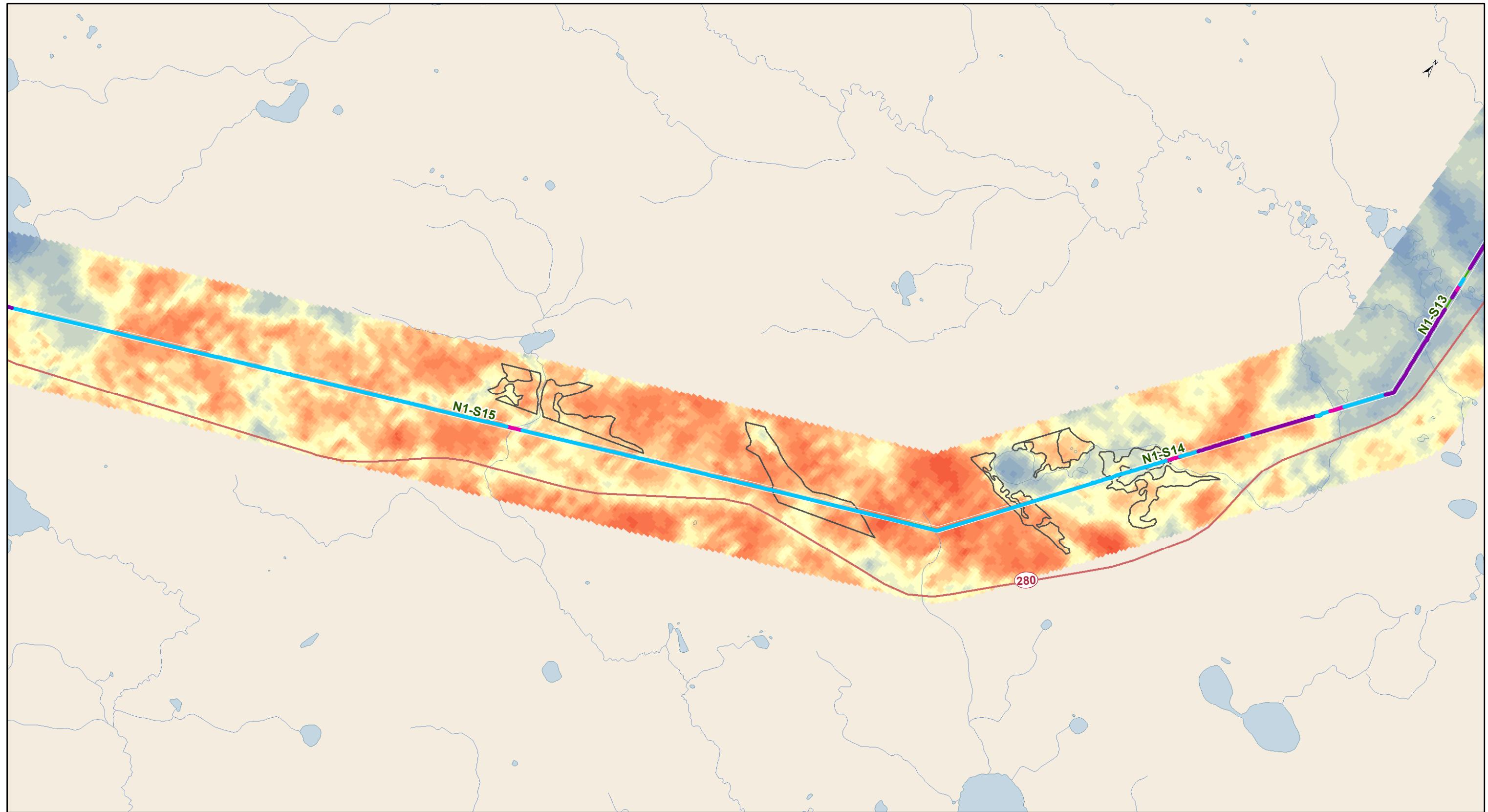
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BPIII Final Preferred Route  
66m ROW

**Landbase**

Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



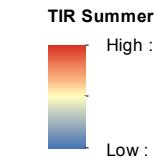
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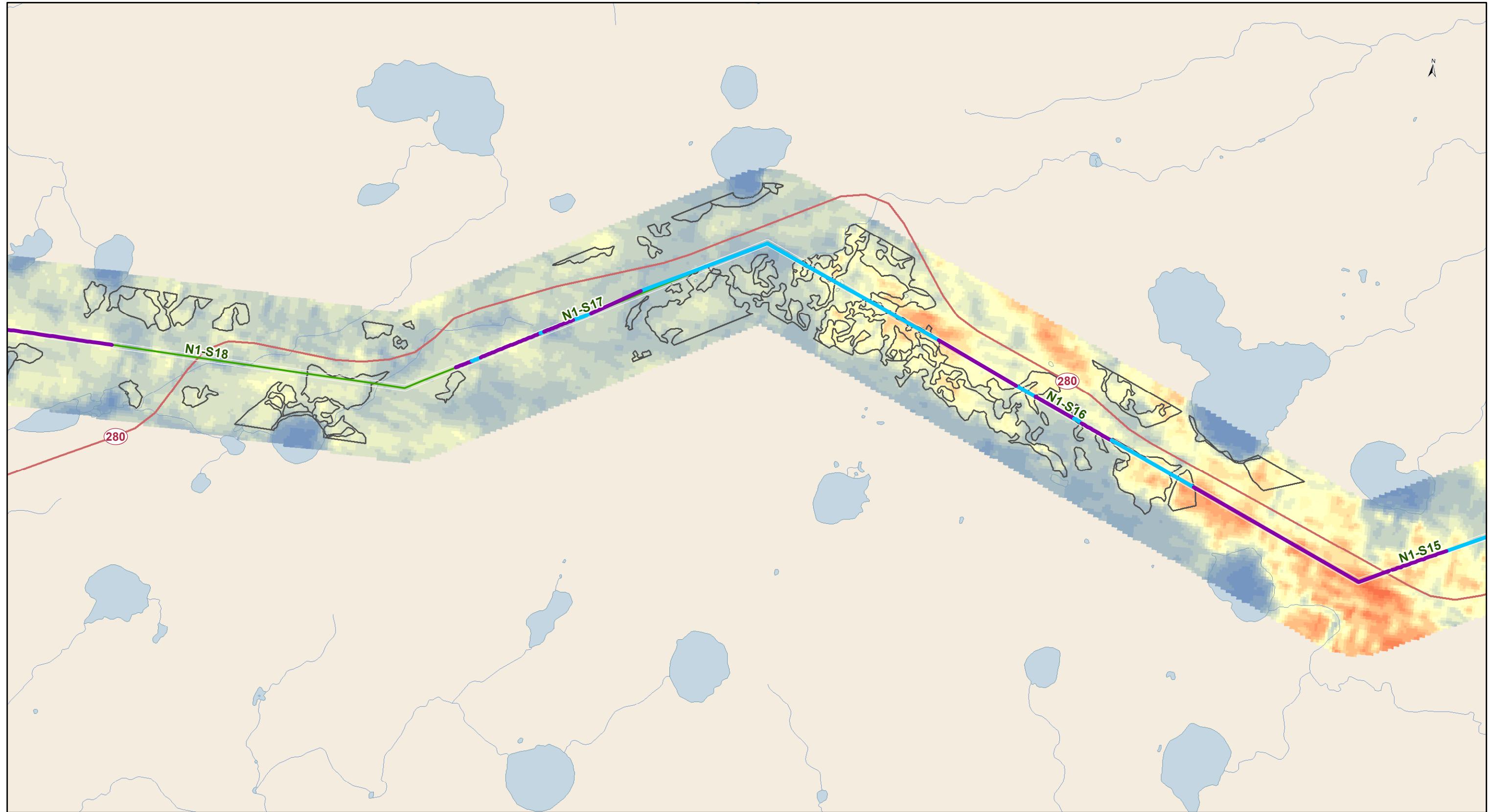
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
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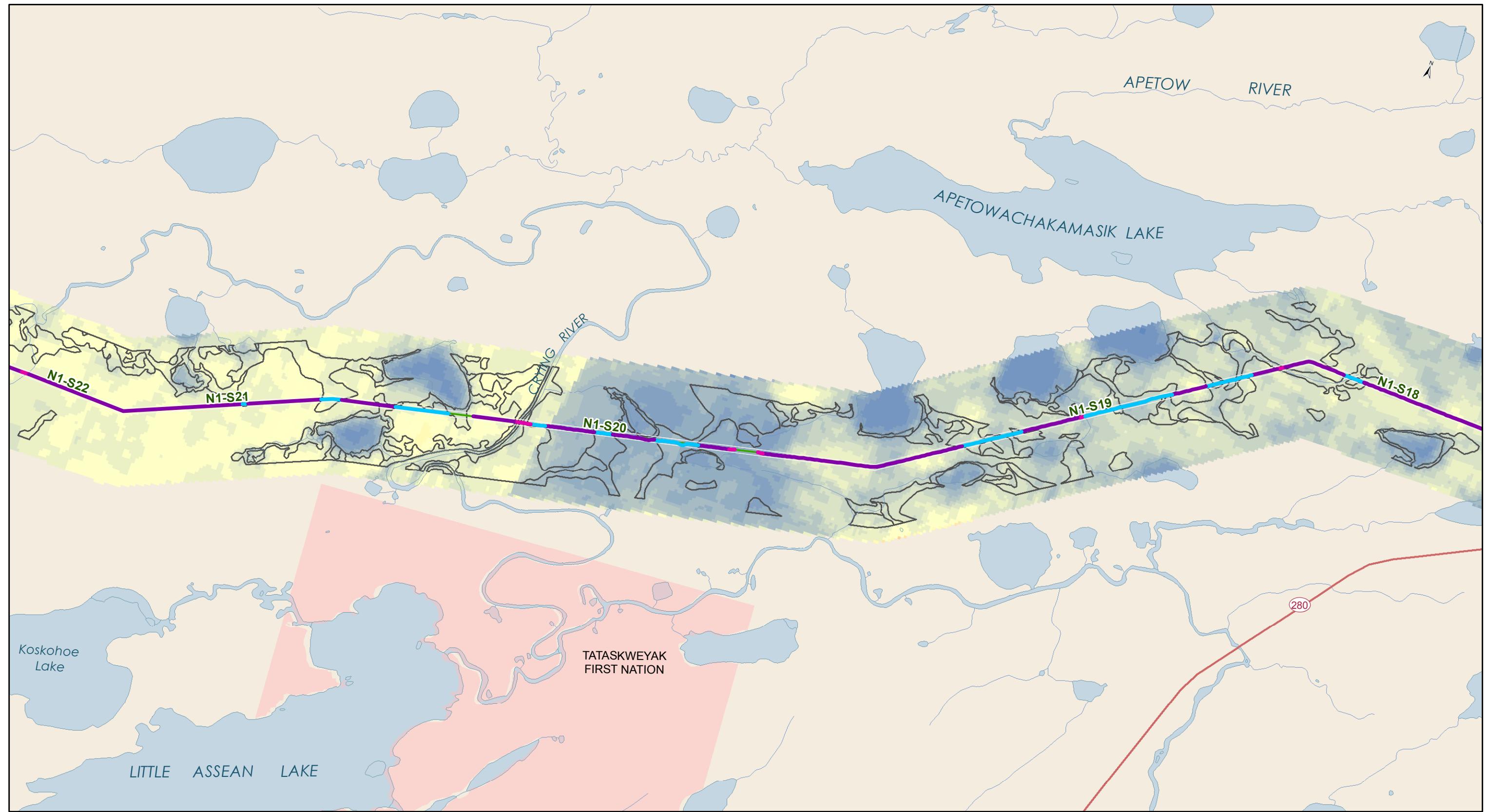
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Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2014 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

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Provincial Road  
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**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



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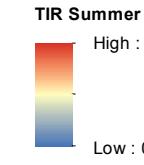
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



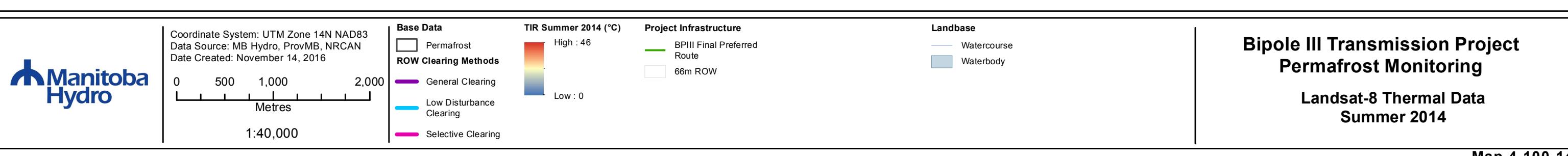
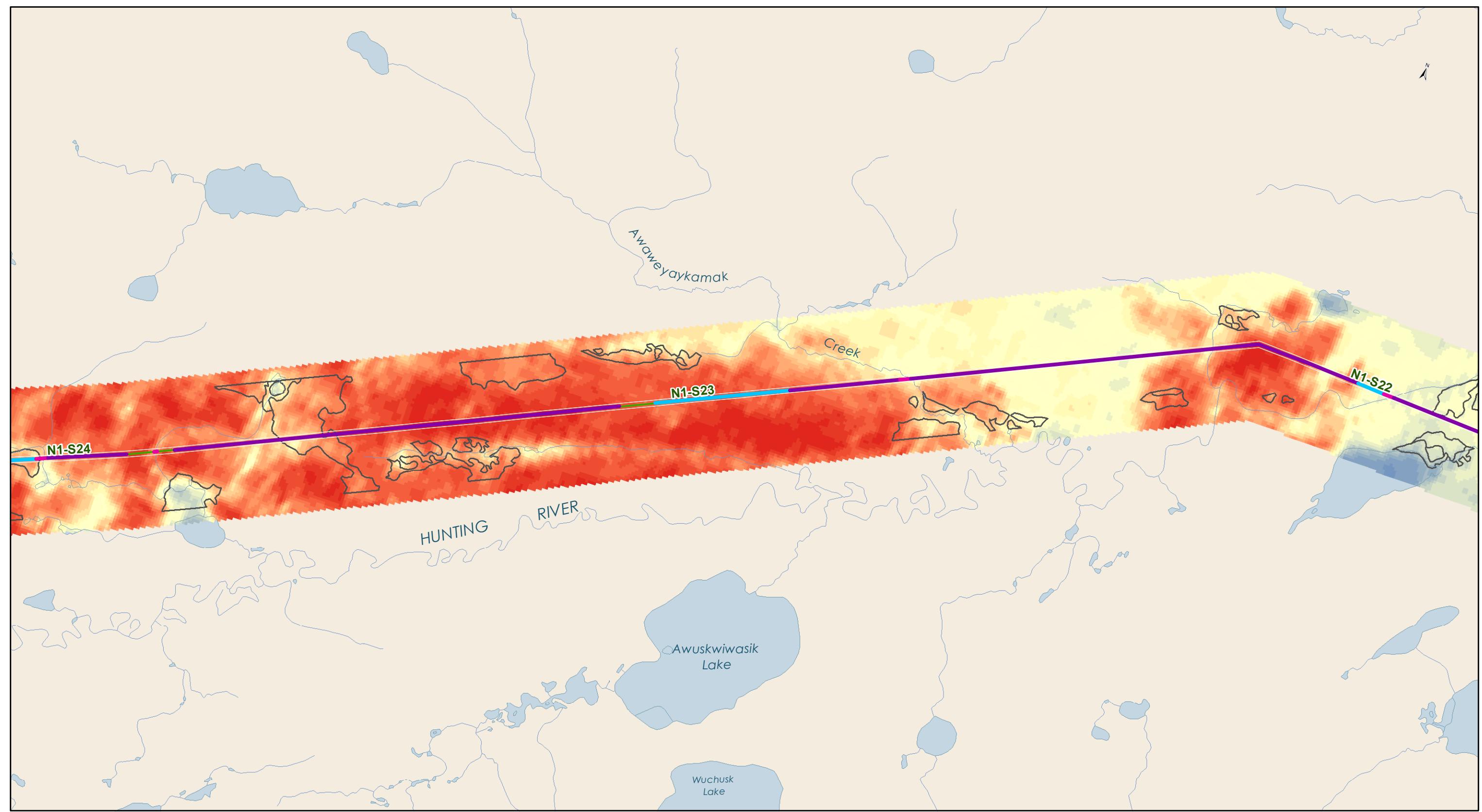
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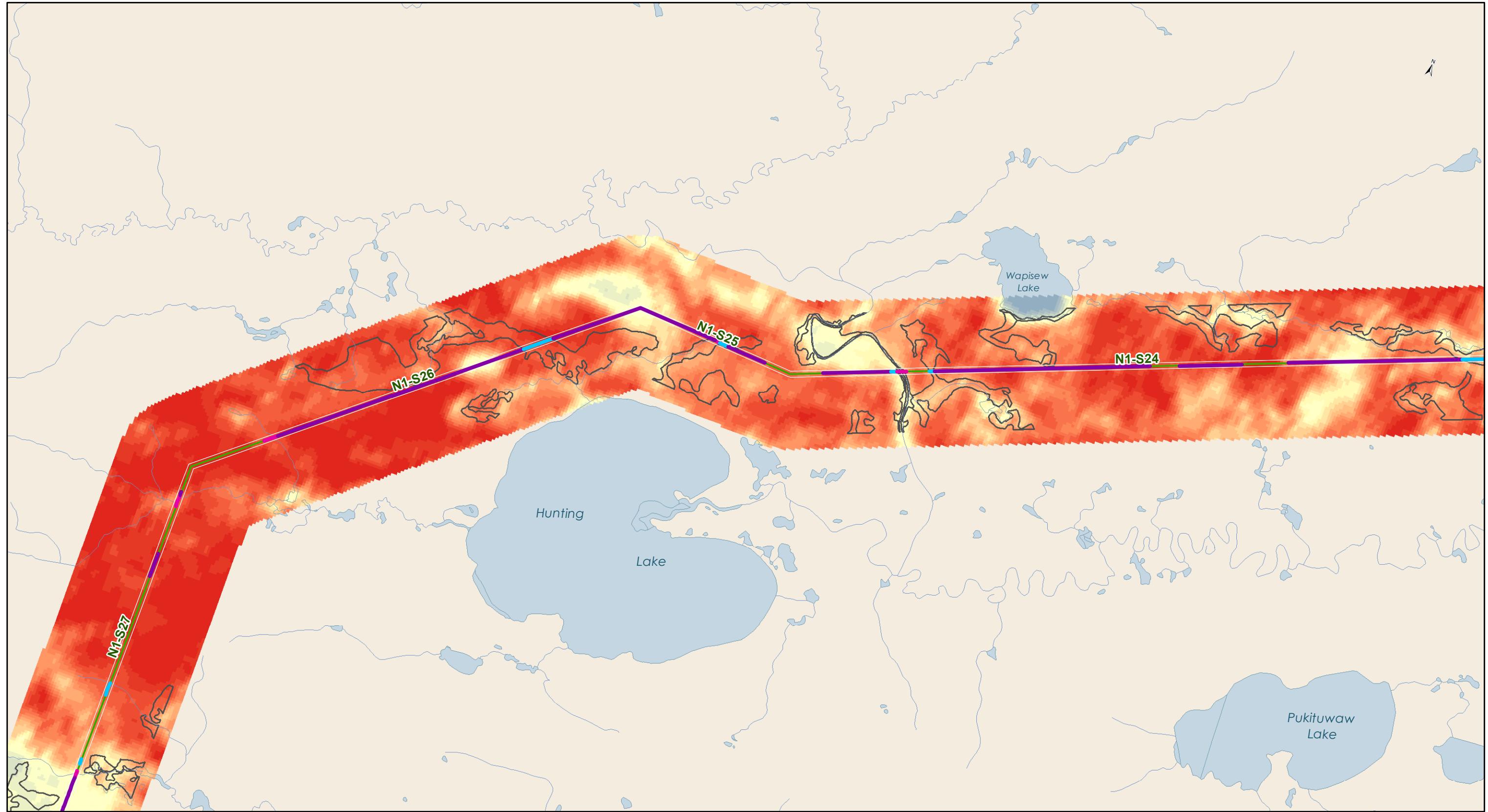
- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- First Nation
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**





0 500 1,000 2,000  
Metres  
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing

High : 46  
Low : 0

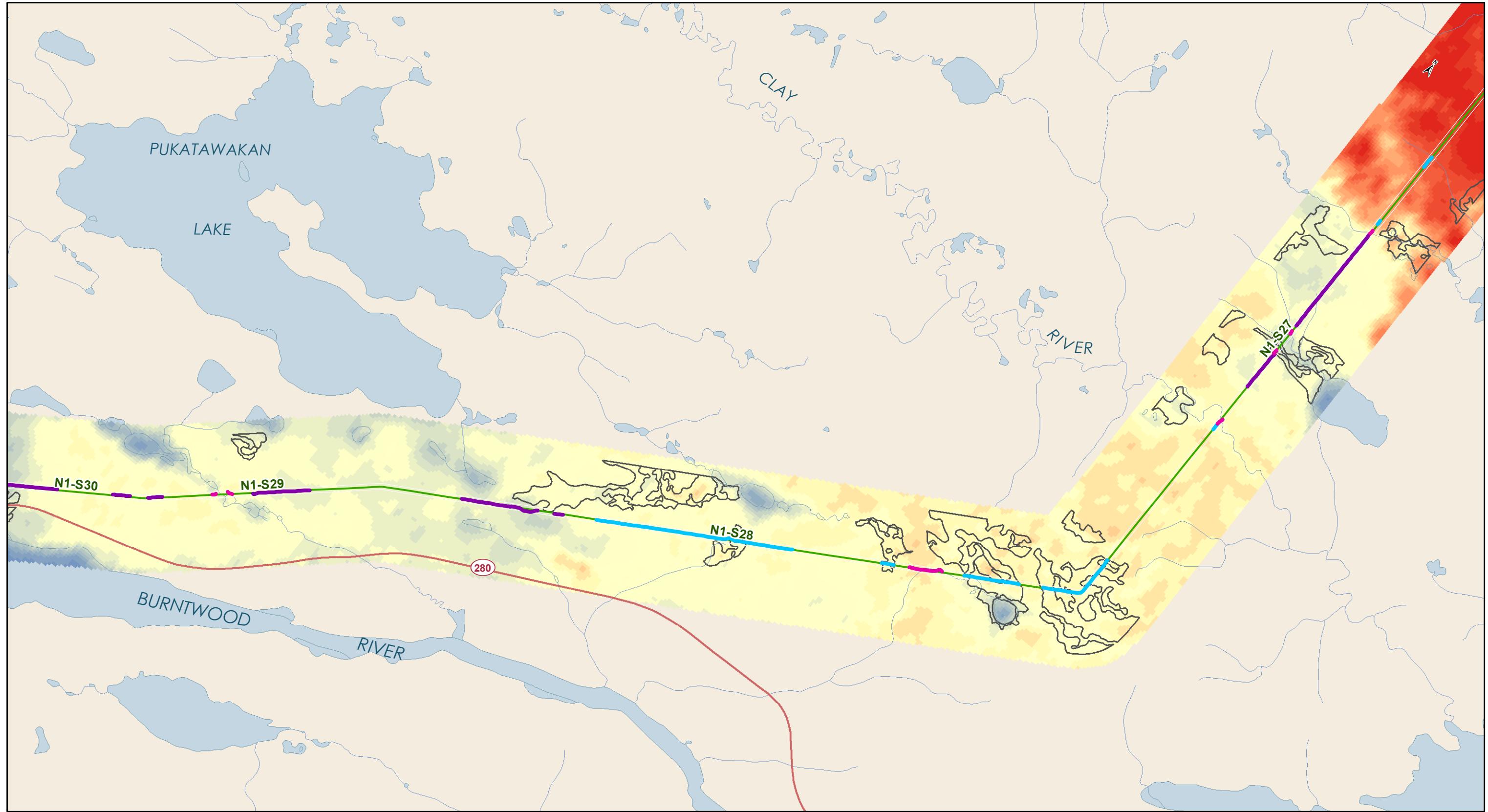
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



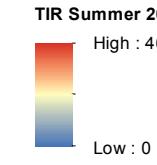
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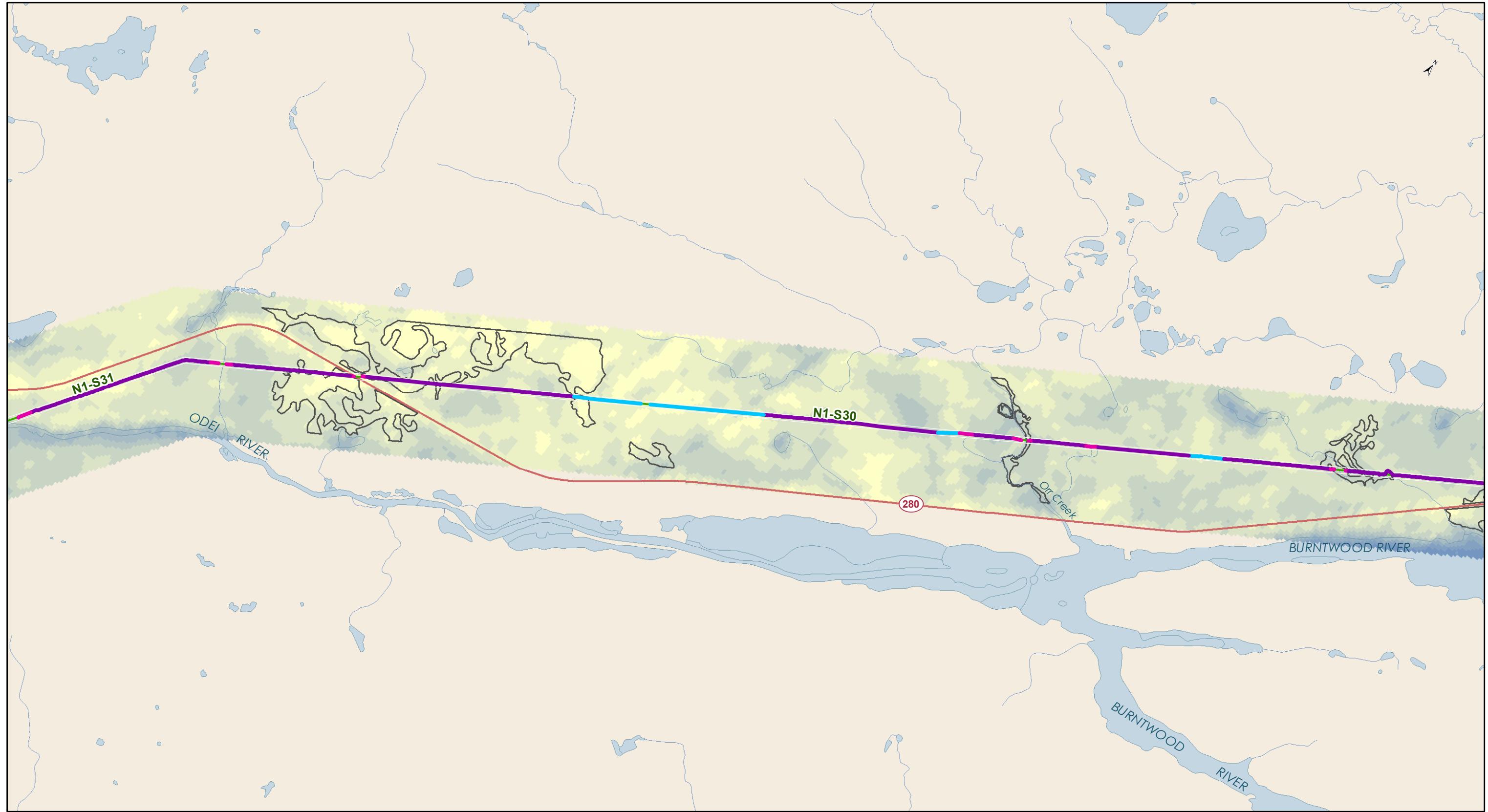
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**

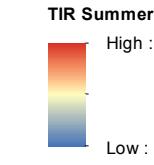


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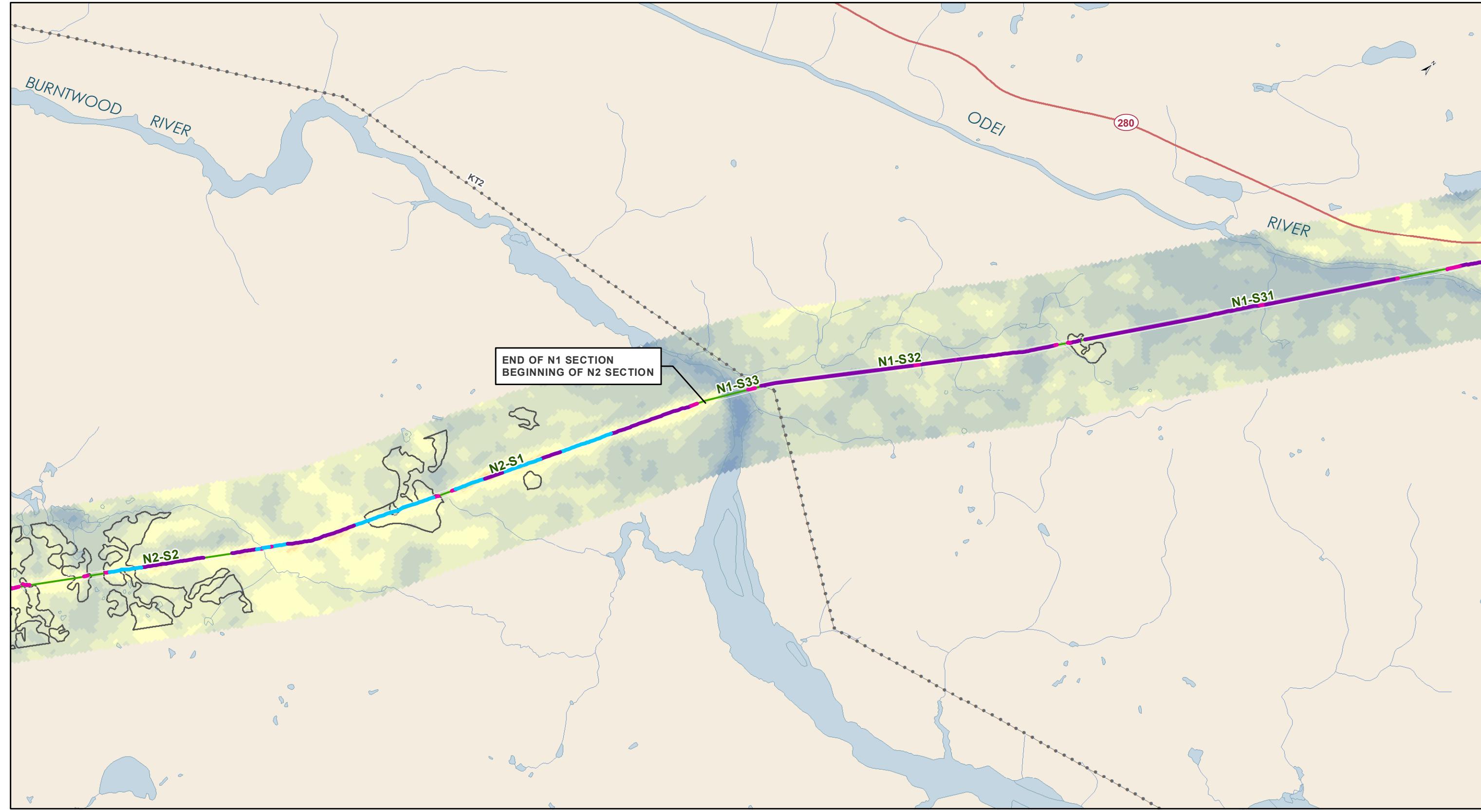
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
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Date Created: November 14, 2016

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#### Base Data

Permafrost

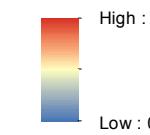
#### ROW Clearing Methods

General Clearing

Low Disturbance Clearing

Selective Clearing

#### TIR Summer 2014 (°C)



#### Project Infrastructure

BPIII Final Preferred Route

66m ROW

#### Landbase

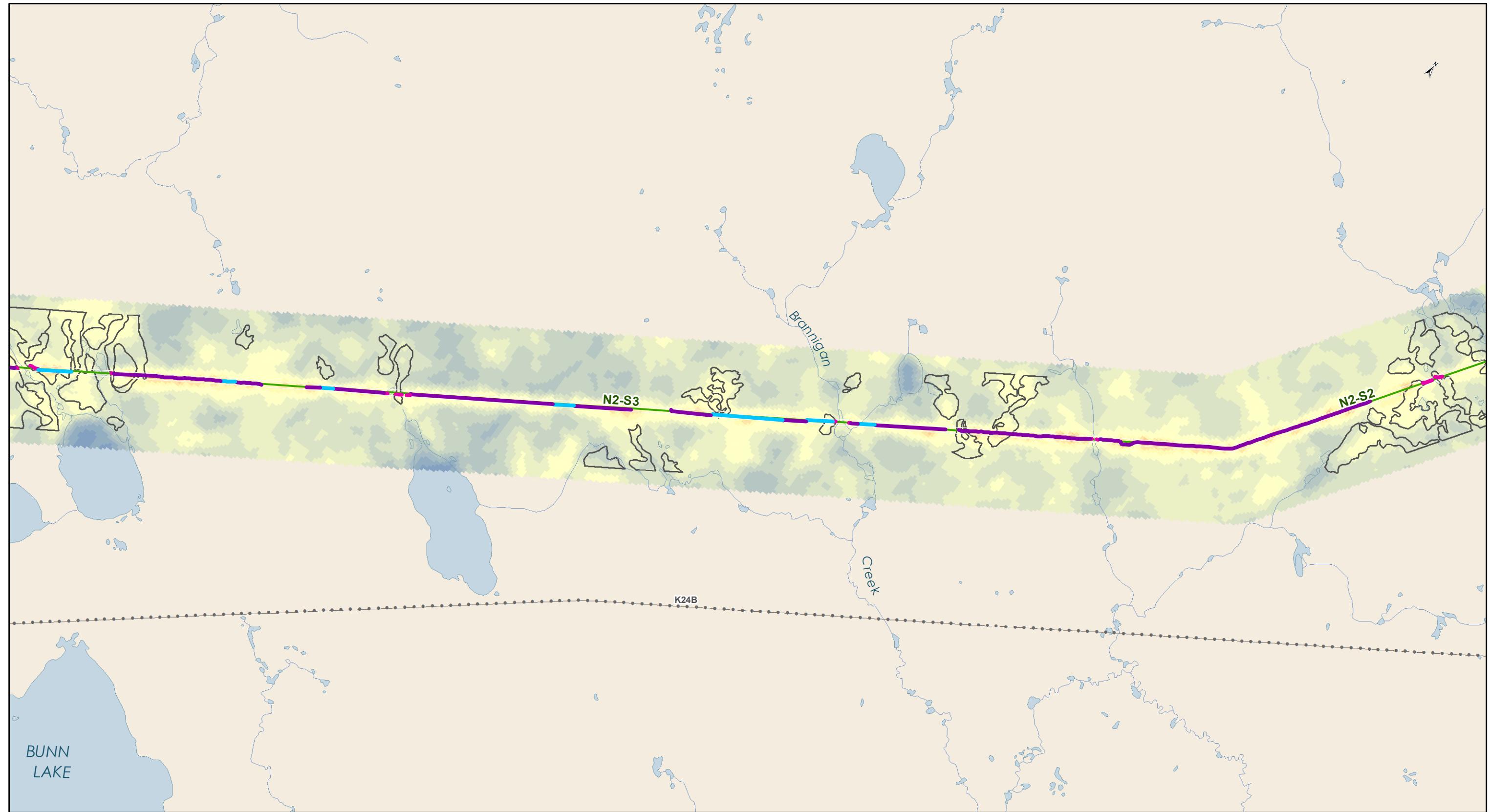
Provincial Road

Transmission Line

Watercourse

Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



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Date Created: November 14, 2016

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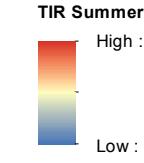
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



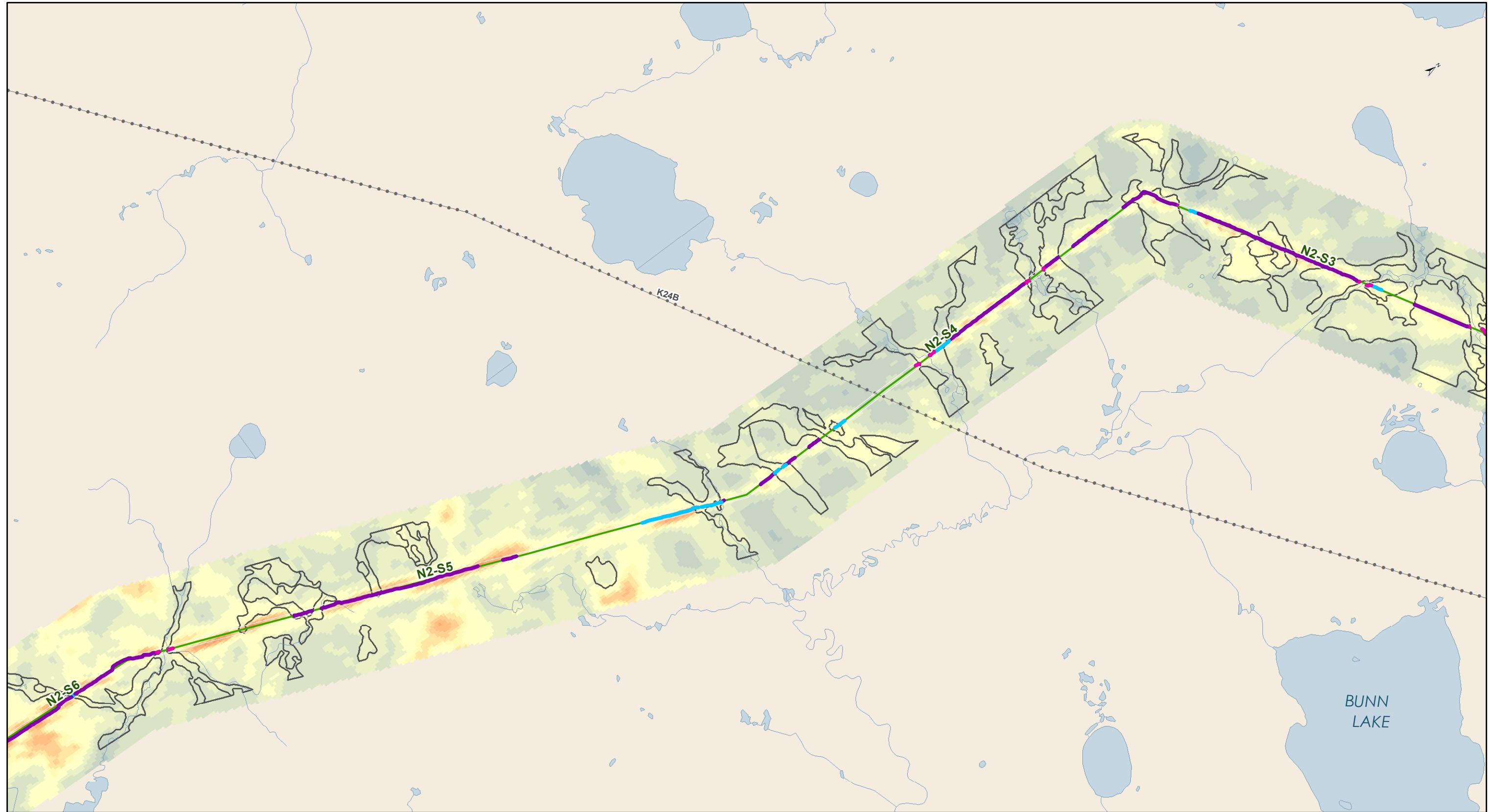
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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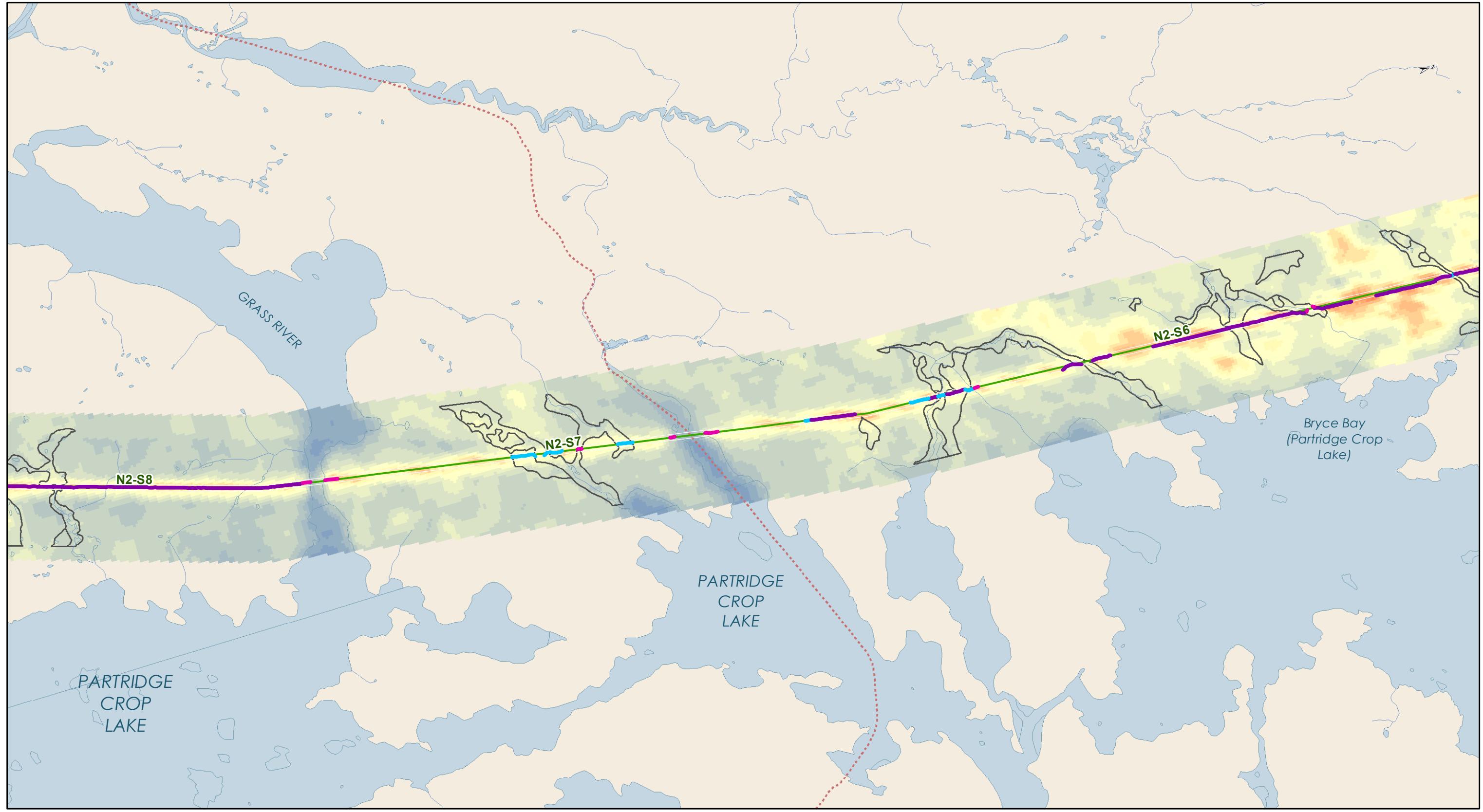
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

TIR Summer 2014 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**

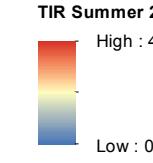


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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
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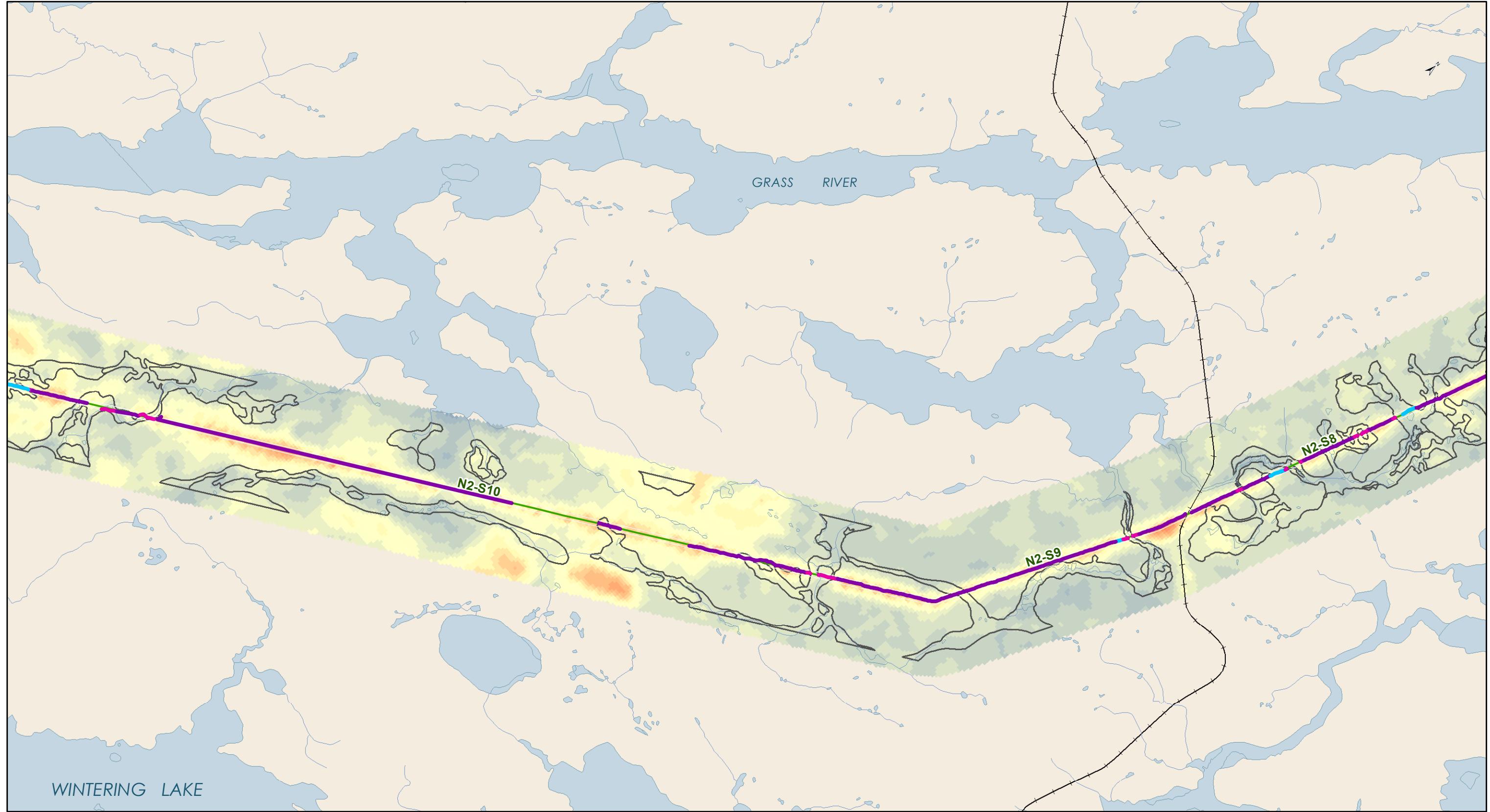
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Winter Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**

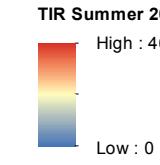


Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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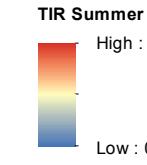
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



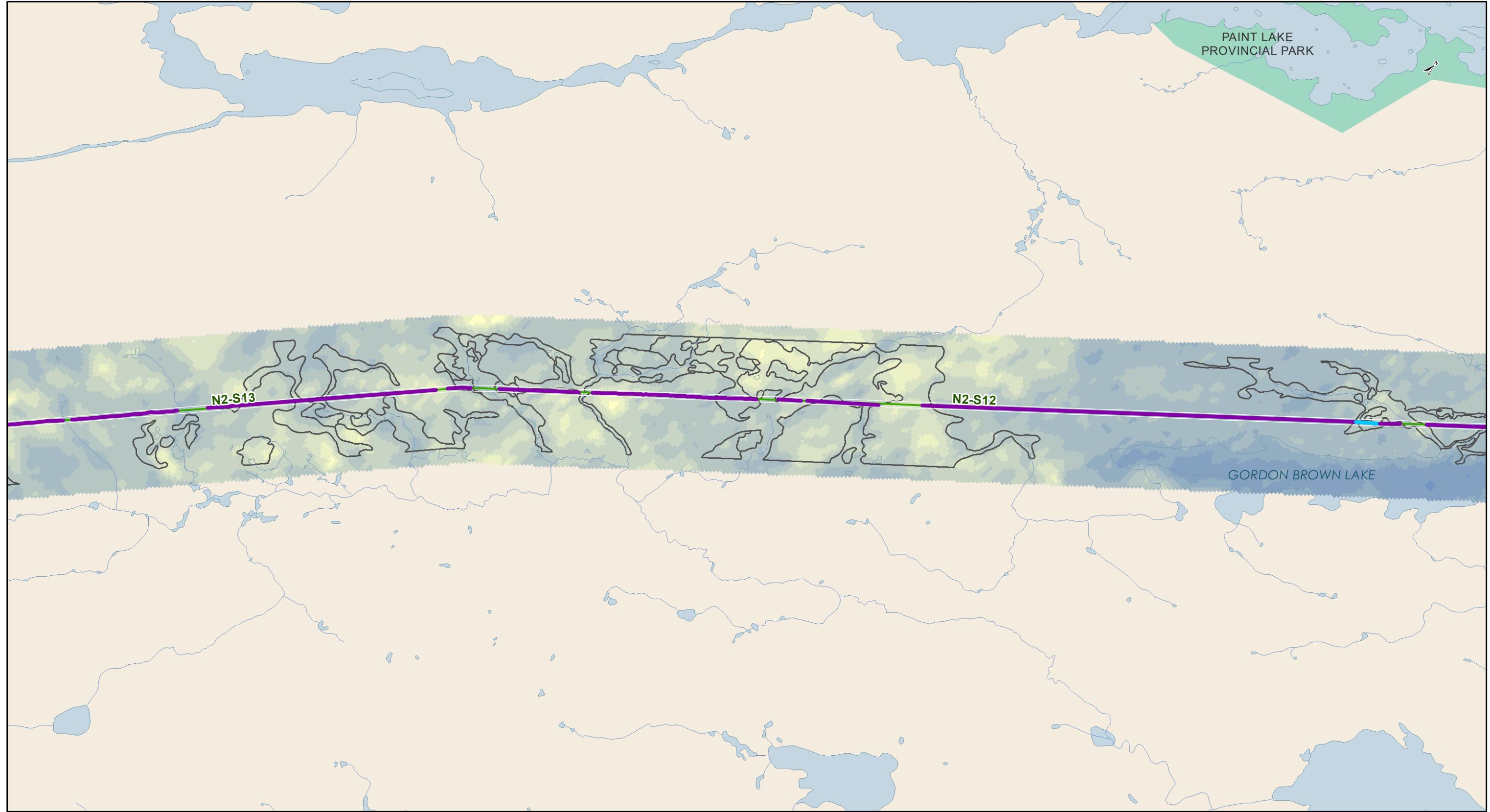
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Winter Road
- Provincial Park
- Watercourse
- Waterbody

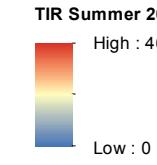
**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 500 1,000 2,000  
Metres  
1:40,000

**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Park  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**

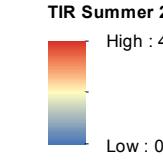


Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
1:40,000

**Base Data**  
Permafrost

**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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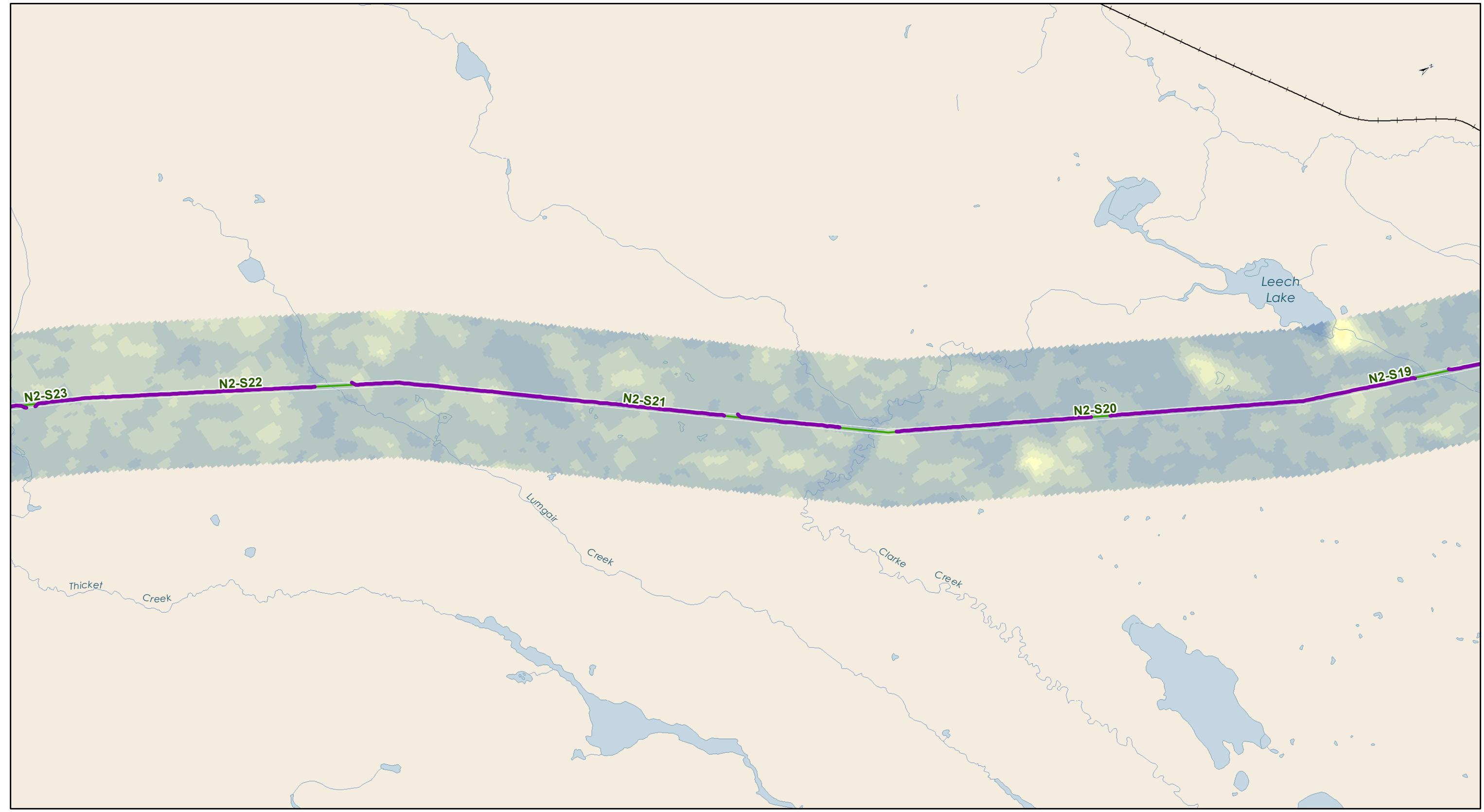
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2014 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2014



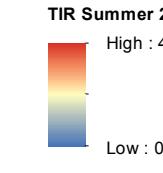
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 Data Source: MB Hydro, ProvMB, NRCan  
 Date Created: November 14, 2016

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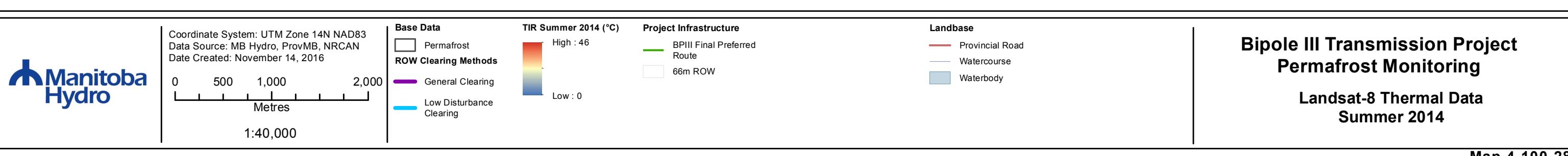
**Base Data**  
 □ Permafrost  
**ROW Clearing Methods**  
 — General Clearing

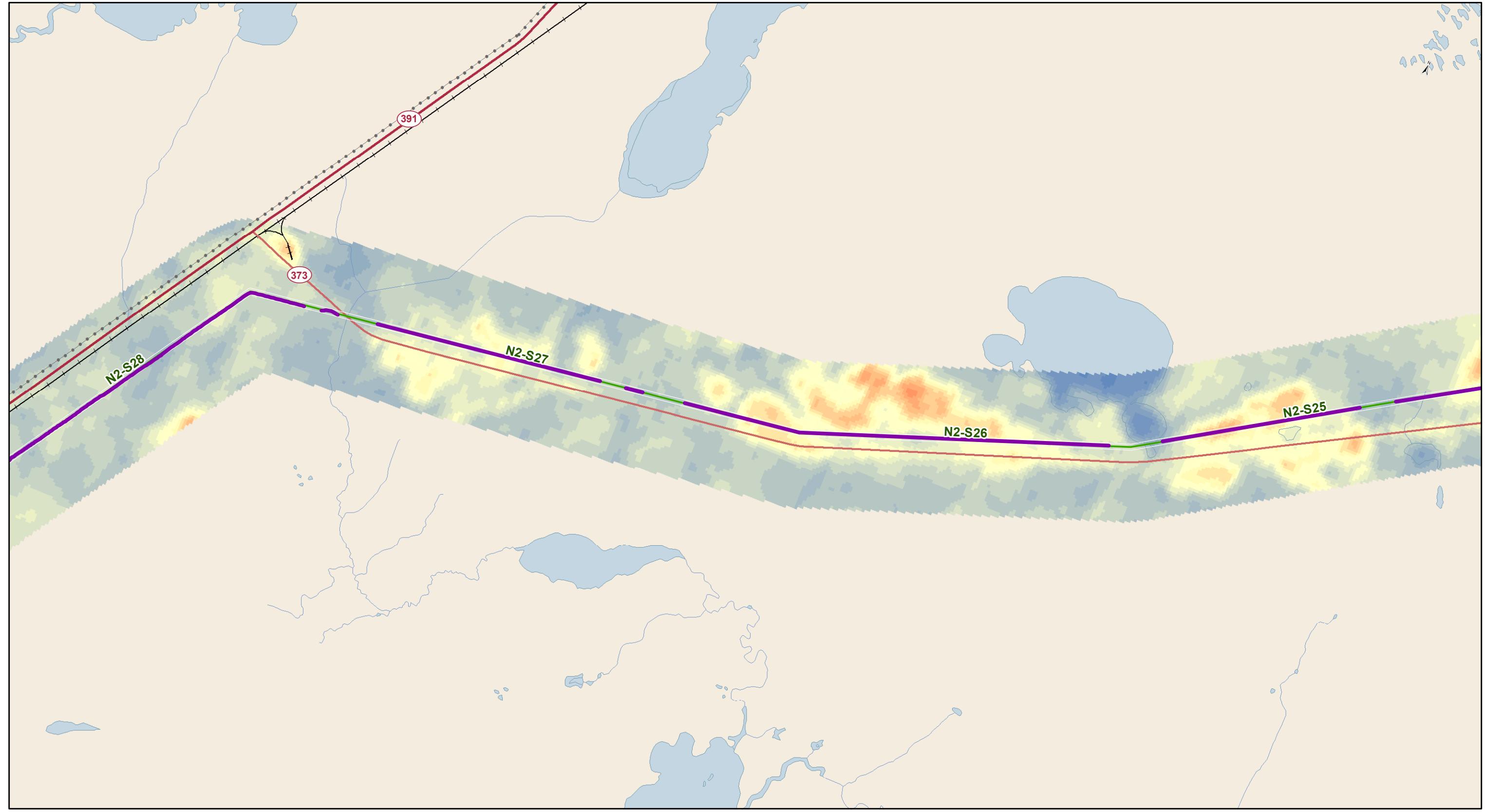


**Project Infrastructure**  
 — BP III Final Preferred Route  
 □ 66m ROW

**Landbase**  
 — Railway (Operational)  
 — Watercourse  
 ■ Waterbody

**Bipole III Transmission Project  
 Permafrost Monitoring**  
**Landsat-8 Thermal Data  
 Summer 2014**





Coordinate System: UTM Zone 14N NAD83  
 Data Source: MB Hydro, ProvMB, NRCan  
 Date Created: November 14, 2016

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 Metres

1:40,000



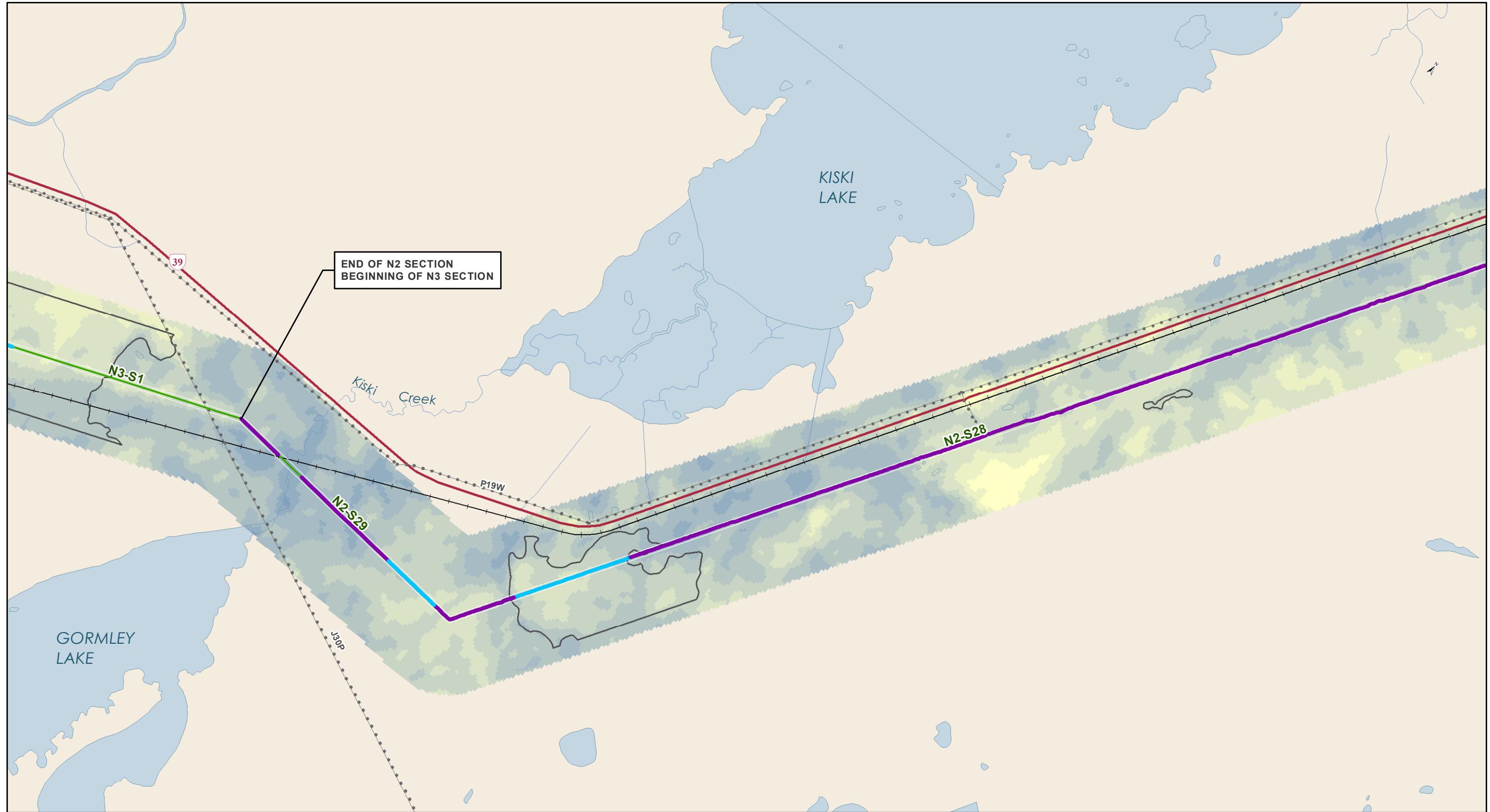
**Base Data**  
 Permafrost  
**ROW Clearing Methods**  
 General Clearing

TIR Summer 2014 (°C)  
 High : 46  
 Low : 0

**Project Infrastructure**  
 BP III Final Preferred Route  
 66m ROW

**Landbase**  
 Provincial Highway  
 Provincial Road  
 Railway (Operational)  
 Transmission Line  
 Watercourse  
 Waterbody

**Bipole III Transmission Project  
 Permafrost Monitoring  
 Landsat-8 Thermal Data  
 Summer 2014**



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Metres  
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**Base Data**  
Permafrost

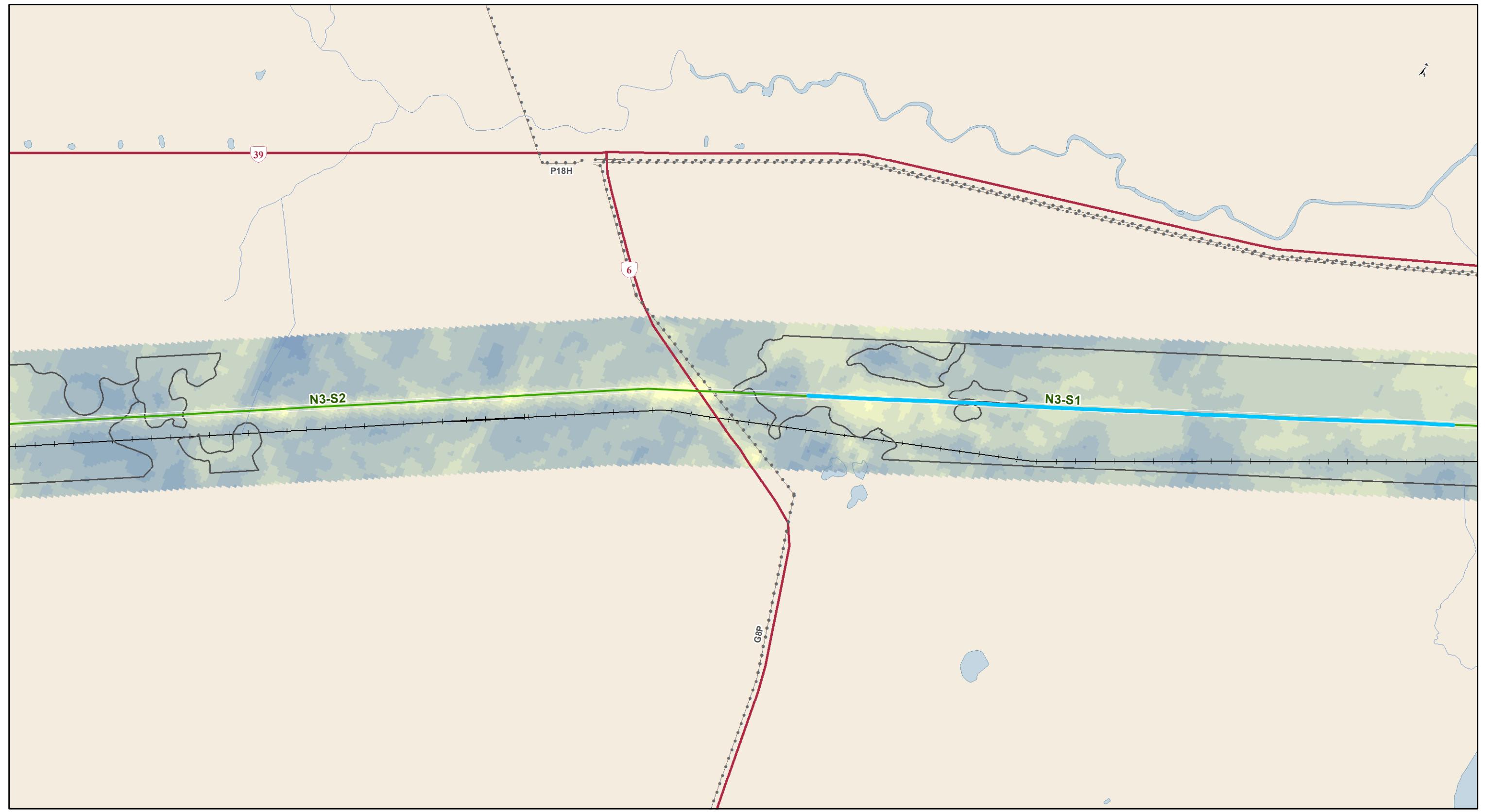
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

**TIR Summer 2014 (°C)**  
High : 46  
Medium-High : 10 - 25  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2014



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
1:40,000

**Base Data**  
Permafrost

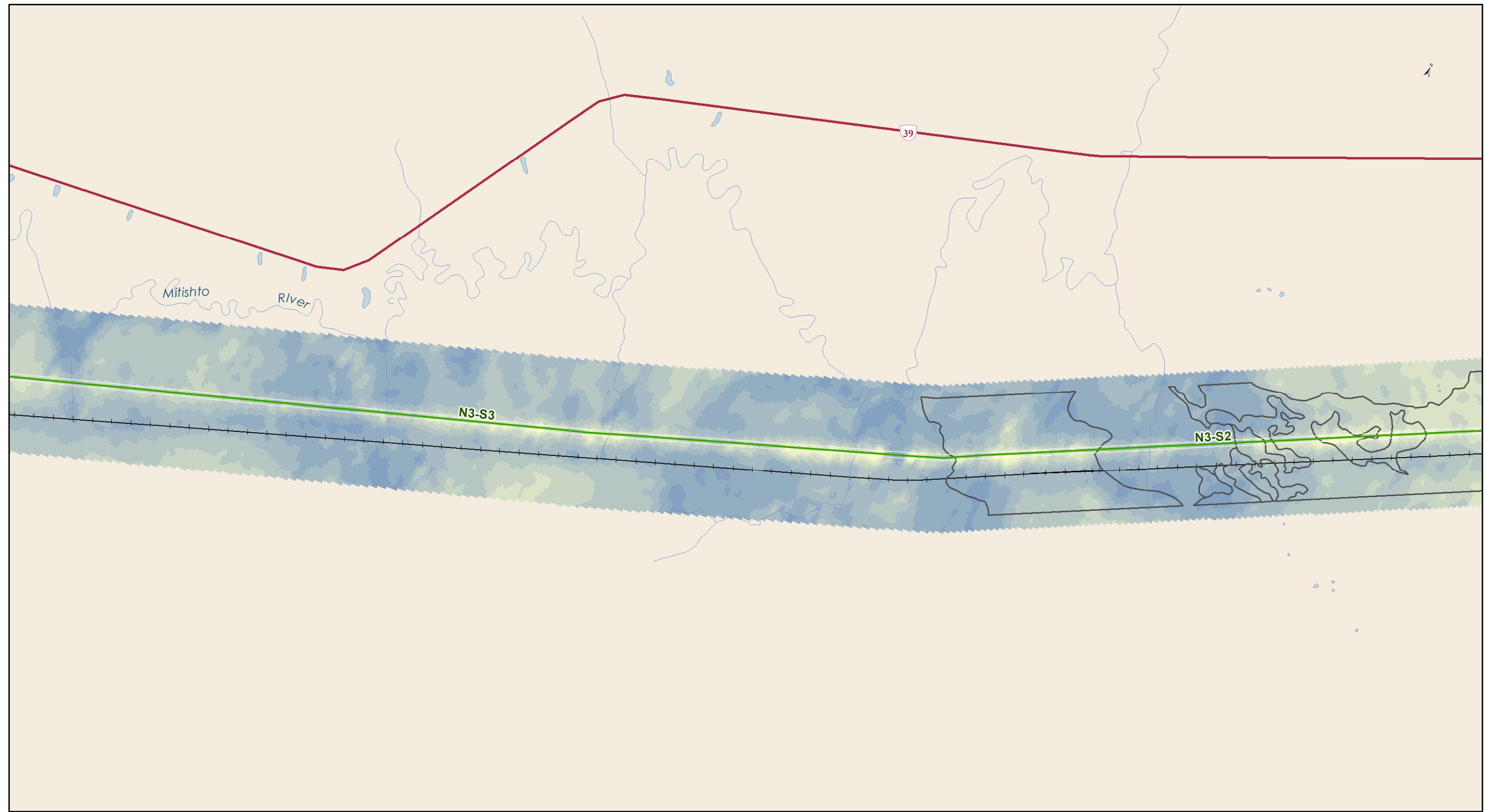
**ROW Clearing Methods**  
Low Disturbance Clearing

**TIR Summer 2014 (°C)**  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

1:40,000

Base Data

Permafrost
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TIR Summer 2014 ( $^{\circ}\text{C}$ )

High : 46  
Low : 0

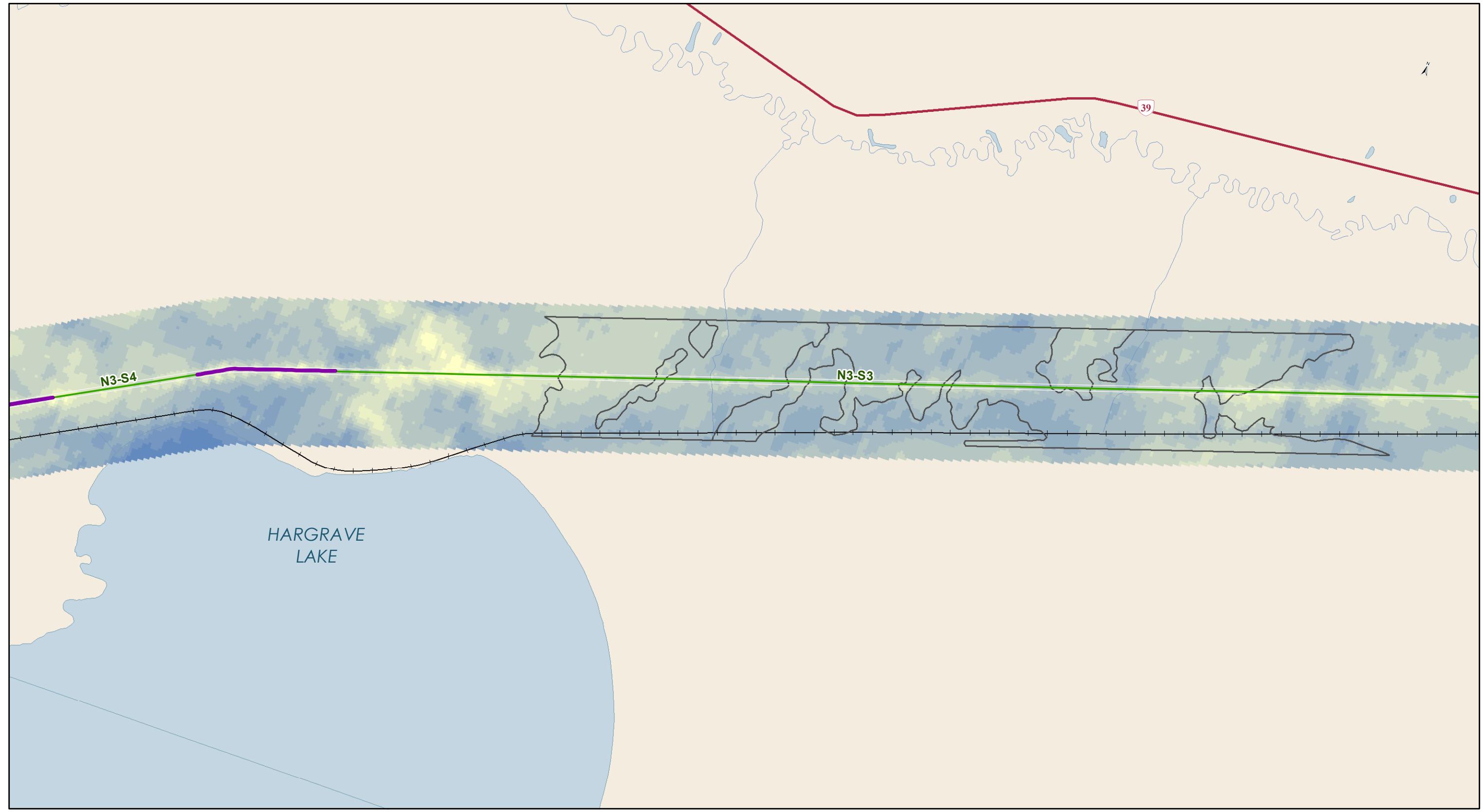
Project Infrastructure

BPIII Final Preferred Route
66m ROW

Landbase

Provincial Highway
Railway (Operational)
Watercourse
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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Metres

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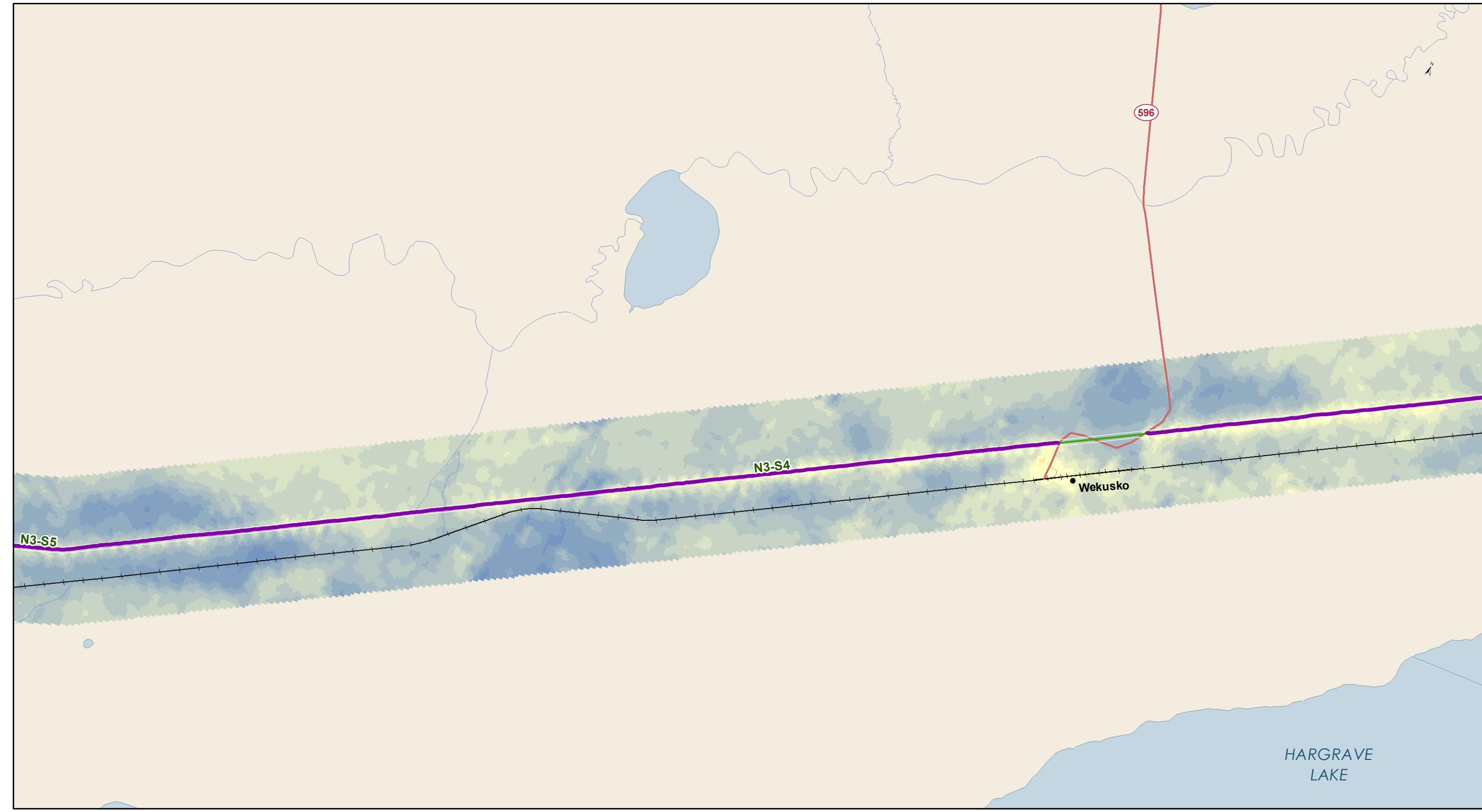
Base Data  
■ Permafrost  
ROW Clearing Methods  
— General Clearing

TIR Summer 2014 (°C)  
High : 46  
Low : 0

Project Infrastructure  
— BP III Final Preferred Route  
□ 66m ROW

Landbase  
— Provincial Highway  
— Railway (Operational)  
— Watercourse  
■ Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

1:40,000

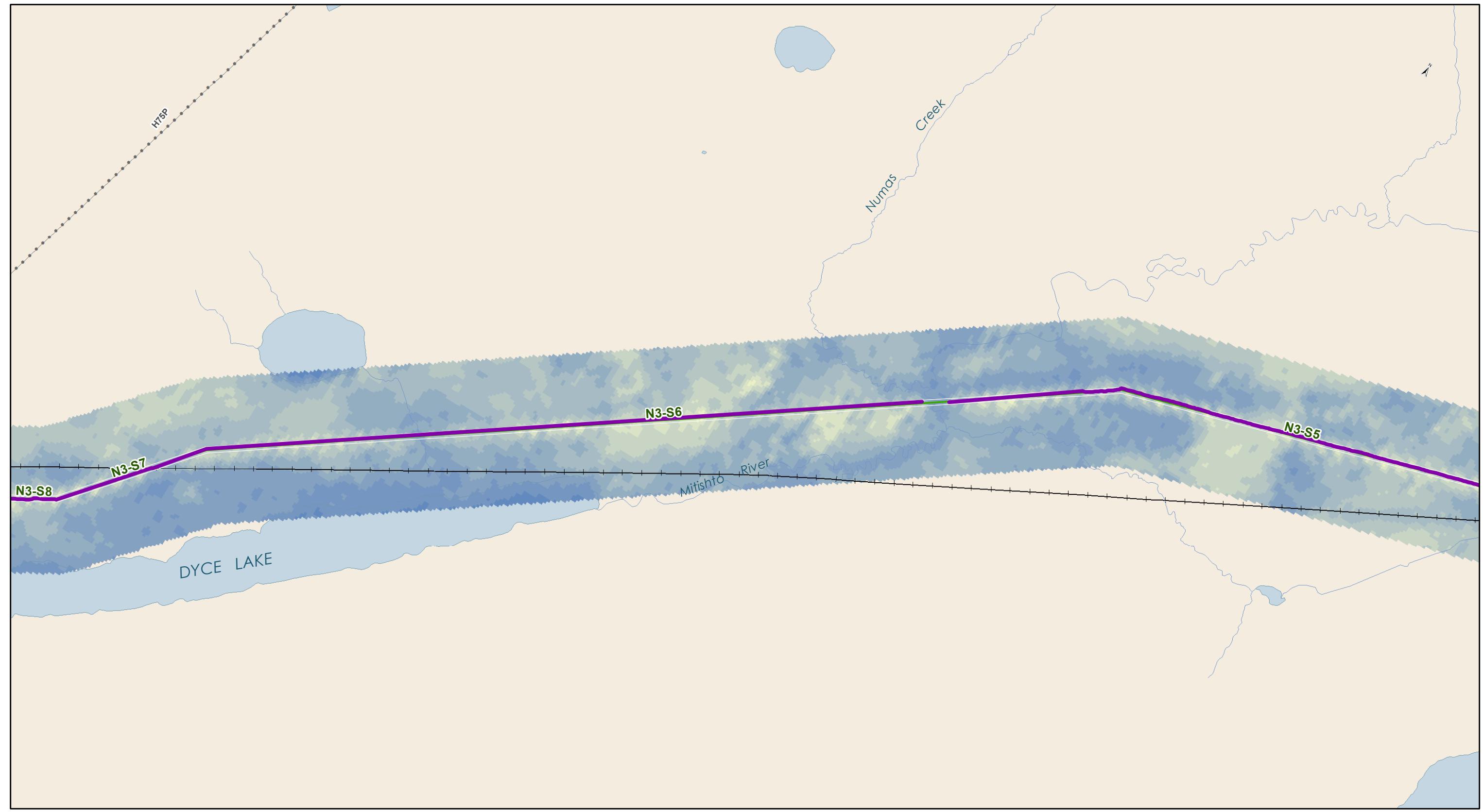
**Base Data**  
□ Permafrost  
**ROW Clearing Methods**  
— General Clearing

TIR Summer 2014 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
— BP III Final Preferred Route  
□ 66m ROW

**Landbase**  
— Provincial Road  
— Local Road  
— Railway (Operational)  
— Watercourse  
□ Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
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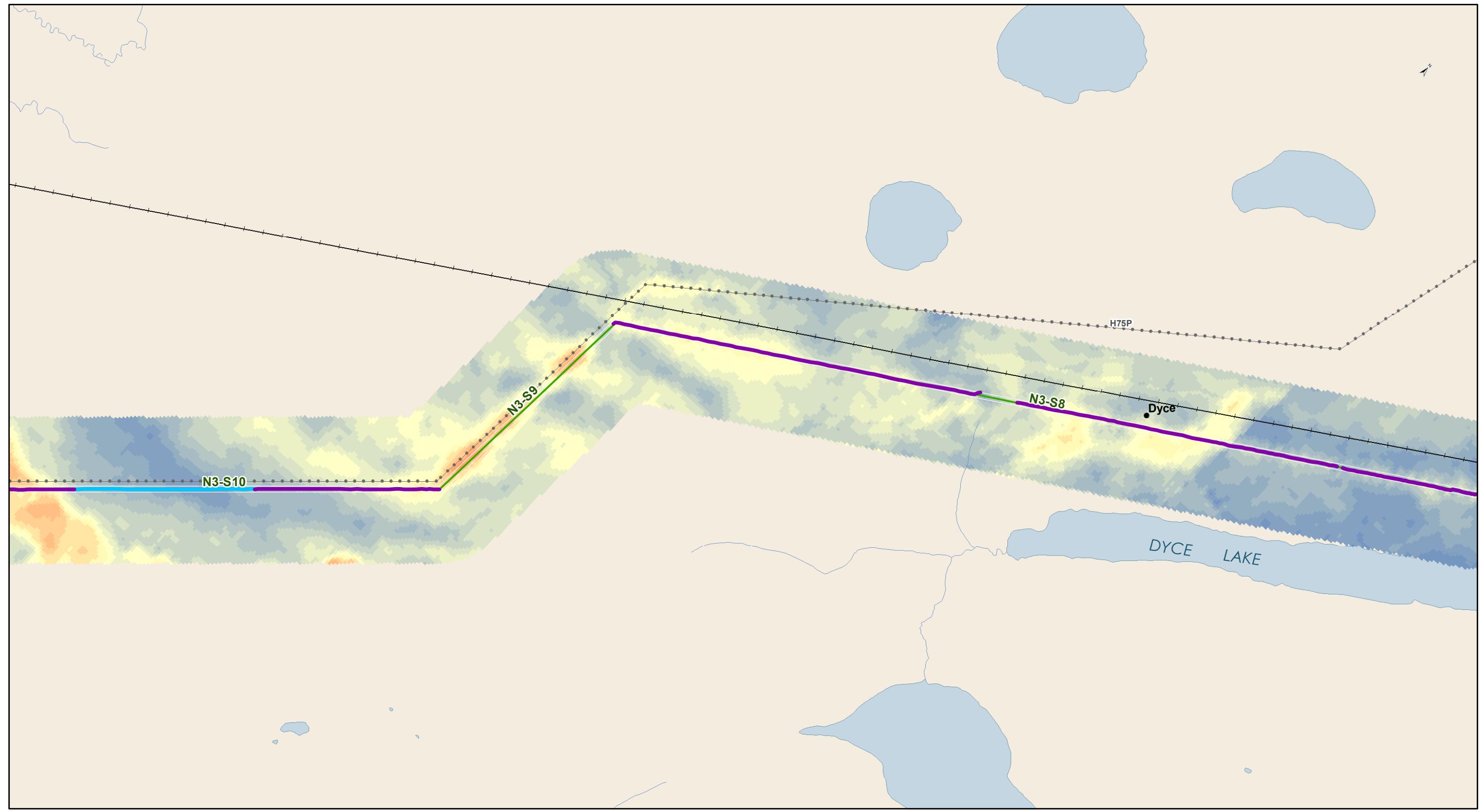
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2014 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**

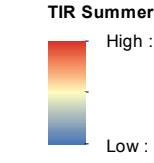


Coordinate System: UTM Zone 14N NAD83  
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Date Created: November 14, 2016

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**Base Data**  
Permafrost

**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



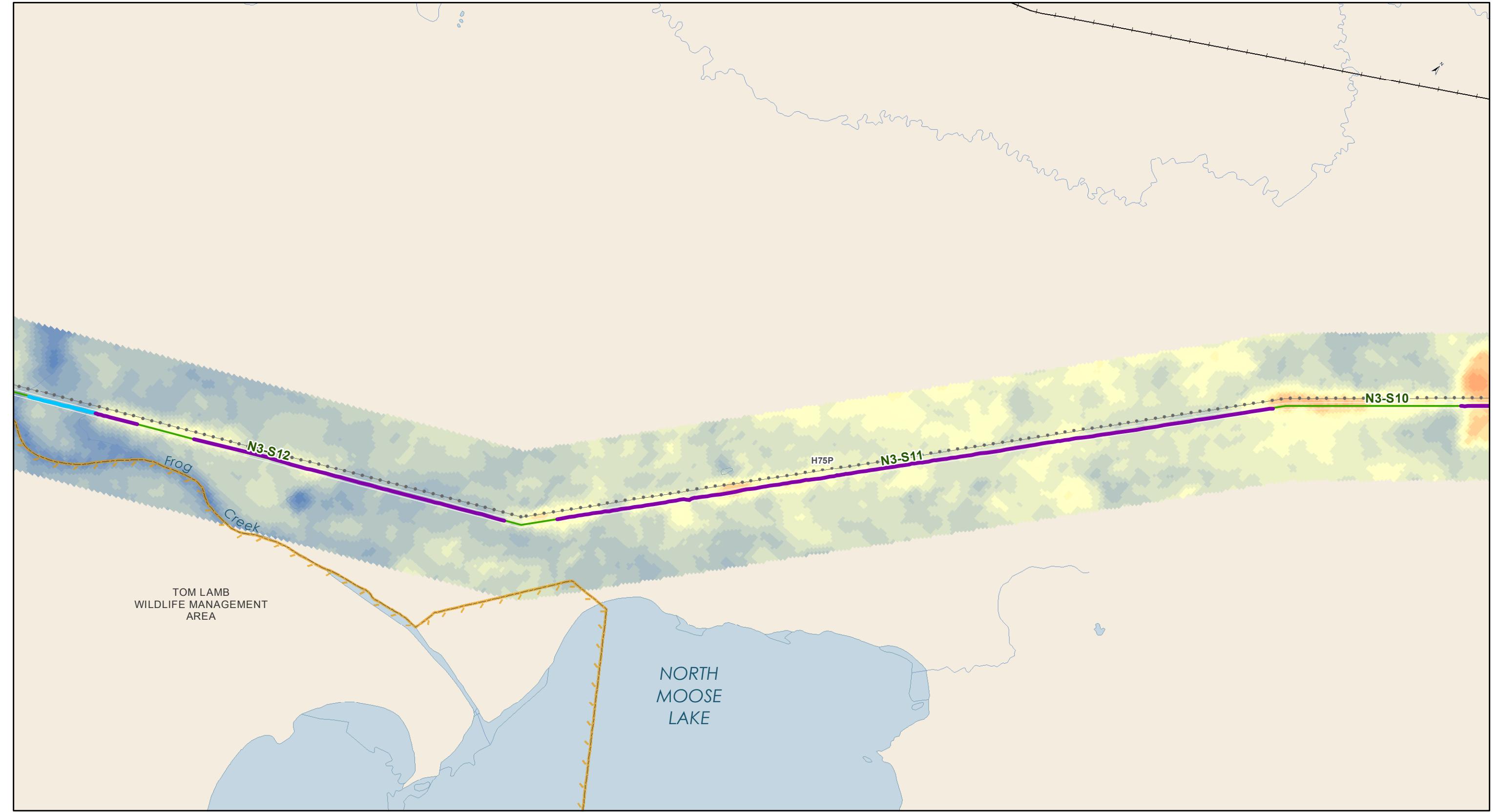
**Project Infrastructure**

BPIII Final Preferred Route  
66m ROW

**Landbase**

Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

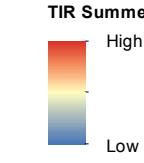
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Metres

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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Low Disturbance Clearing



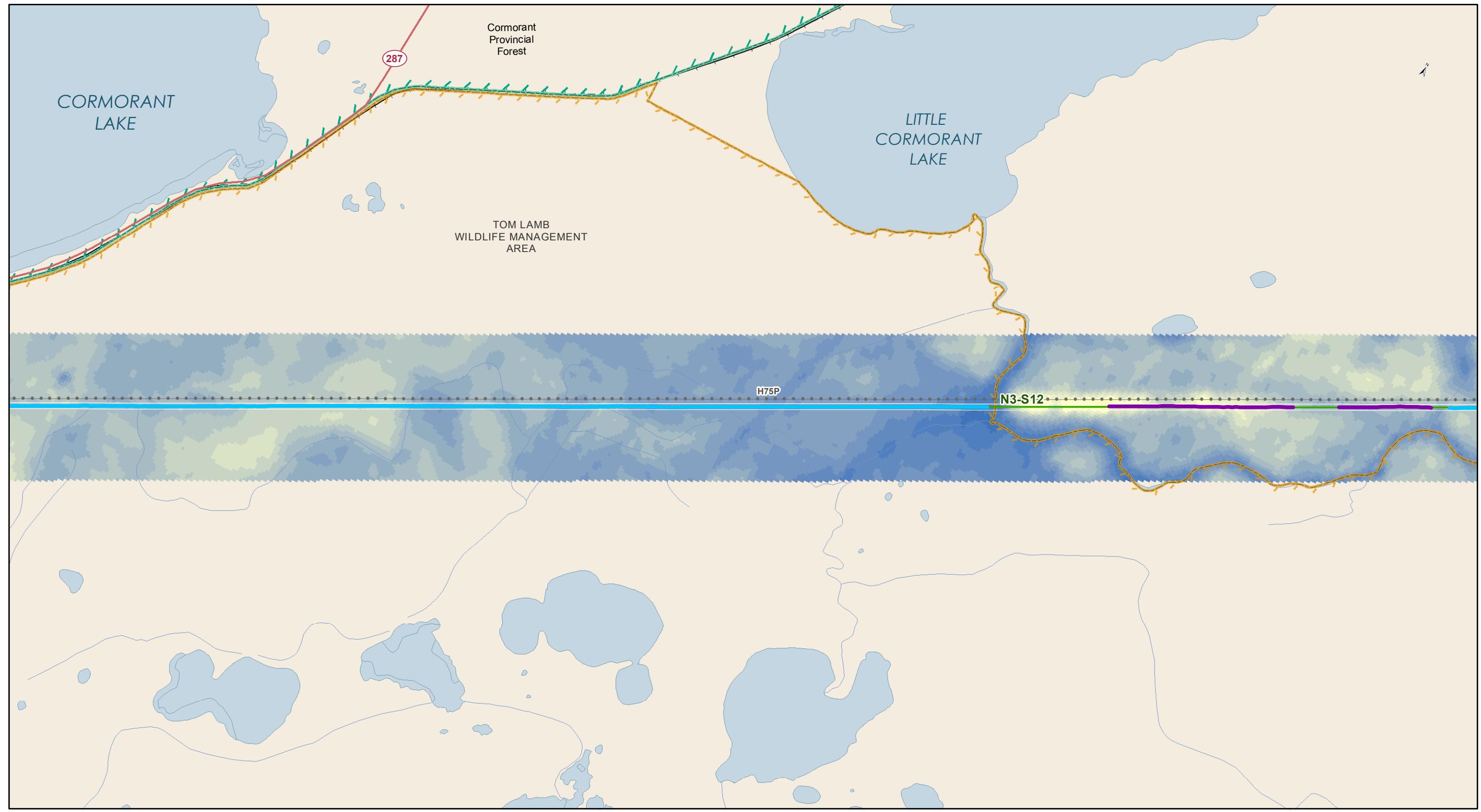
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

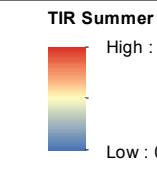
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**Base Data**  
Permafrost

**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

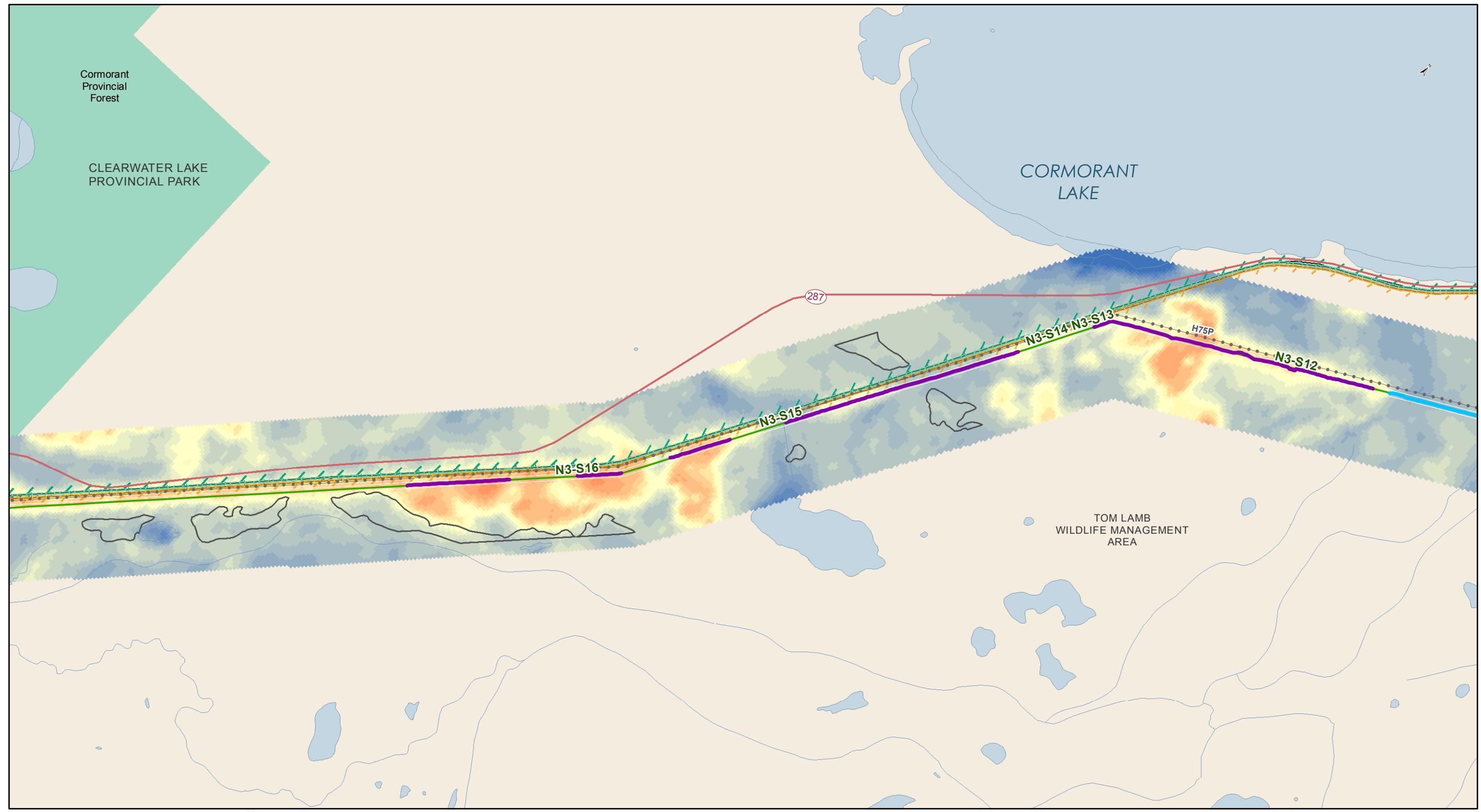


**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Railway (Operational)  
Transmission Line  
Provincial Forest

Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

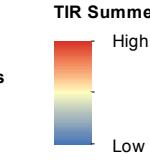
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**Base Data**  
Permafrost

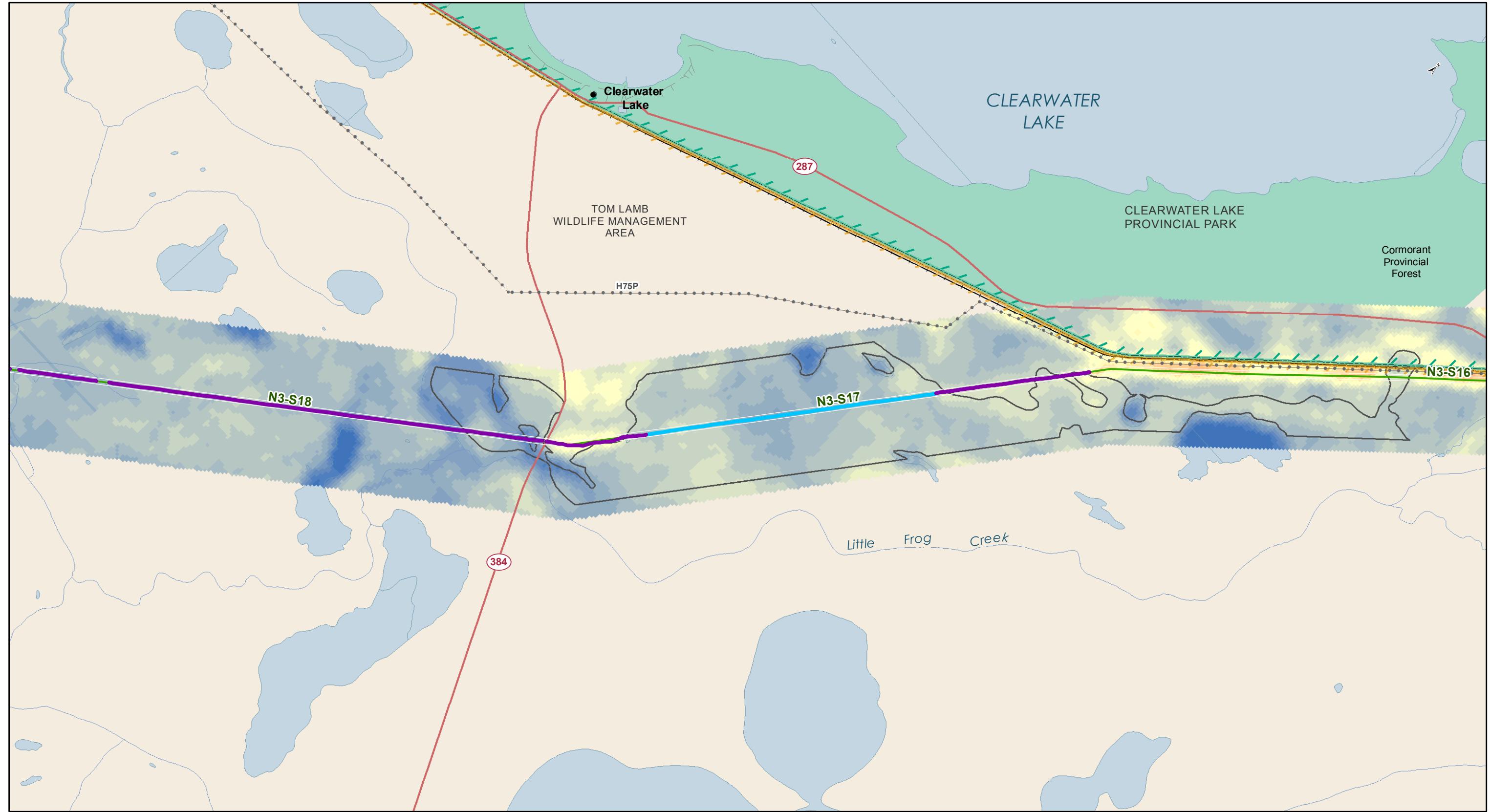
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Railway (Operational)  
Transmission Line  
Provincial Park  
Provincial Forest  
Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 500 1,000 2,000 Metres

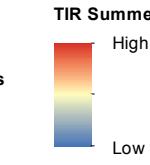
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing



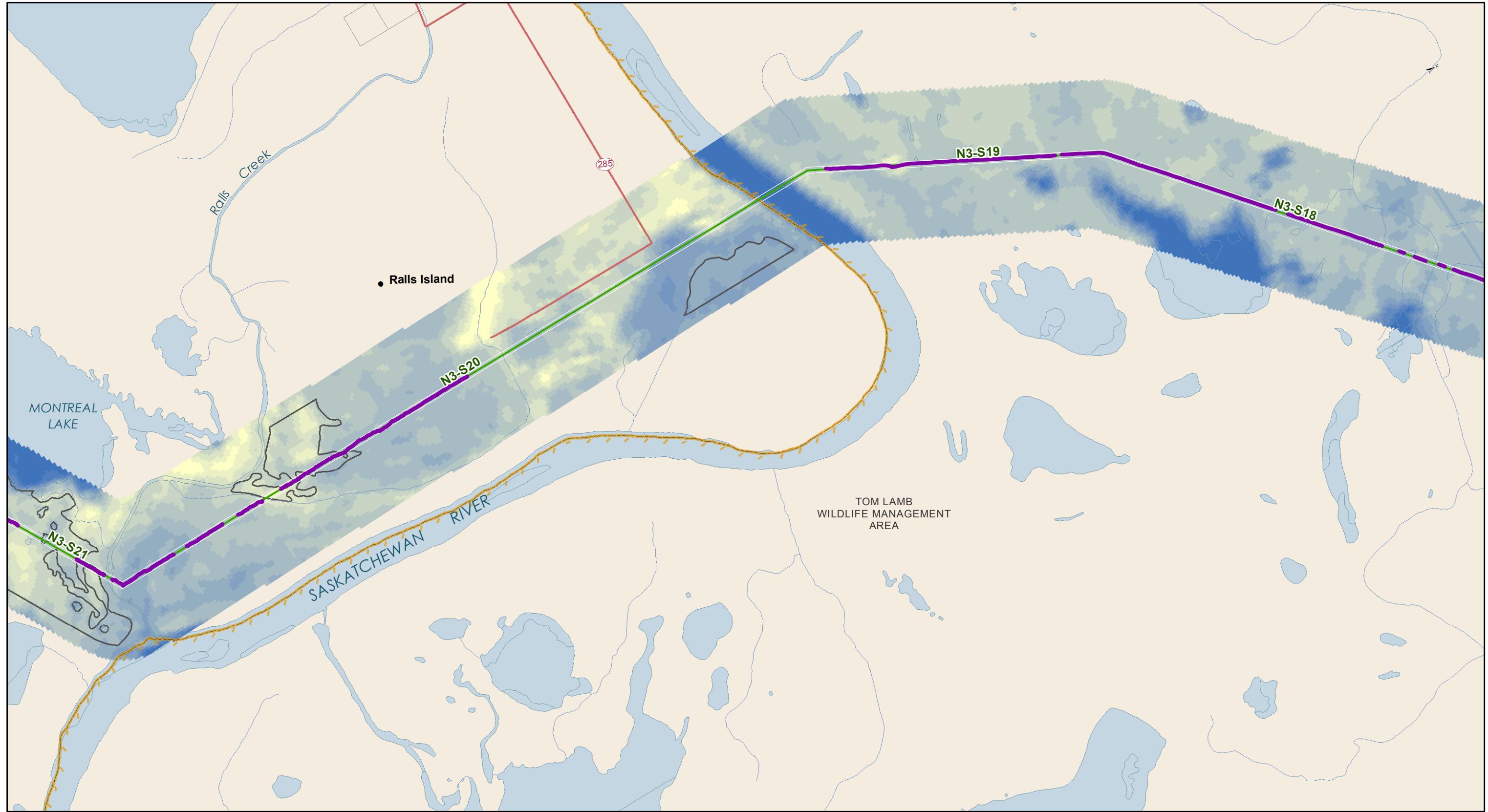
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Local Road
- Railway (Operational)
- Transmission Line
- Provincial Park
- Provincial Forest
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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Metres

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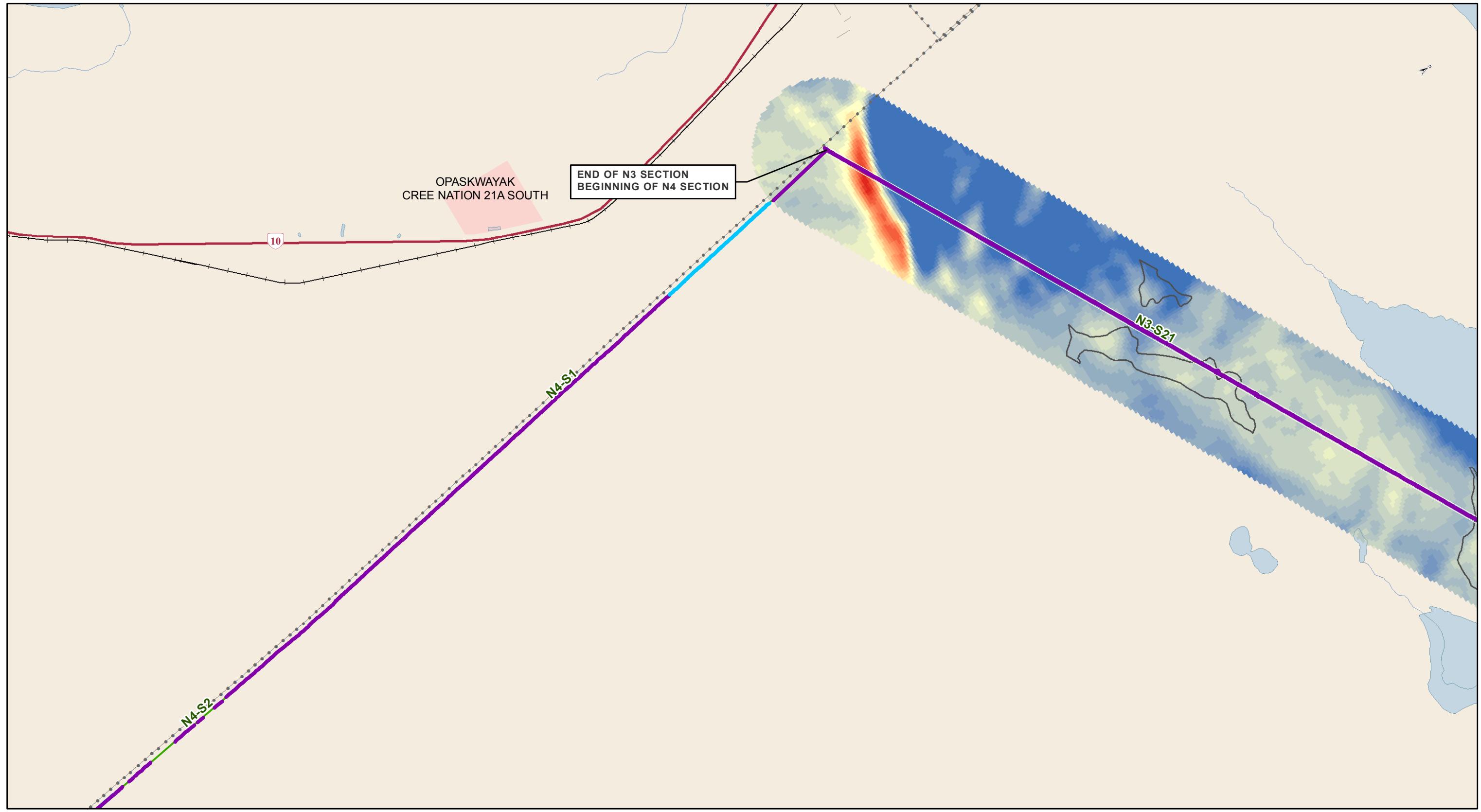
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

**TIR Summer 2014 (°C)**  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
Local Road  
66m ROW

**Landbase**  
Provincial Road  
Local Road  
Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

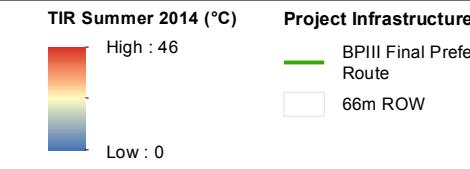
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**Base Data**  
Permafrost

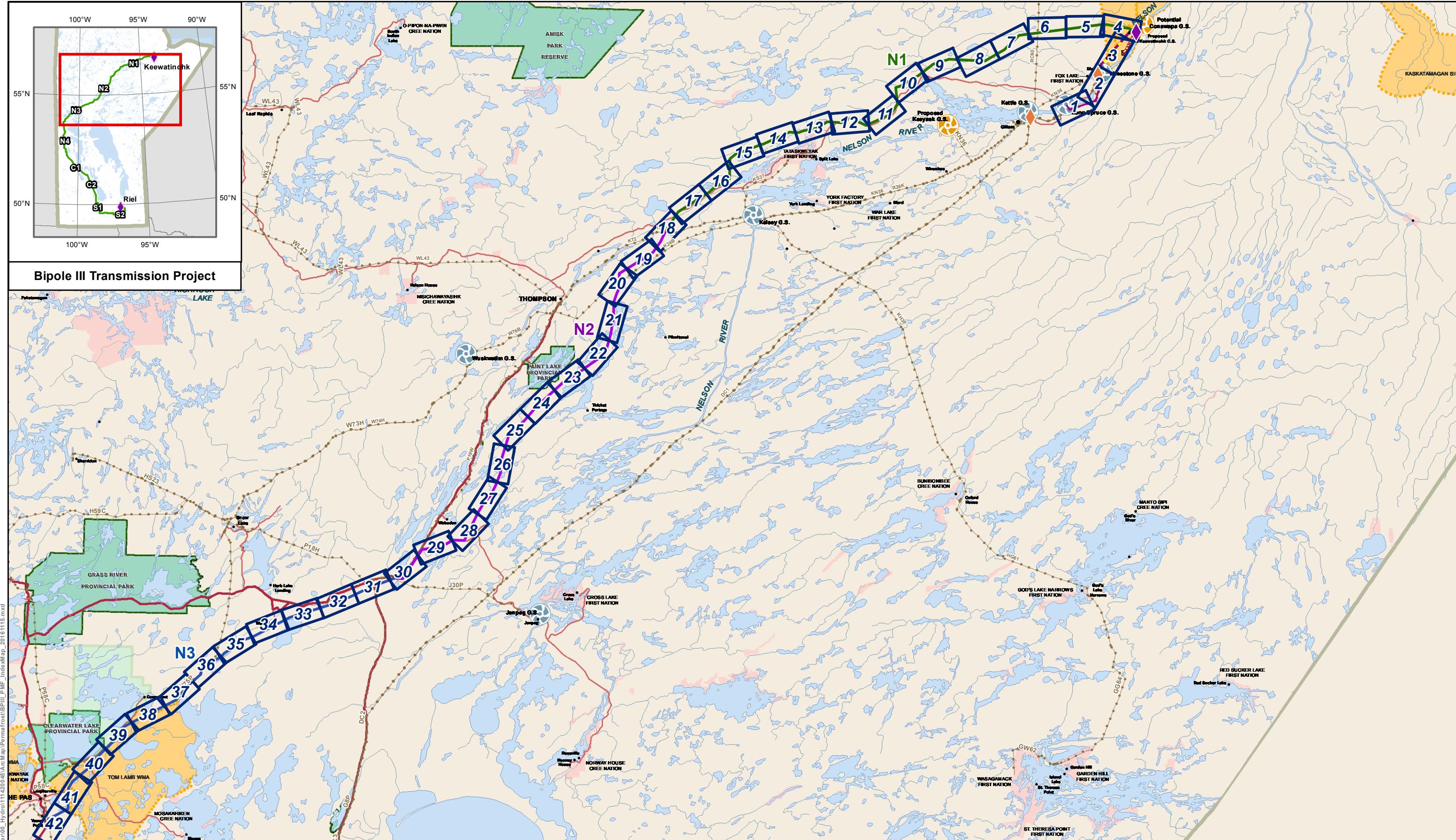
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Local Road  
Railway (Operational)  
Transmission Line  
First Nation  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2014**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, Stantec, ProvMB, NRCAN  
Date Created: November 15, 2016

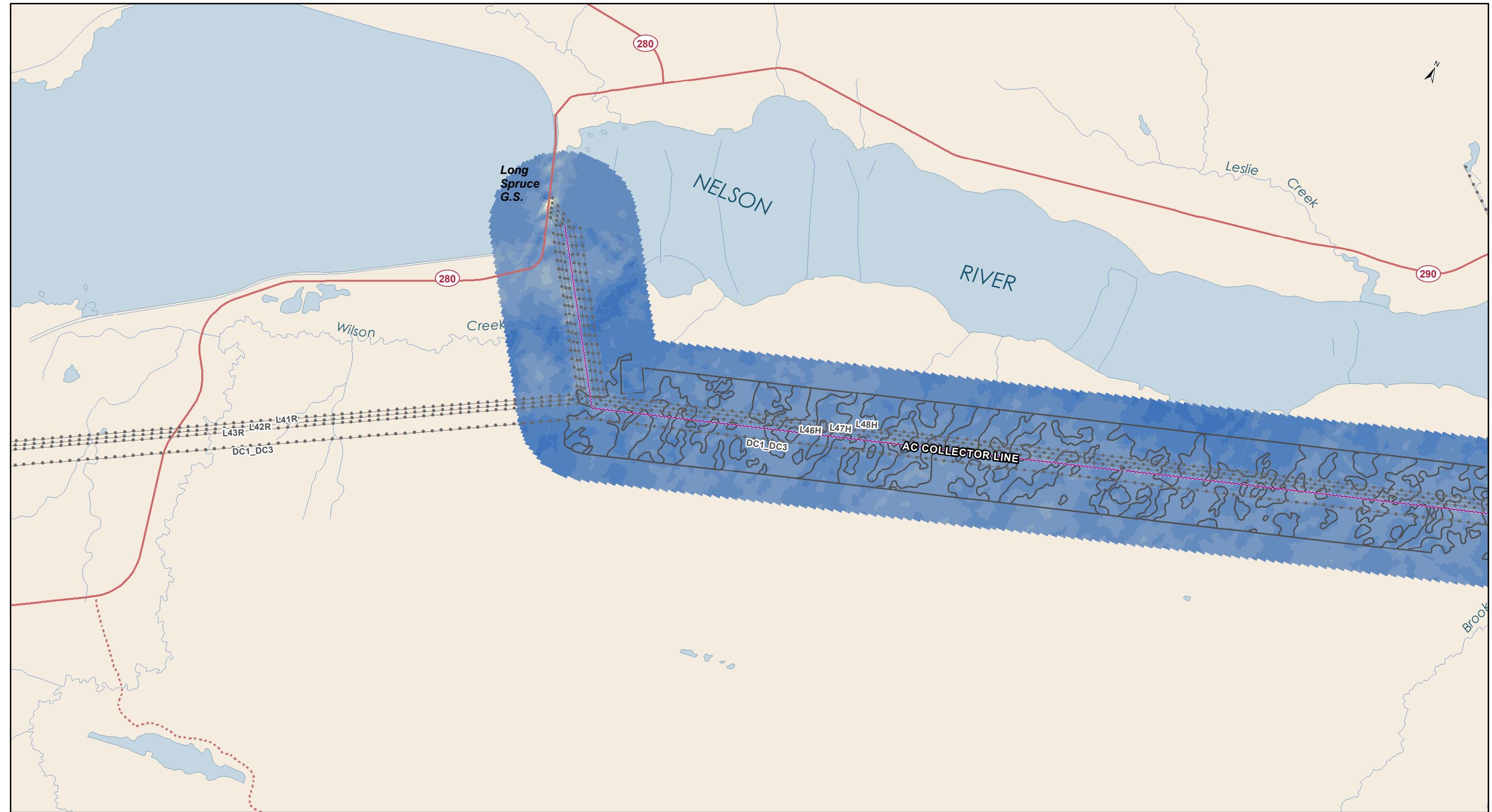
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0 5 10 Miles

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**BPIII Final Preferred Route**

- Section N1
- Section N2
- Section N3

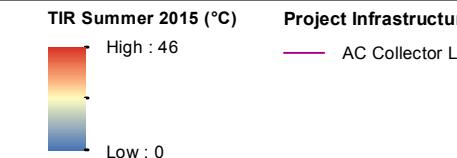
**Bipole III Transmission Project  
Permafrost Monitoring Field Program**  
**Landsat-8 Thermal Data  
Map Index**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
1:40,000

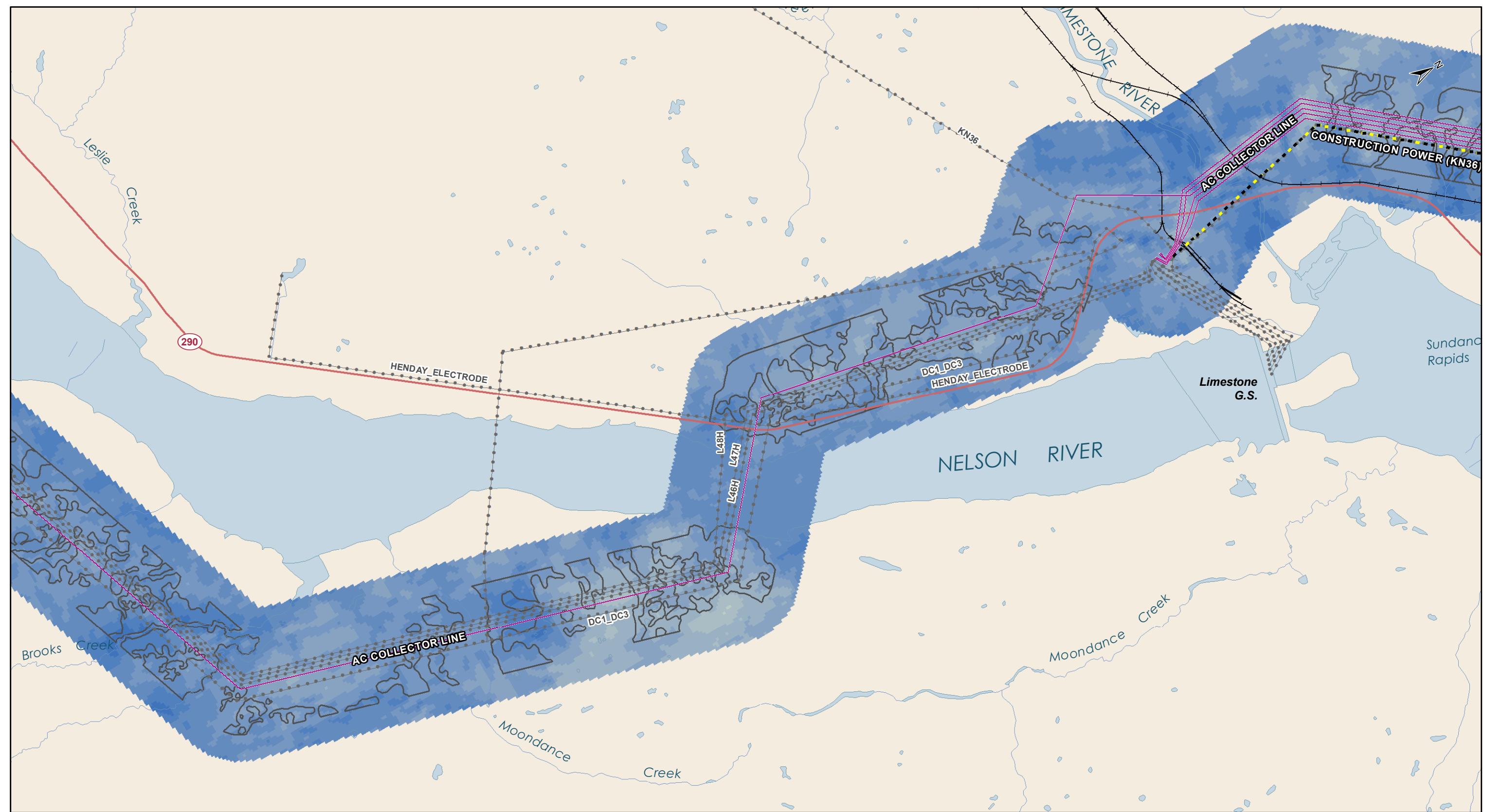
**Base Data**  
Permafrost



**Project Infrastructure**

- Landbase**
- Provincial Road
  - Winter Road
  - Transmission Line
  - Watercourse
  - Waterbody

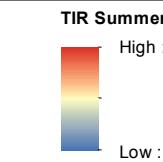
**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 15, 2016

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Metres  
1:40,000

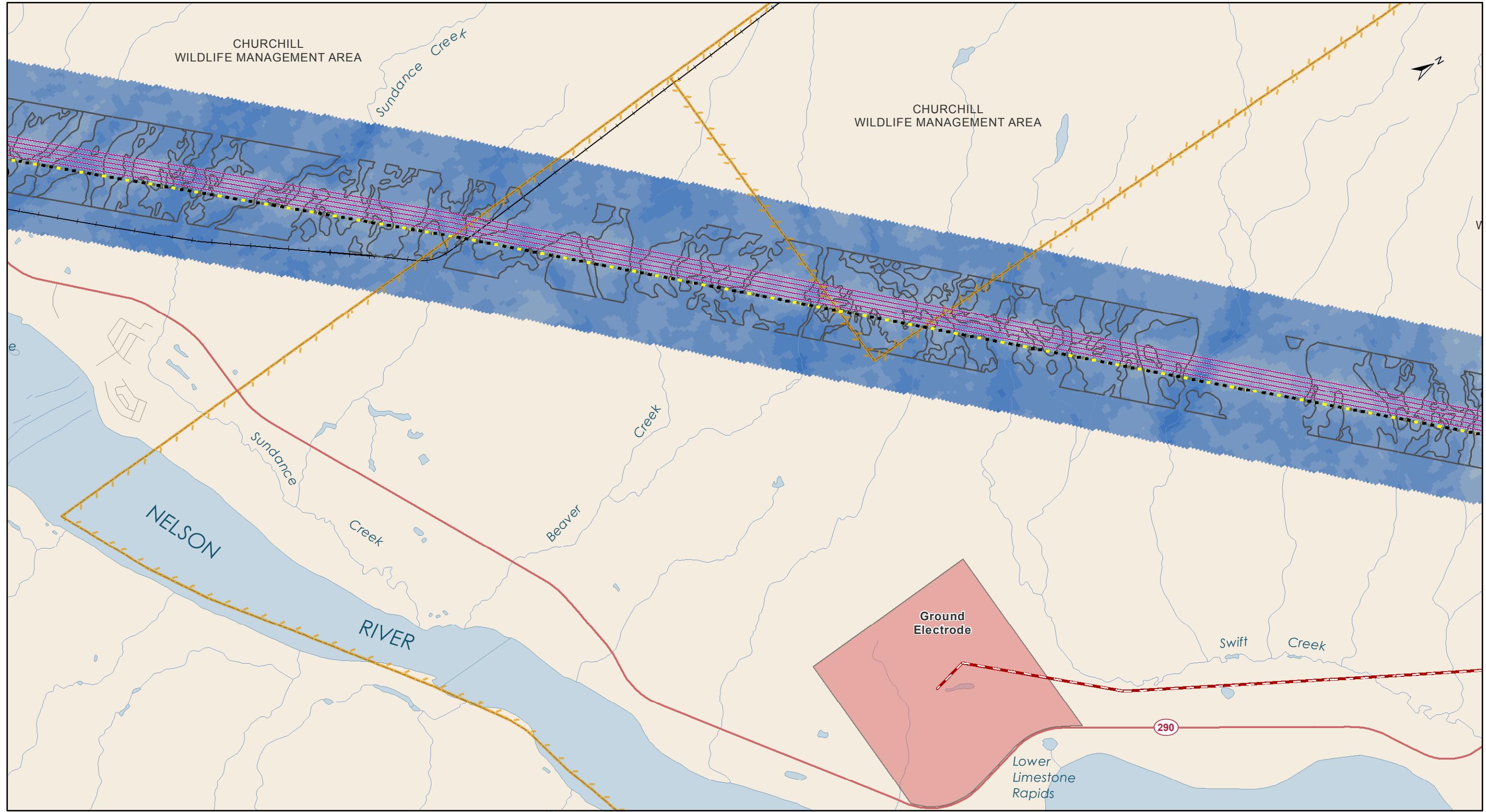
Base Data  
Permafrost



Project Infrastructure  
Construction Power (KN36)  
AC Collector Line

Landbase  
Provincial Road  
Railway (Operational)  
Transmission Line  
First Nation  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2015



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 15, 2016

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Metres  
1:40,000

**Base Data**

**TIR Summer 2015 (°C)**

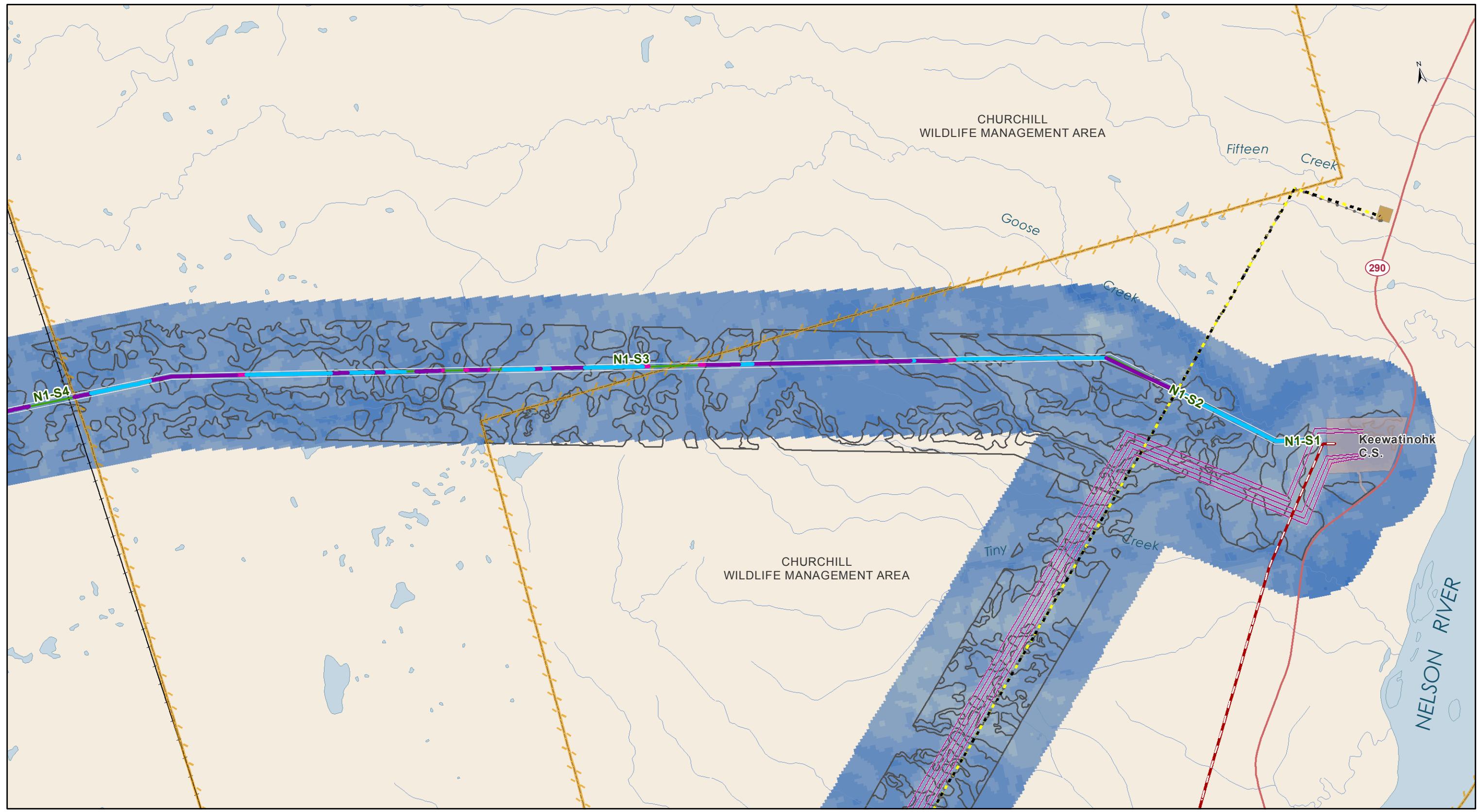
**Project Infrastructure**

- Construction Power (KN36)
- Ground Electrode Line
- AC Collector Line
- Ground Electrode

**Landbase**

- Provincial Road
- Local Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 500 1,000 2,000 Metres

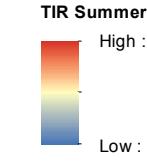
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



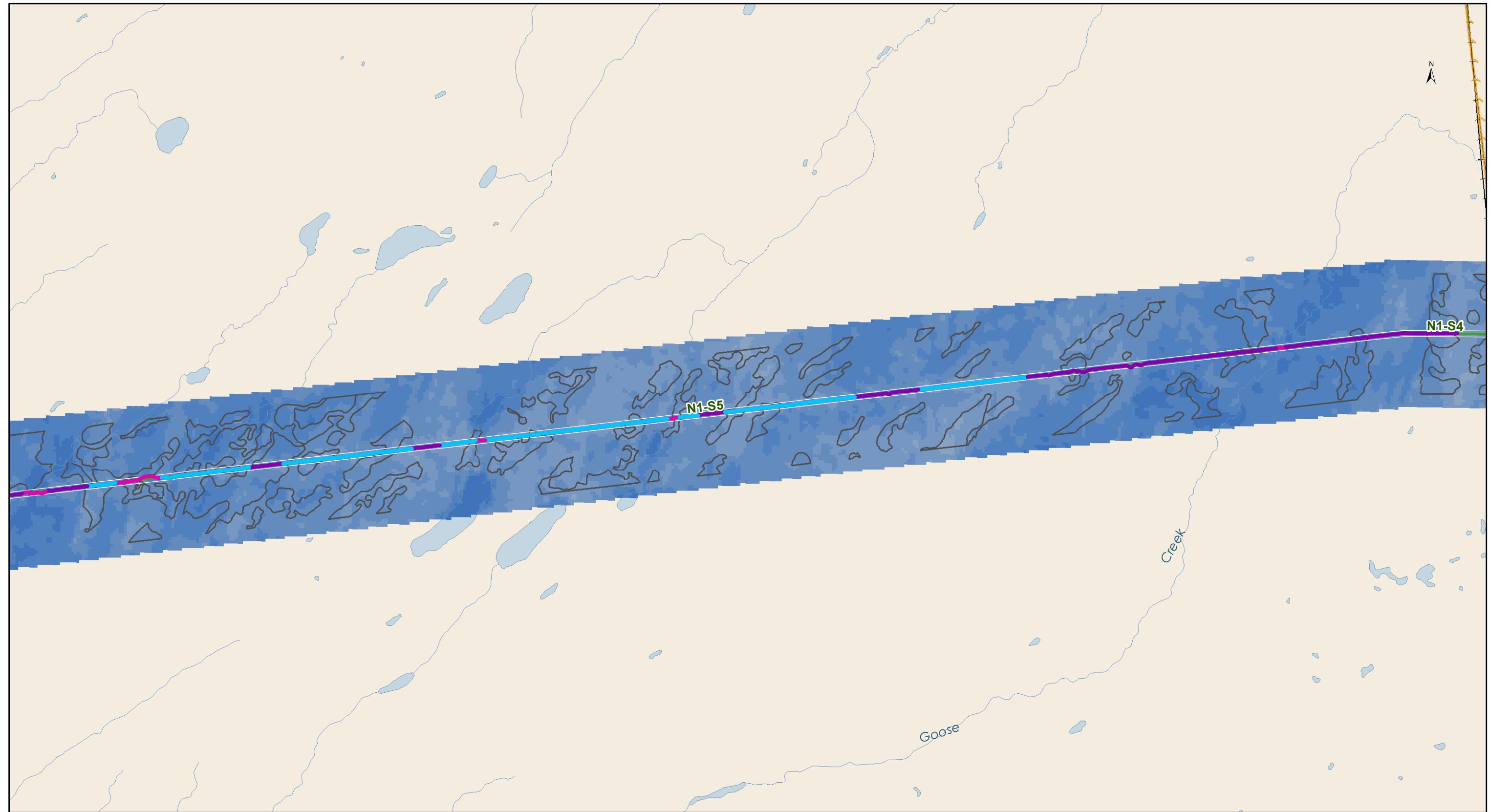
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW
- Construction Power (KN36)
- Ground Electrode Line
- AC Collector Line

**Landbase**

- Provincial Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

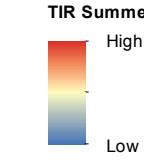
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Metres  
1:40,000



**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



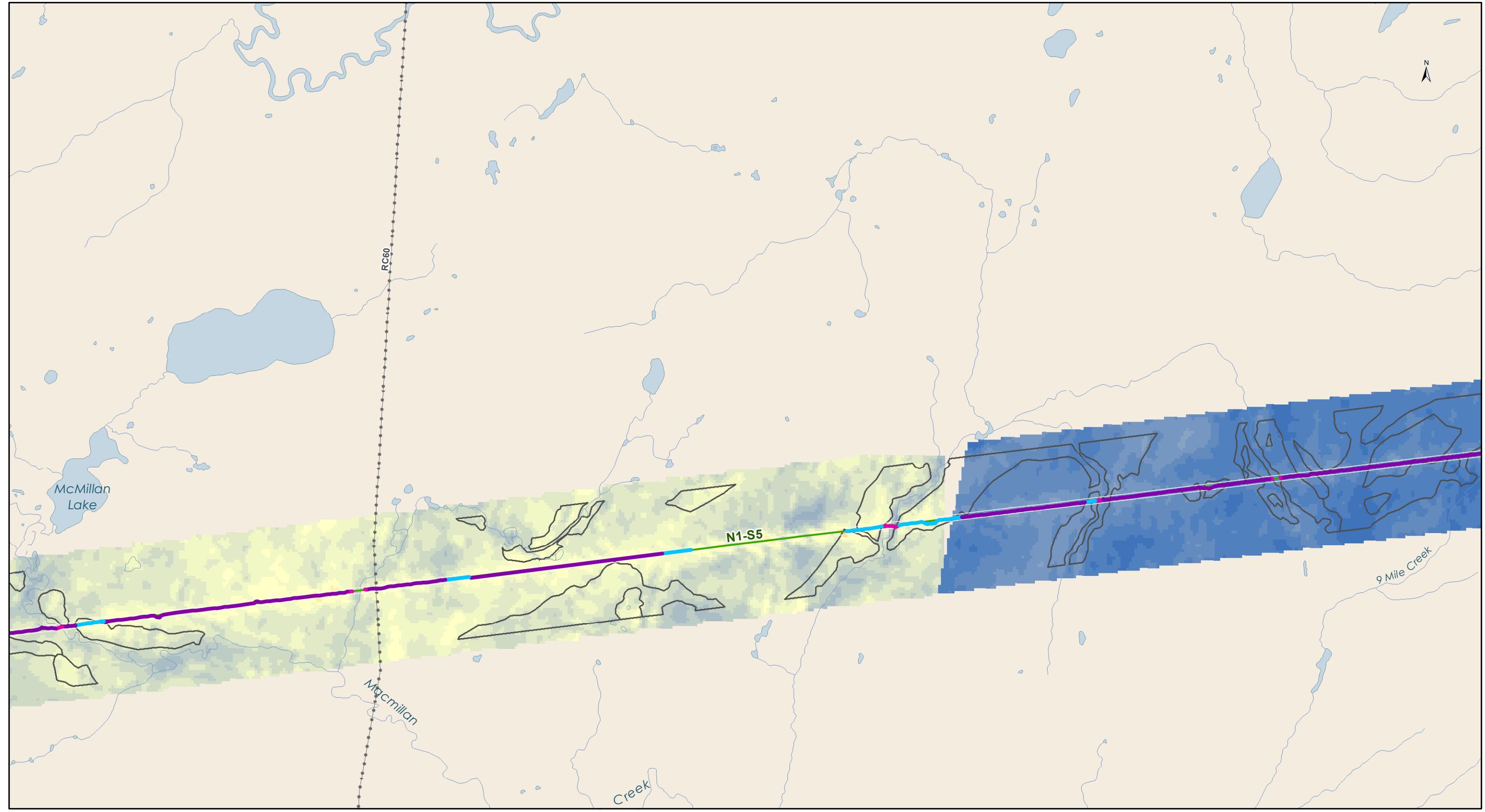
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Railway (Operational)
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

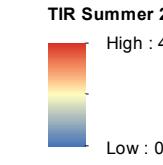
0 500 1,000 2,000  
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1:40,000



**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



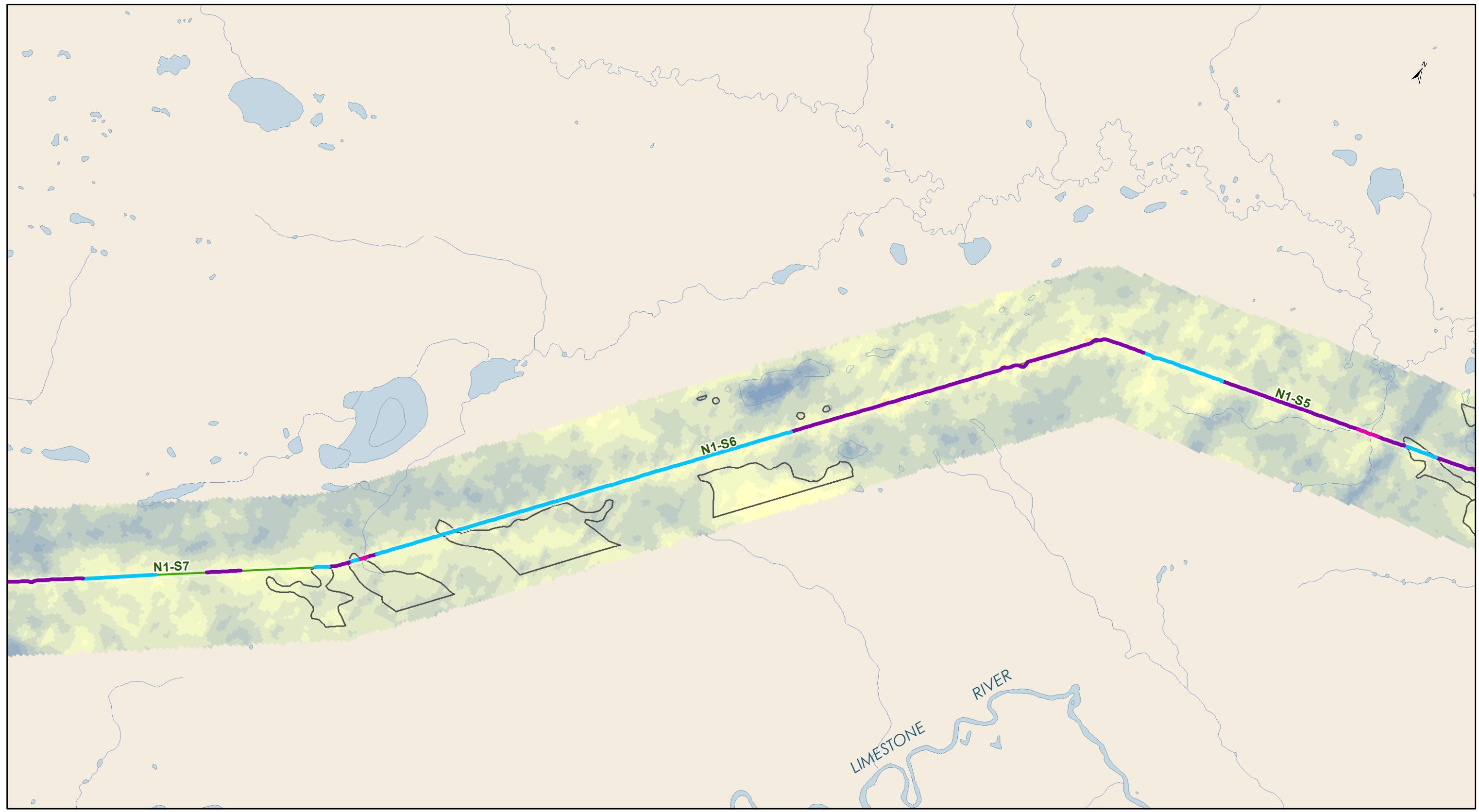
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



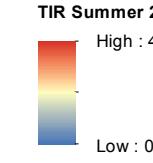
Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 500 1,000 2,000  
Metres  
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



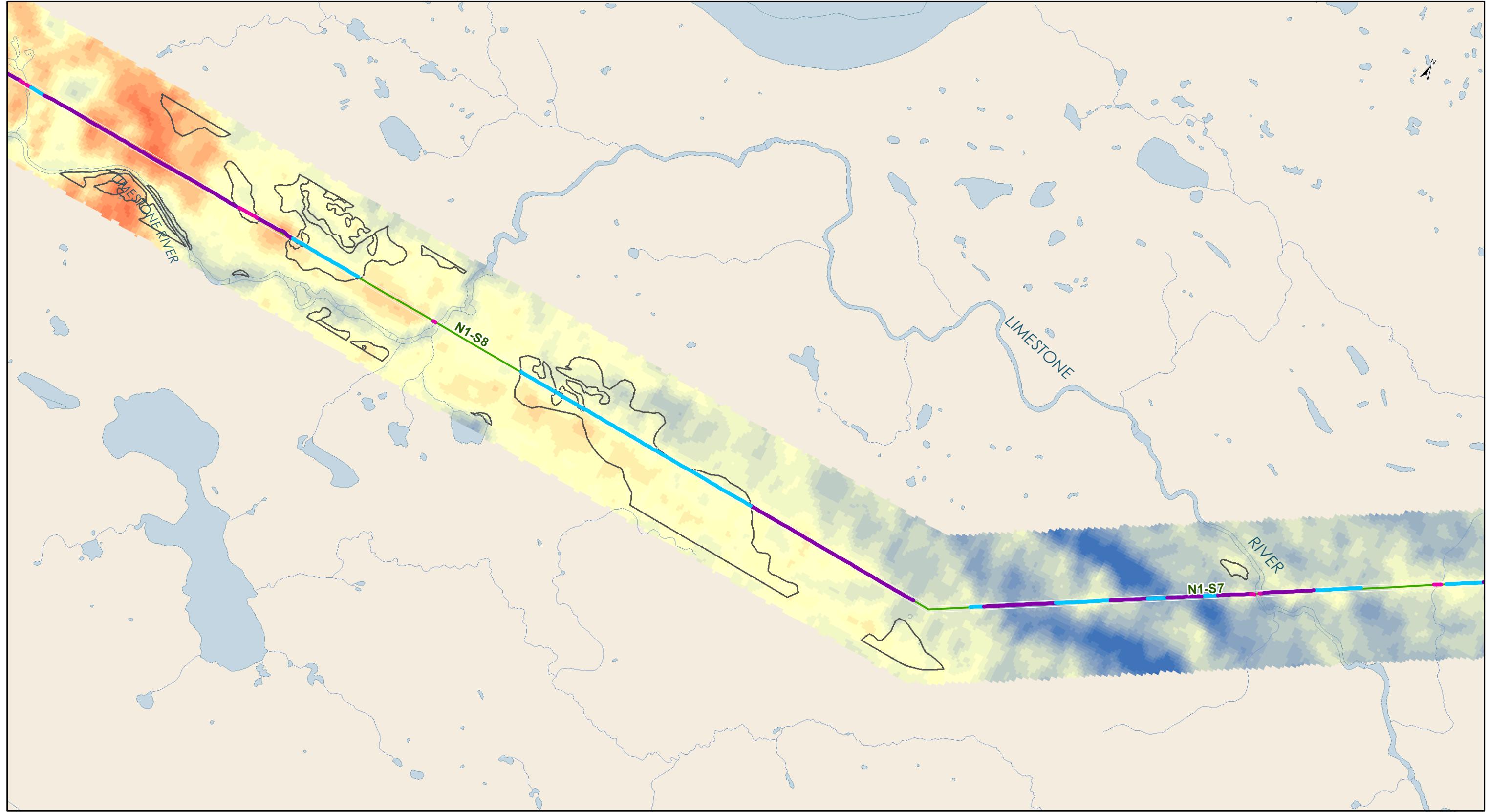
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

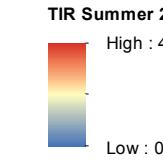


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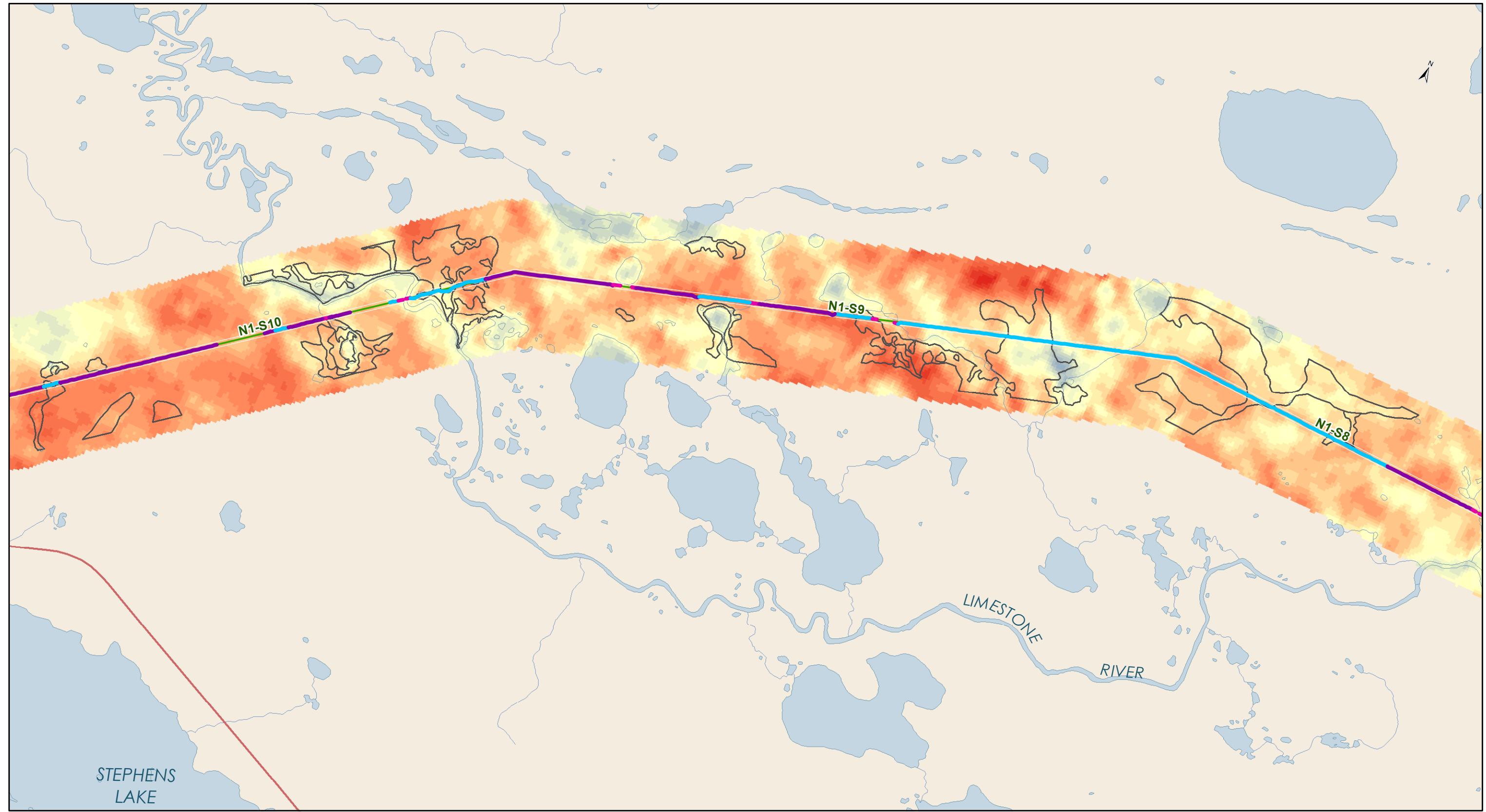
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



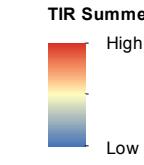
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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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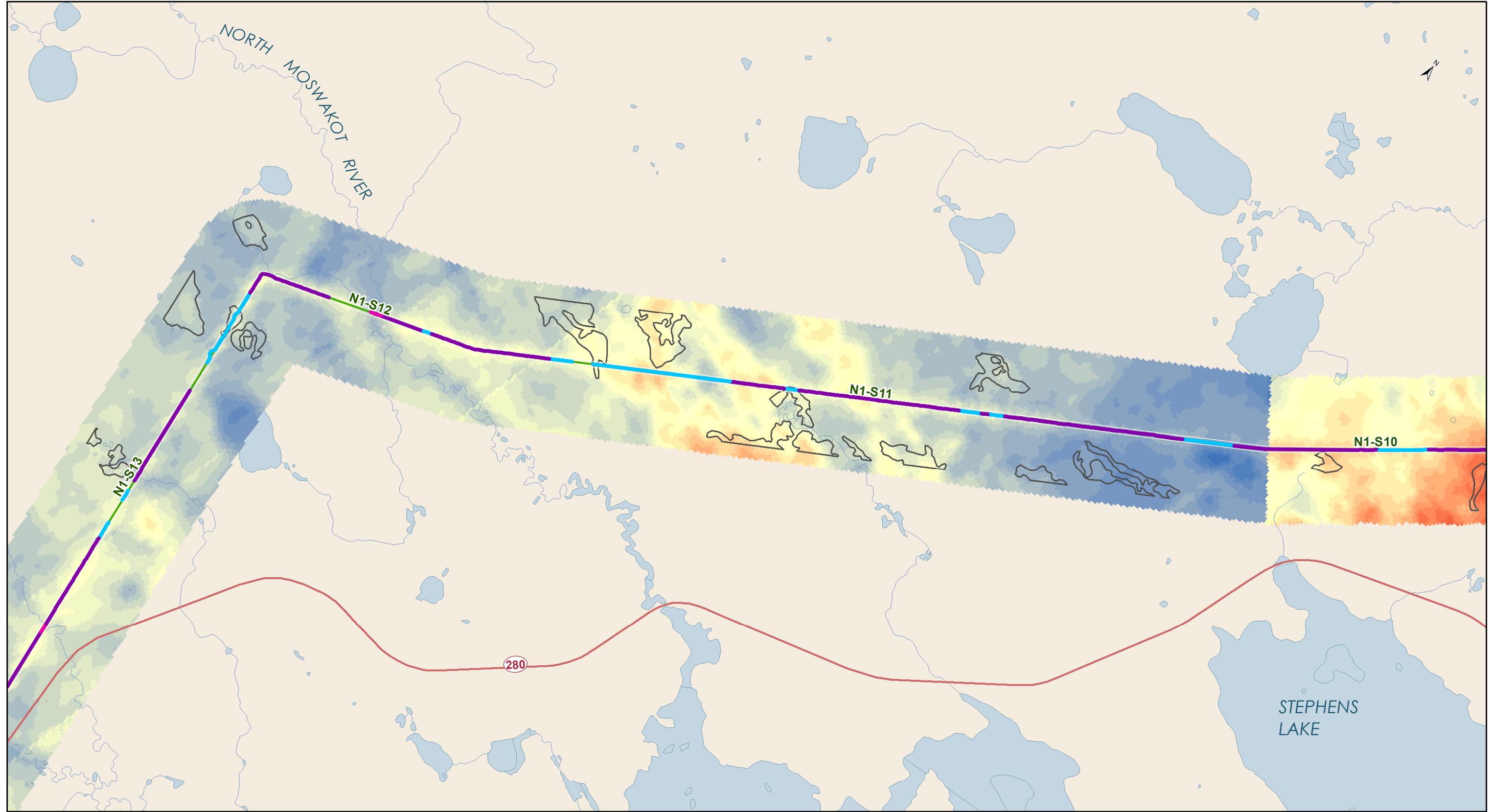
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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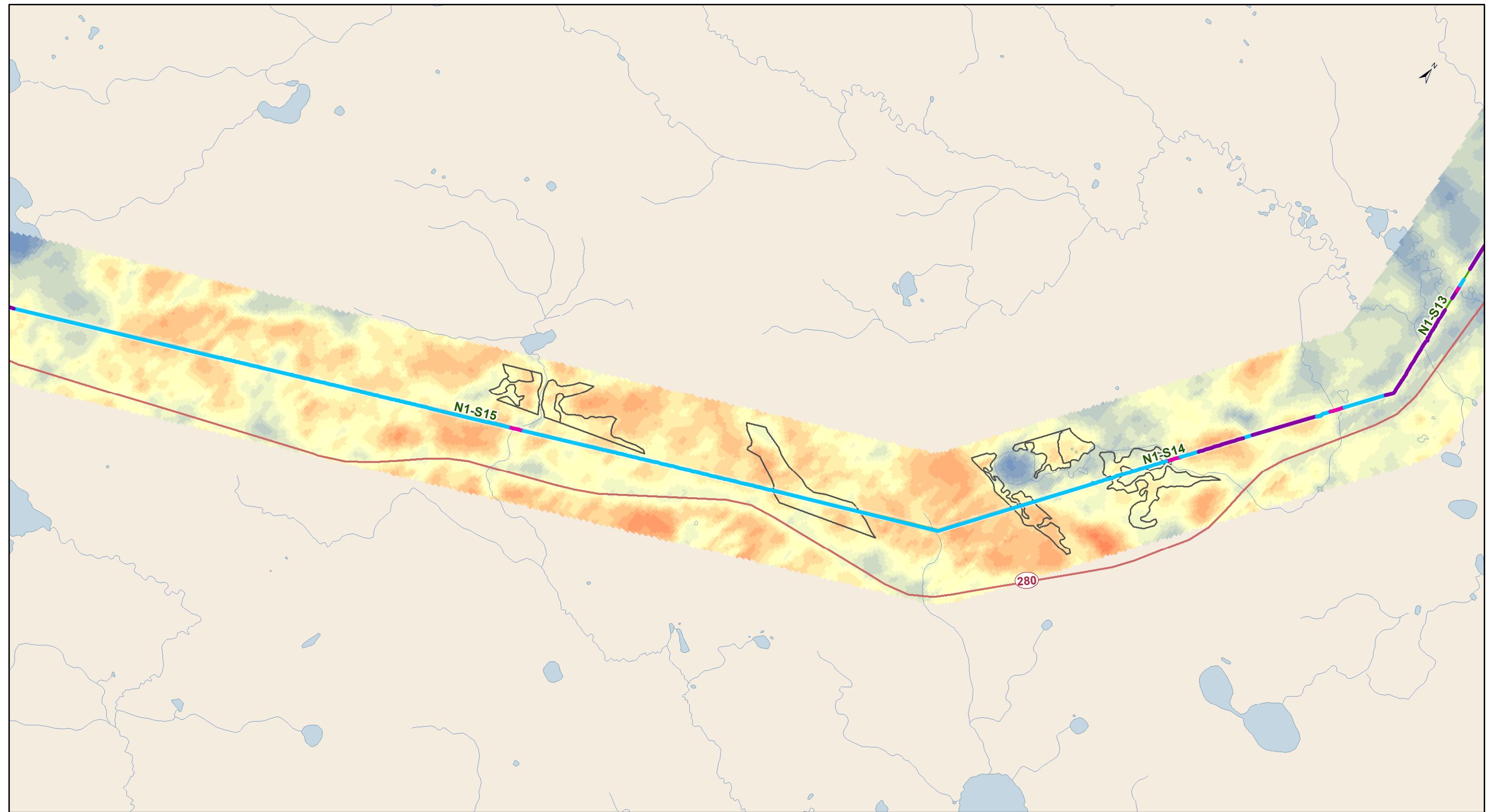
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Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

**TIR Summer 2015 (°C)**  
High : 46  
Medium : 10  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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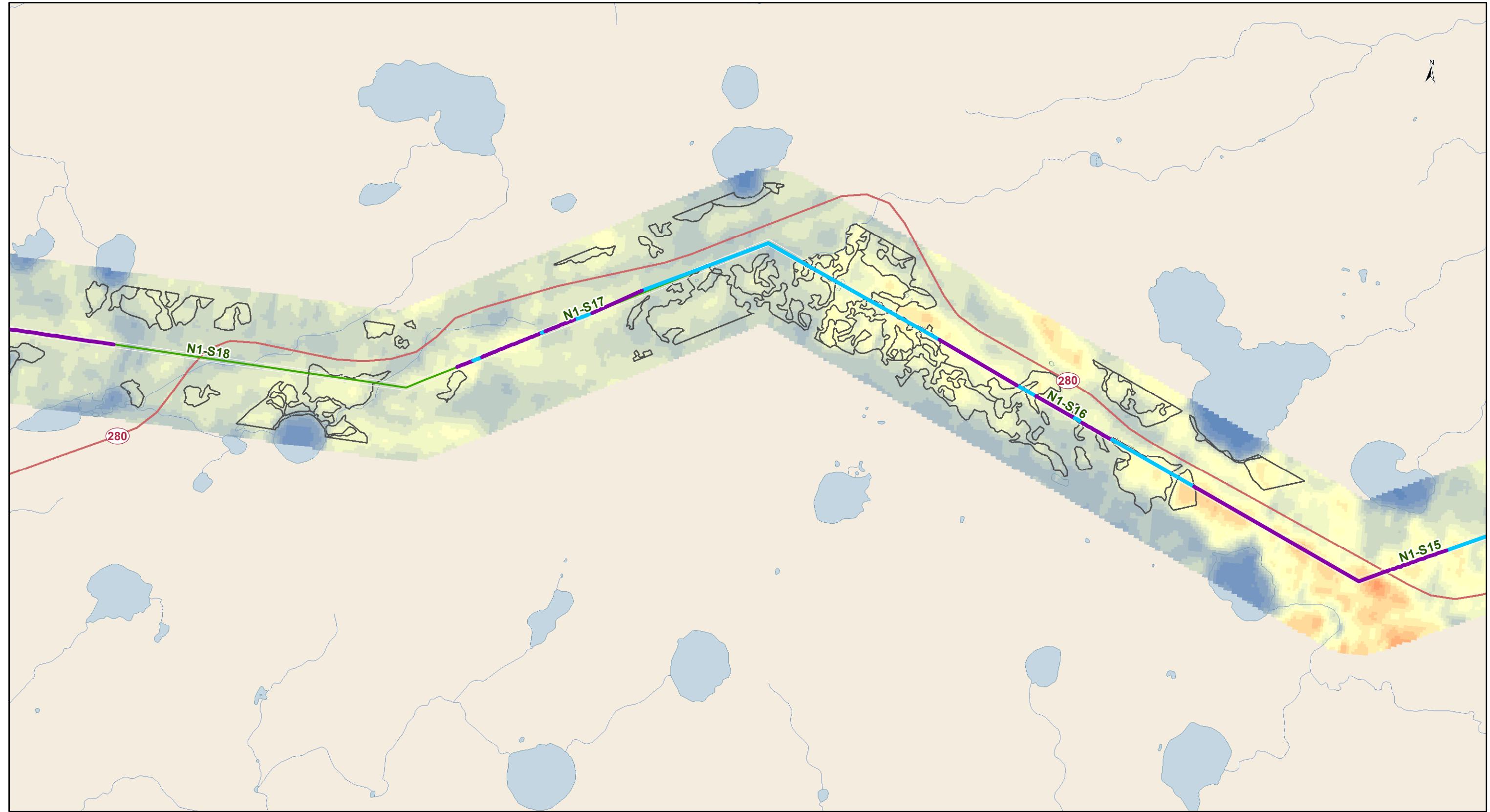
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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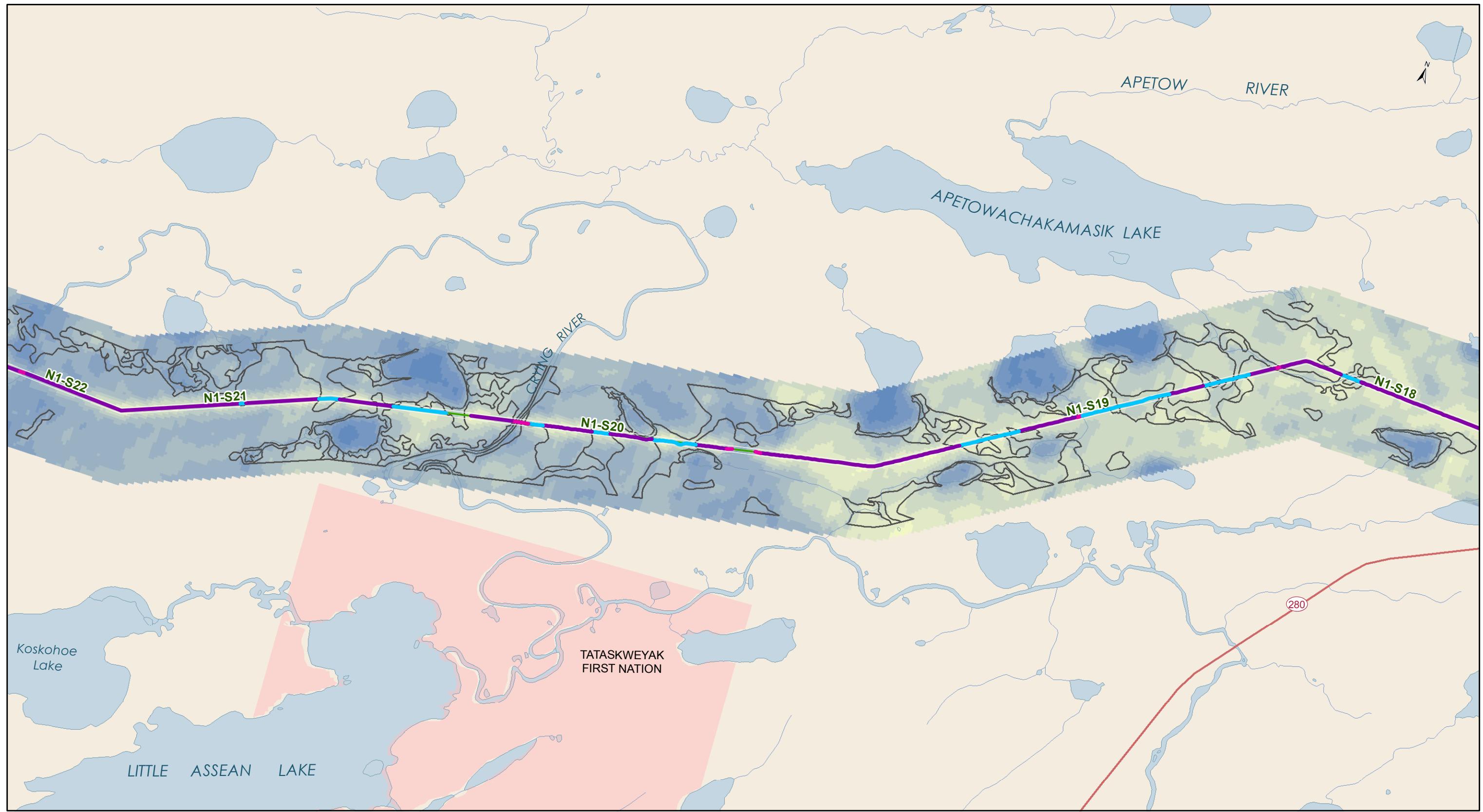
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Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

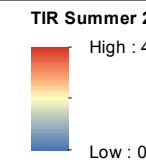


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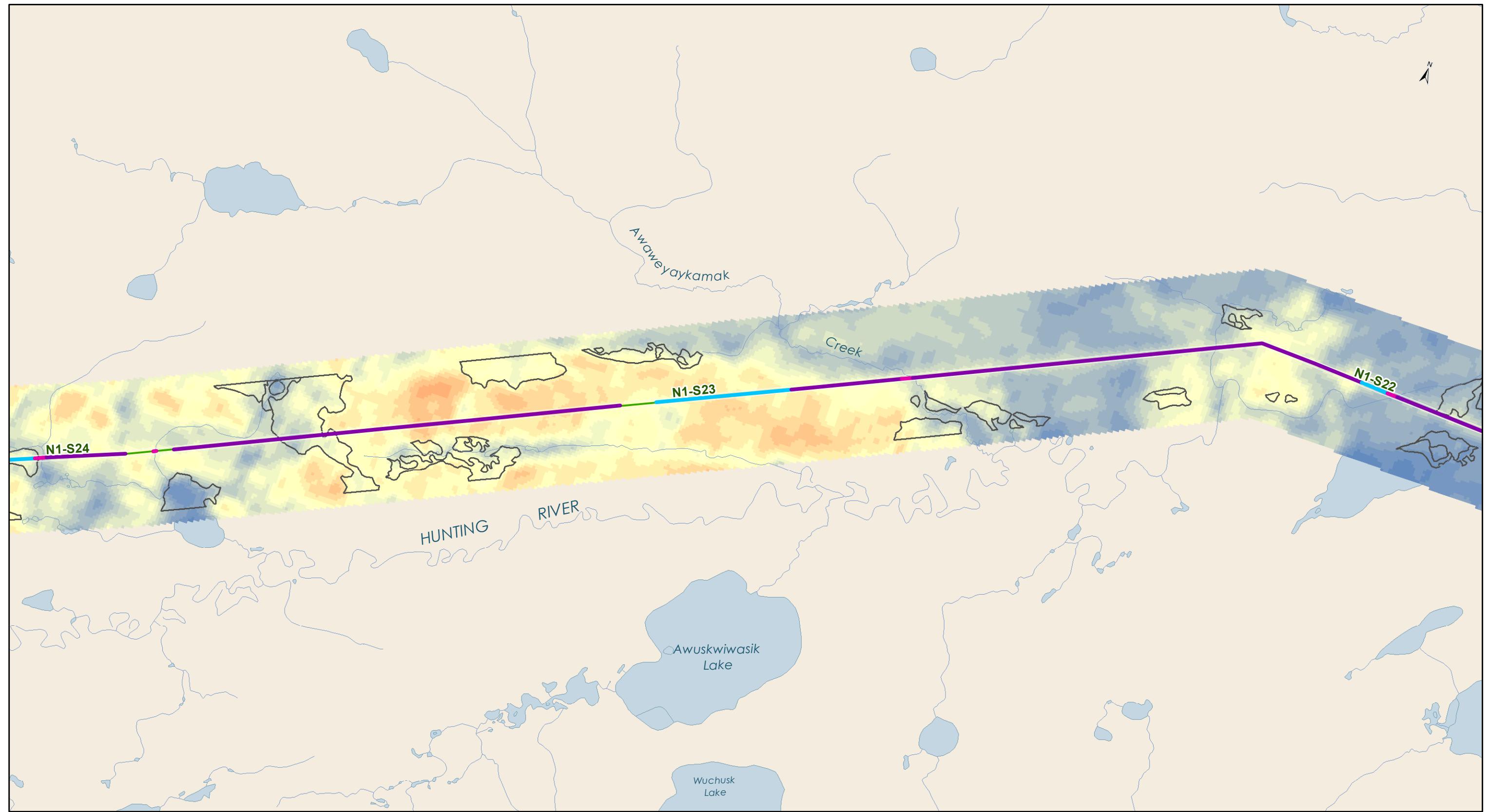
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Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
First Nation  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

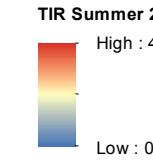


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Date Created: November 14, 2016

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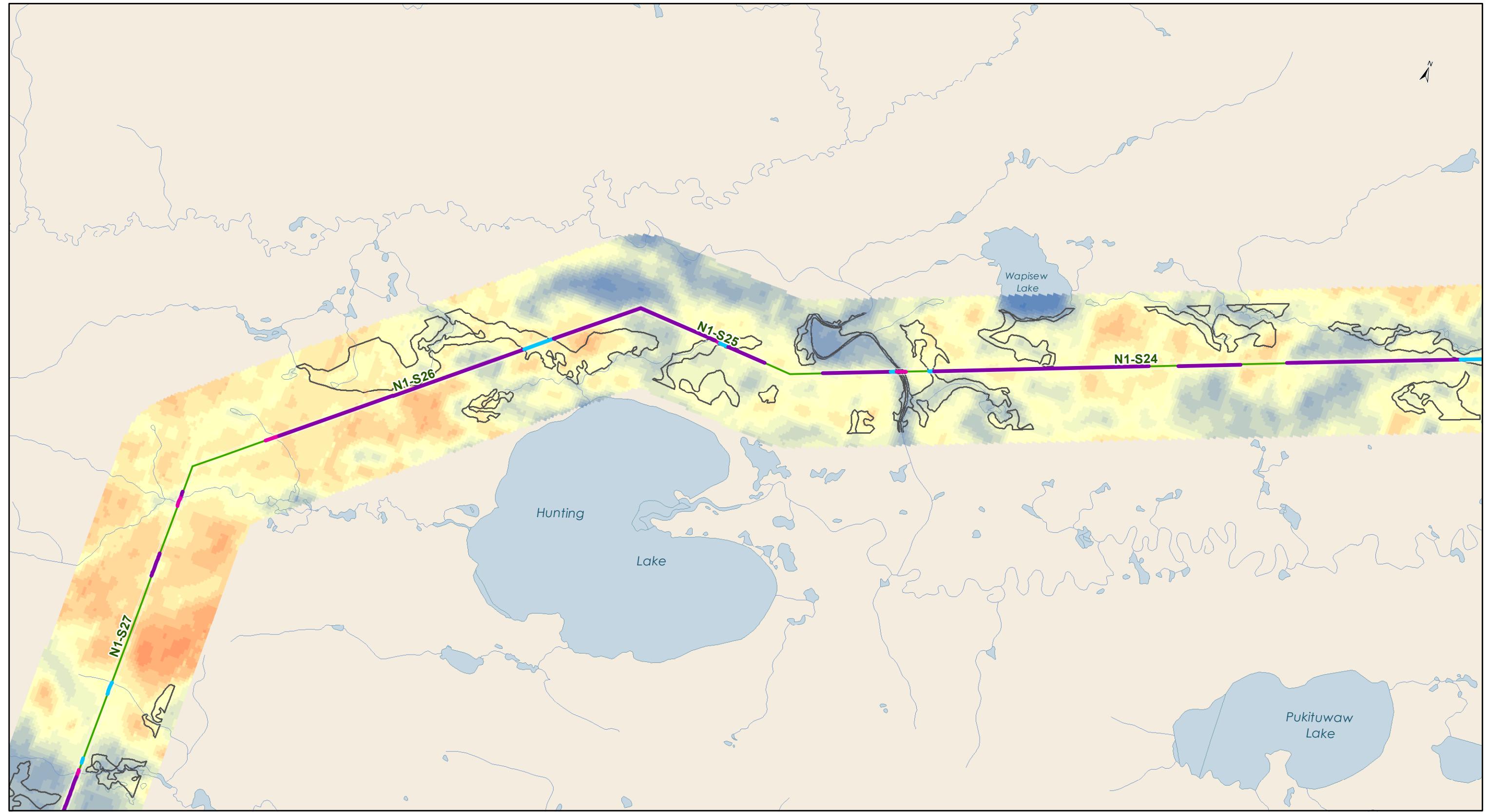
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□ Permafrost  
**ROW Clearing Methods**  
— General Clearing  
— Low Disturbance Clearing  
— Selective Clearing



**Project Infrastructure**  
— BP III Final Preferred Route  
□ 66m ROW

**Landbase**  
— Watercourse  
— Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

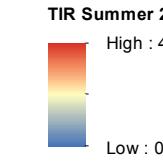


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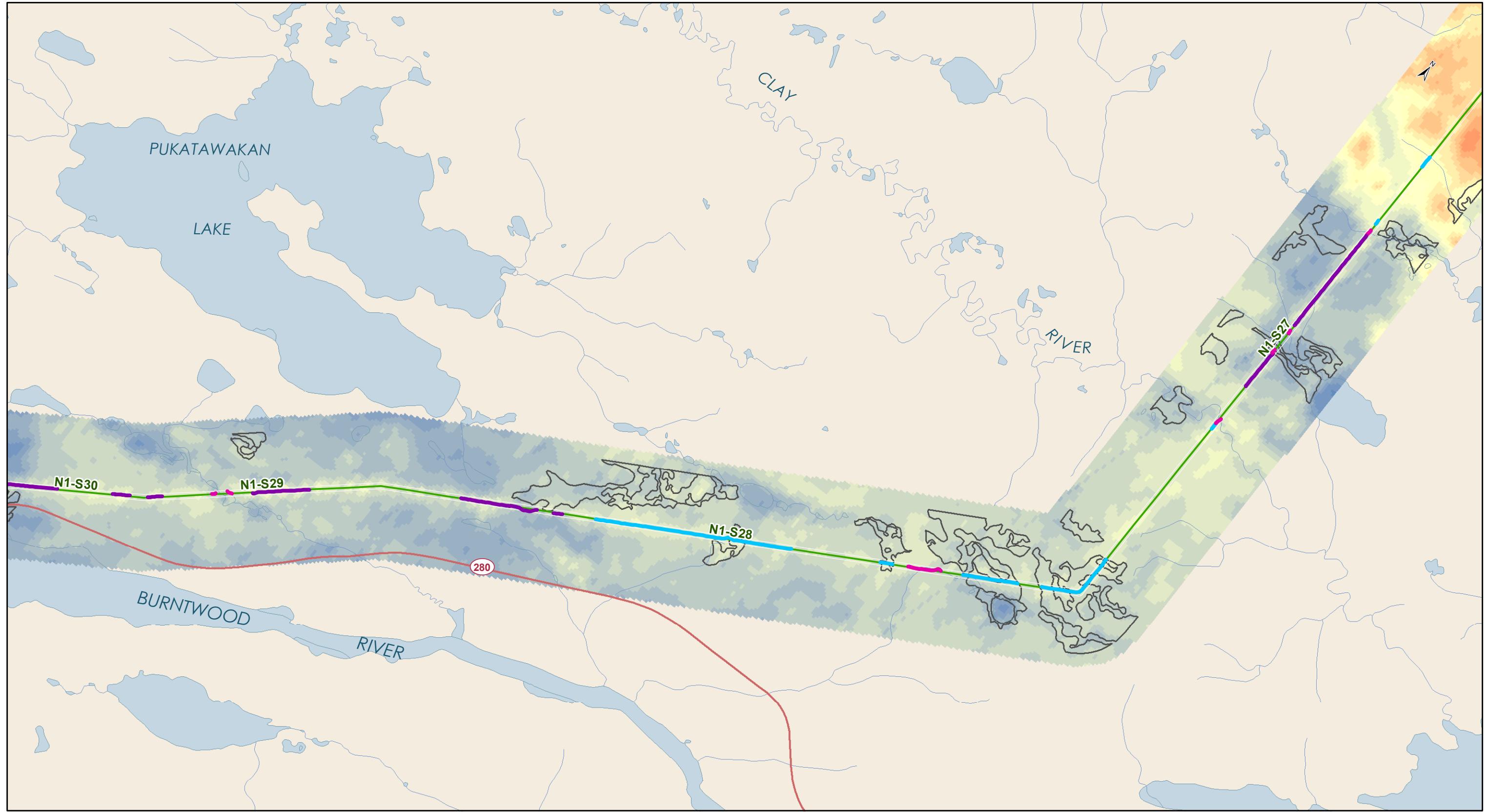
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Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

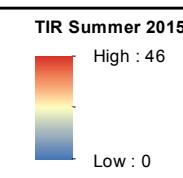


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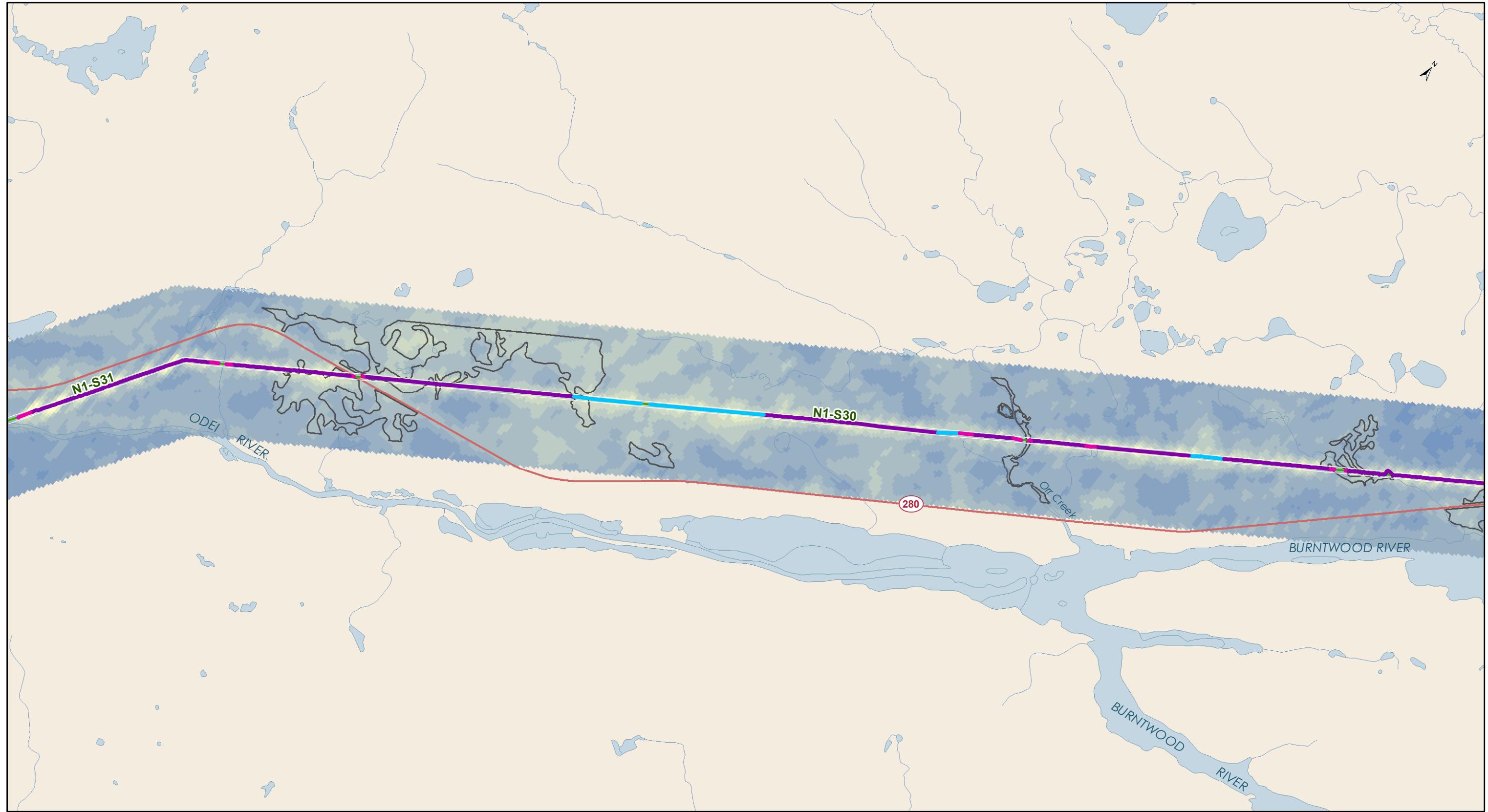
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

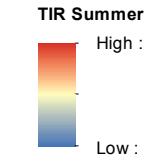
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



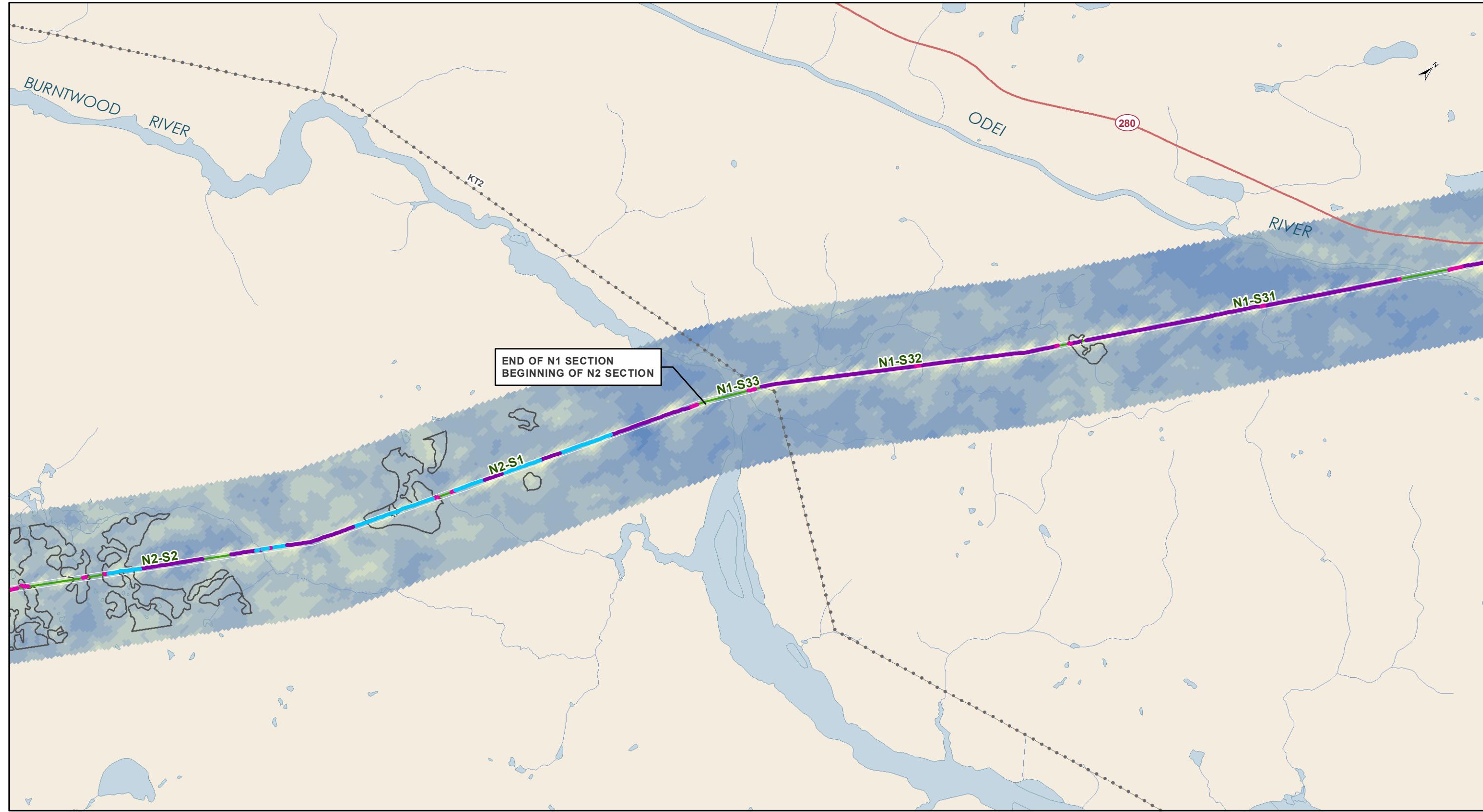
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

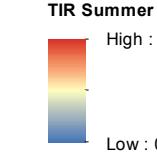
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



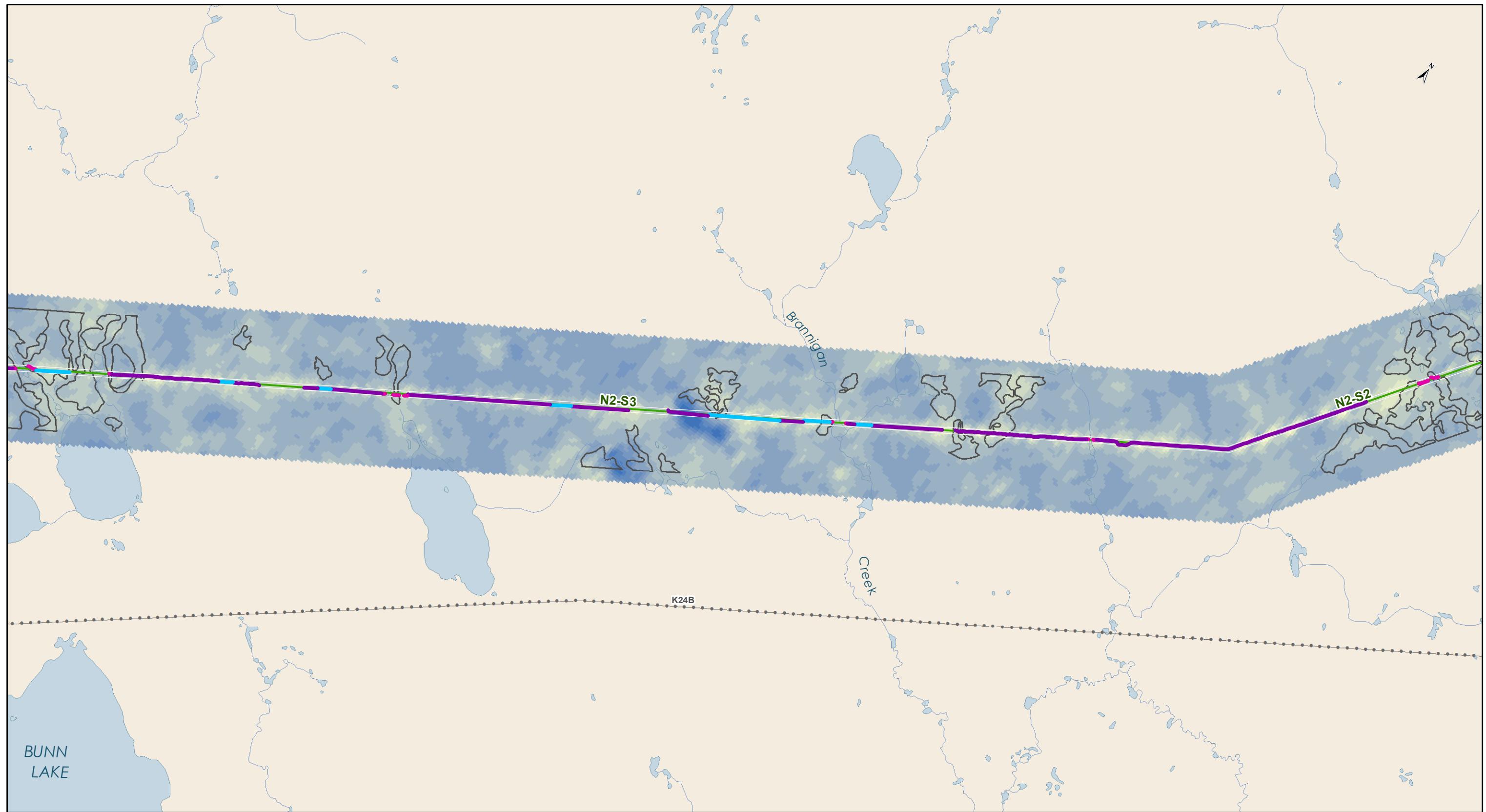
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

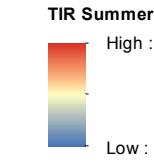


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Date Created: November 14, 2016

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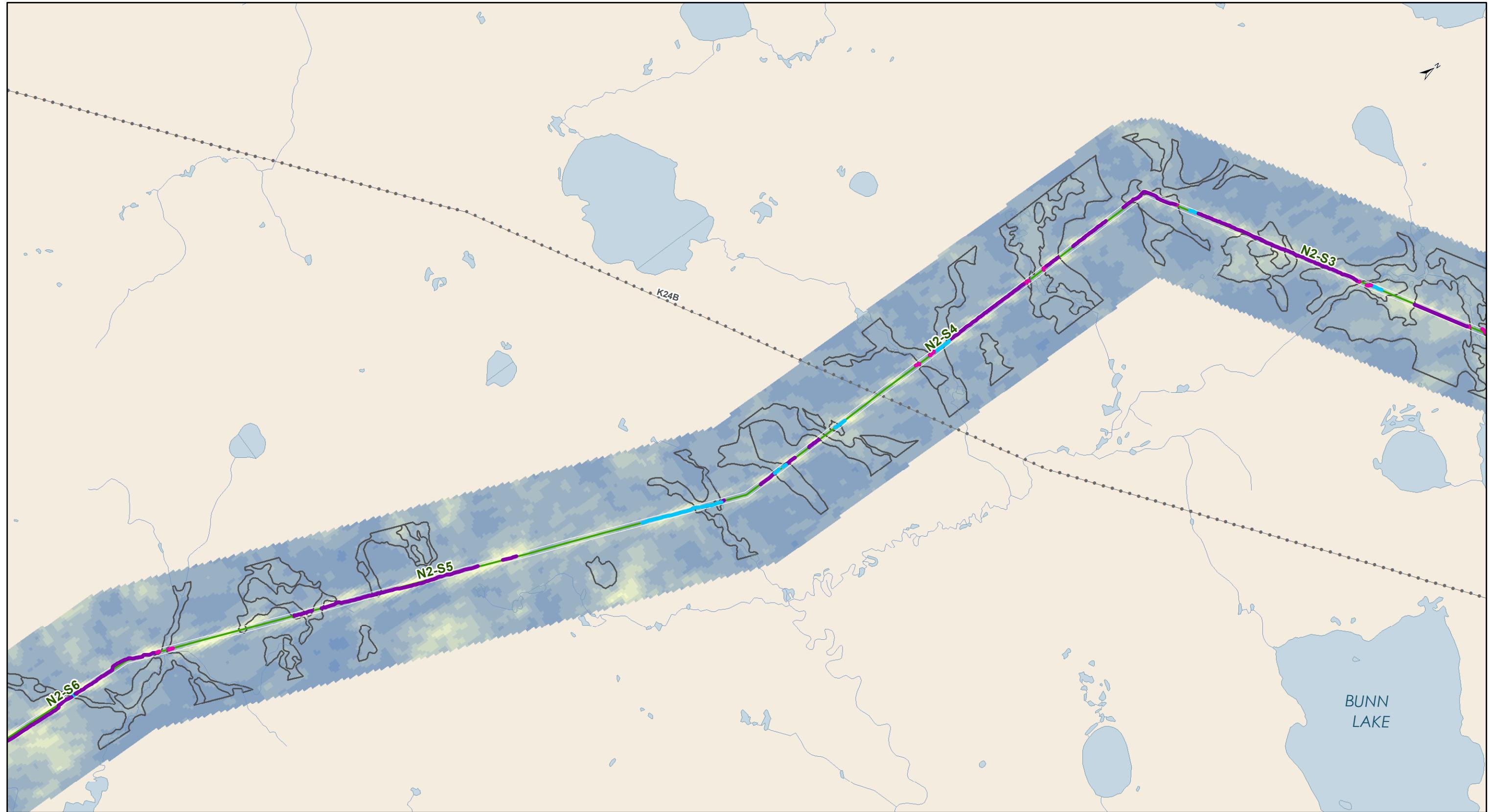
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**

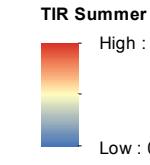


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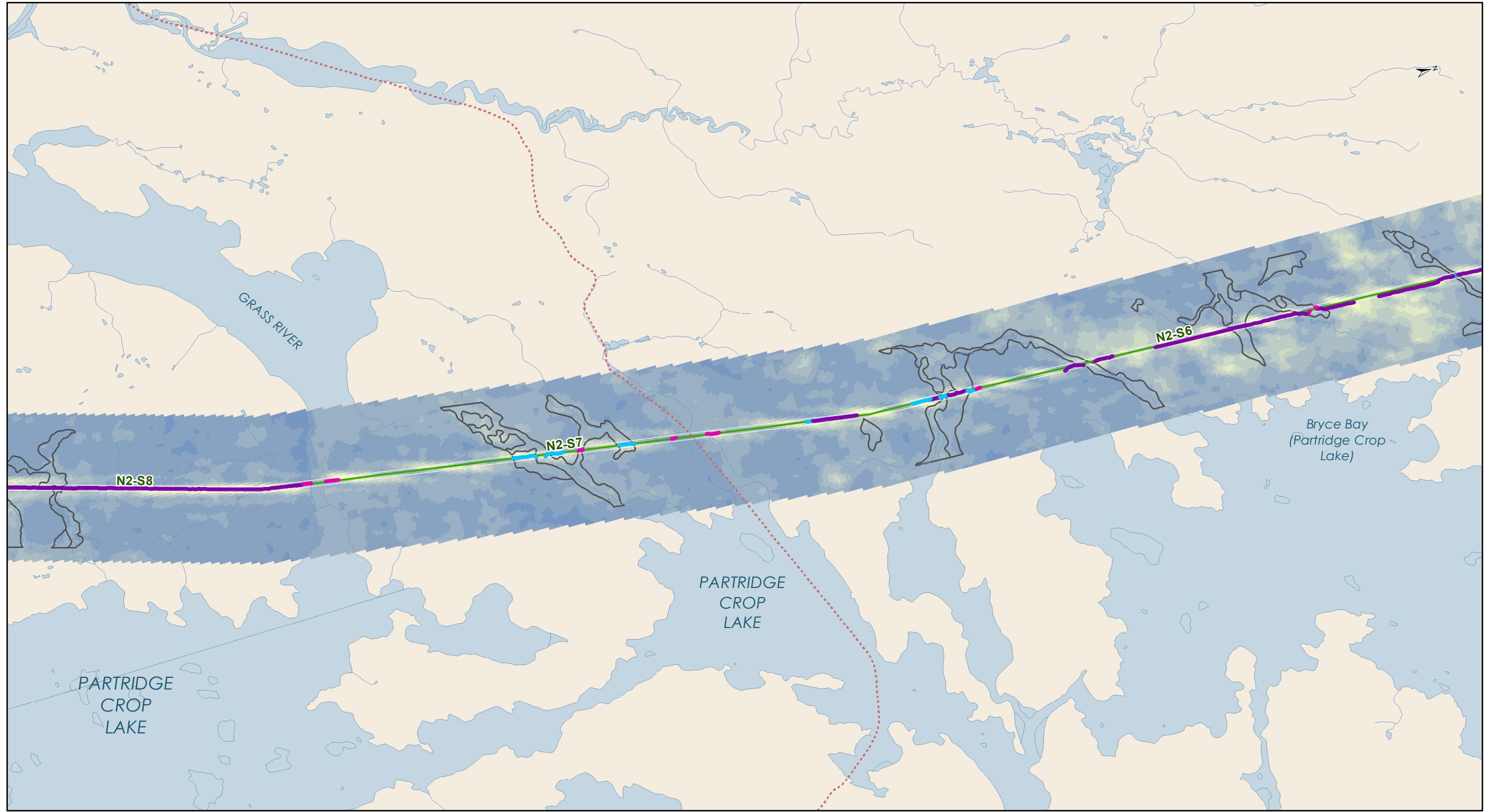
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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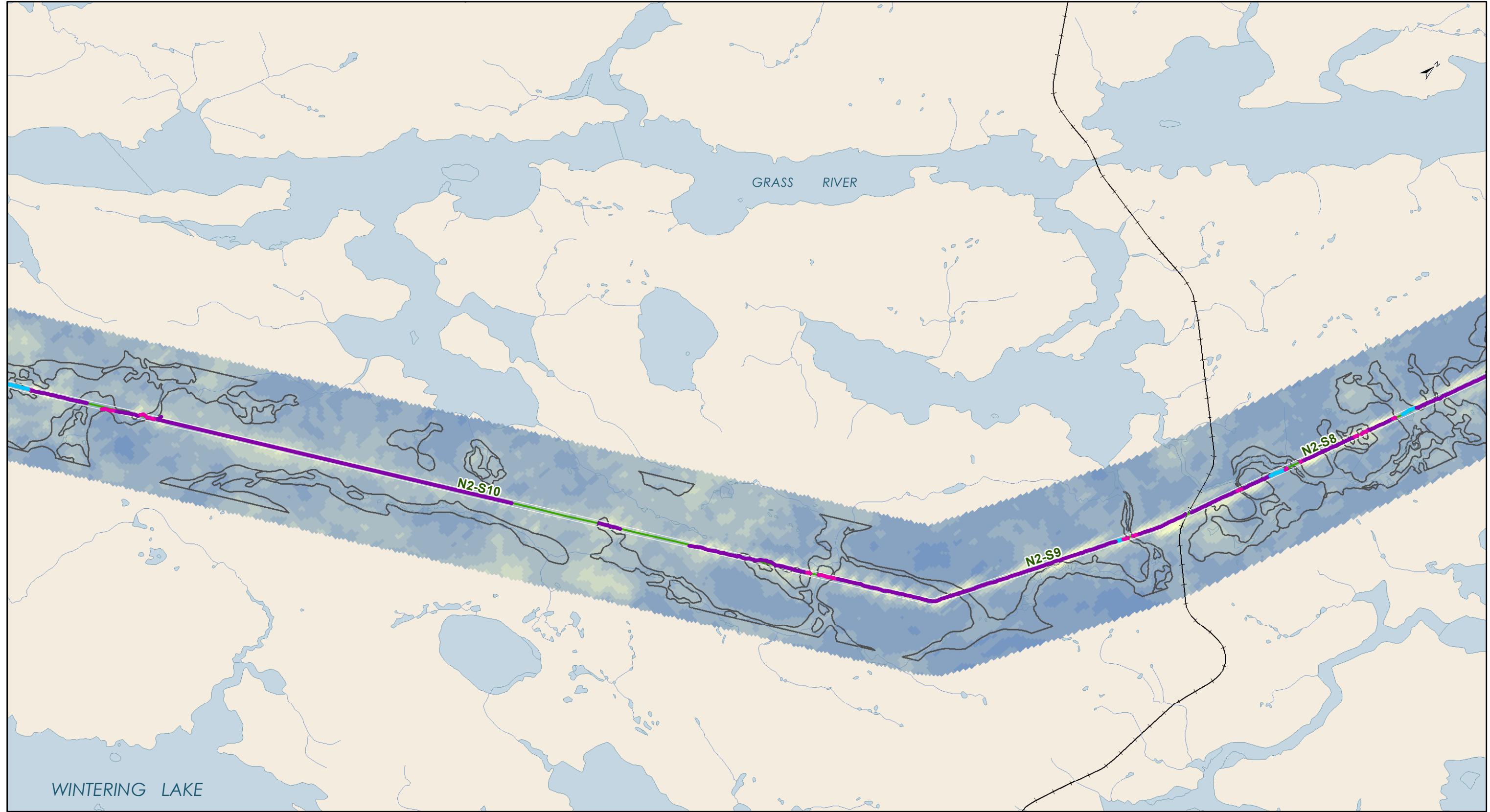
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Winter Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

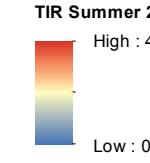
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Metres  
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Railway (Operational)
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



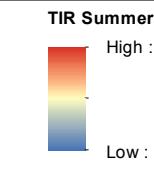
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Date Created: November 14, 2016

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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



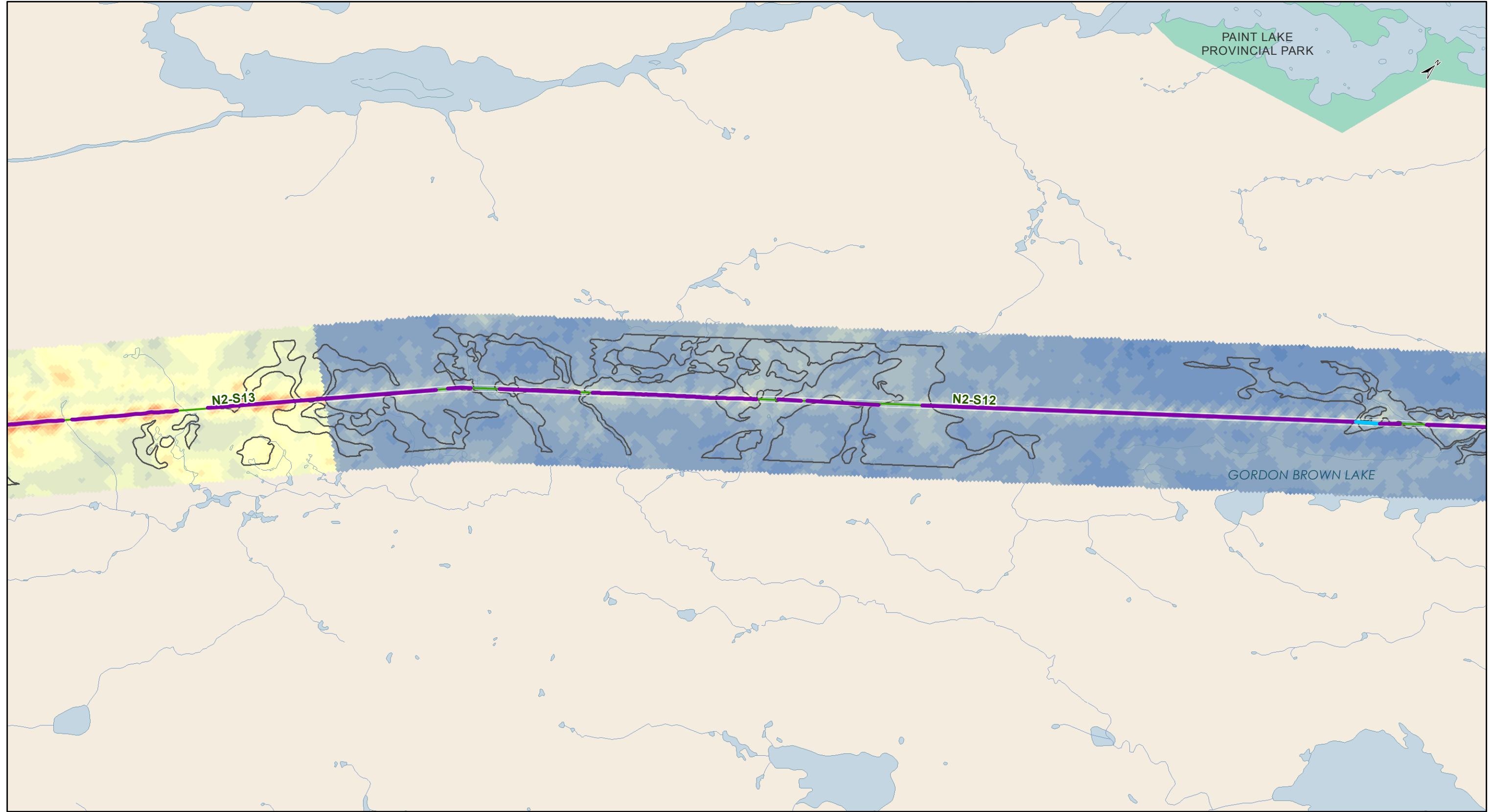
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Winter Road
- Provincial Park
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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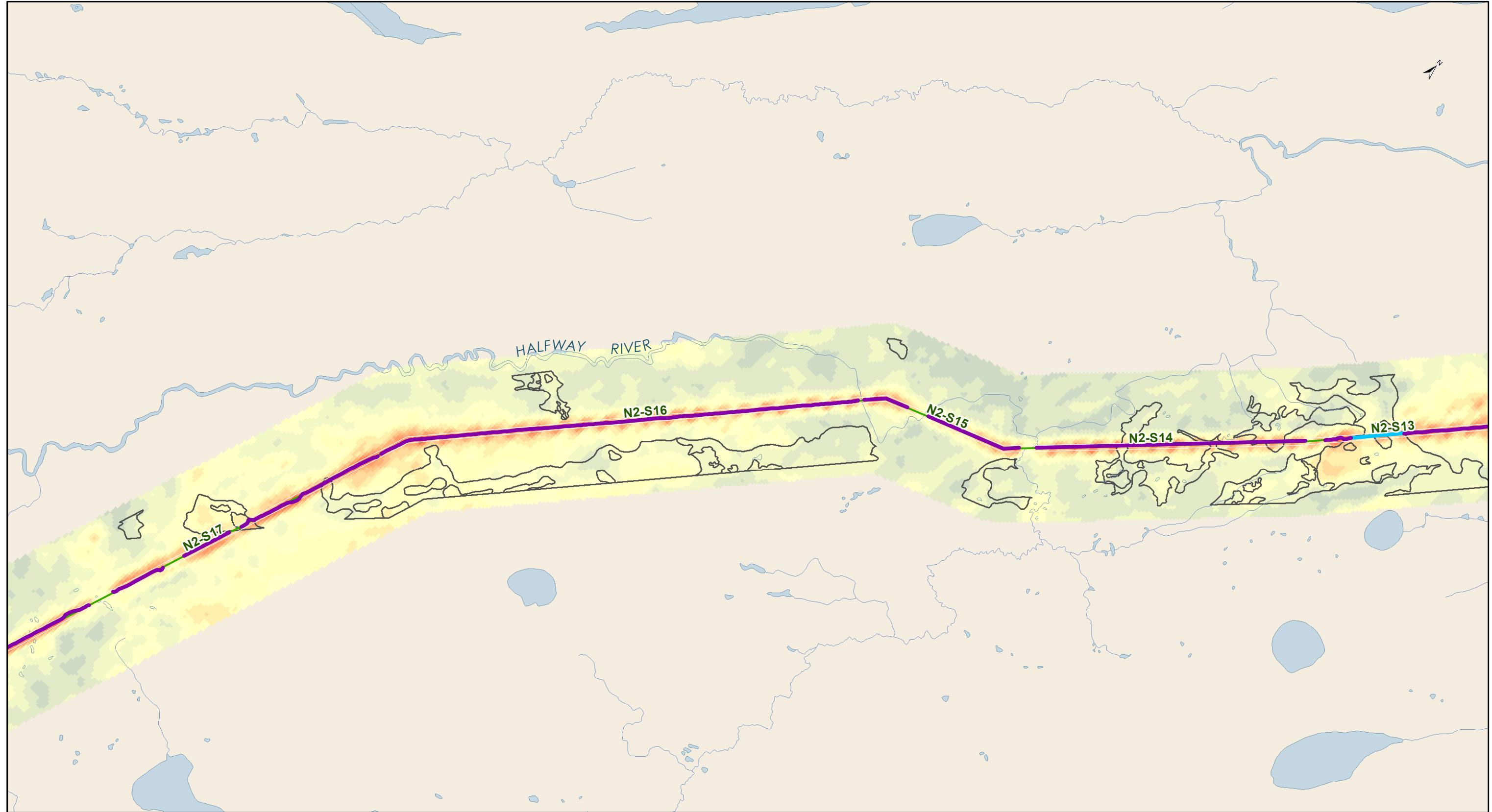
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Park  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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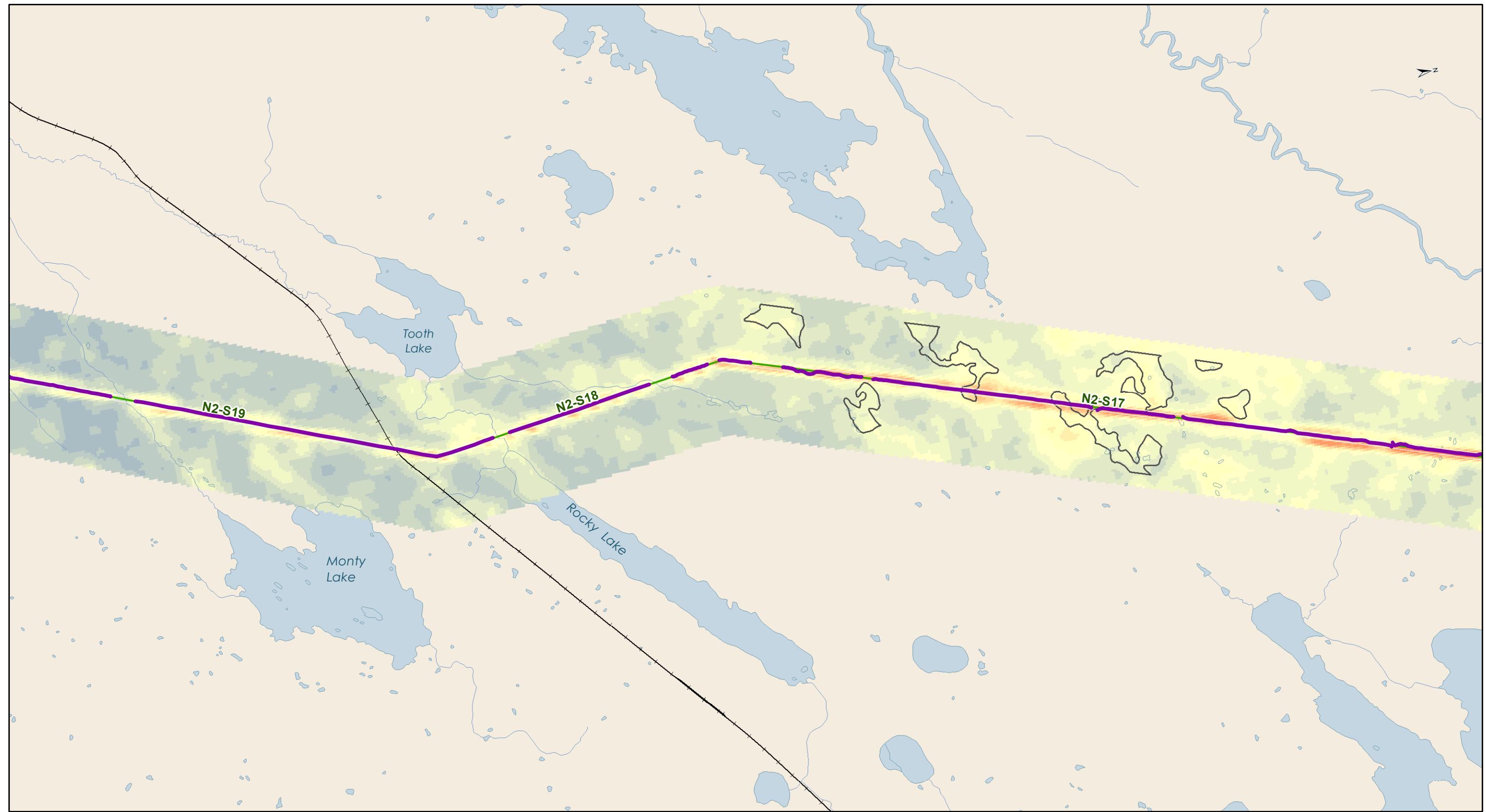
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
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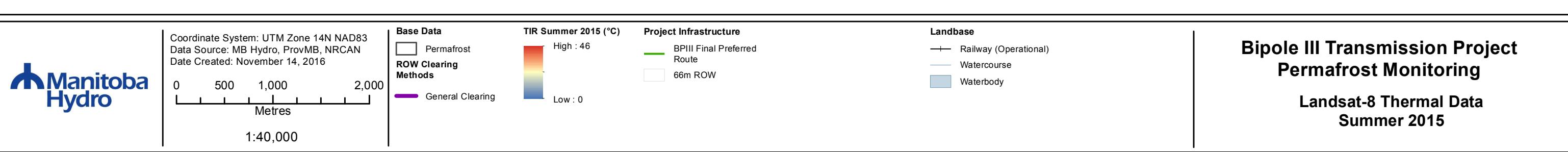
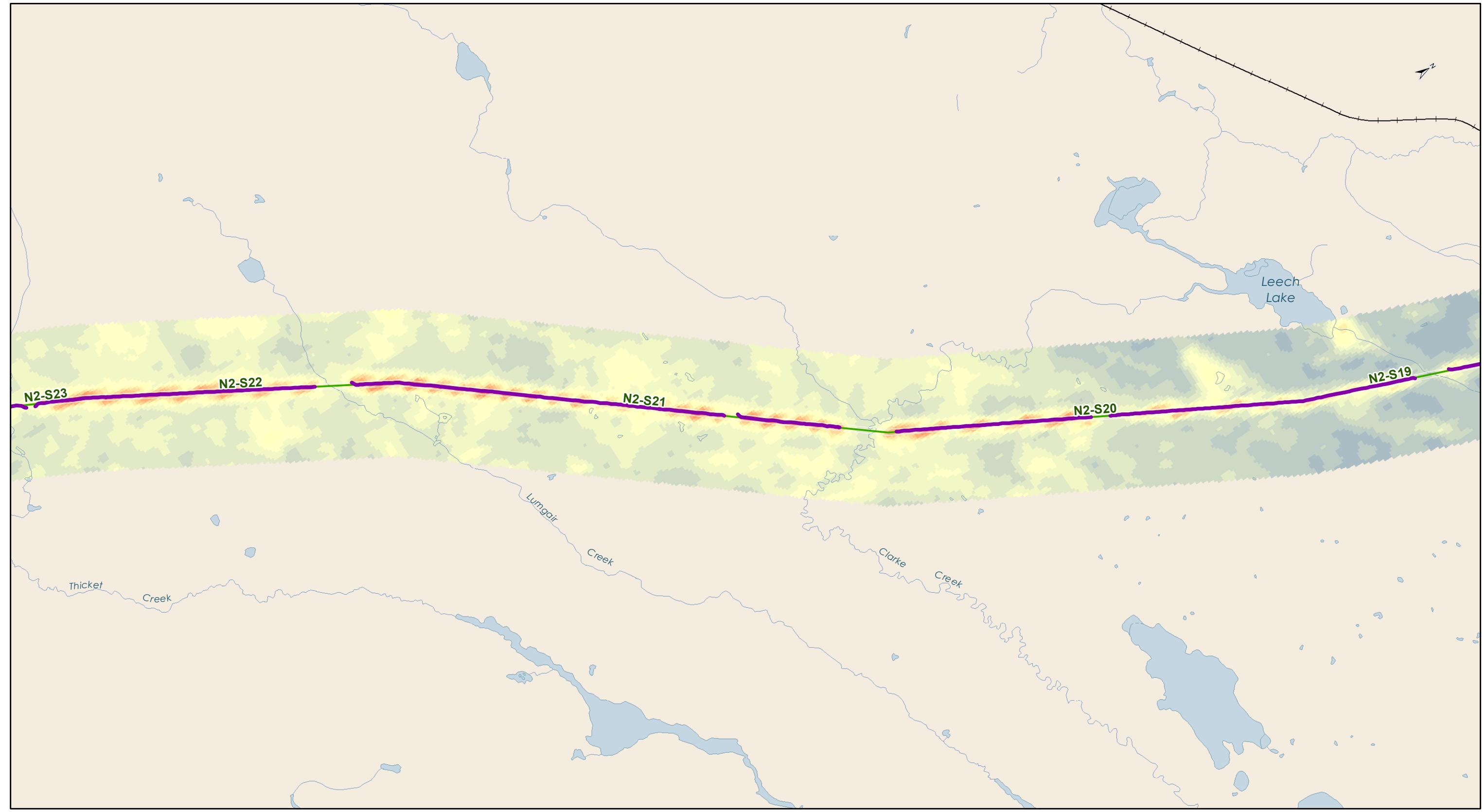
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

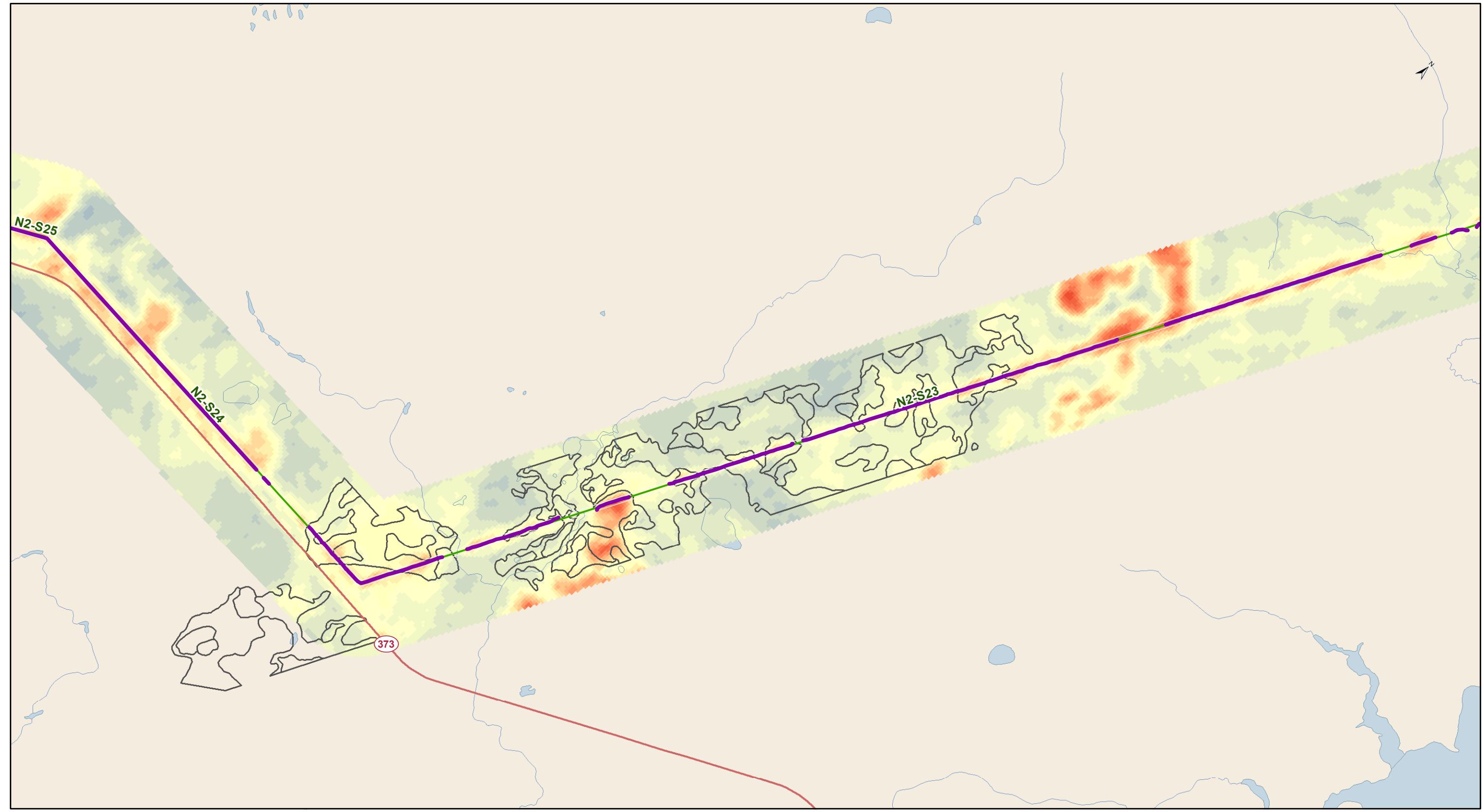
TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2015





Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

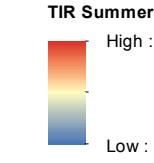
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**Base Data**  
Permafrost

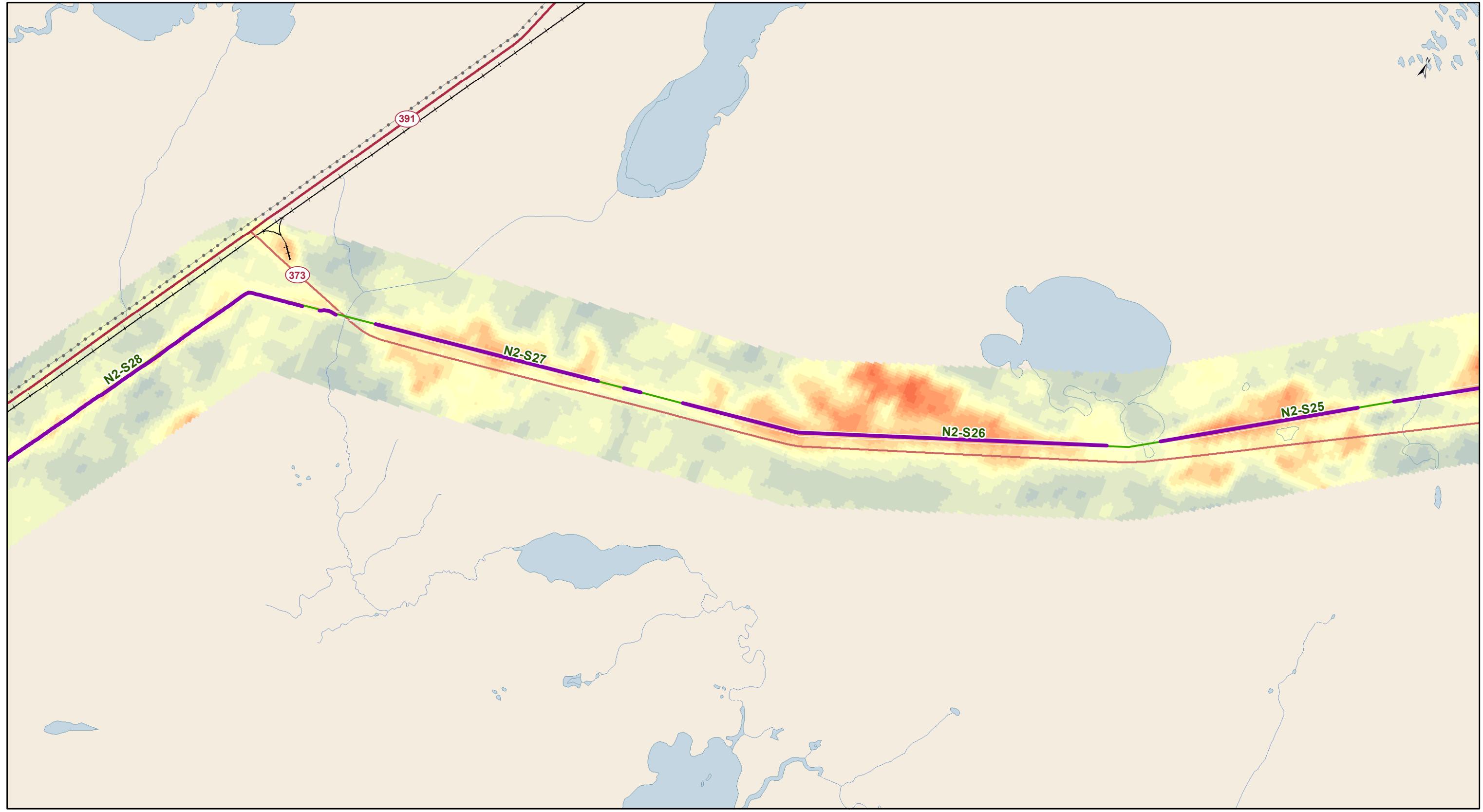
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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Metres

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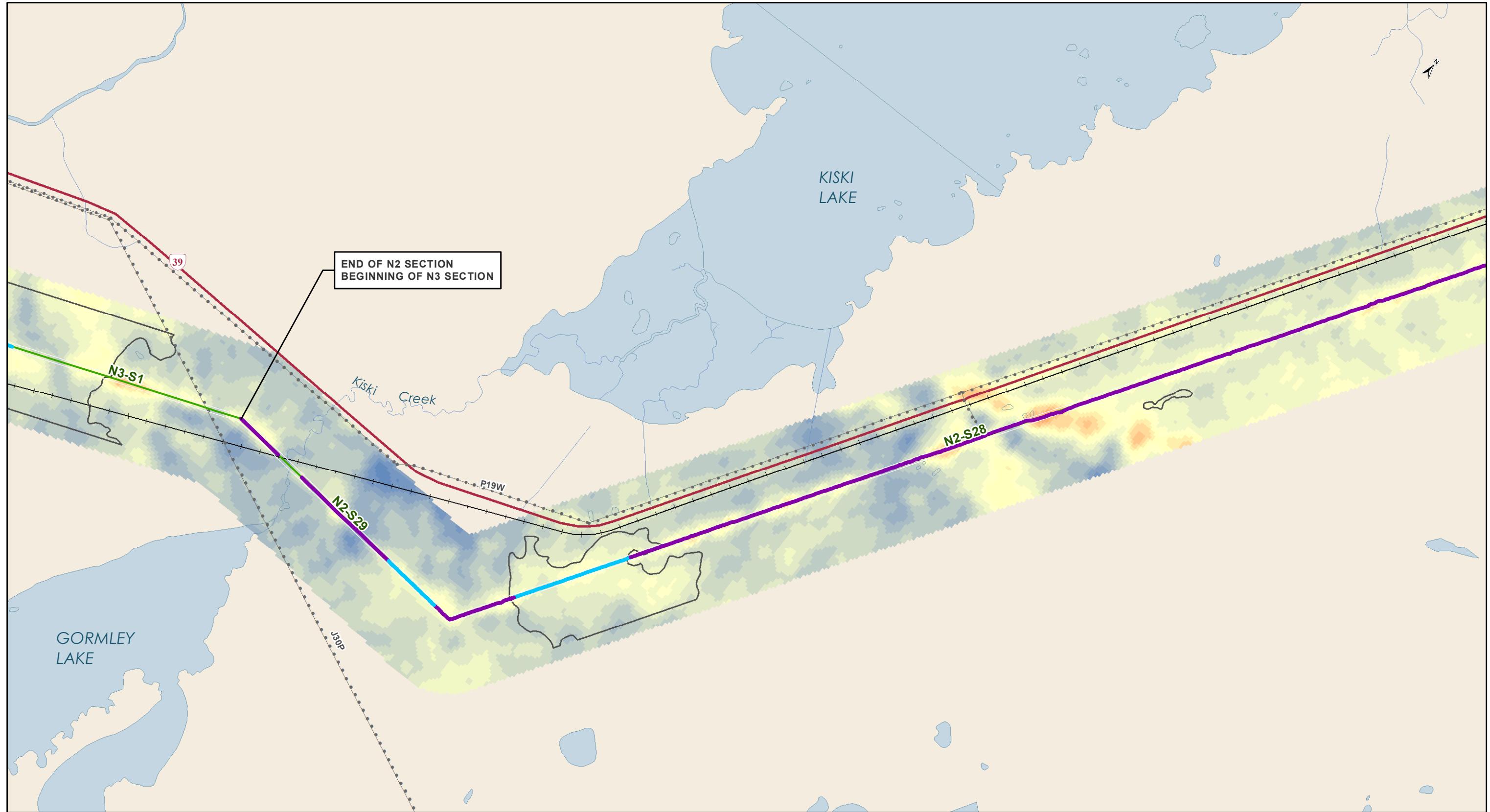
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Provincial Road  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

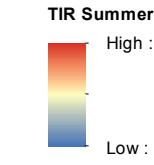
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Metres

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**Base Data**  
Permafrost

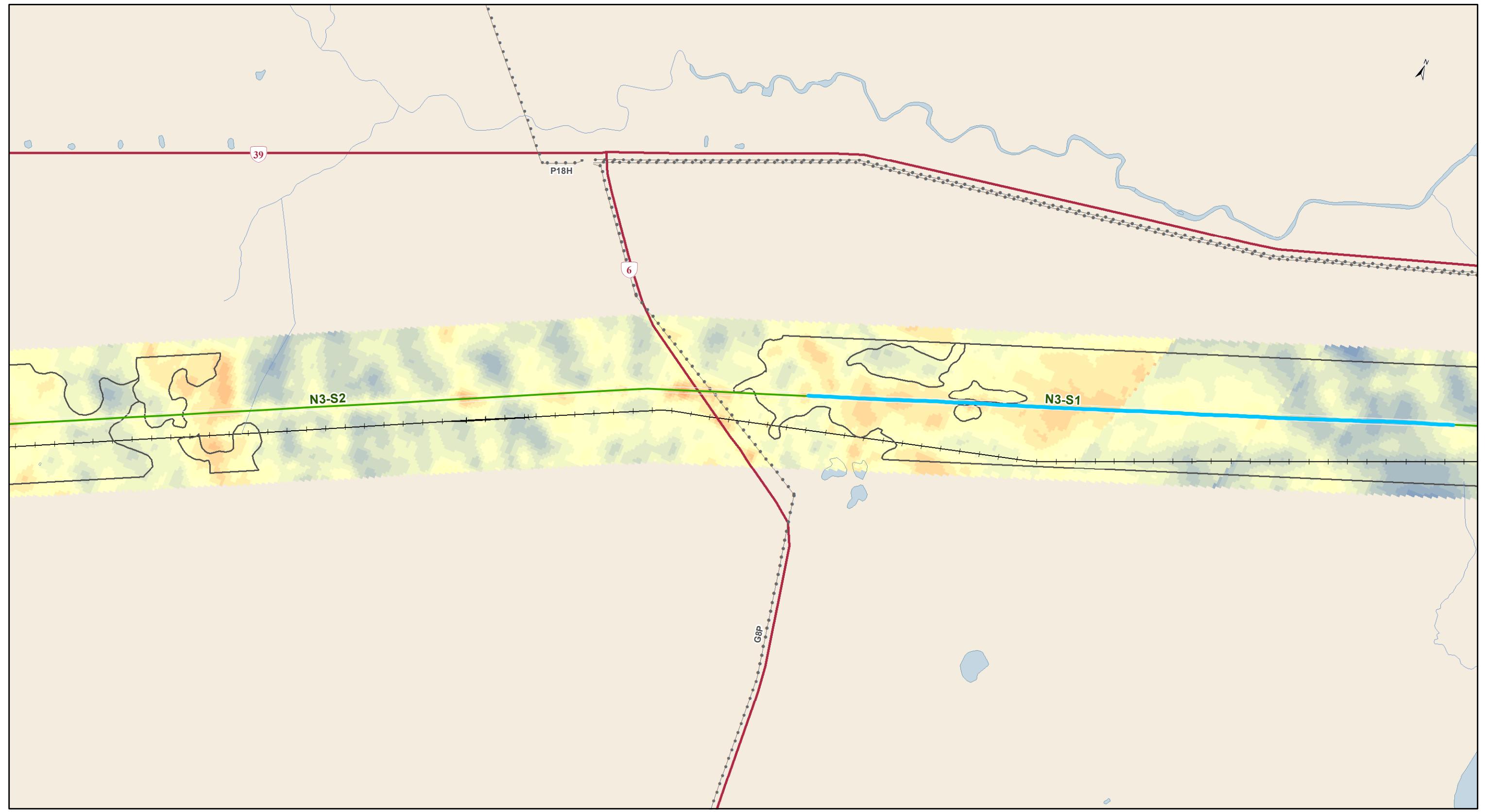
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
1:40,000

**Base Data**  
Permafrost

**ROW Clearing Methods**  
Low Disturbance Clearing

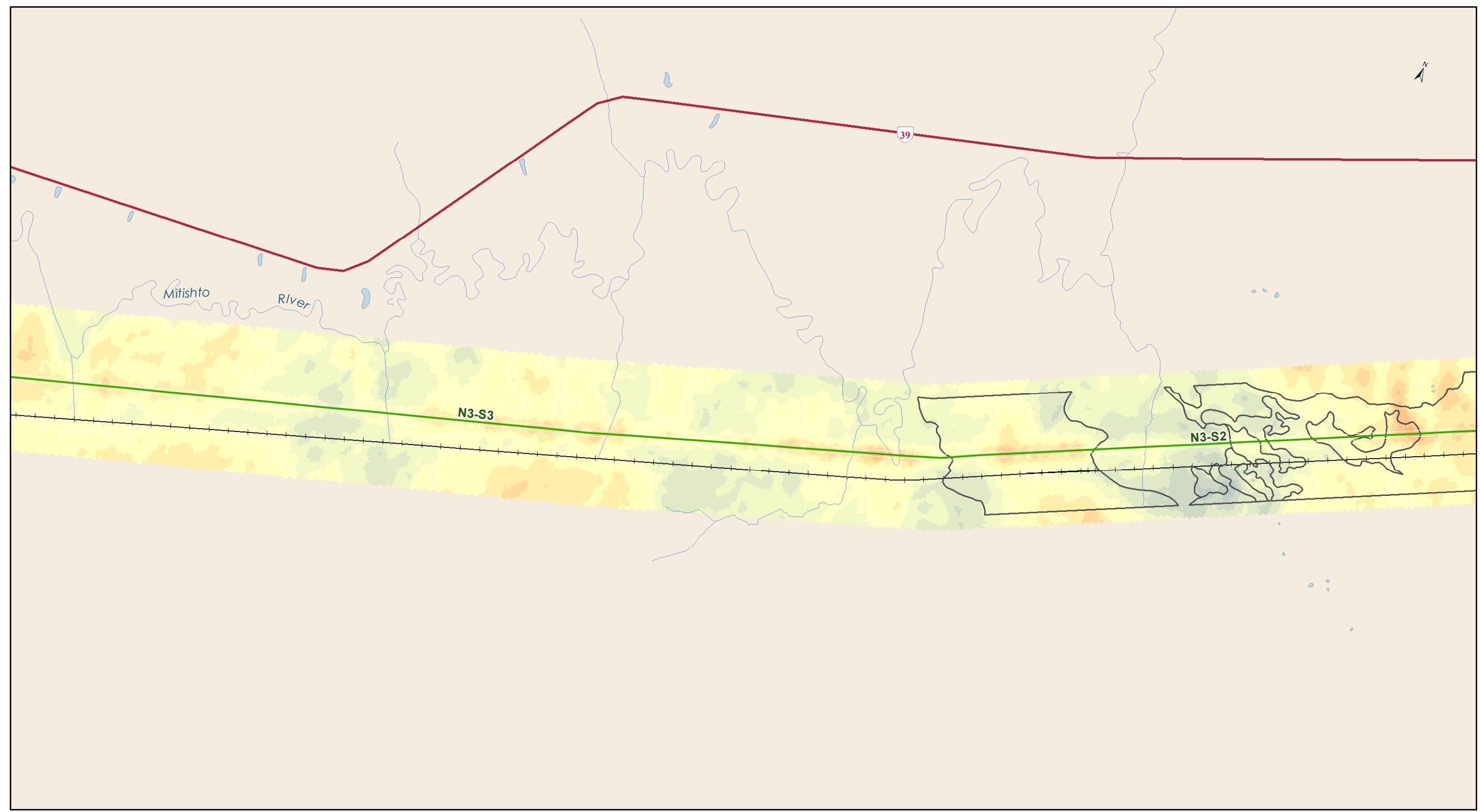
**TIR Summer 2015 (°C)**  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**

- Provincial Highway
- Railway (Operational)
- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

1:40,000



Base Data  
Permafrost



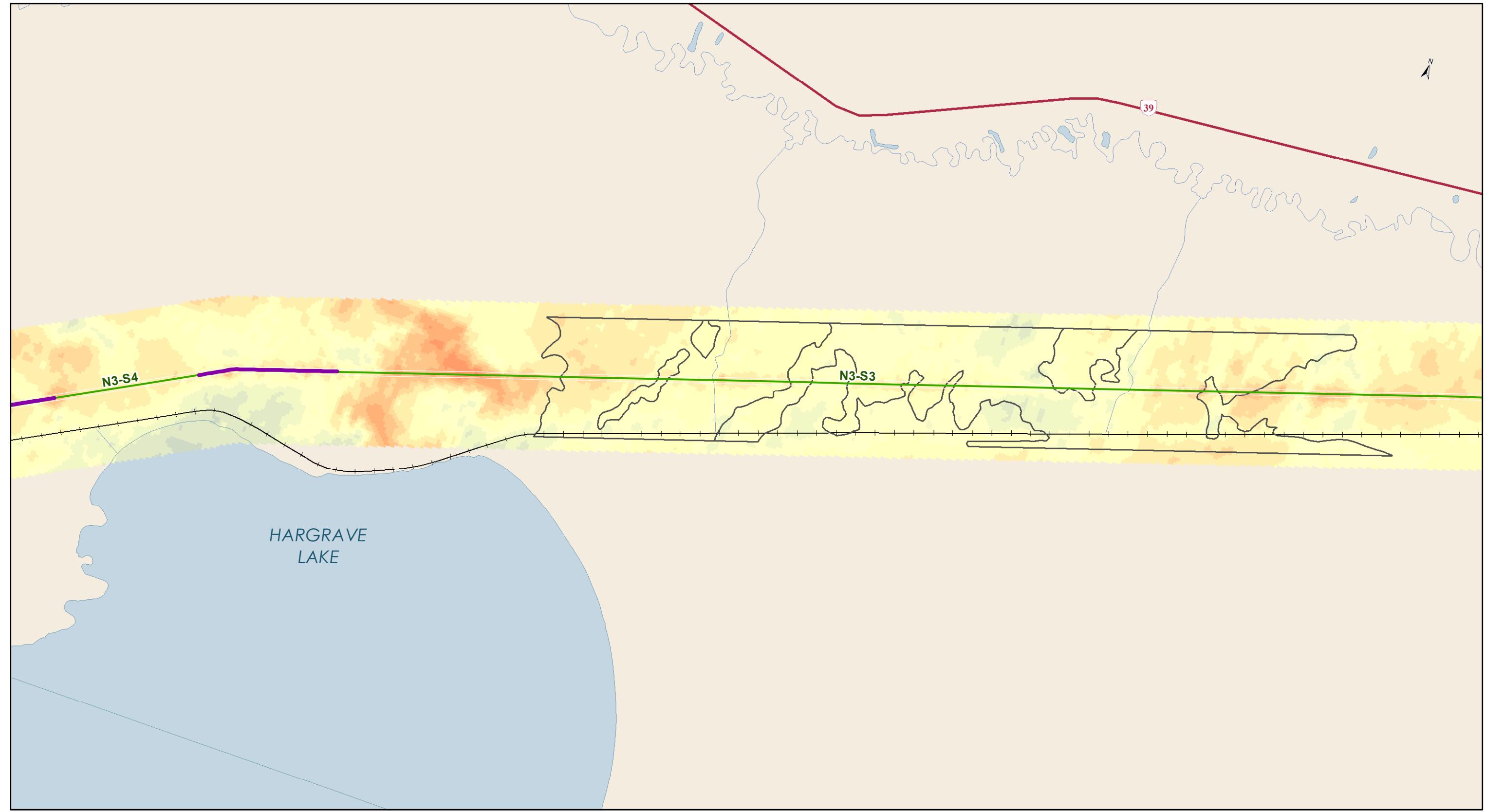
Project Infrastructure

- BP III Final Preferred Route
- 66m ROW

Landbase

- Provincial Highway
- Railway (Operational)
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

1:40,000



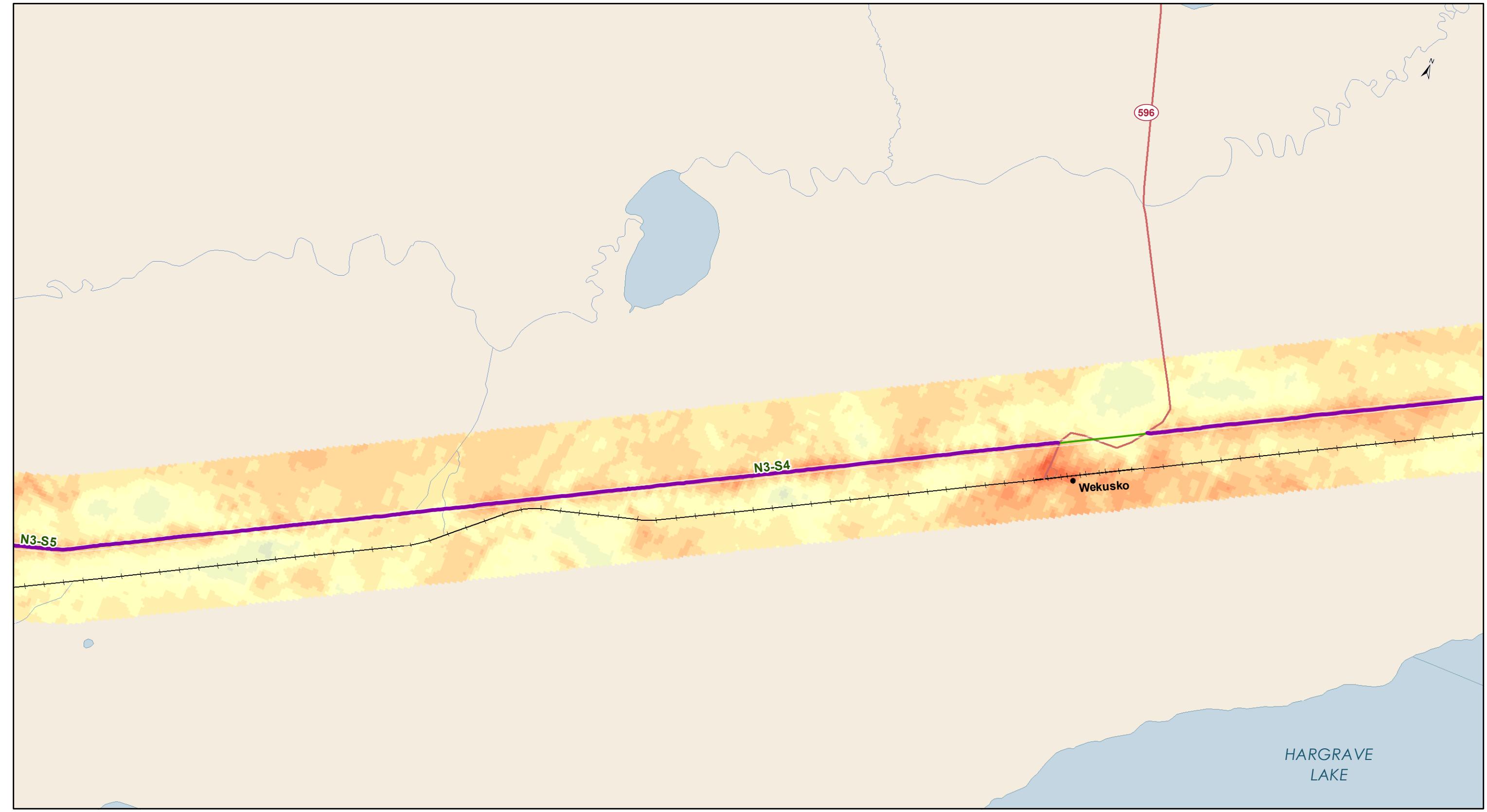
Base Data  
Permafrost  
ROW Clearing Methods  
General Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

Project Infrastructure  
BPIII Final Preferred Route  
66m ROW

Landbase  
Provincial Highway  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
1:40,000

**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

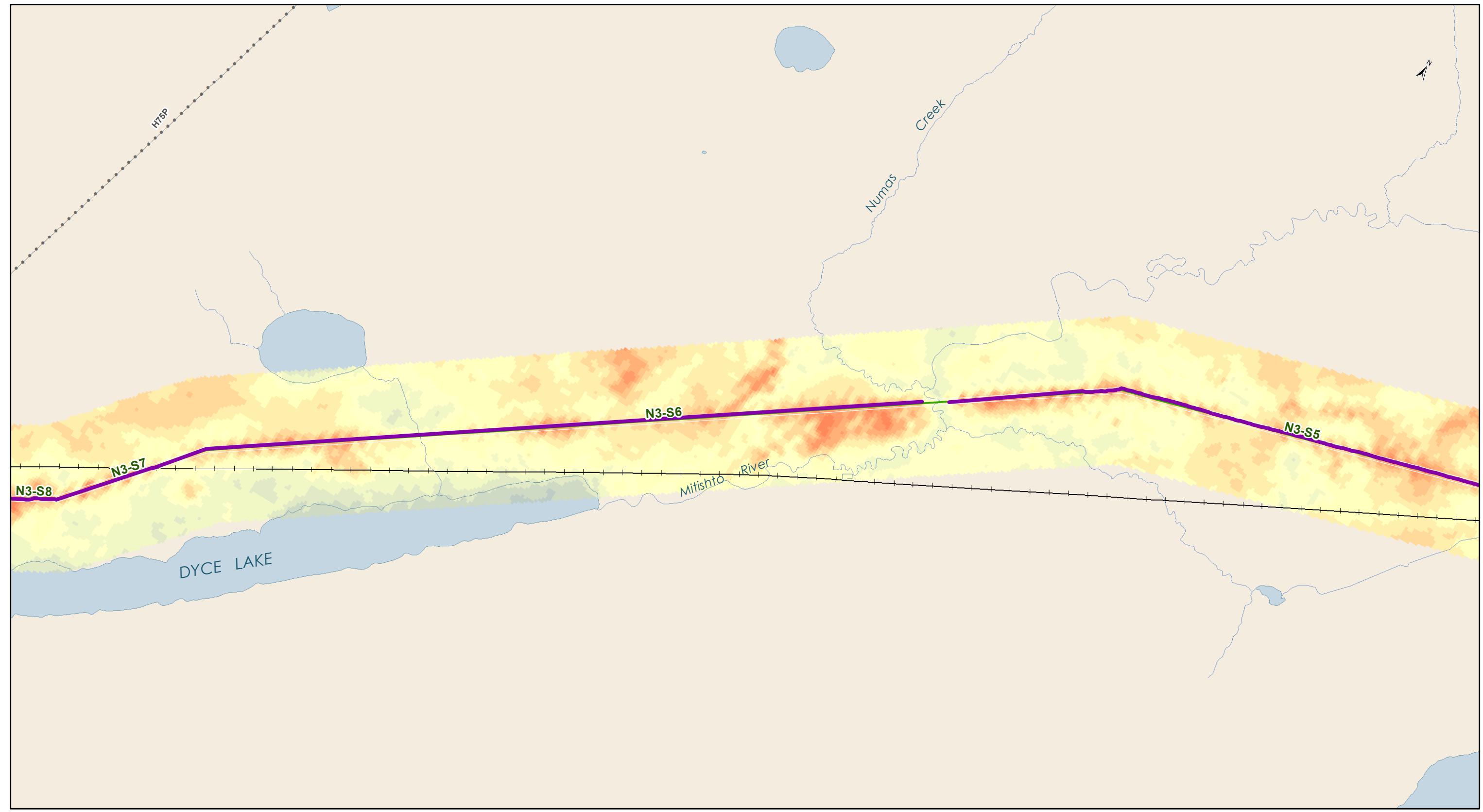
**TIR Summer 2015 (°C)**  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**

- Provincial Road
- Local Road
- Railway (Operational)
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016  
0 500 1,000 2,000 Metres  
1:40,000

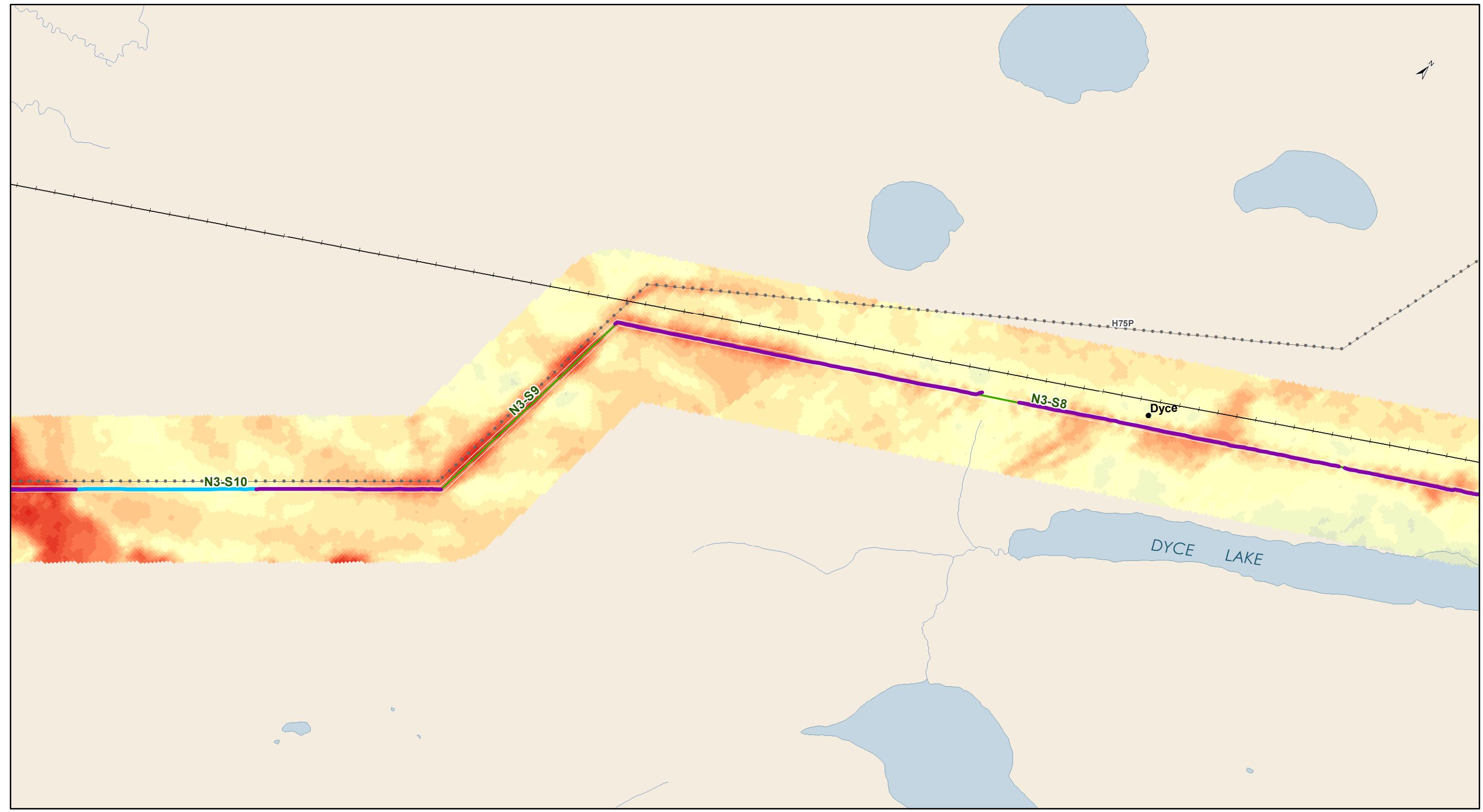
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
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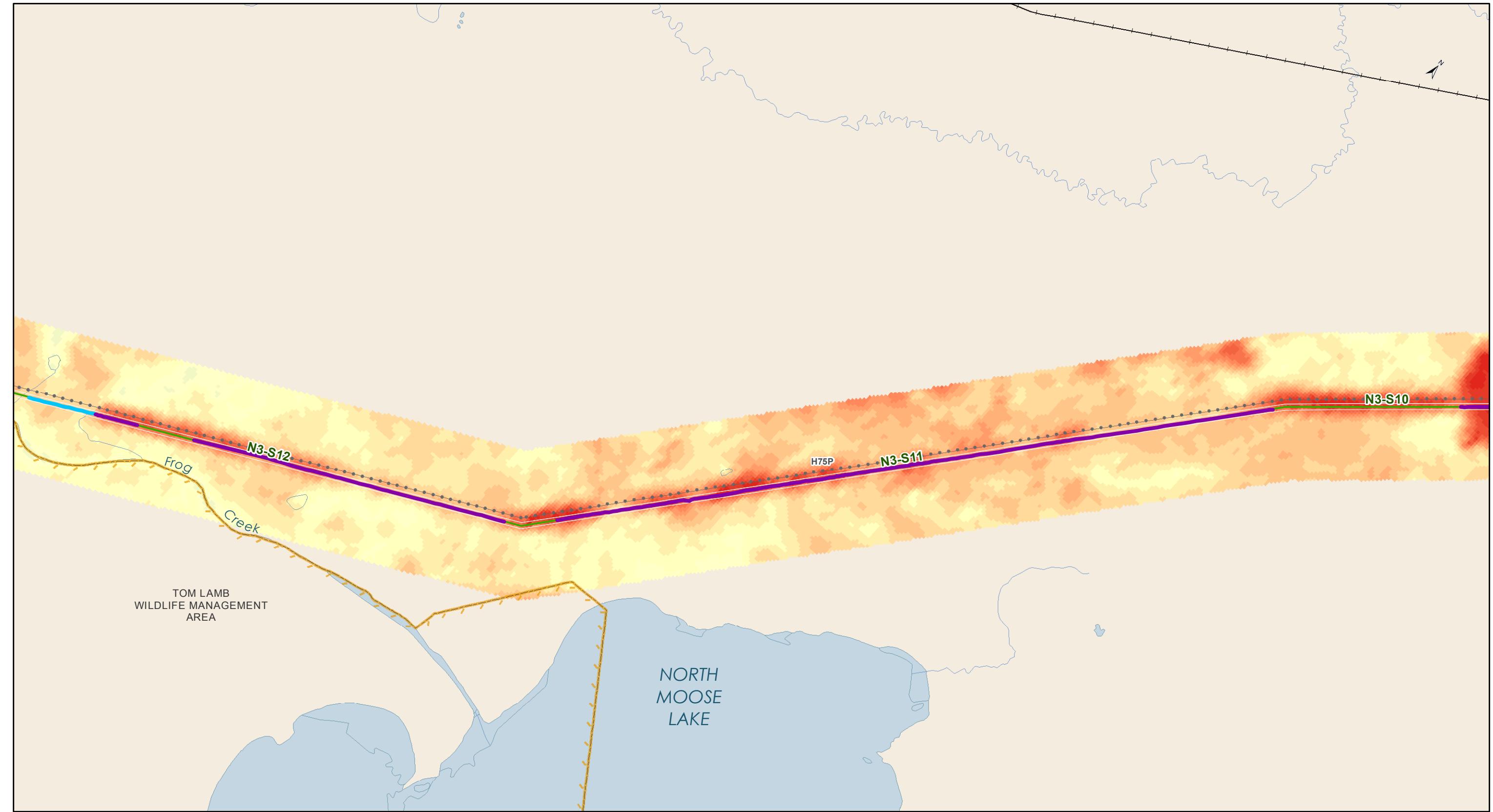
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



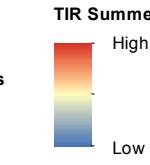
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Date Created: November 14, 2016

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**Base Data**  
Permafrost

**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

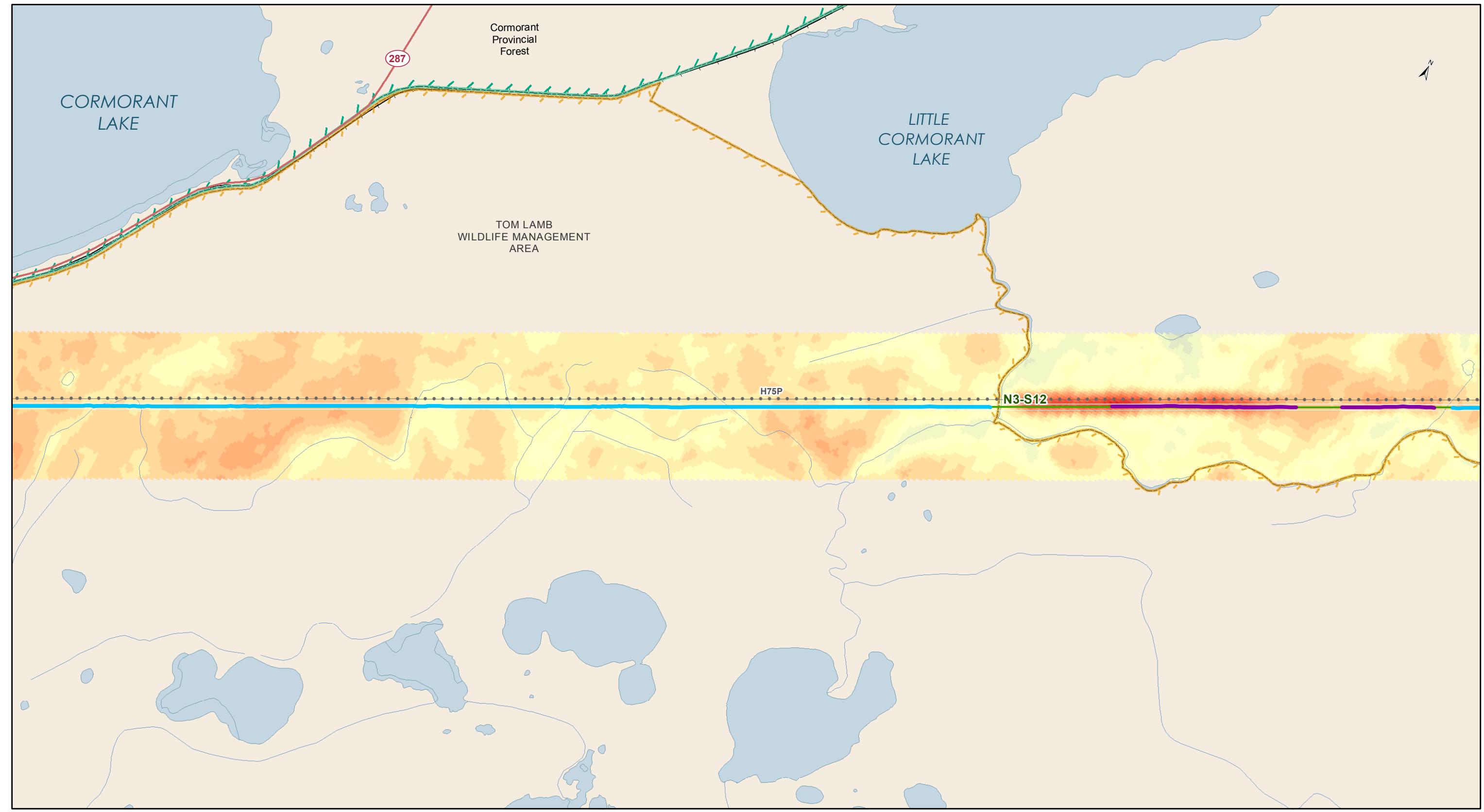


**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line

Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

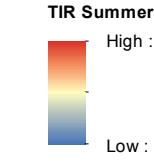
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Low Disturbance Clearing



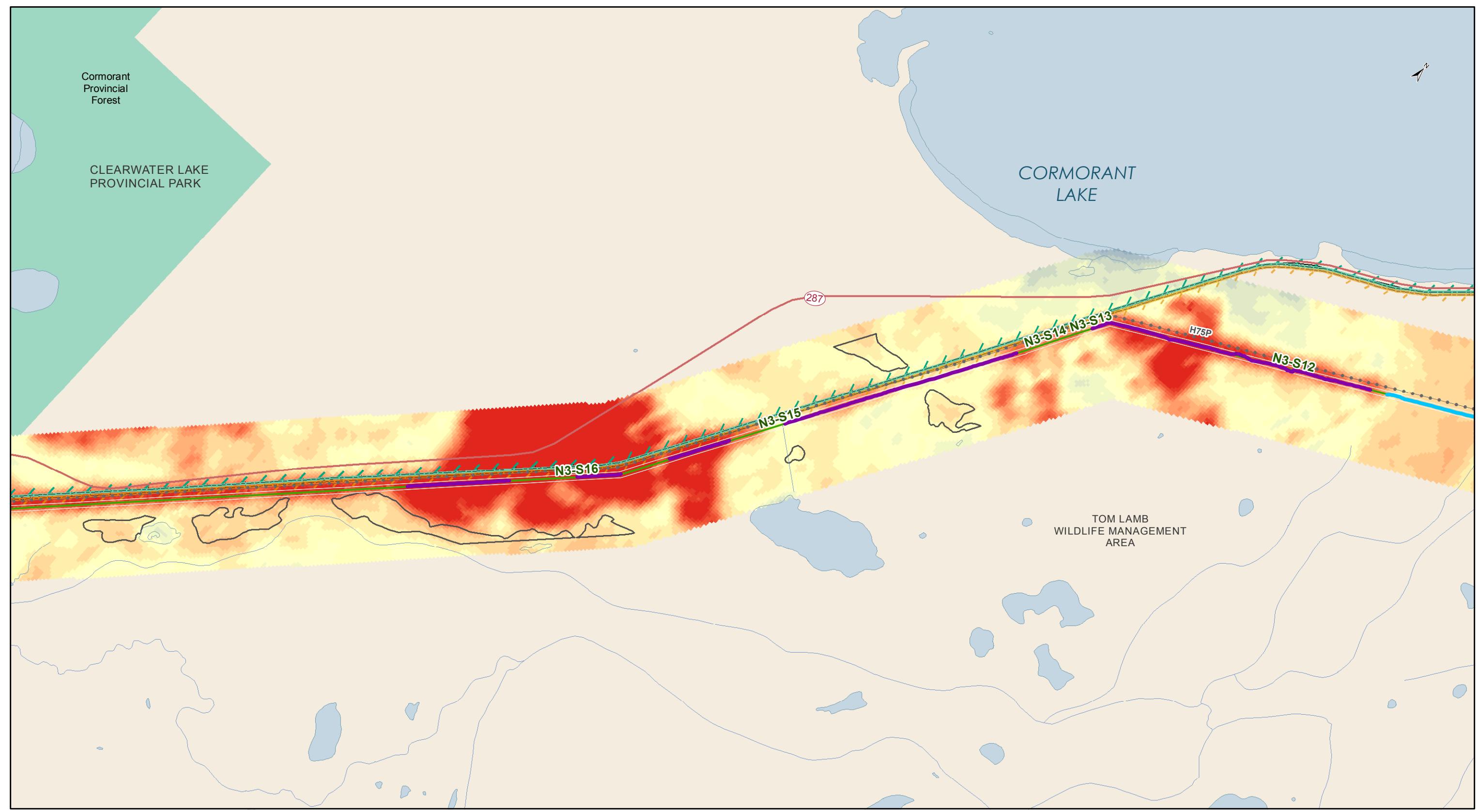
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody
- Provincial Forest

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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**Base Data**  
Permafrost

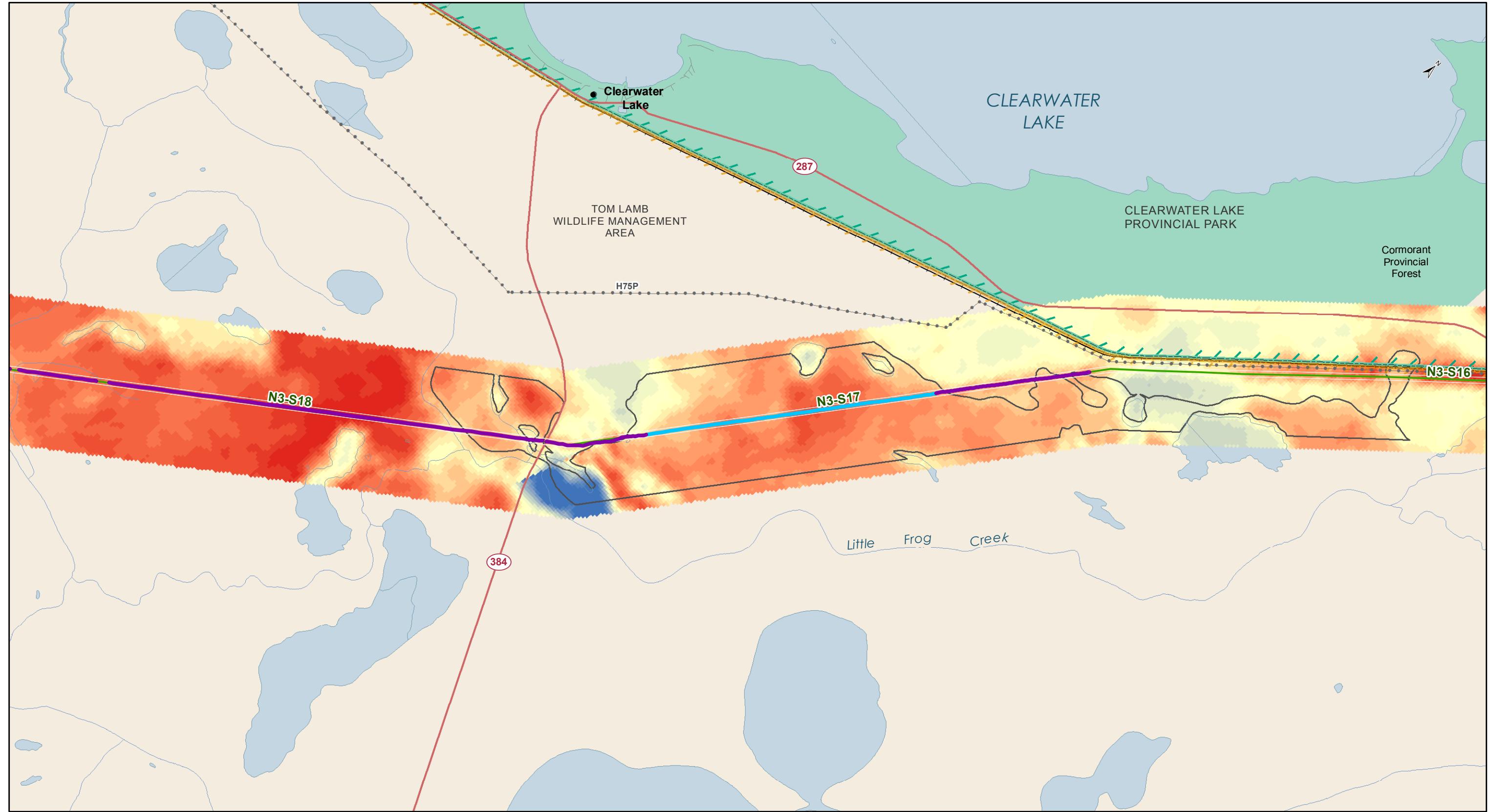
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Railway (Operational)  
Transmission Line  
Provincial Park  
Provincial Forest

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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**Base Data**  
Permafrost

**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2015 (°C)

High : 46
Low : 0

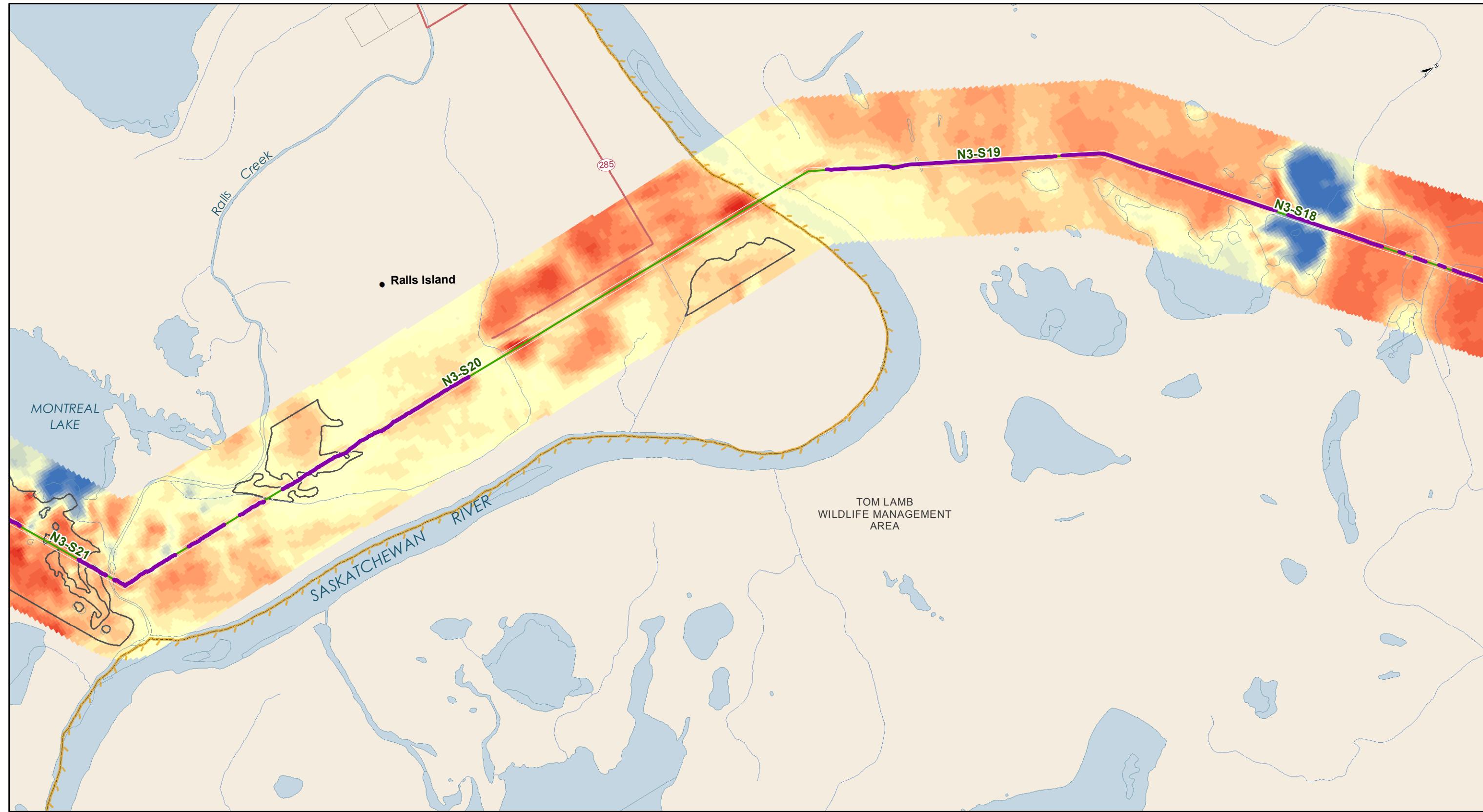
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Local Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody
- Provincial Park
- Provincial Forest

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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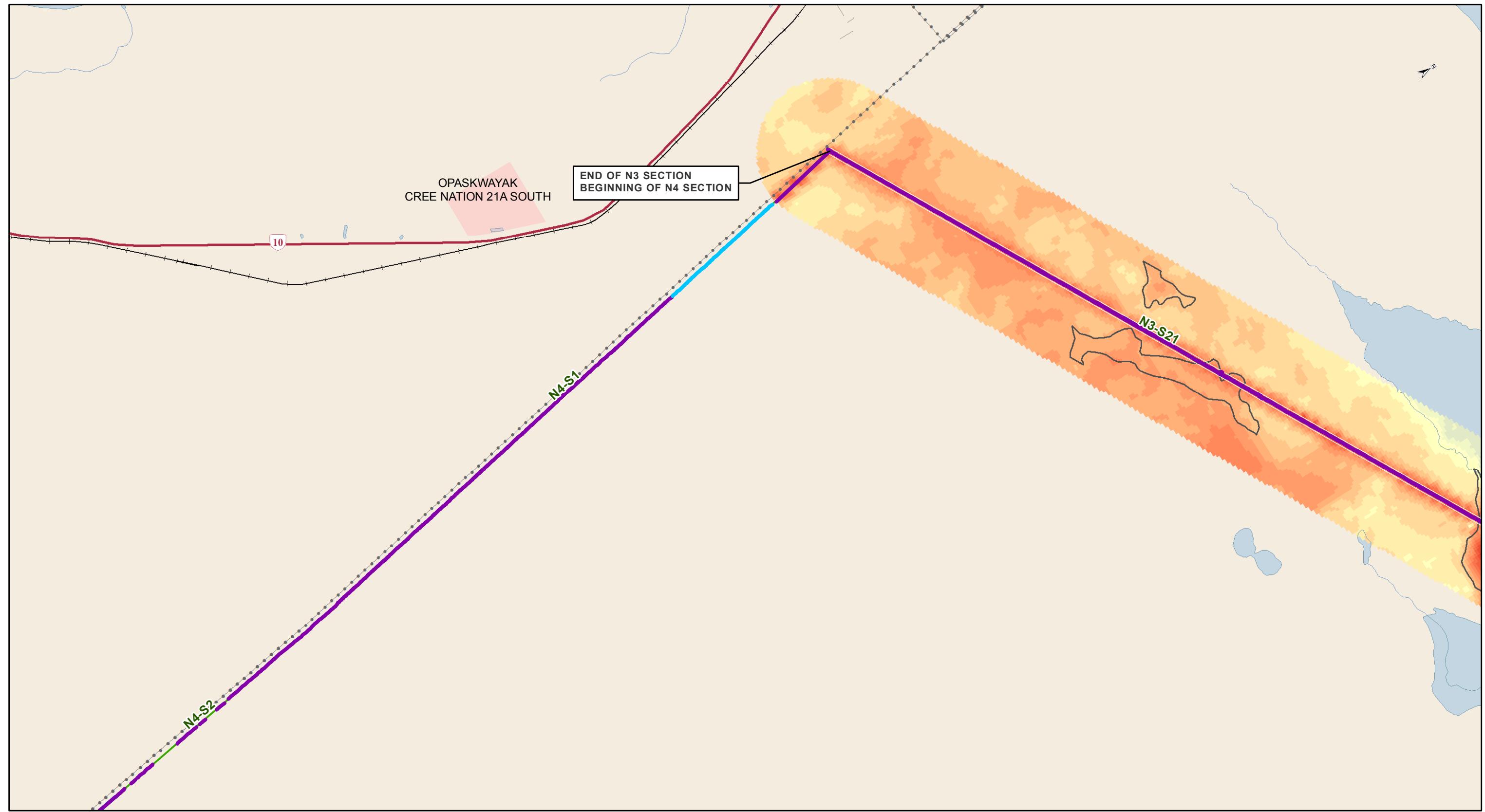
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2015 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Local Road  
Watercourse  
Waterbody  
Wildlife Management Area

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

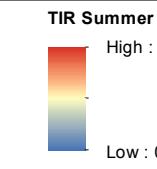
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**Base Data**  
Permafrost

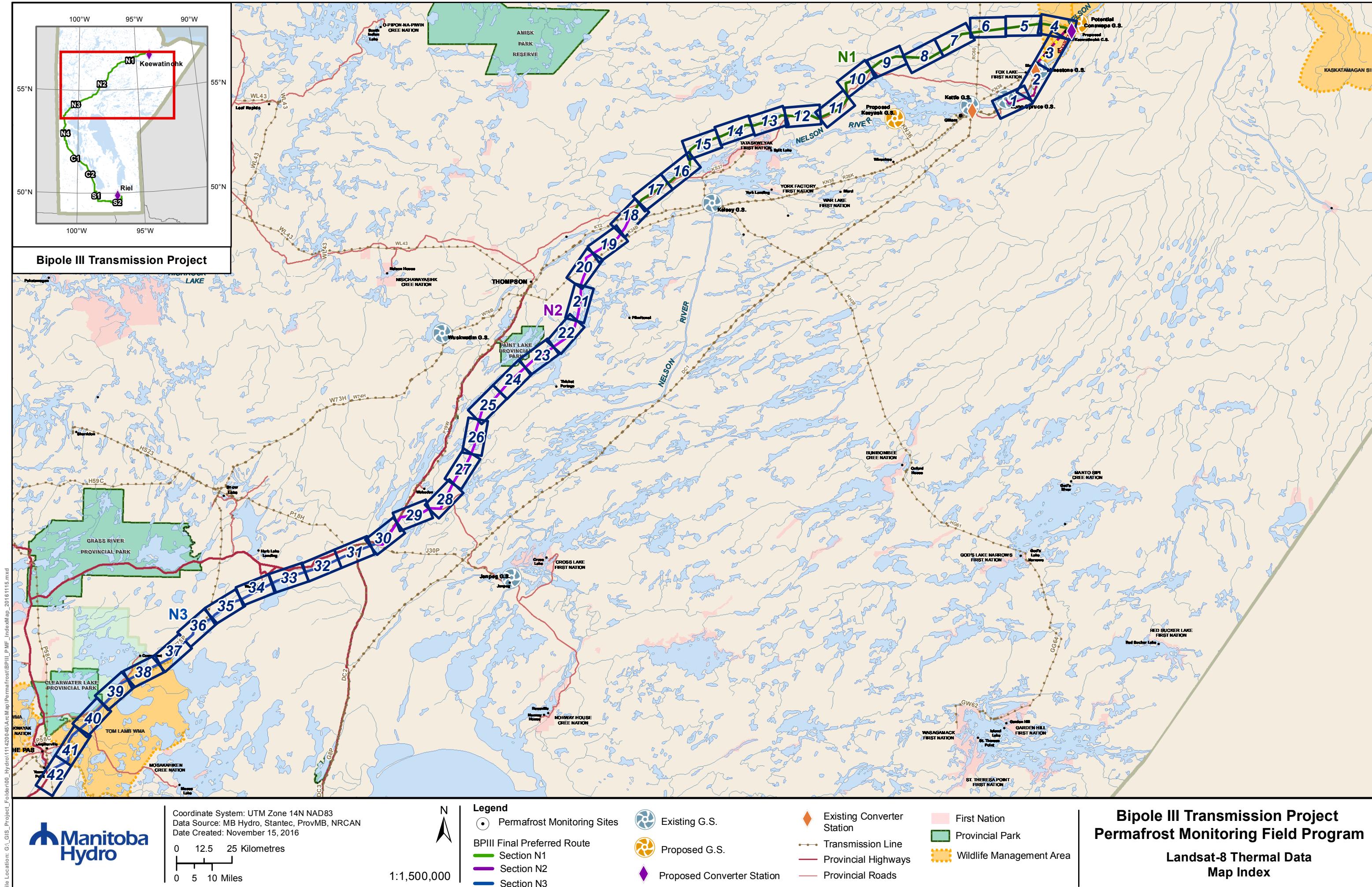
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Local Road  
Railway (Operational)  
Transmission Line  
First Nation  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2015**



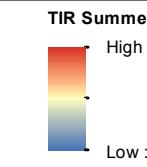


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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016



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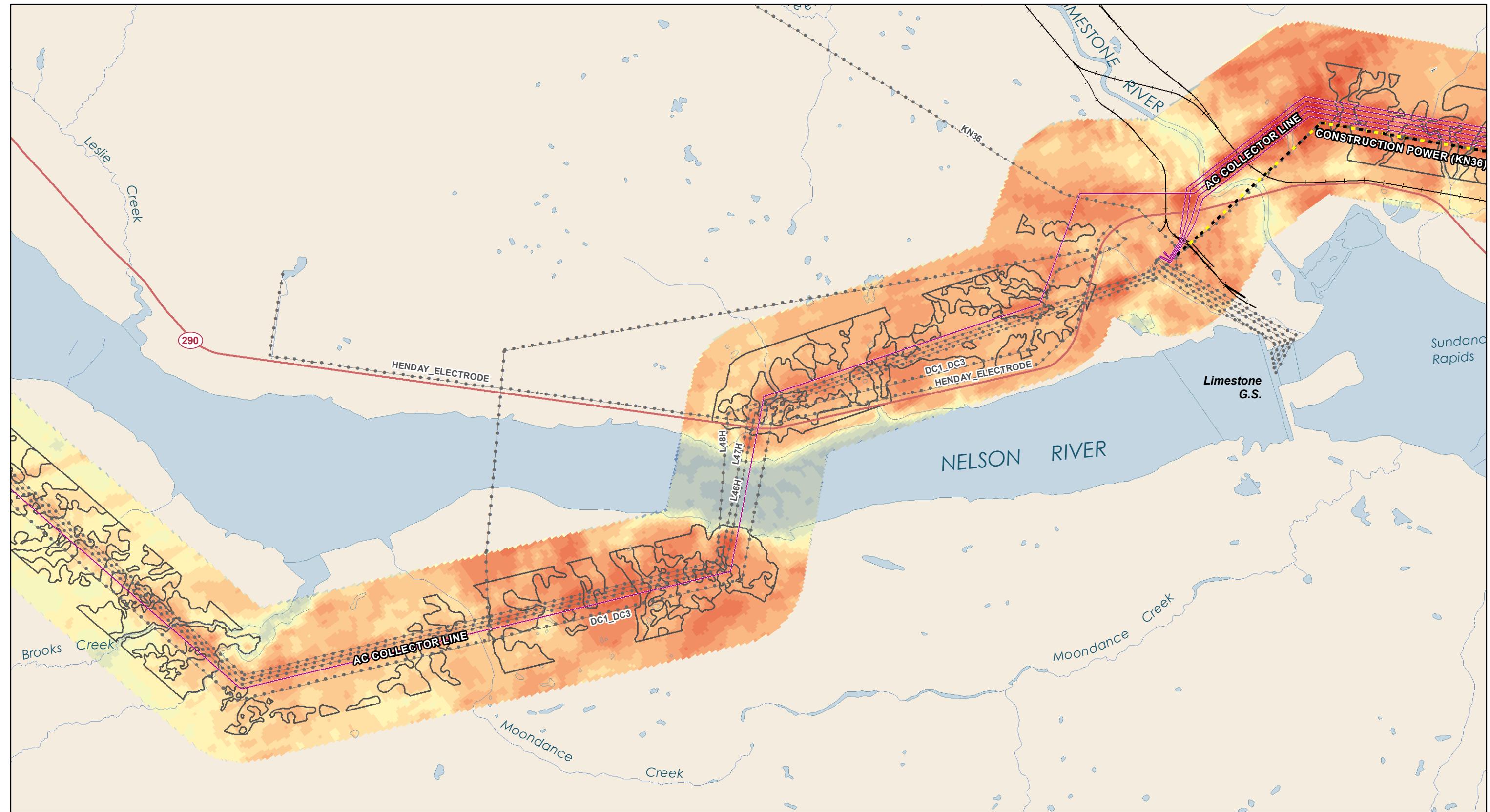
Base Data  
Permafrost



Project Infrastructure  
AC Collector Line

Landbase  
Provincial Road  
Winter Road  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2016



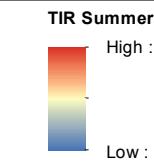
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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 15, 2016

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Base Data  
Permafrost



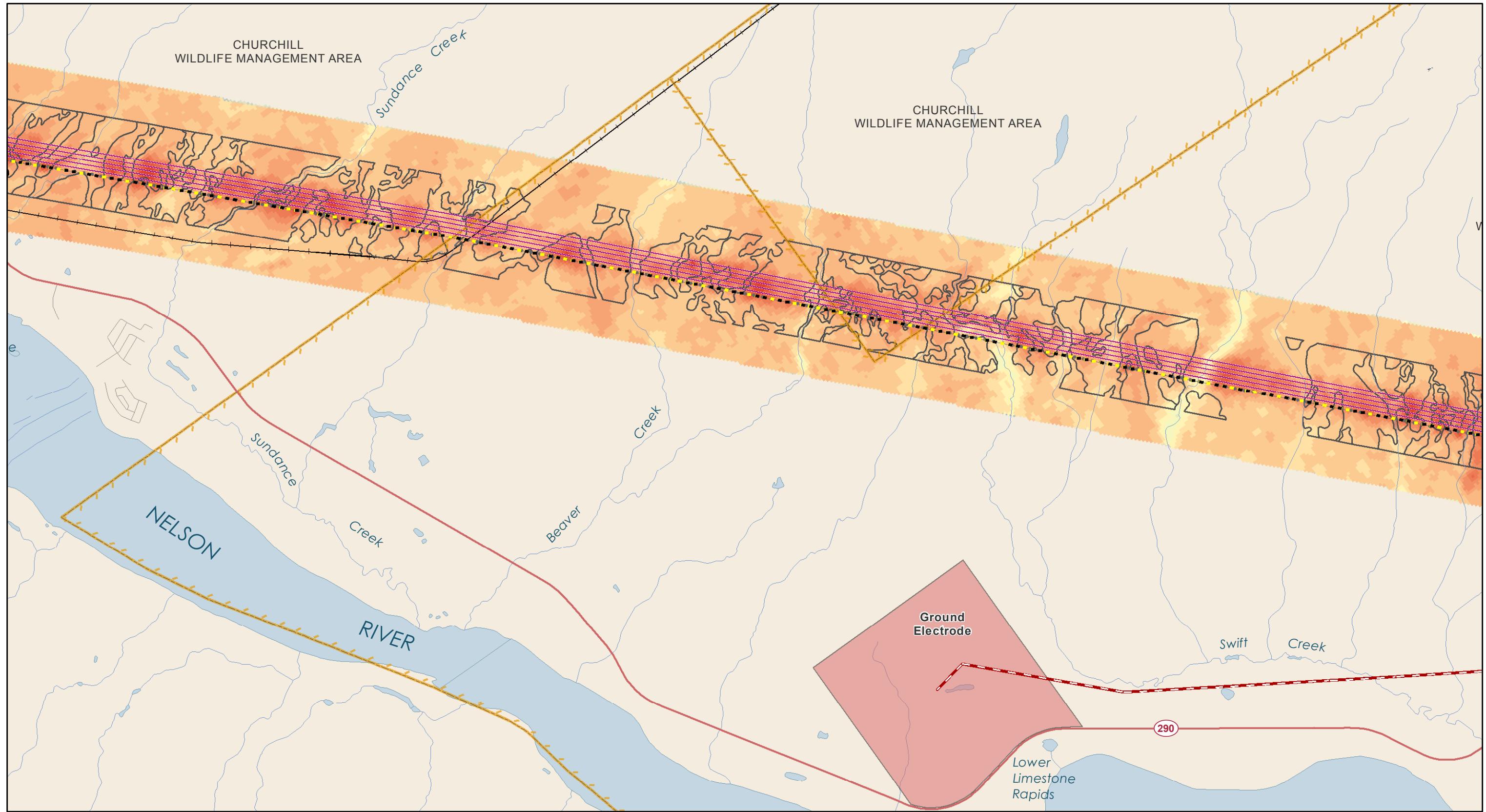
Project Infrastructure

- Construction Power (KN36)
- AC Collector Line

Landbase

- Provincial Road
- Railway (Operational)
- Transmission Line
- First Nation
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2016



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 15, 2016

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#### Base Data



TIR Summer 2016 (°C)  
High : 46  
Low : 0

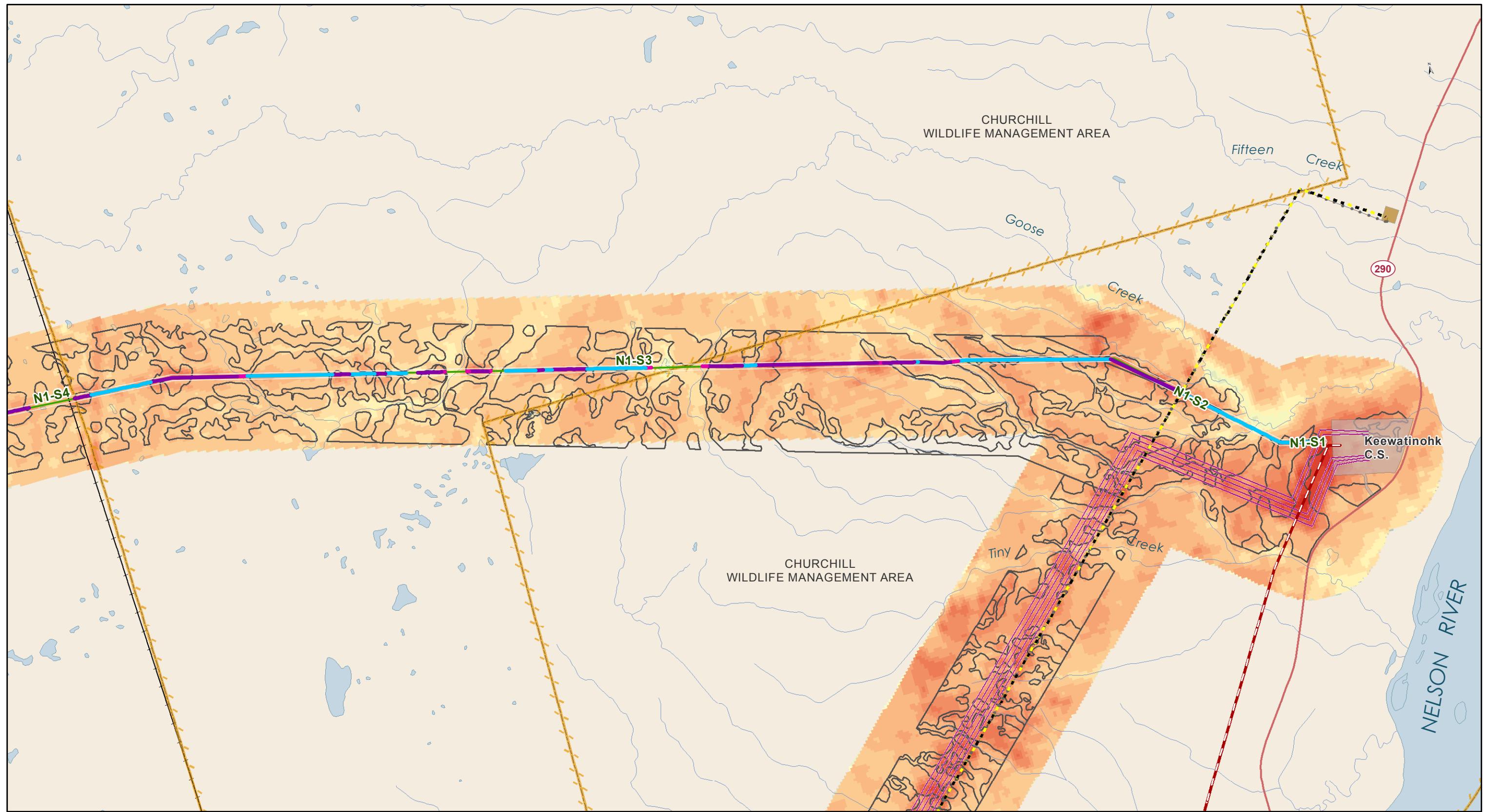
#### Project Infrastructure

- Construction Power (KN36)
- Ground Electrode Line
- AC Collector Line
- Ground Electrode

#### Landbase

- Provincial Road
- Local Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

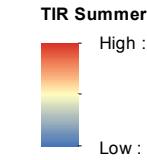
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**Base Data**

- Permafrost
- ROW Clearing Methods
- General Clearing
- Low Disturbance Clearing
- AC Collector Line
- Selective Clearing



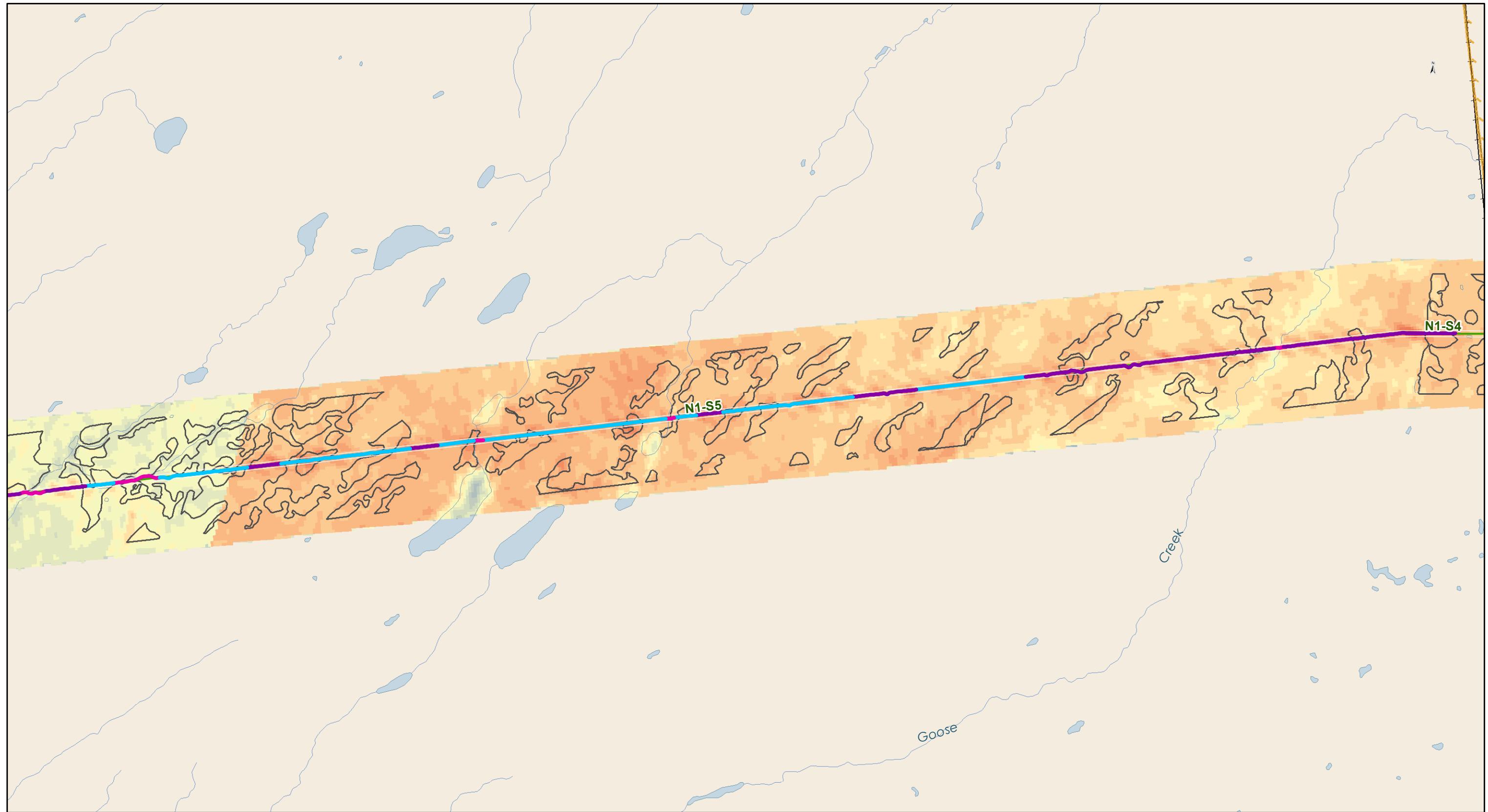
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW
- Construction Power (KN36)
- Ground Electrode Line
- AC Collector Line

**Landbase**

- Keewatinohk Converter Station
- Construction Power Station
- Provincial Road
- Railway (Operational)
- Transmission Line
- Wildlife Management Area
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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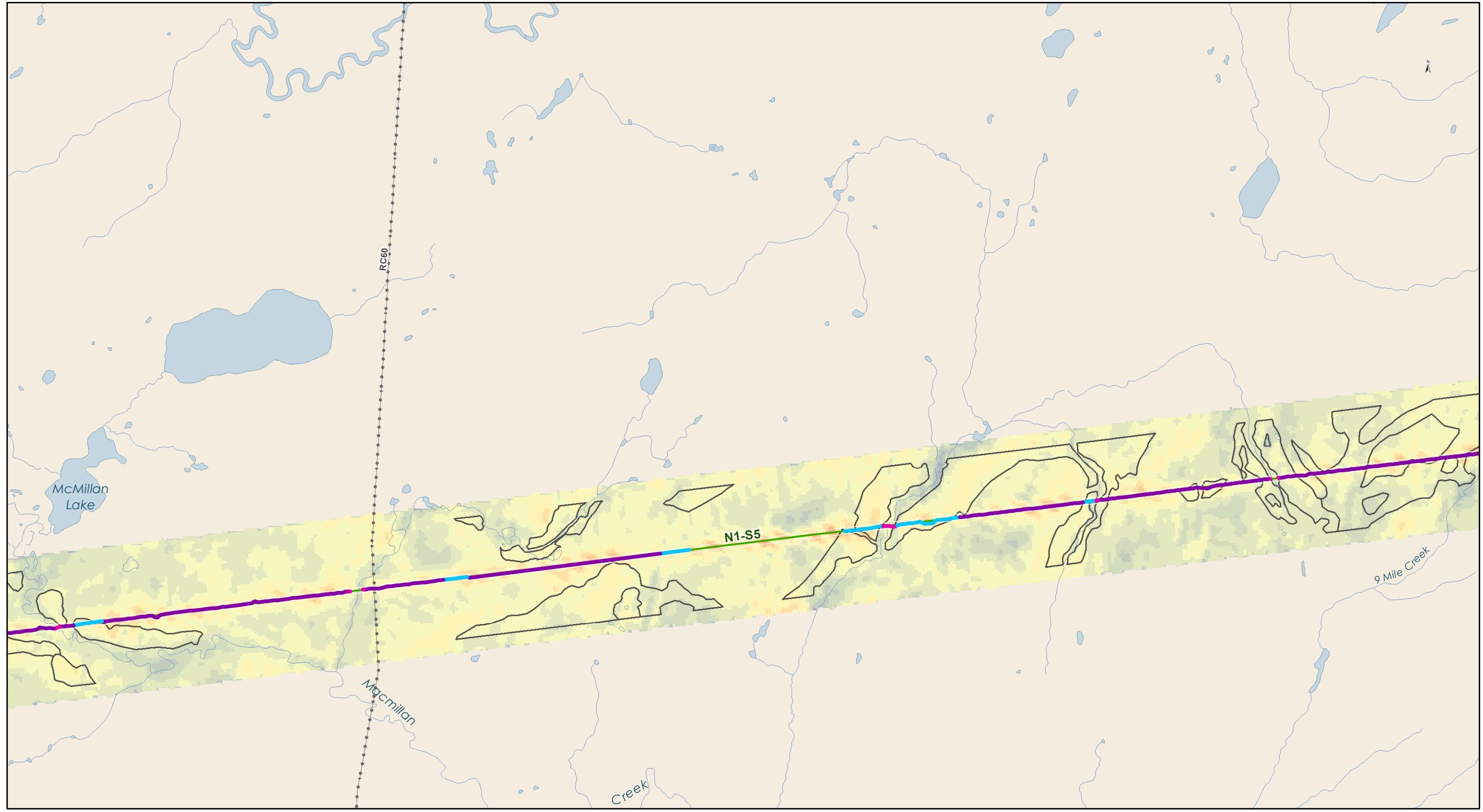
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing

TIR Summer 2016 (°C)

High : 46
Low : 0

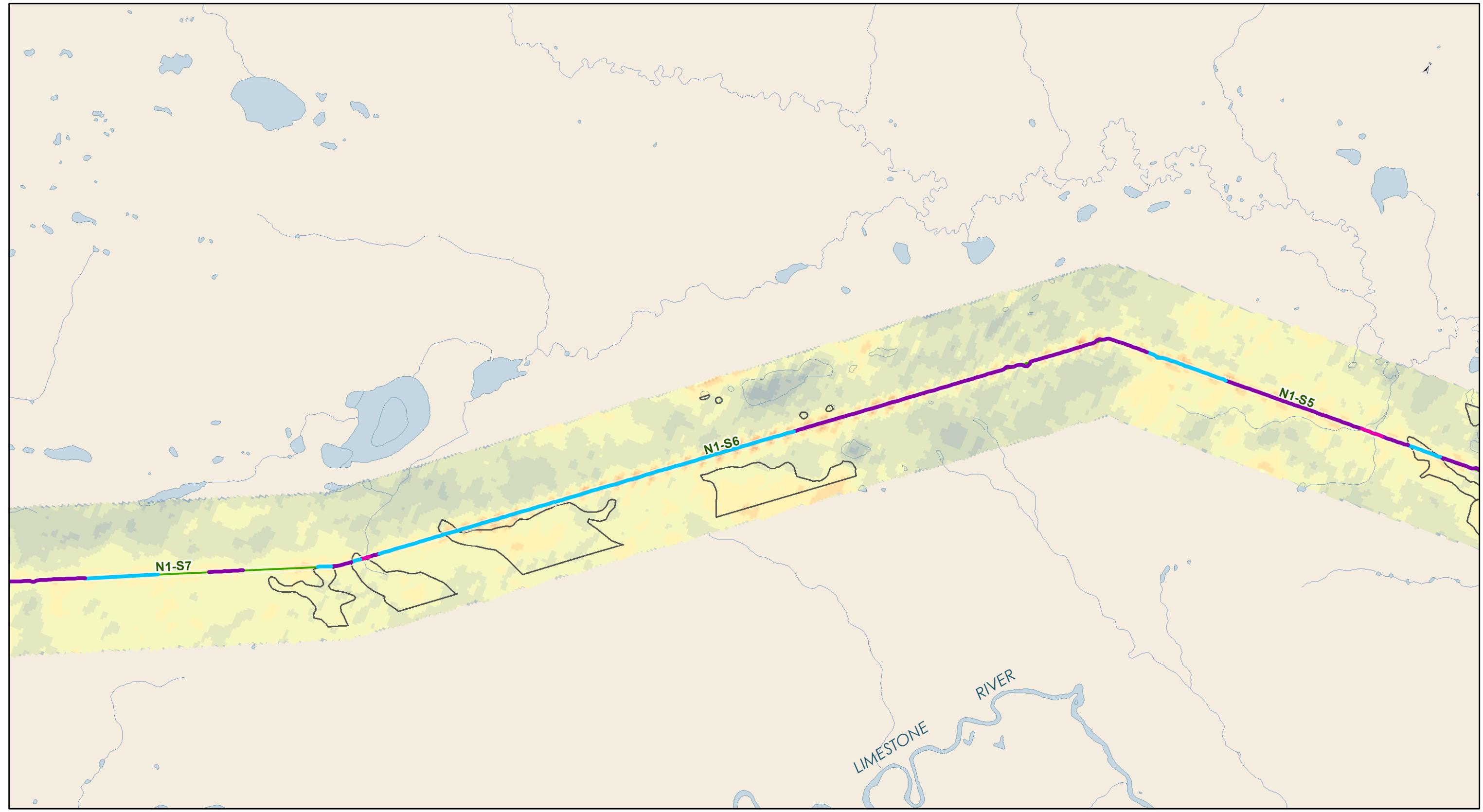
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

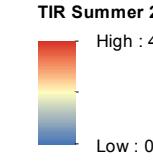
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



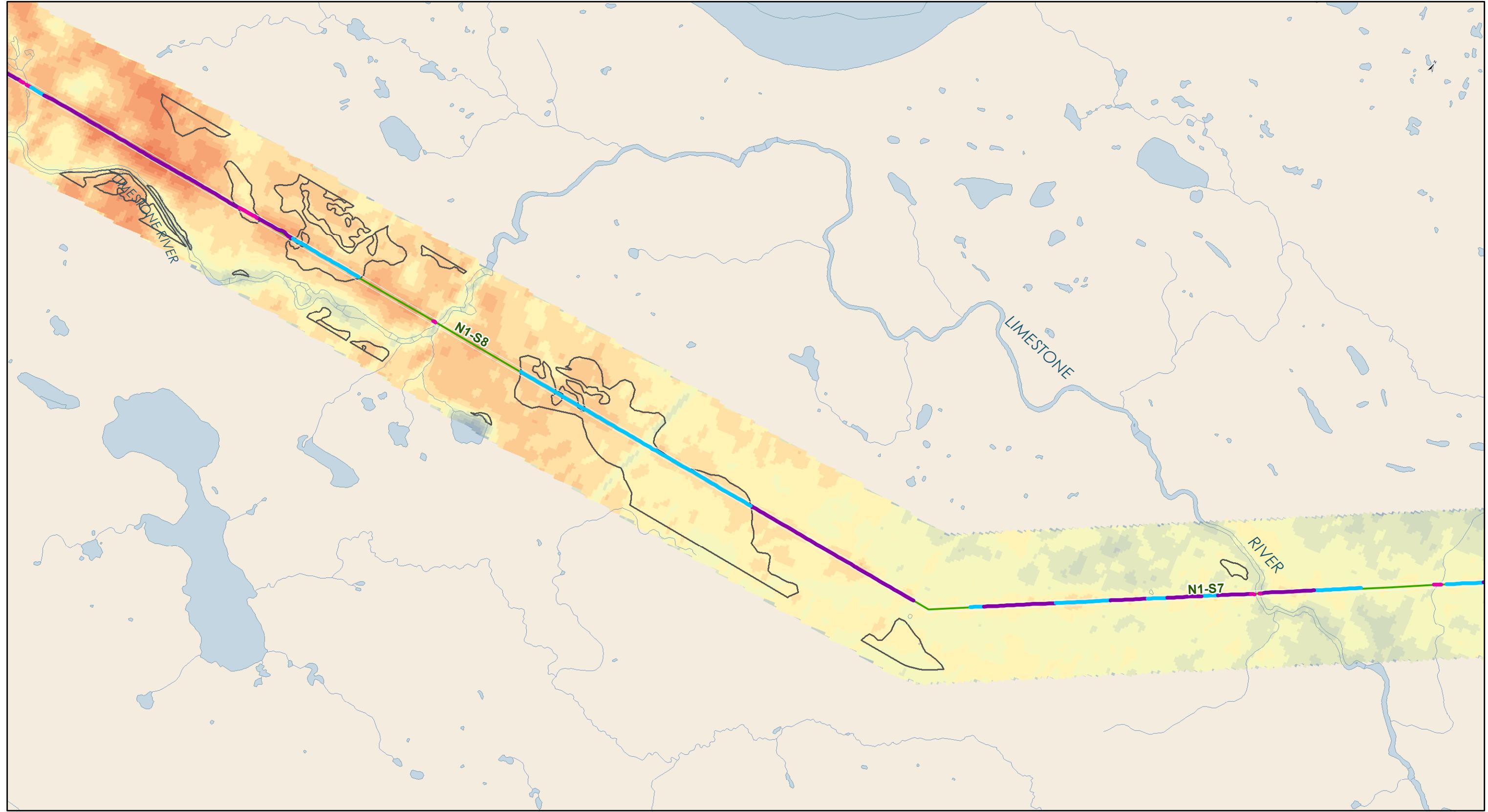
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

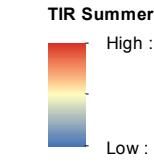


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Date Created: November 14, 2016

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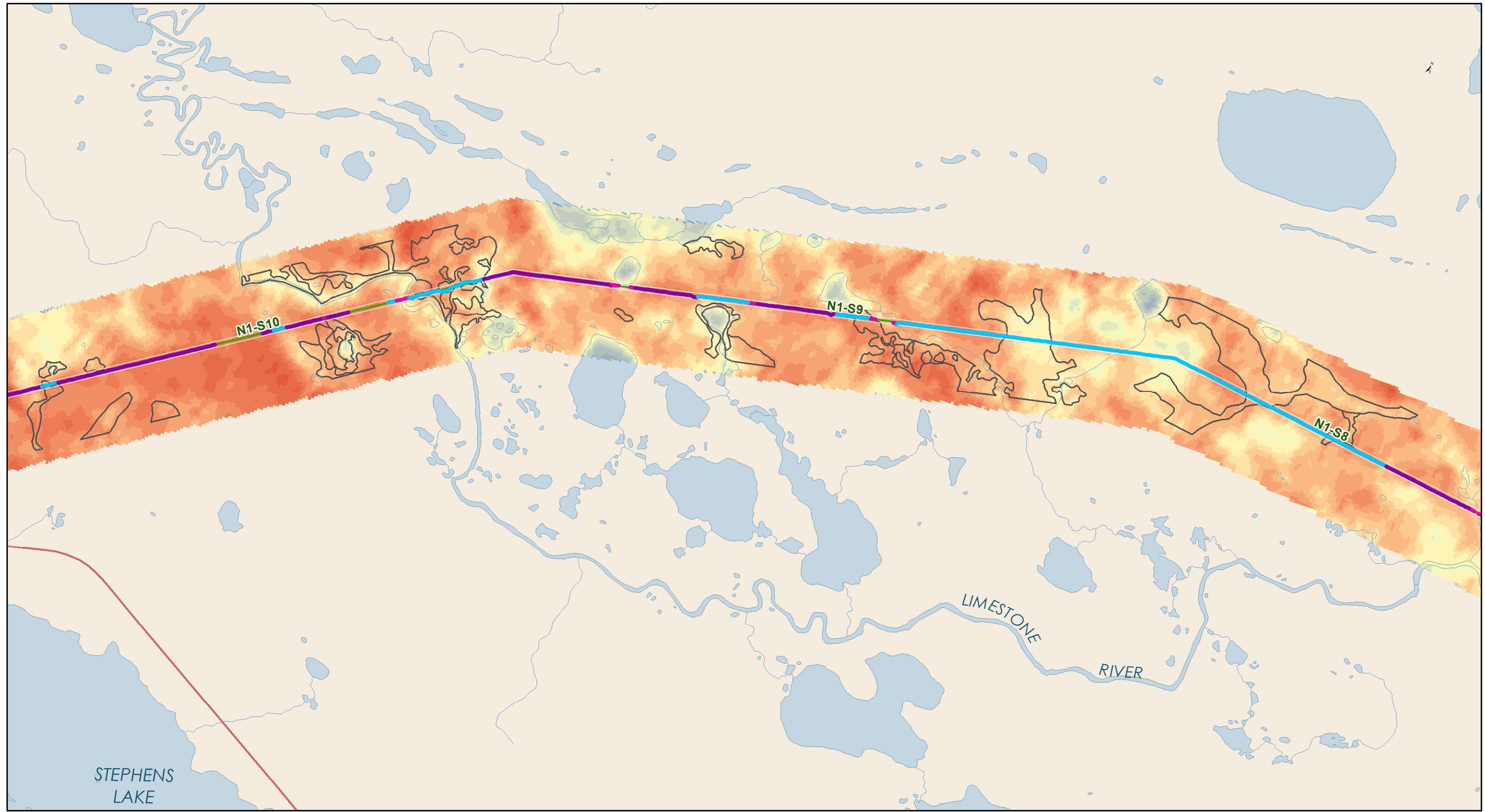
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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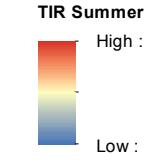
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**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



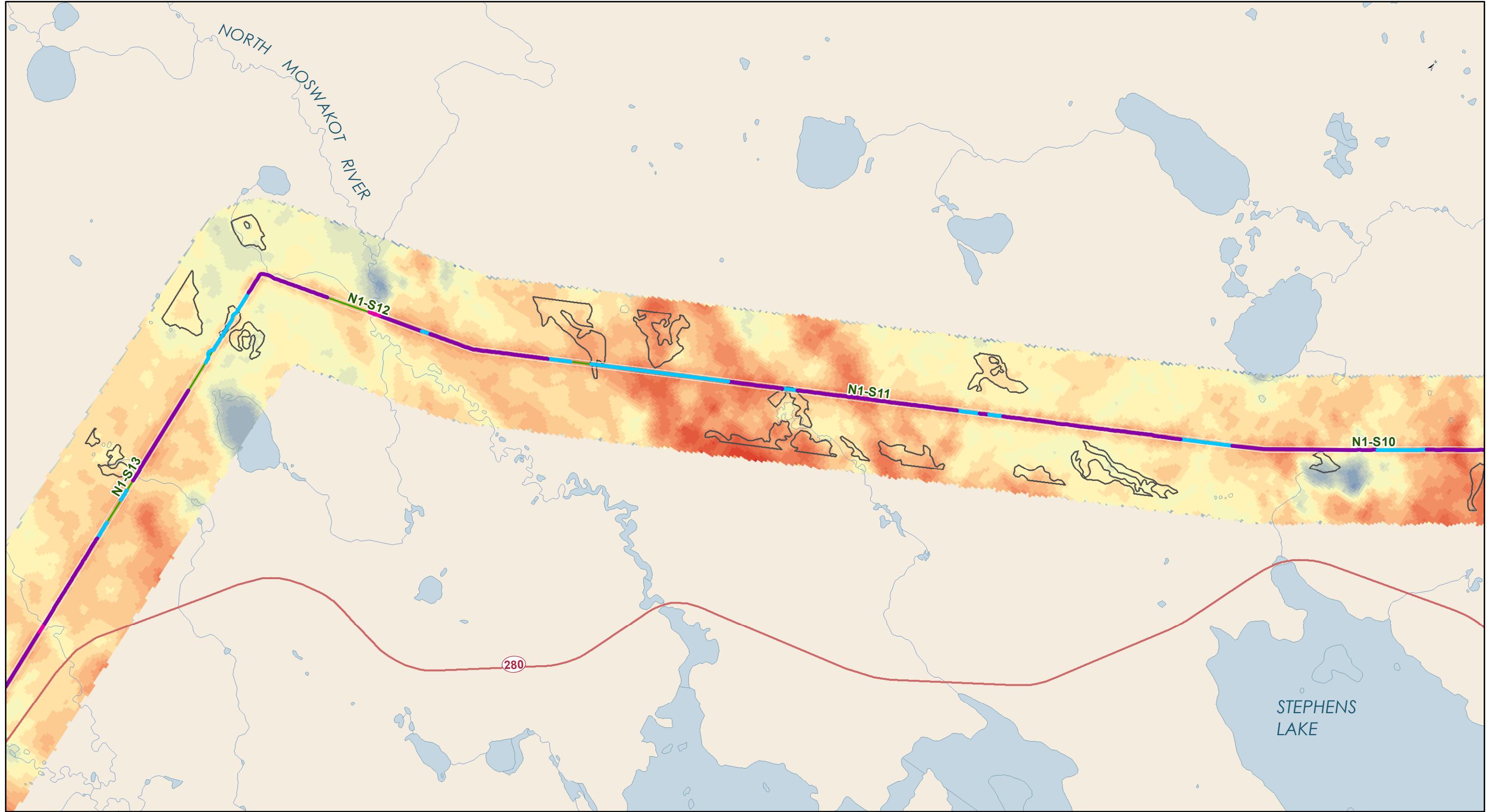
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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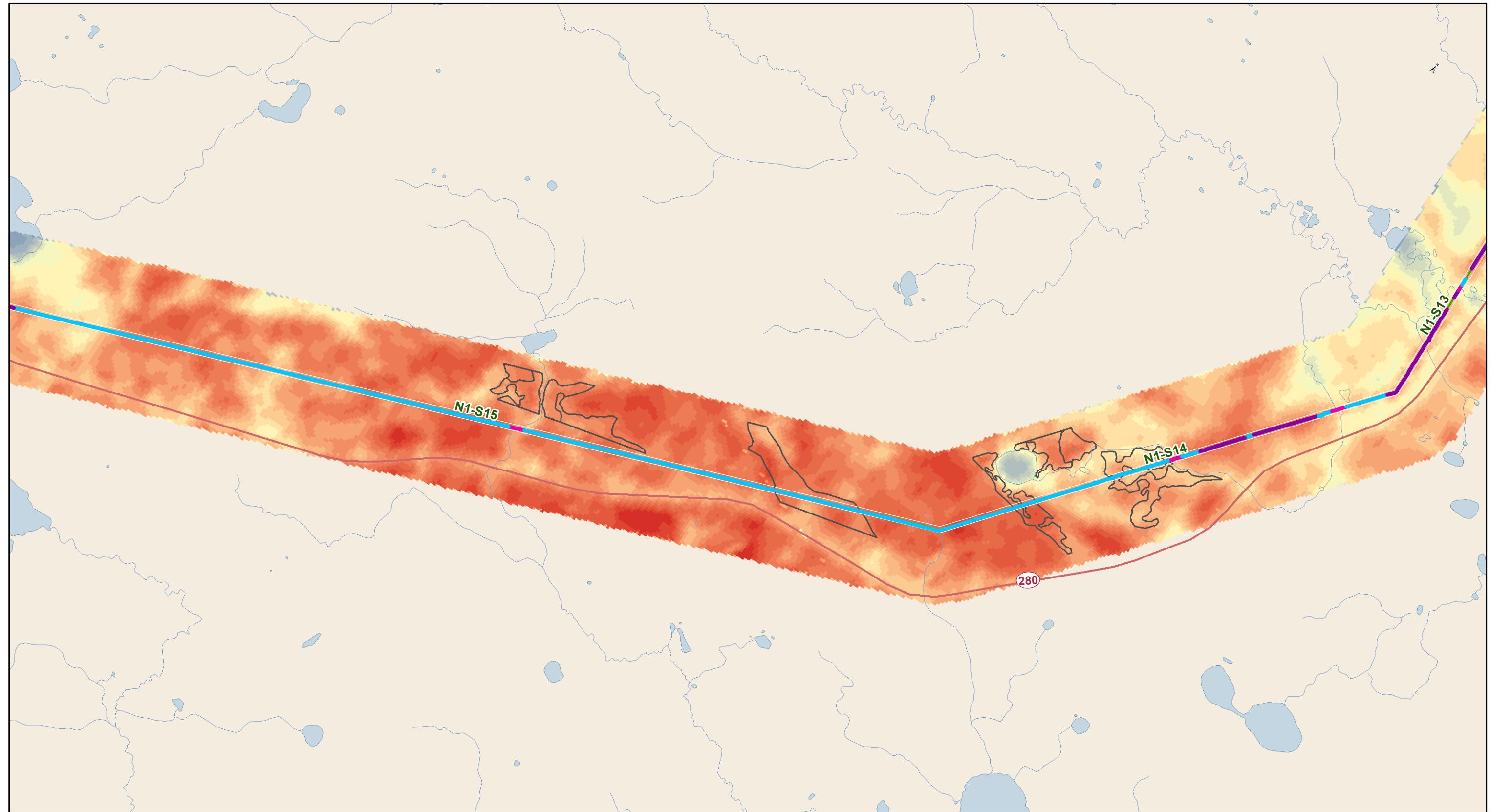
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

**TIR Summer 2016 (°C)**  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



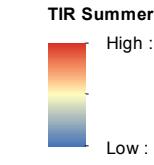
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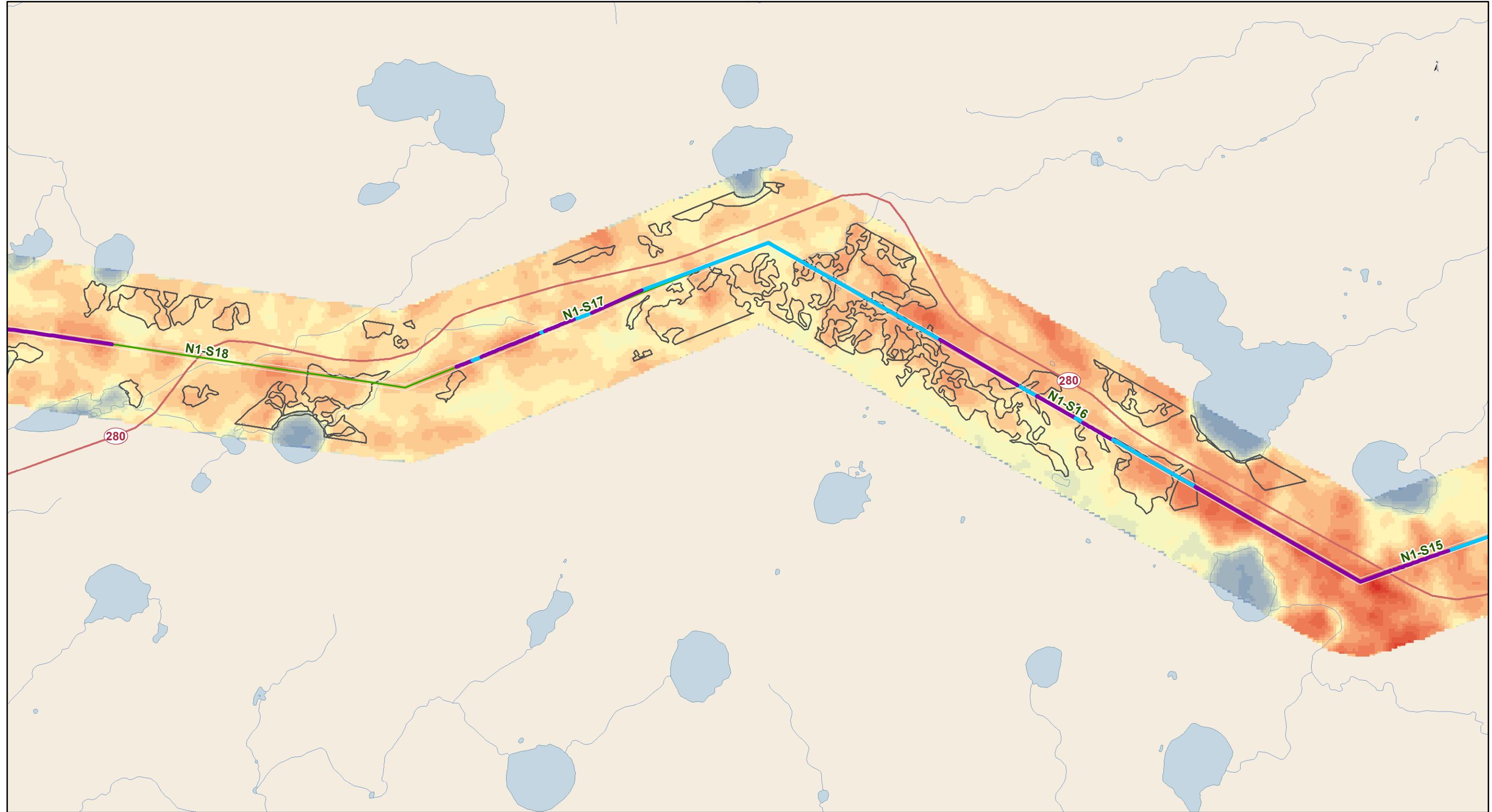
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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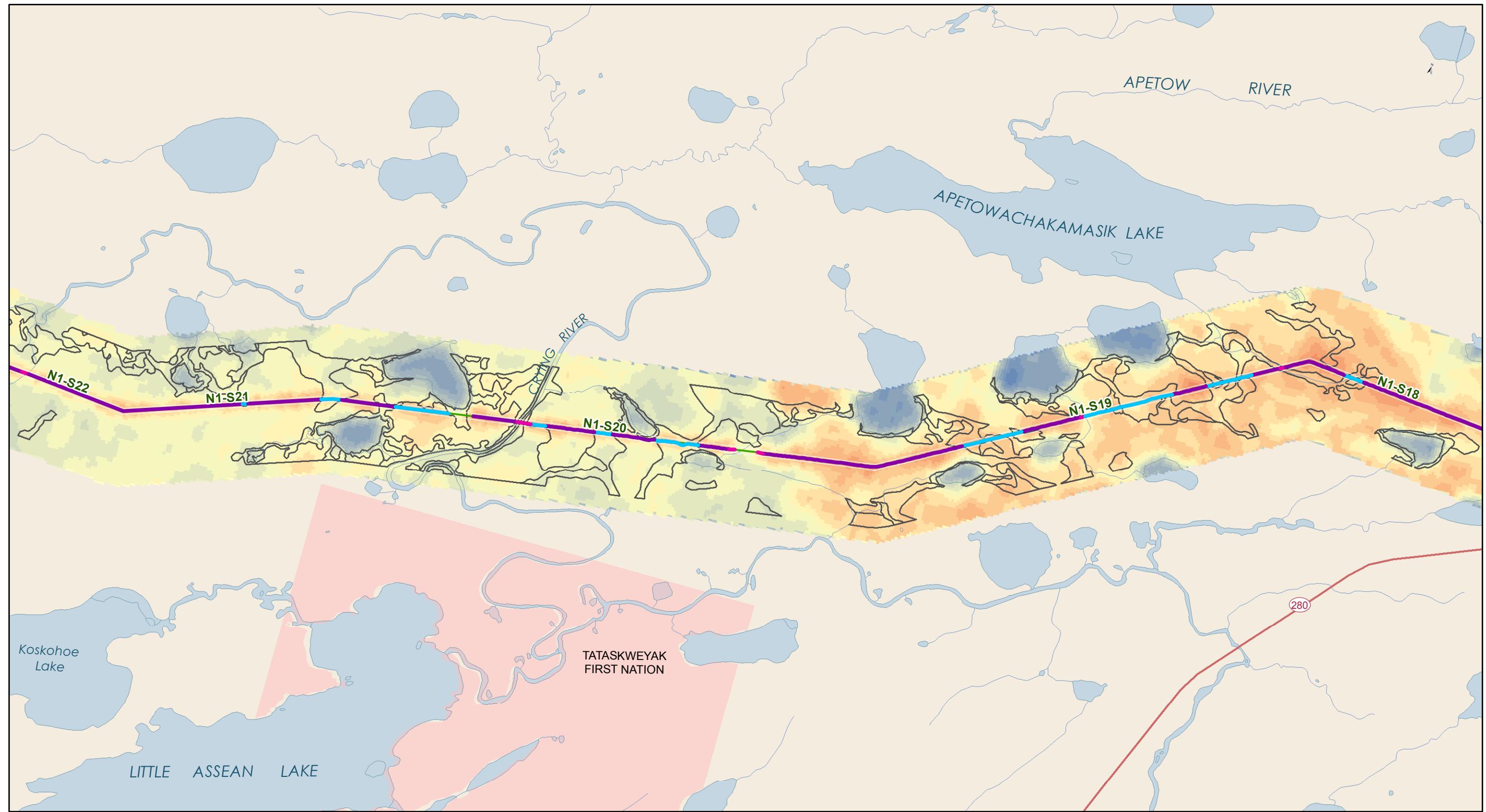
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

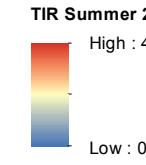


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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
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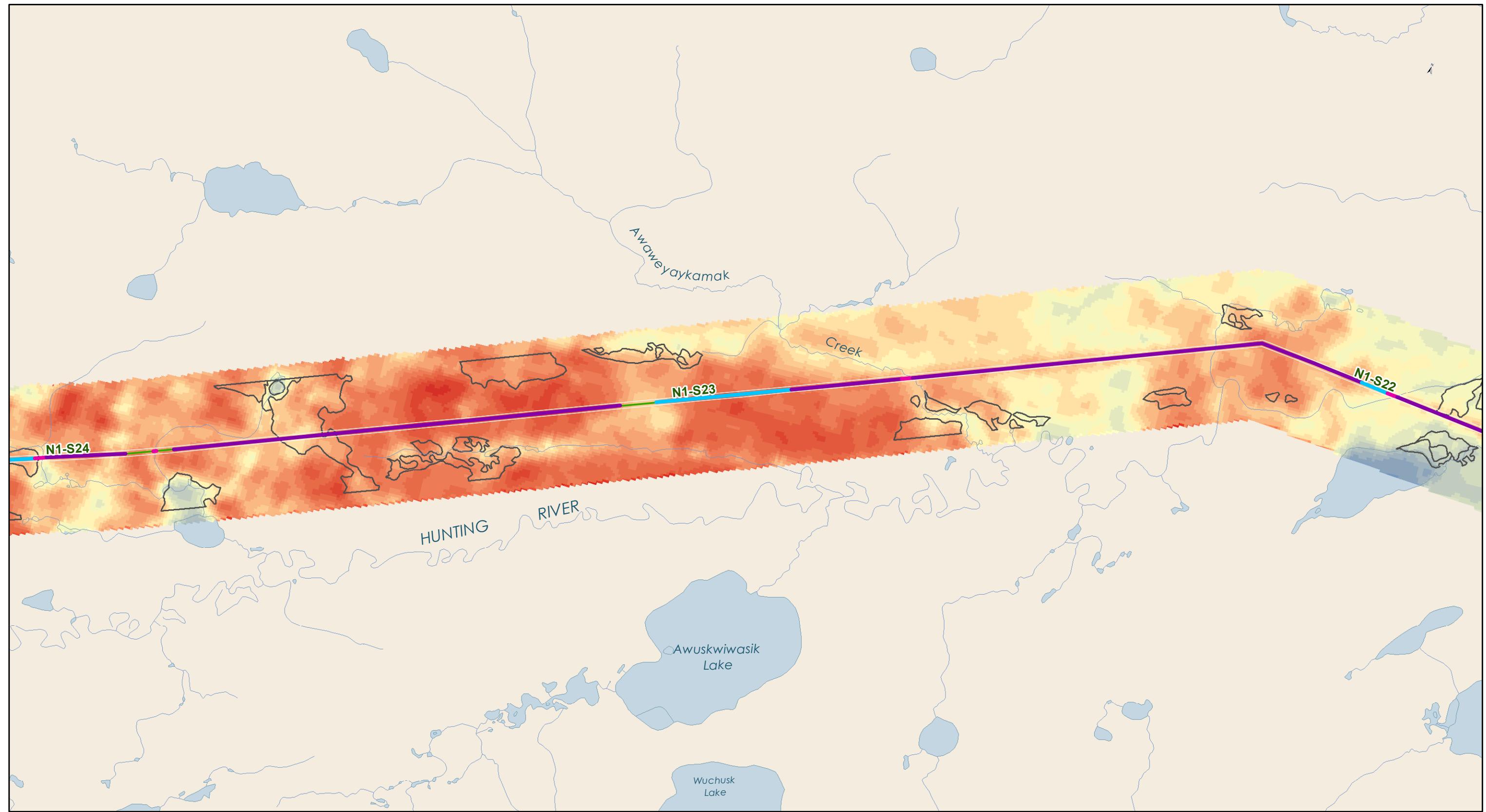
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
First Nation  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

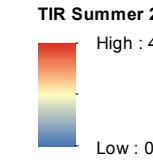


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Metres

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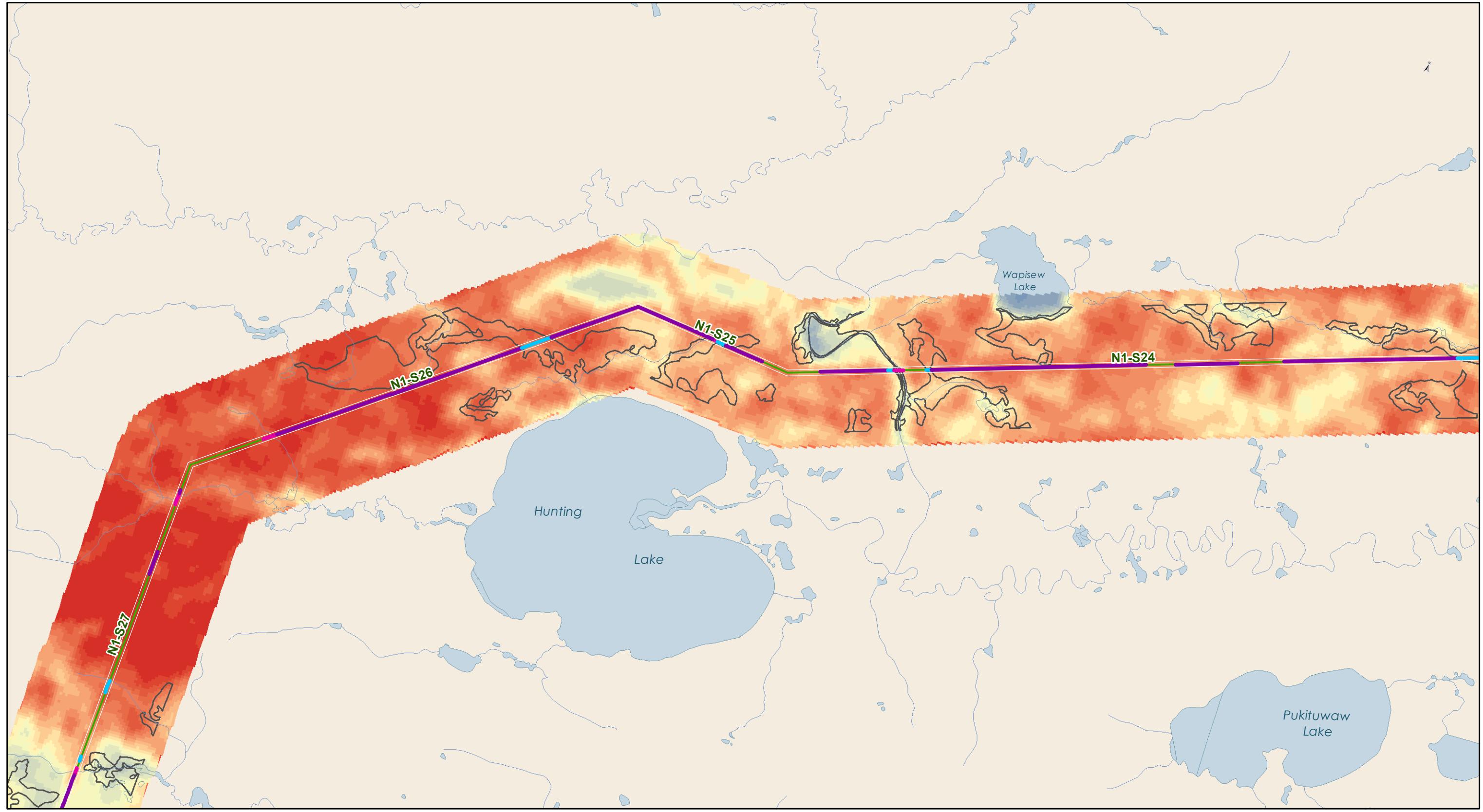
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



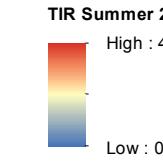
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Date Created: November 14, 2016

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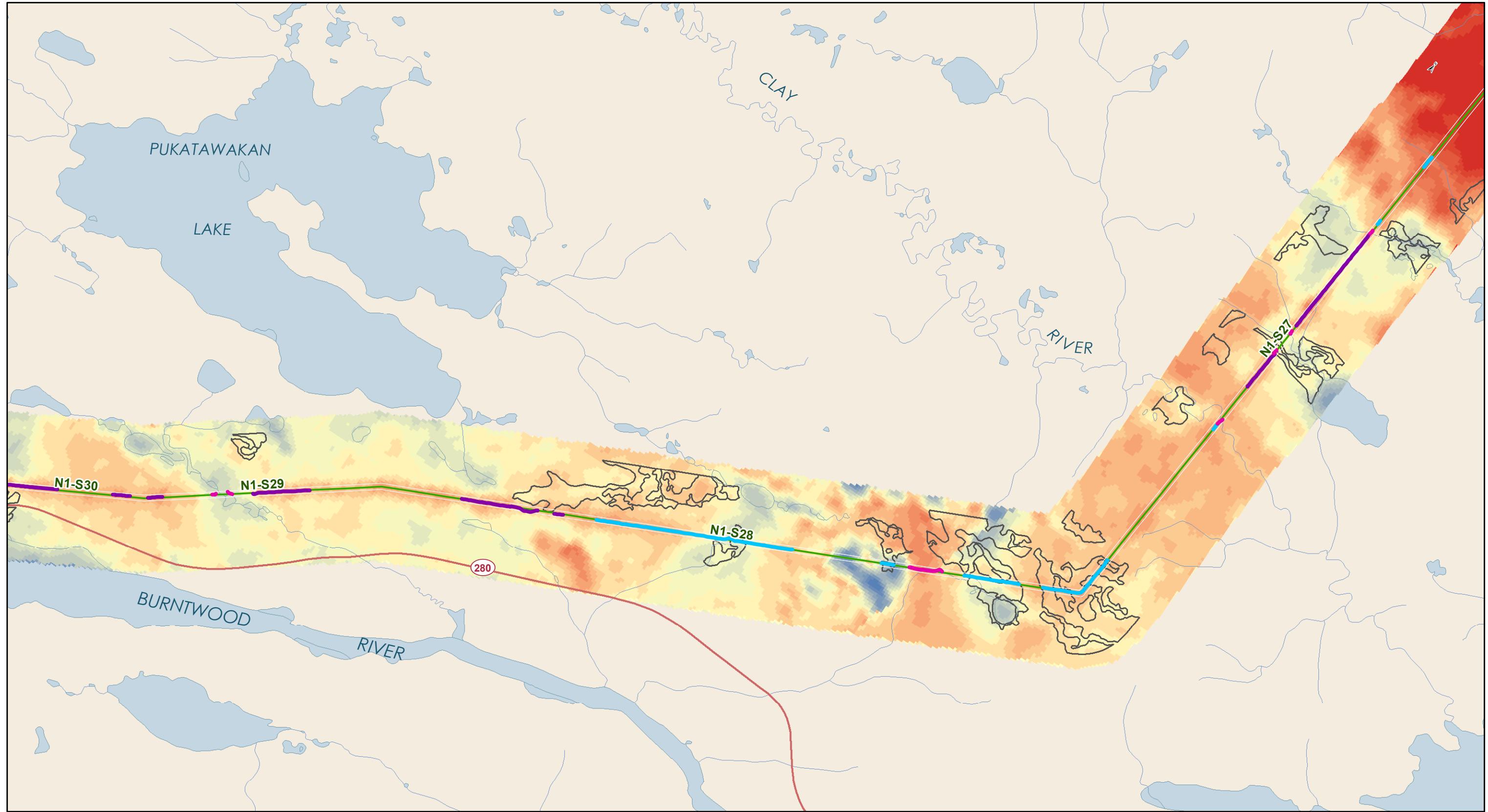
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

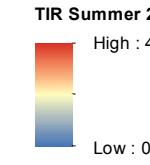


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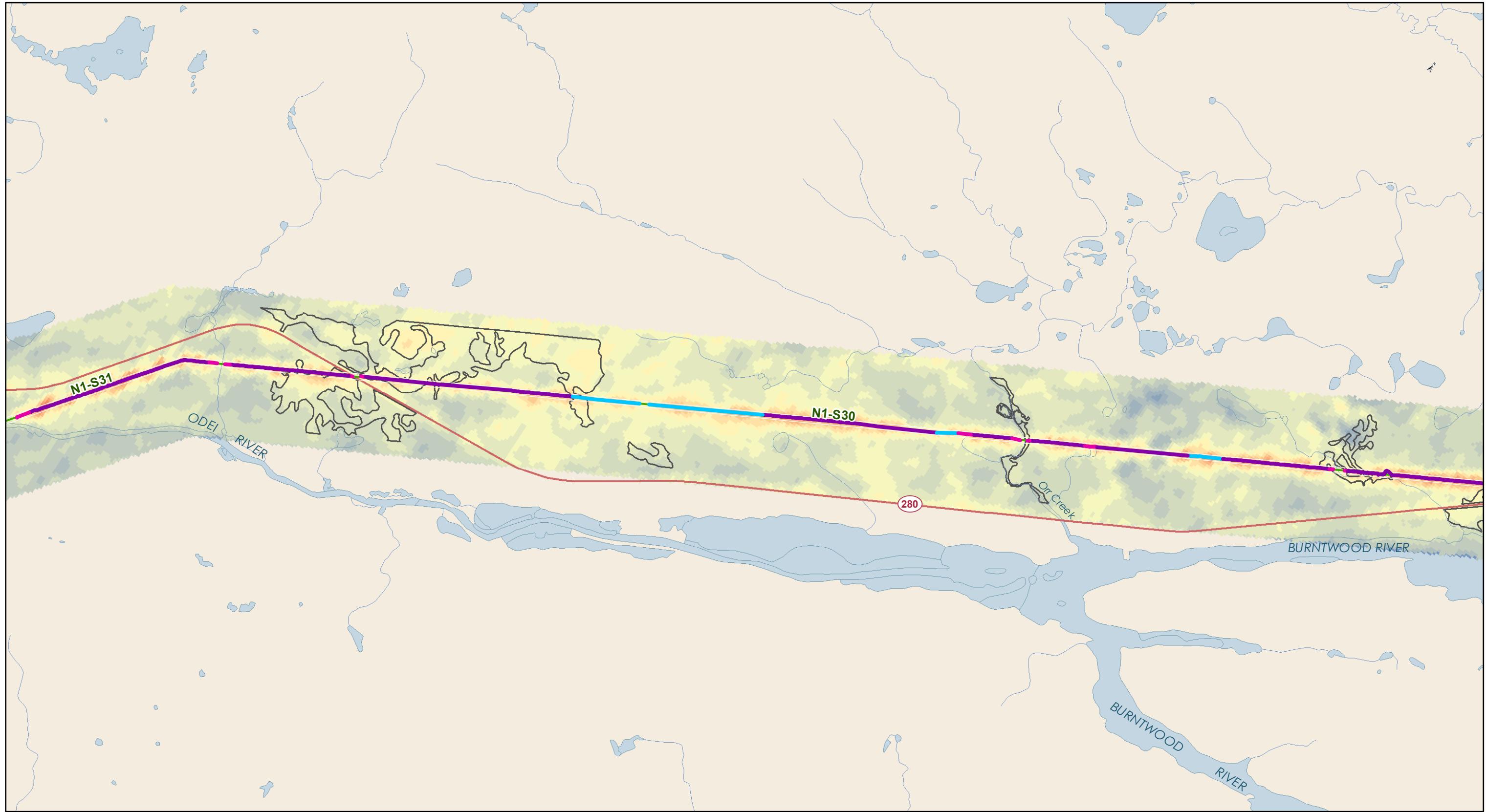
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2016



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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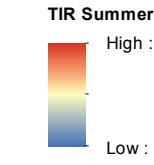
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**Base Data**

- Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing



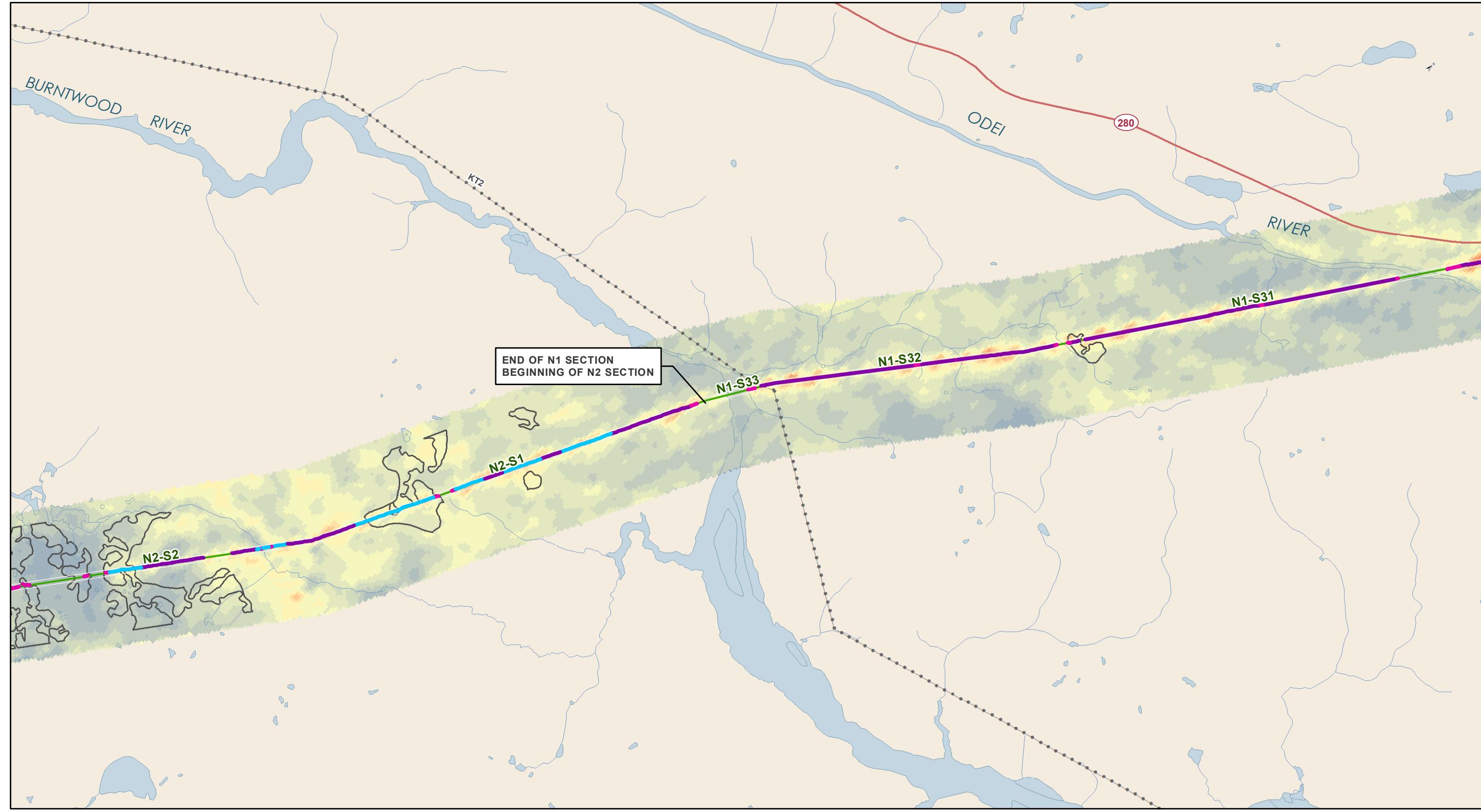
**Project Infrastructure**

- BPIII Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 500 1,000 2,000  
Metres  
1:40,000

**Base Data**  
Permafrost

**ROW Clearing Methods**

- General Clearing
- Low Disturbance Clearing
- Selective Clearing

**TIR Summer 2016 (°C)**

High : 46  
Low : 0

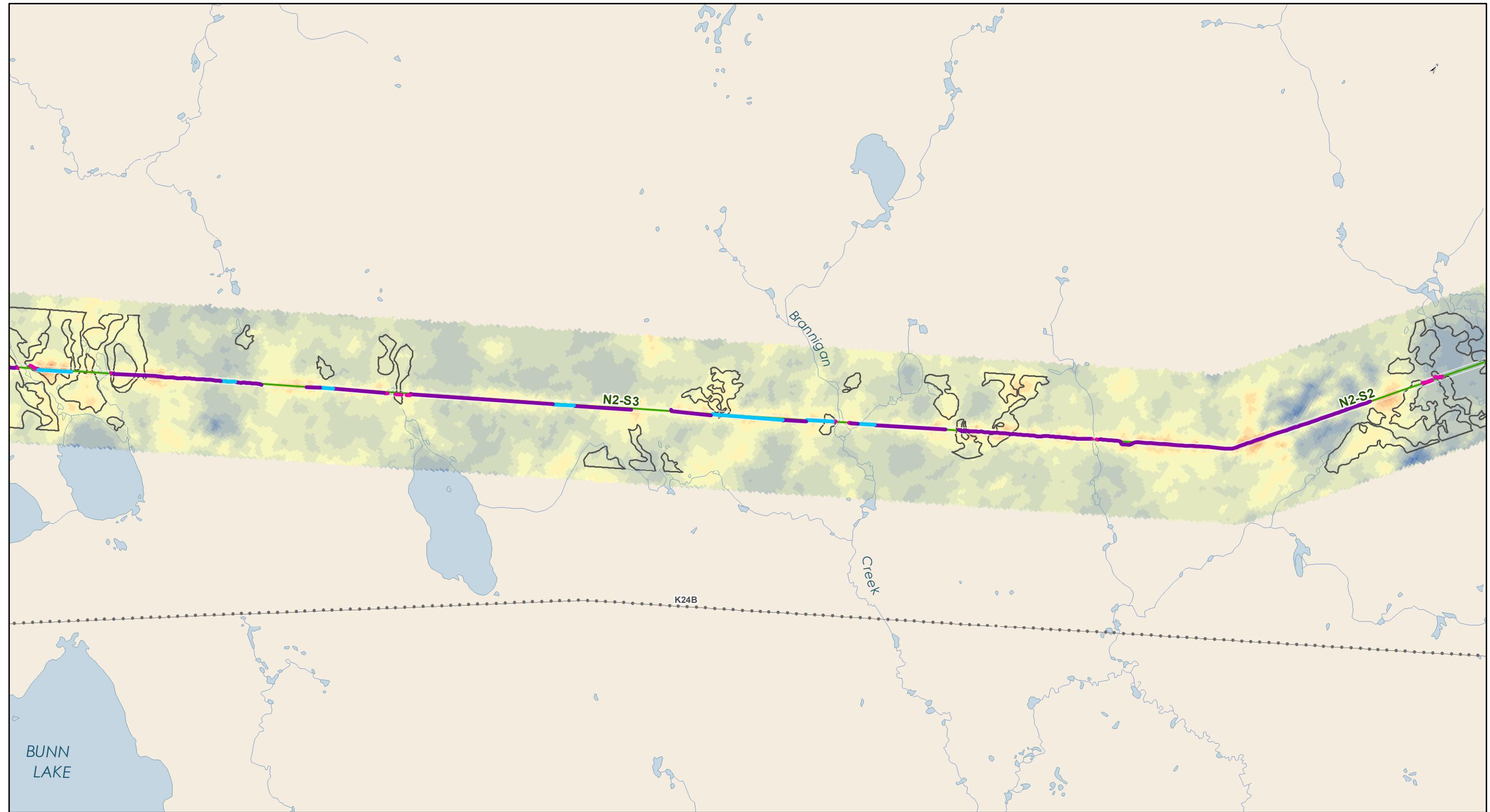
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Road
- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

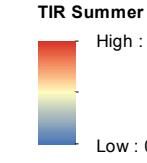


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Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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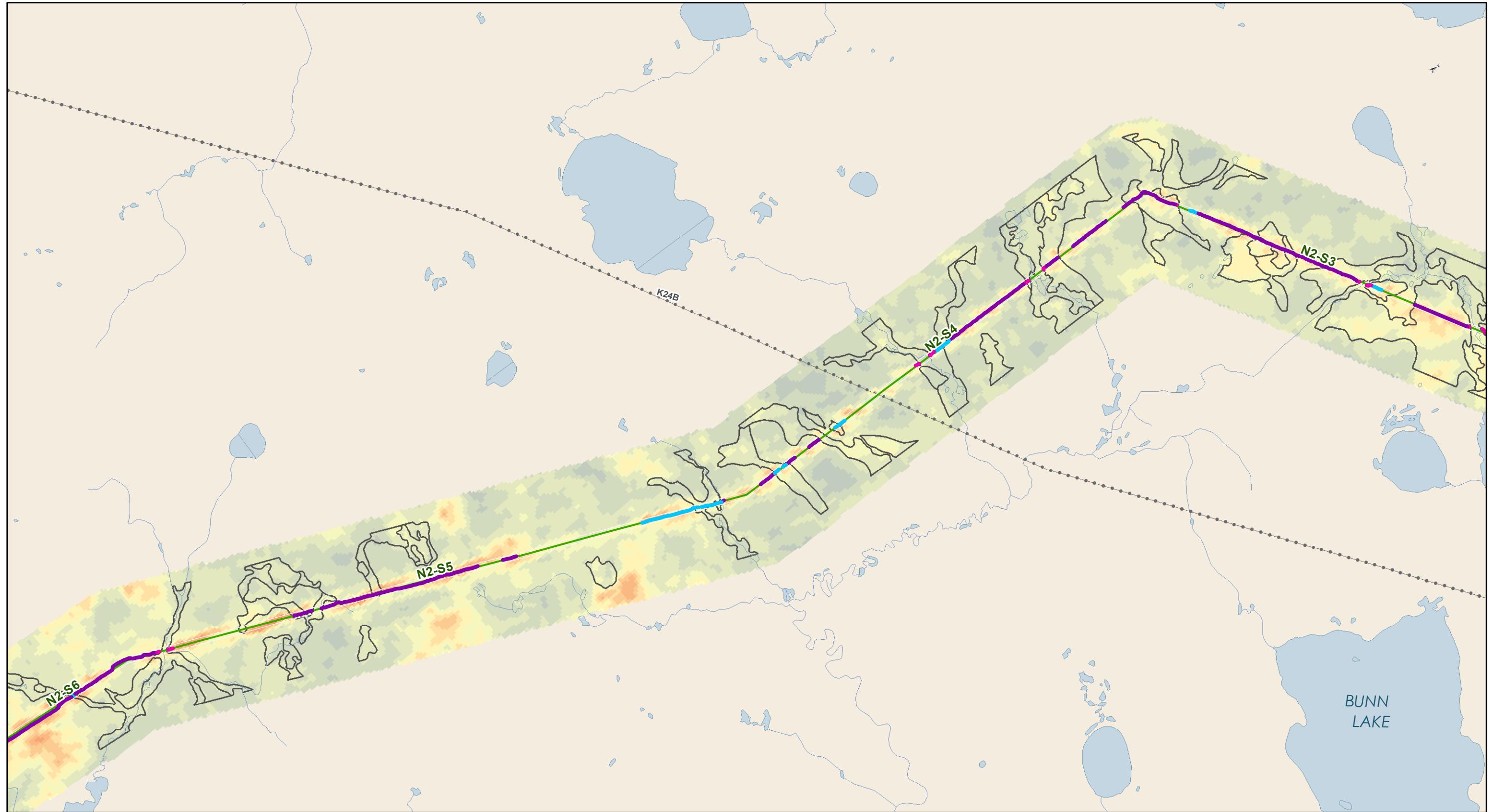
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



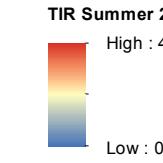
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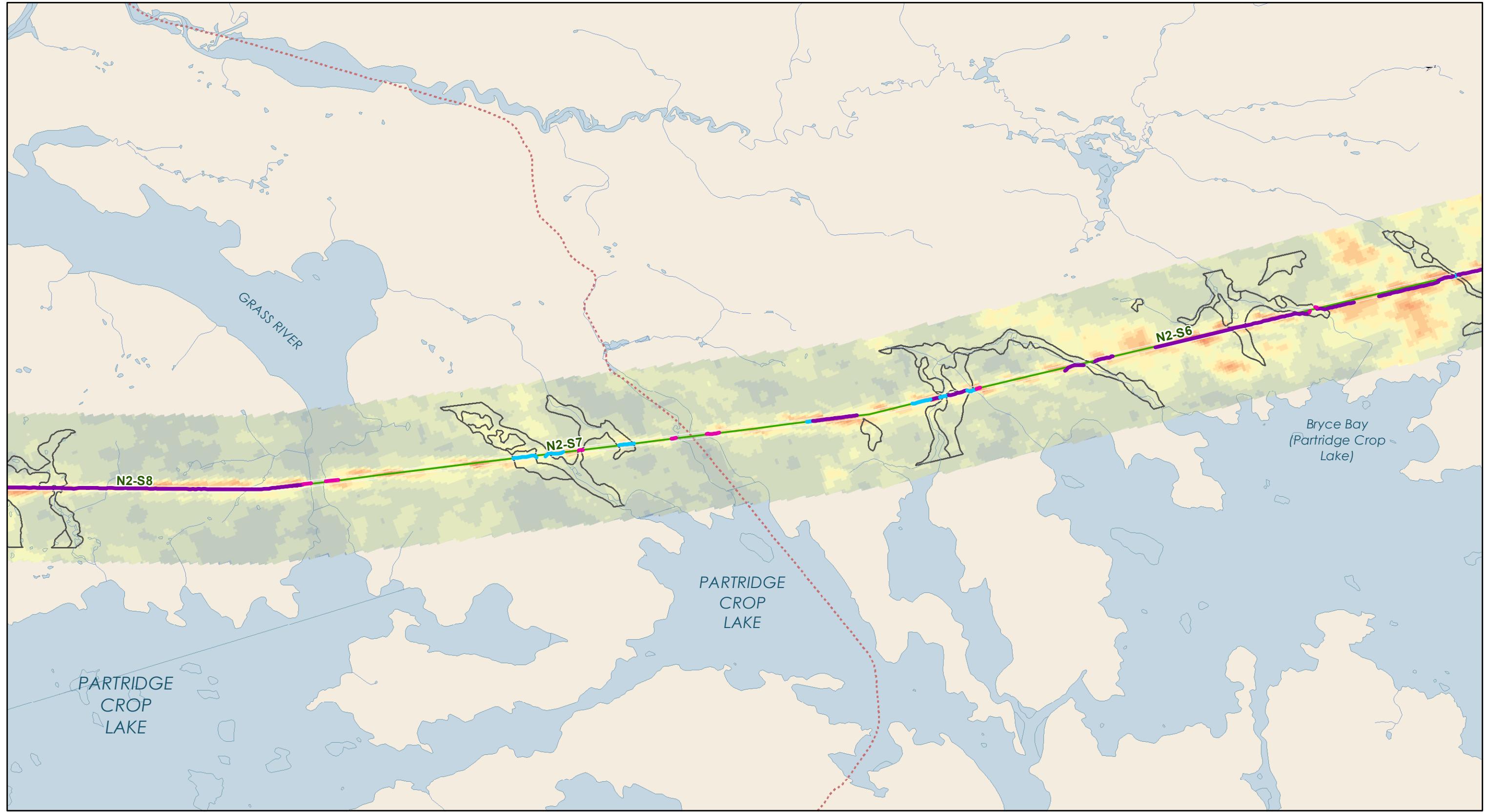
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
Winter Road  
Watercourse  
66m ROW

**Landbase**  
Waterbody  
Watercourse

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

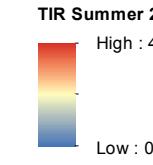


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Date Created: November 14, 2016

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**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing



**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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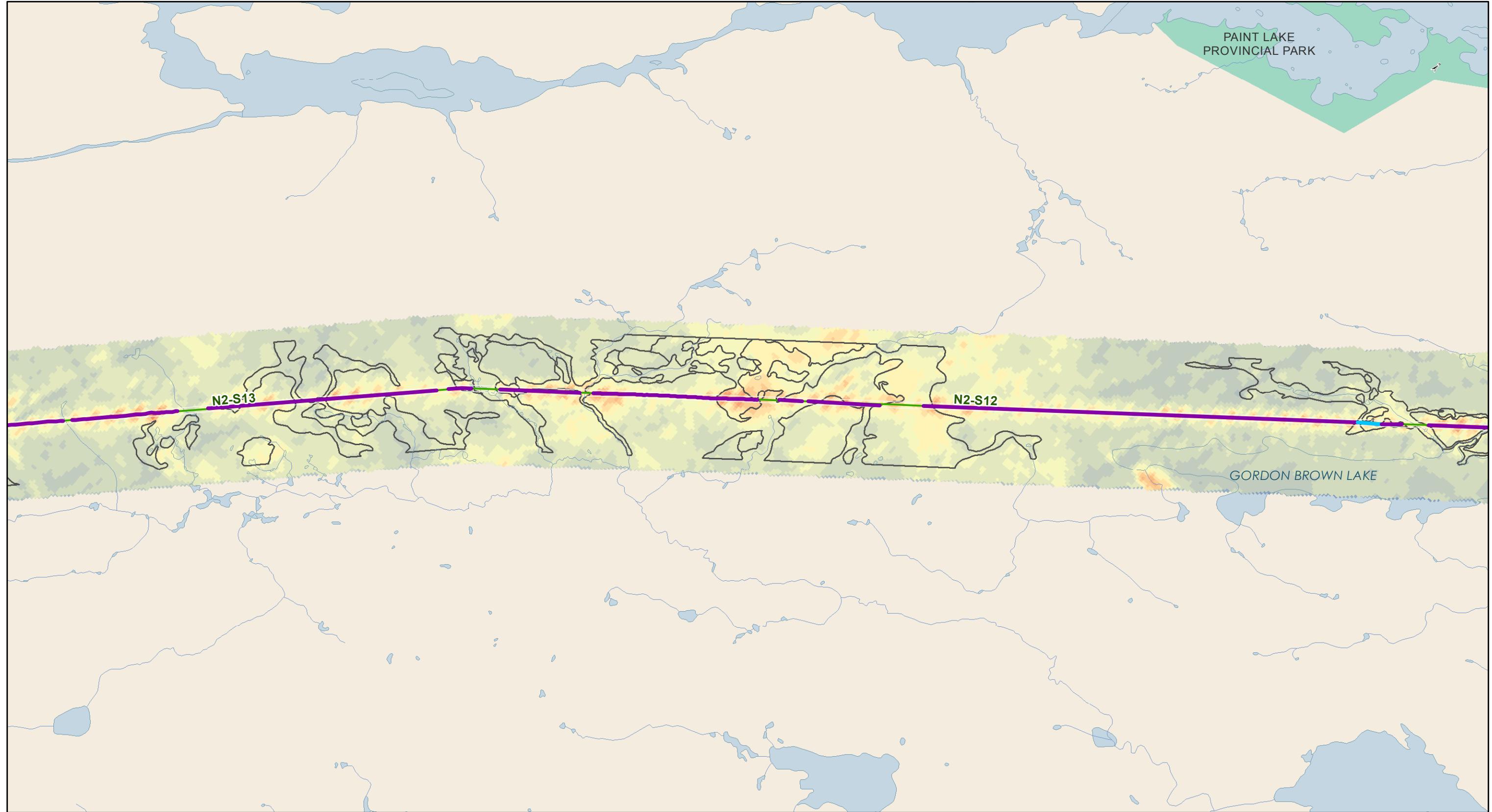
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing  
Selective Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Winter Road  
Provincial Park  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
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**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Park  
Watercourse  
Waterbody

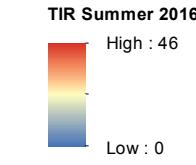
**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing



**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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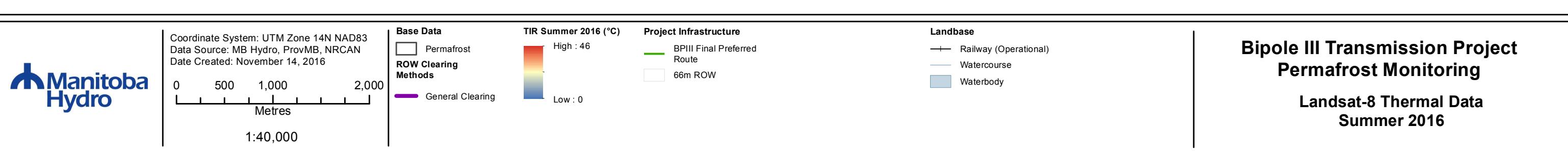
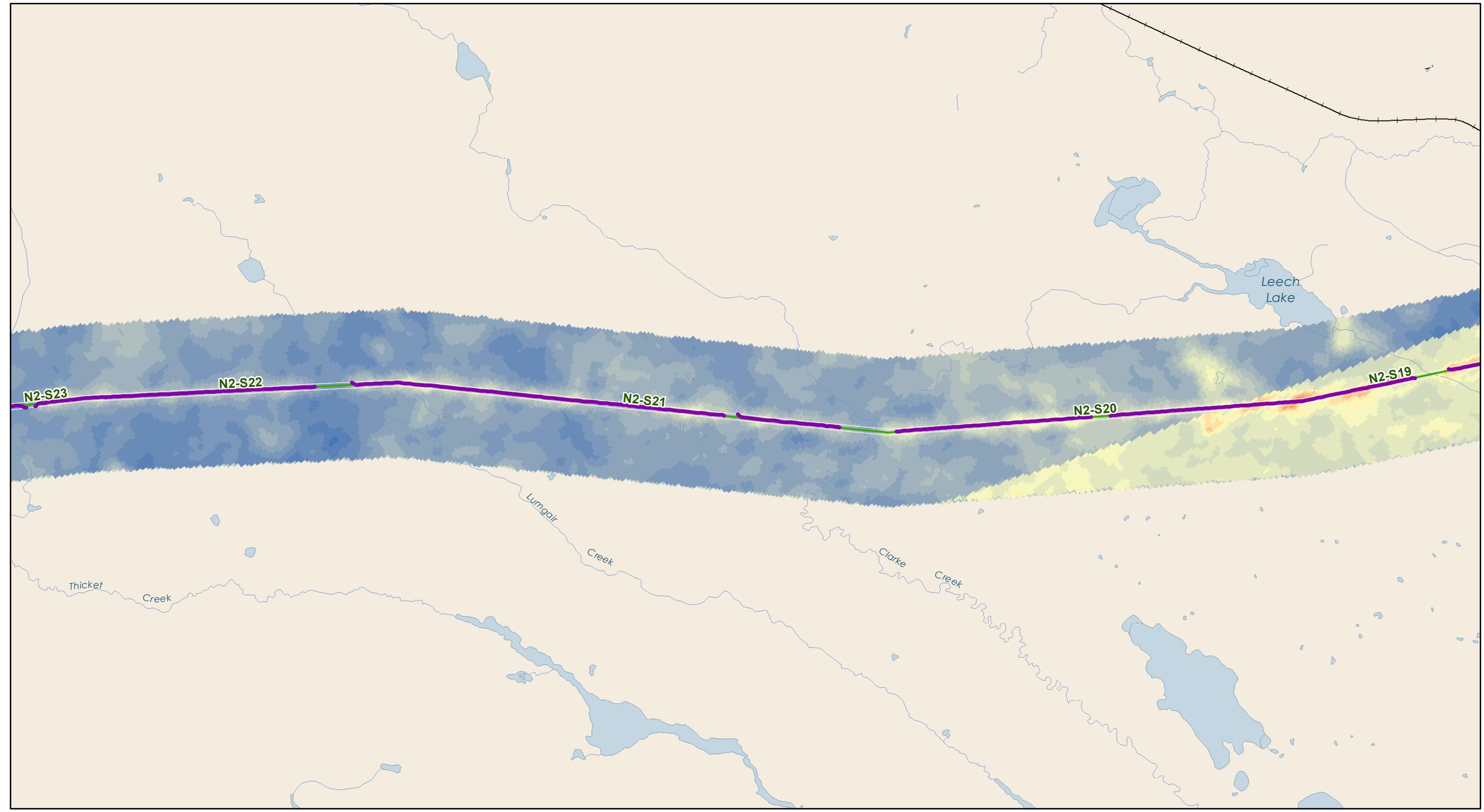
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Permafrost  
**ROW Clearing Methods**  
General Clearing

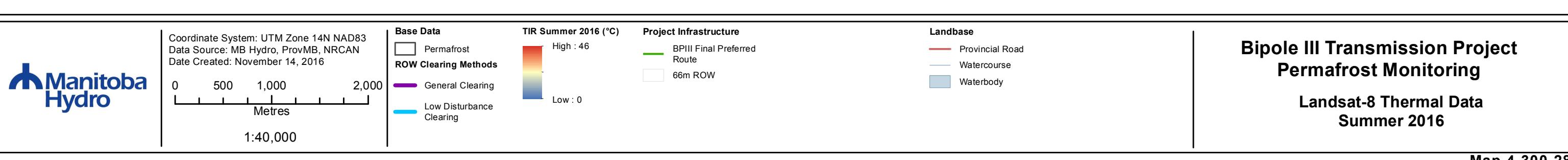
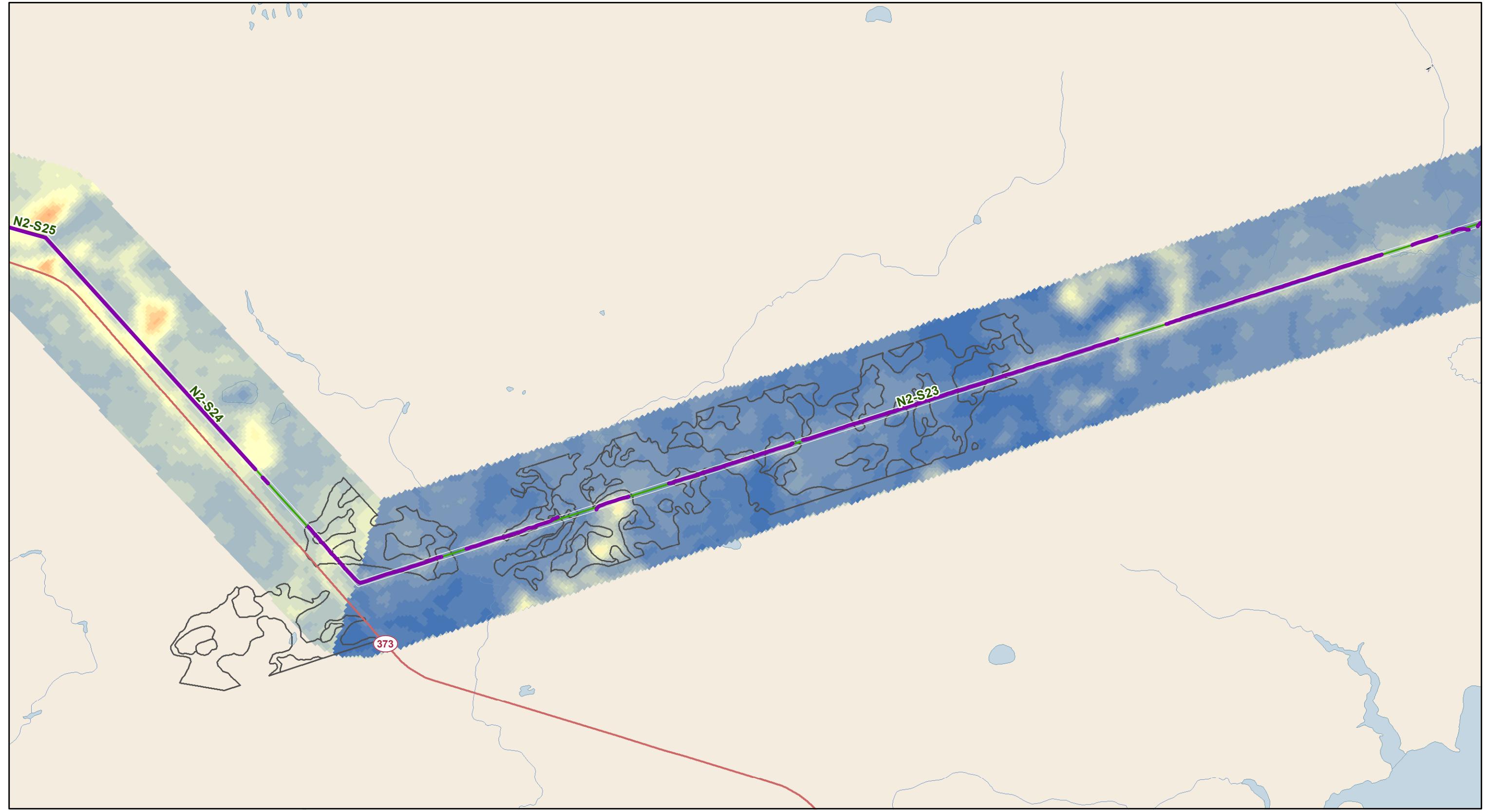
TIR Summer 2016 (°C)  
High : 46  
Low : 0

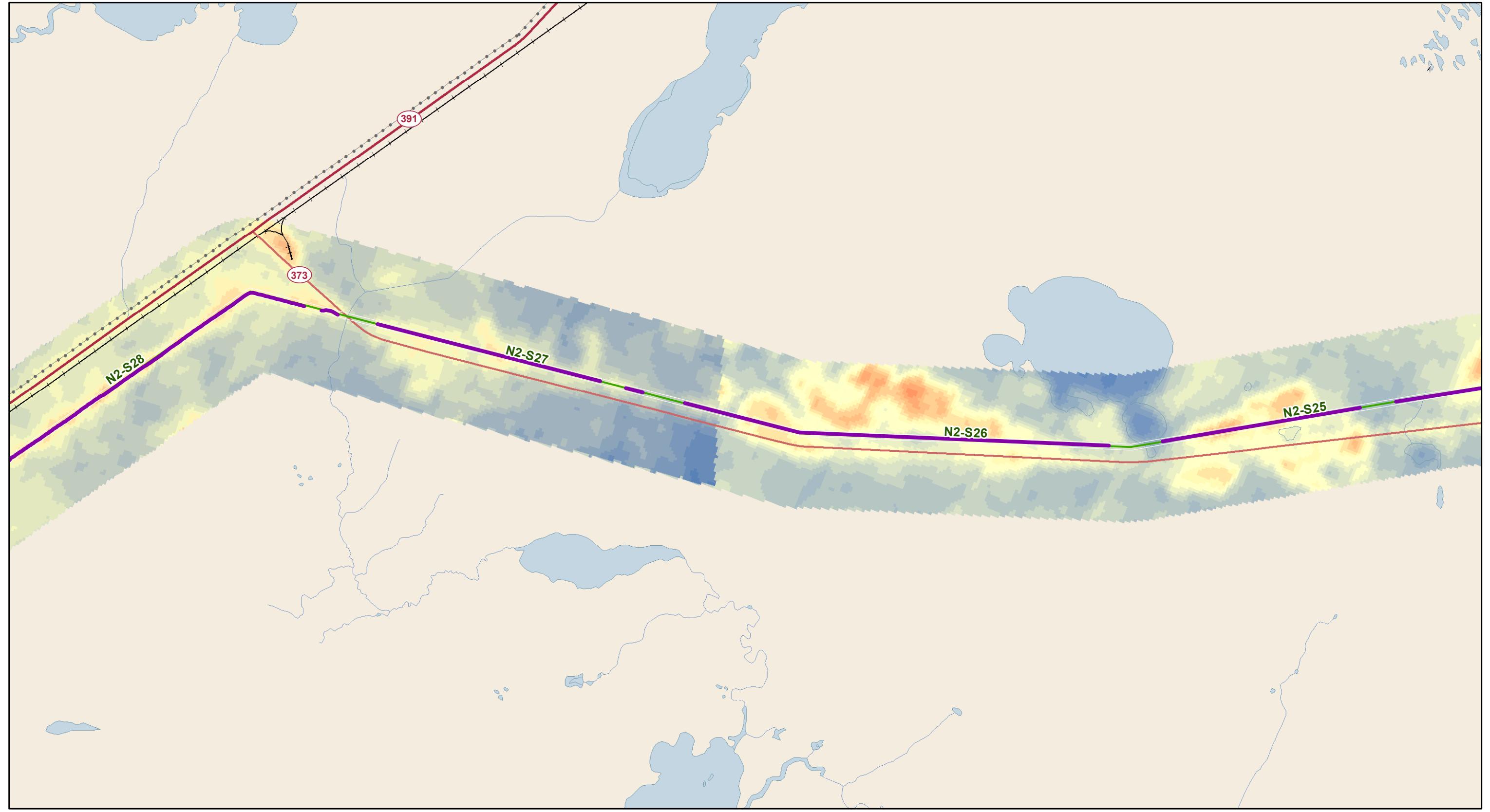
**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**







Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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Metres  
1:40,000

**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Provincial Road  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres  
1:40,000

**Base Data**  
Permafrost

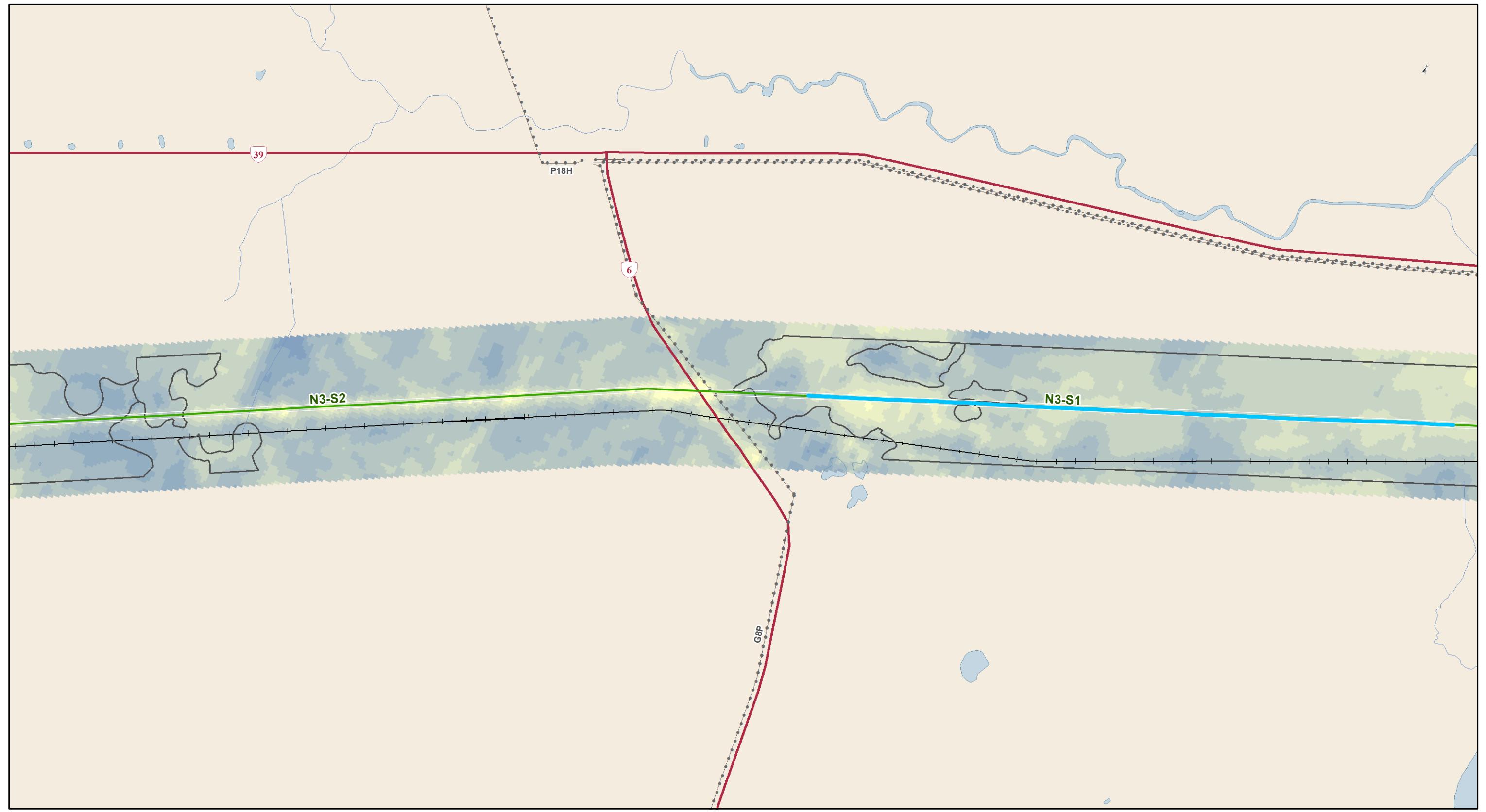
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

**TIR Summer 2016 (°C)**  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

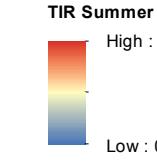
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**Base Data**  
Permafrost

**ROW Clearing Methods**  
Low Disturbance Clearing



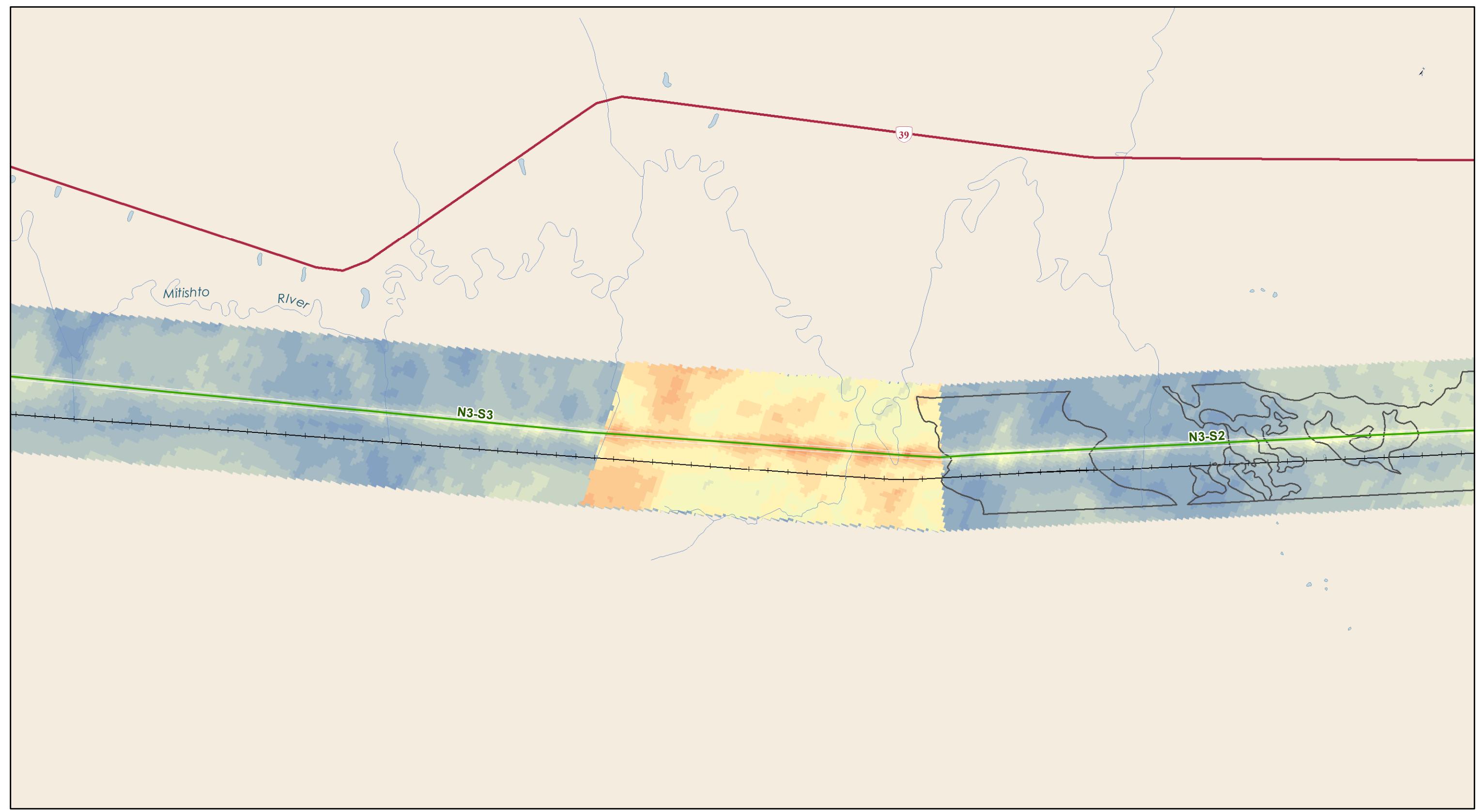
**Project Infrastructure**

- BP III Final Preferred Route
- 66m ROW

**Landbase**

- Provincial Highway
- Railway (Operational)
- Transmission Line
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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Base Data  
□ Permafrost



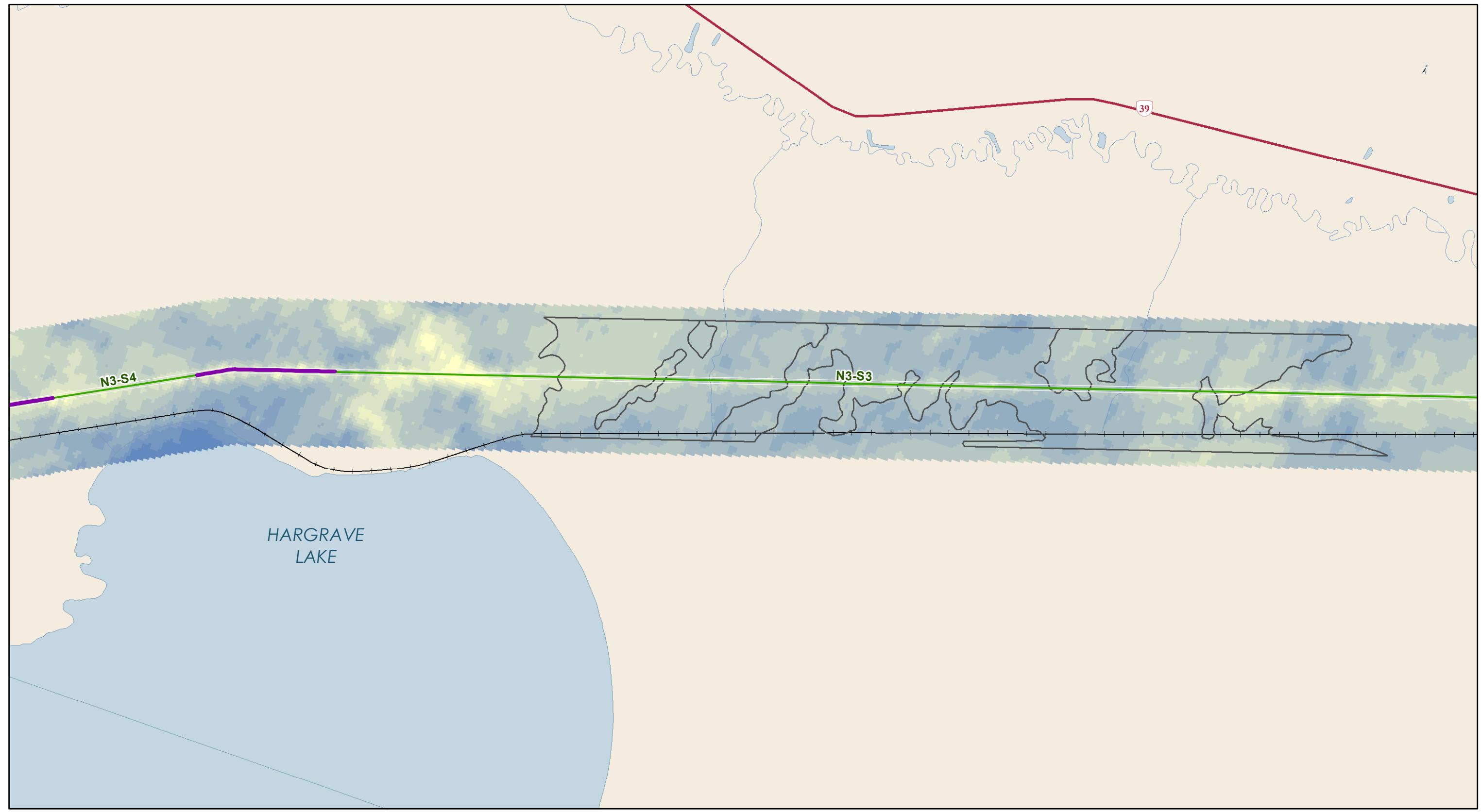
Project Infrastructure

- BPIII Final Preferred Route
- 66m ROW

Landbase

- Provincial Highway
- Railway (Operational)
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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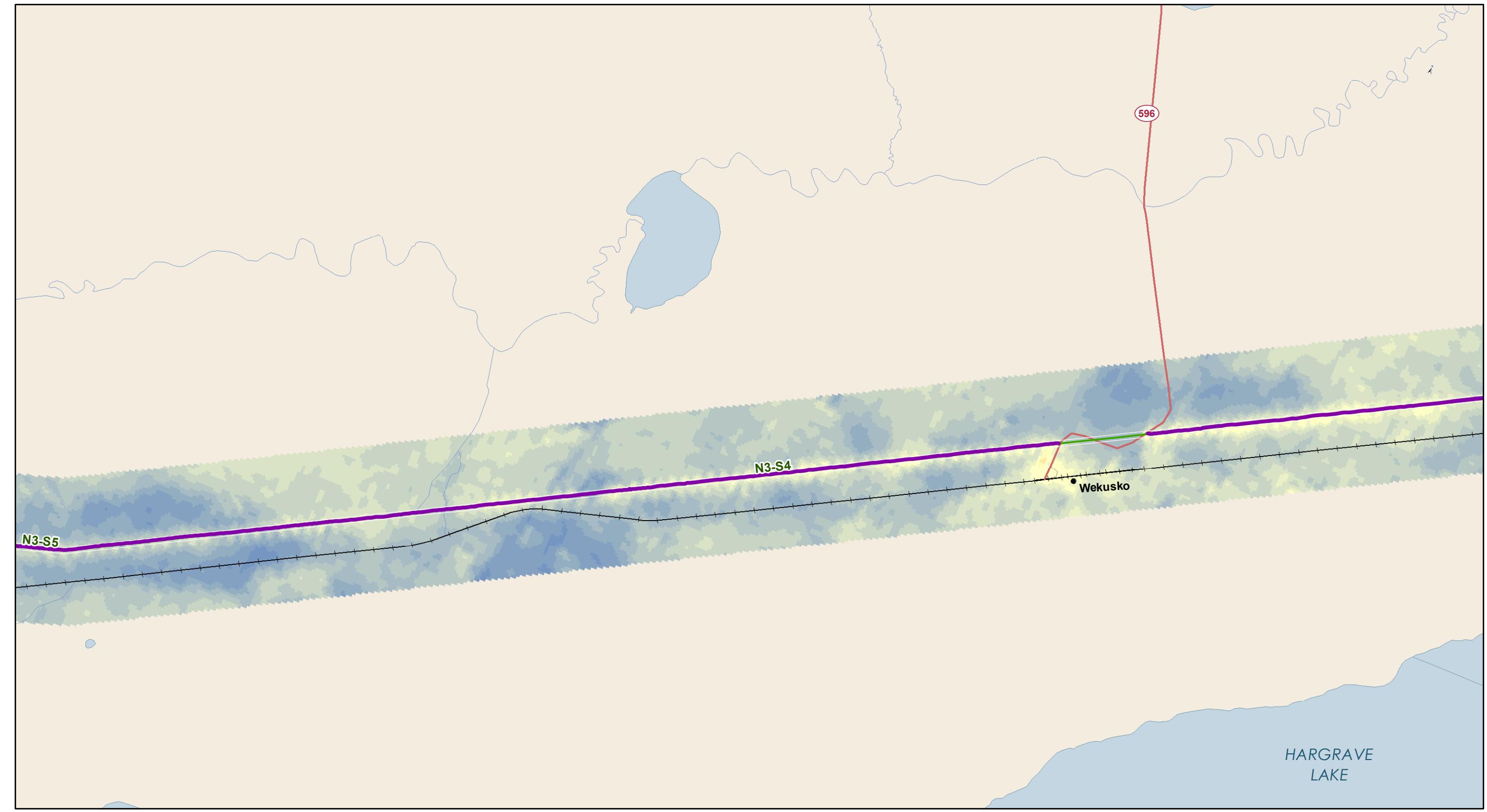
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Highway  
Railway (Operational)  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring**  
Landsat-8 Thermal Data  
Summer 2016



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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Metres

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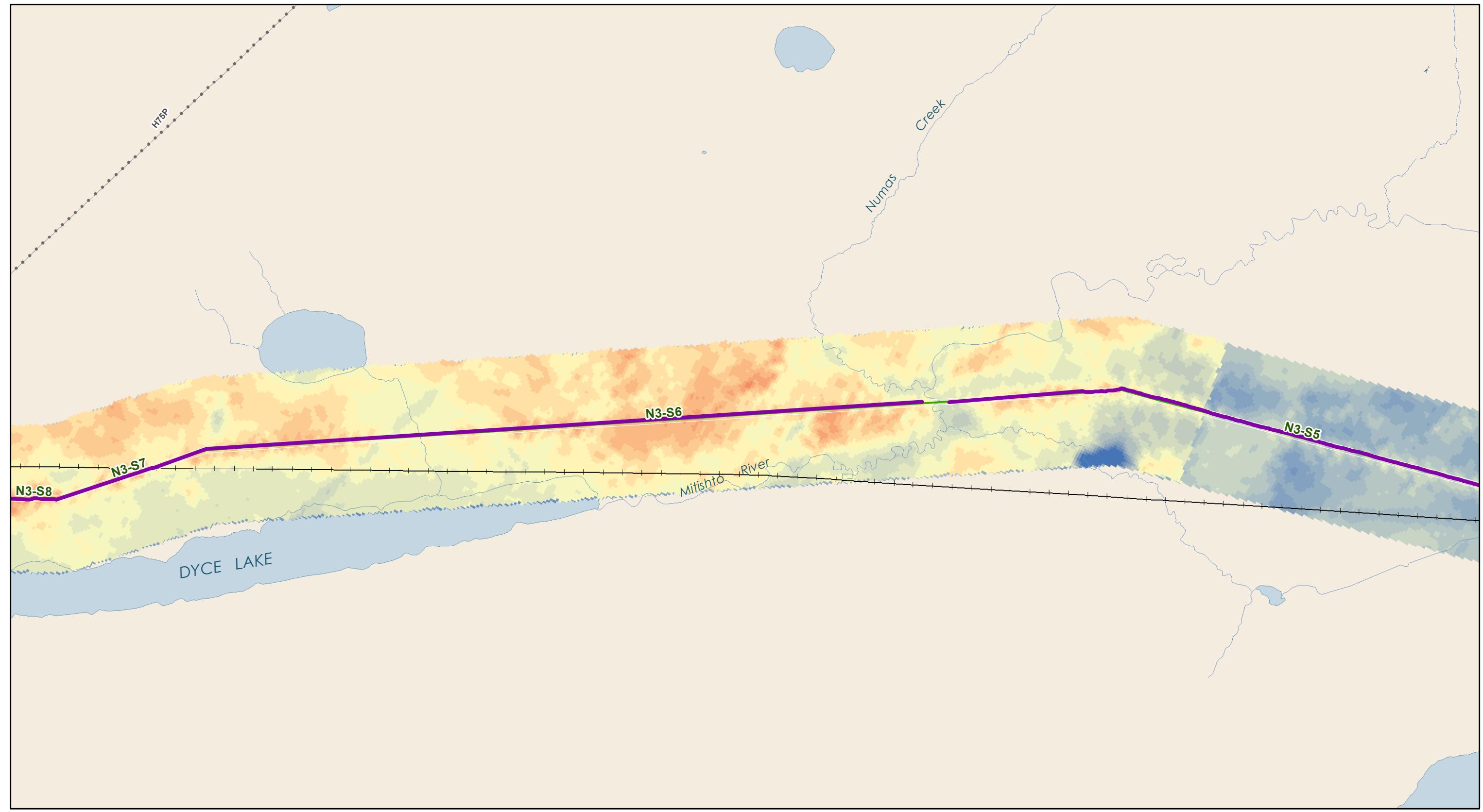
**Base Data**  
□ Permafrost  
**ROW Clearing Methods**  
— General Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
— BPIII Final Preferred Route  
□ 66m ROW

**Landbase**  
— Provincial Road  
— Local Road  
— Railway (Operational)  
— Watercourse  
■ Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
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Date Created: November 14, 2016

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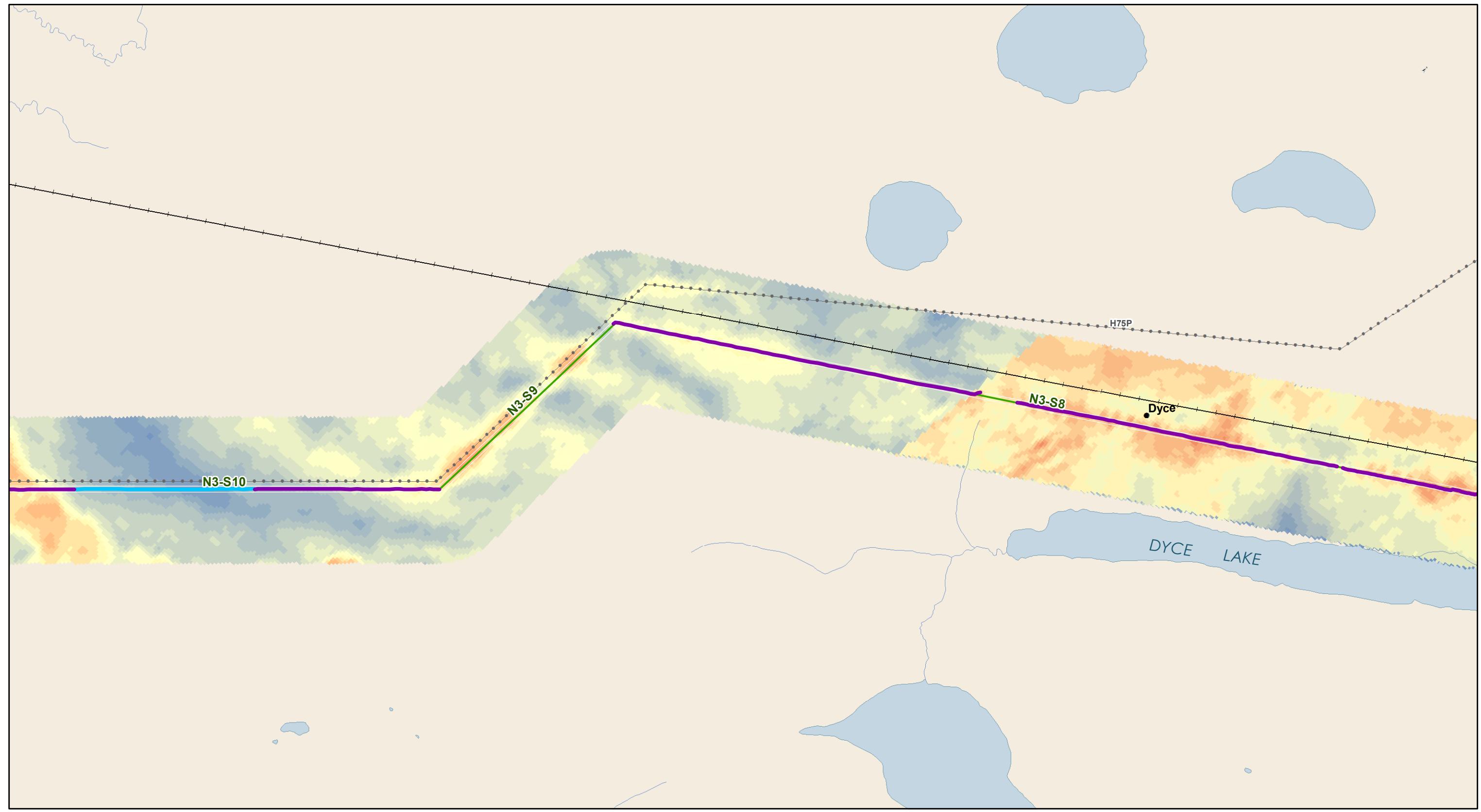
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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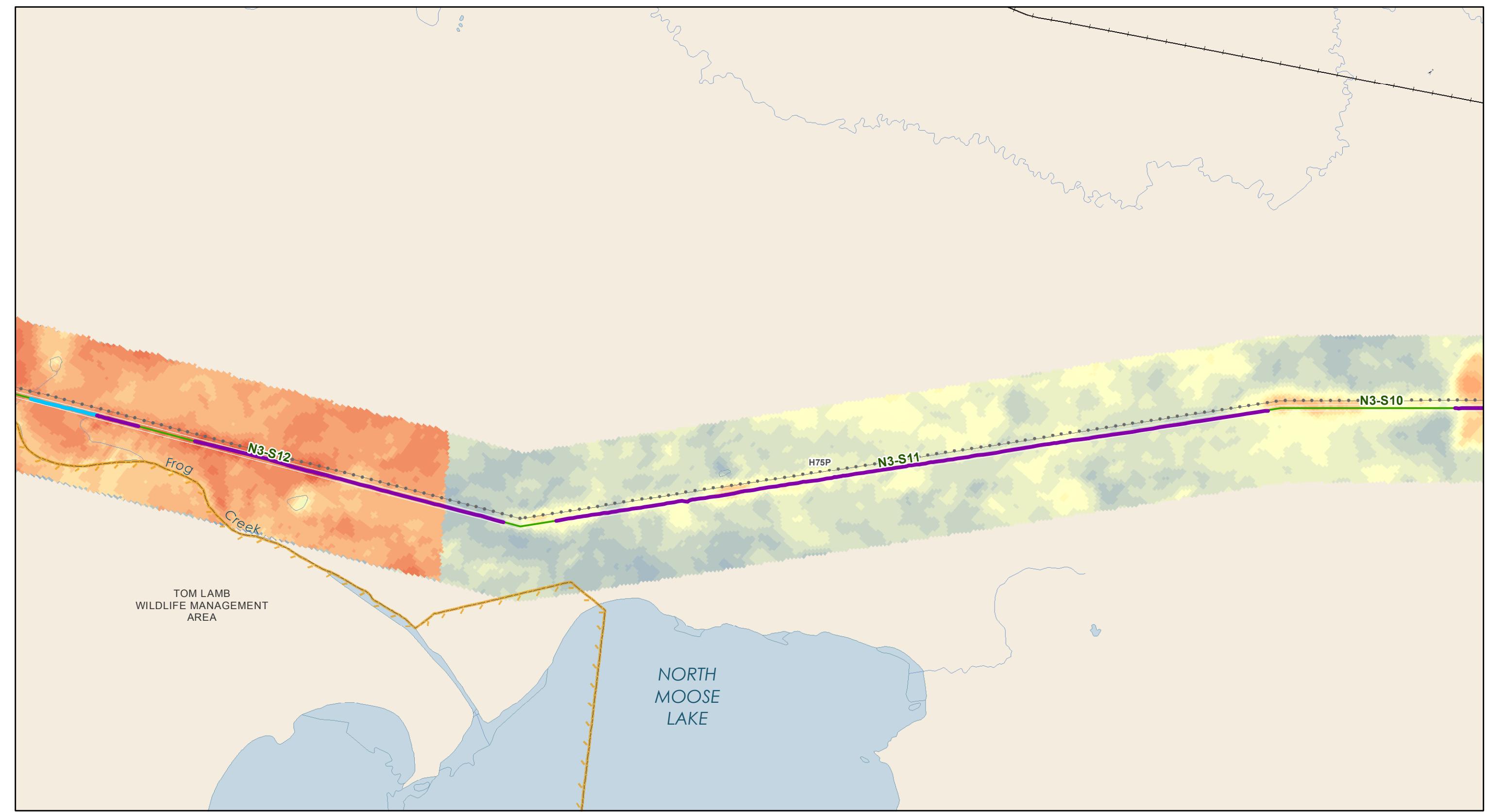
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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**Base Data**  
Permafrost

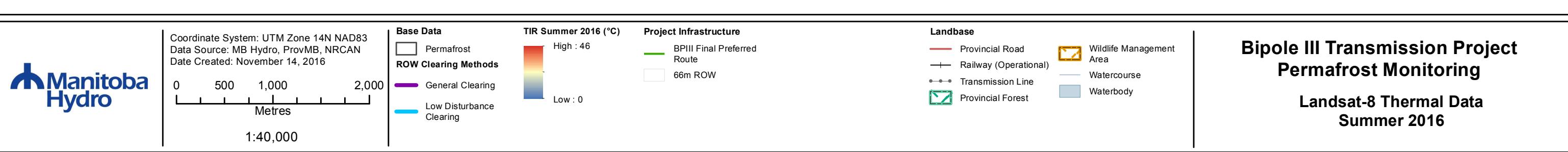
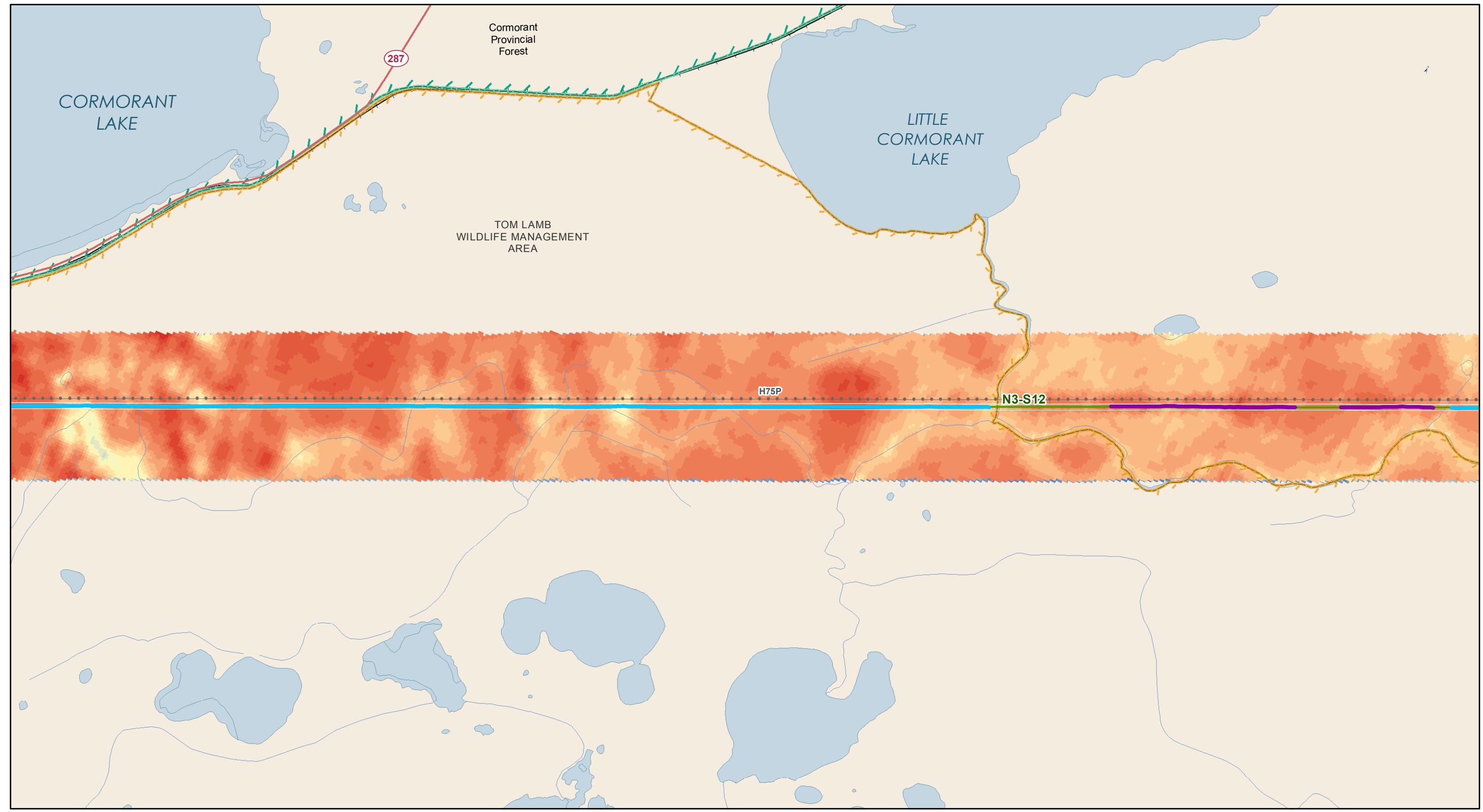
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General Clearing  
Low Disturbance Clearing  
Low : 0  
High : 46

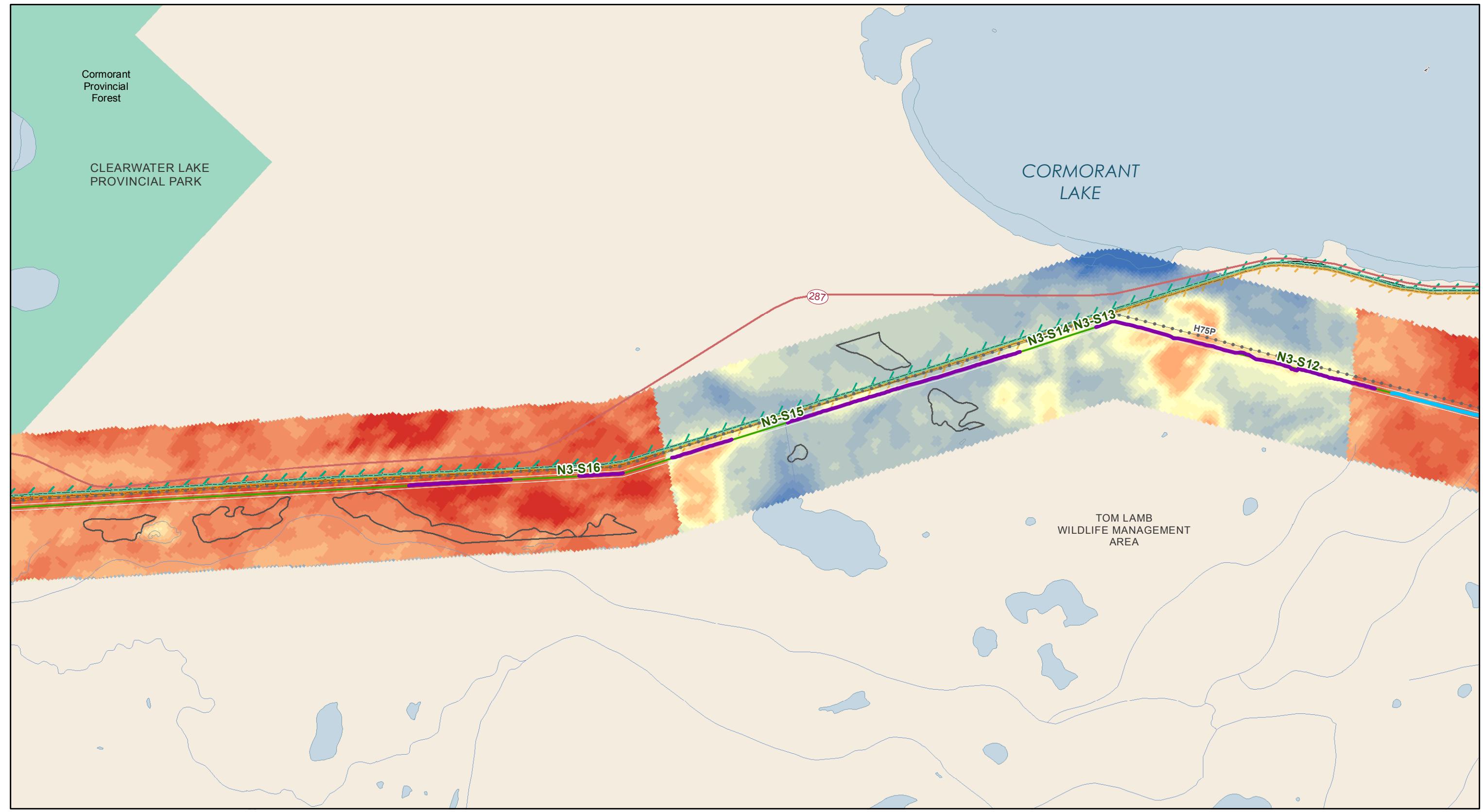
**TIR Summer 2016 (°C)**

**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**  
Railway (Operational)  
Transmission Line  
Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**





Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

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**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

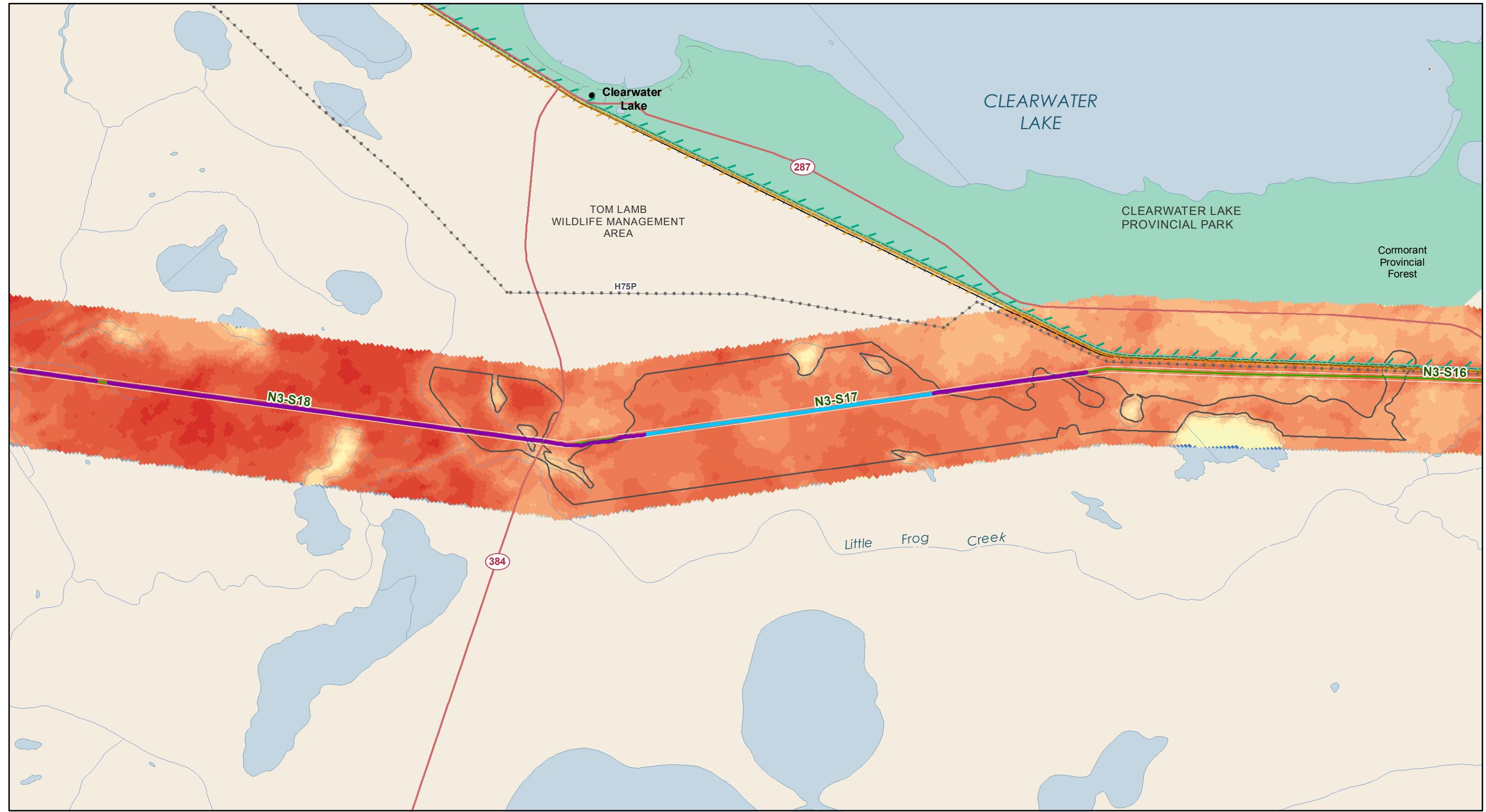
TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Railway (Operational)  
Transmission Line  
Provincial Park  
Provincial Forest

Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
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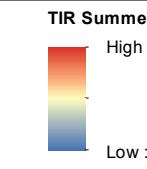
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**Base Data**  
Permafrost

**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

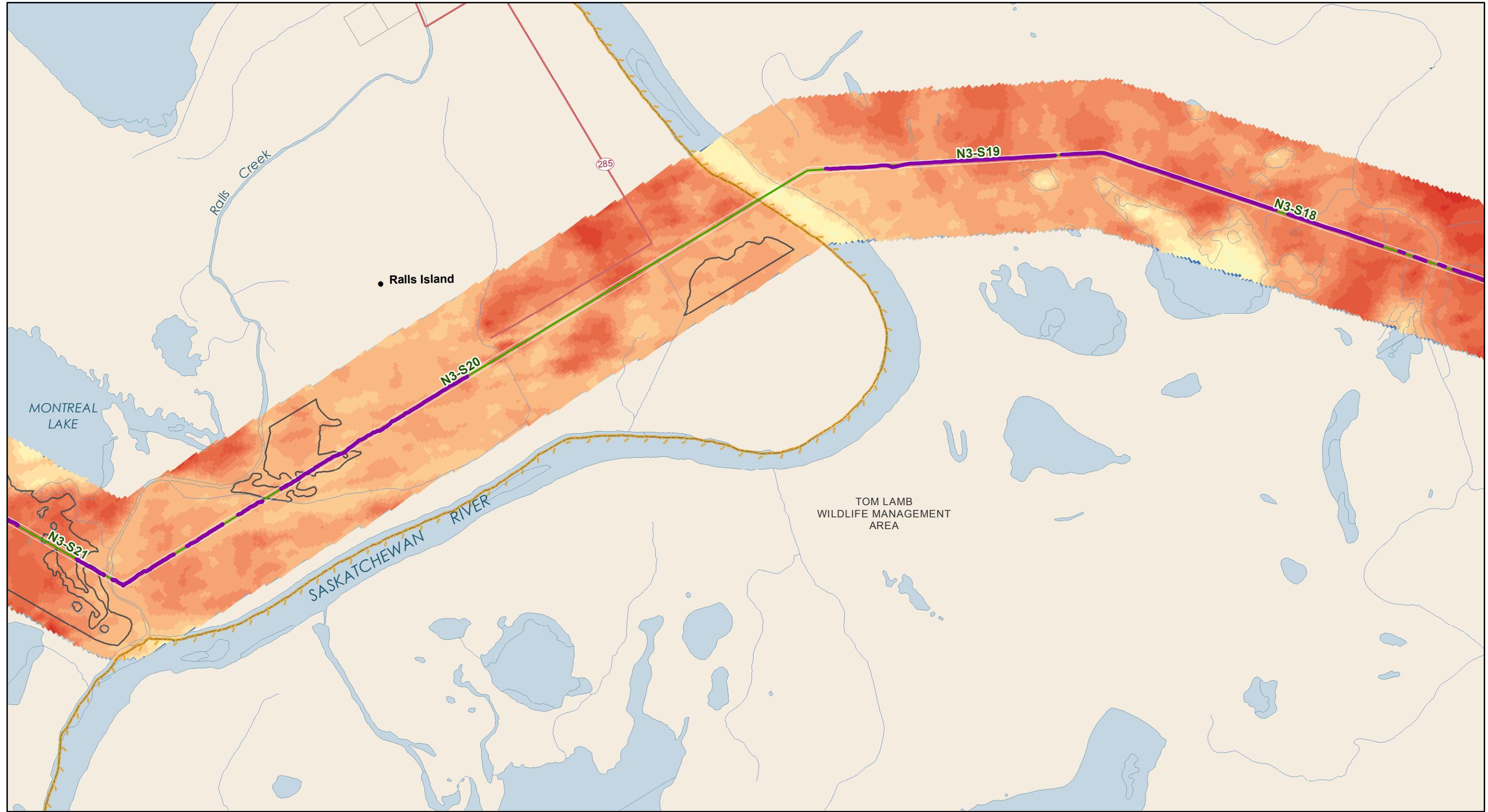


**Project Infrastructure**  
BP III Final Preferred Route  
66m ROW

**Landbase**

- Provincial Road
- Local Road
- Railway (Operational)
- Transmission Line
- Watercourse
- Waterbody
- Wildlife Management Area
- Provincial Park
- Provincial Forest

**Bipole III Transmission Project  
Permafrost Monitoring**  
**Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCan  
Date Created: November 14, 2016

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1:40,000

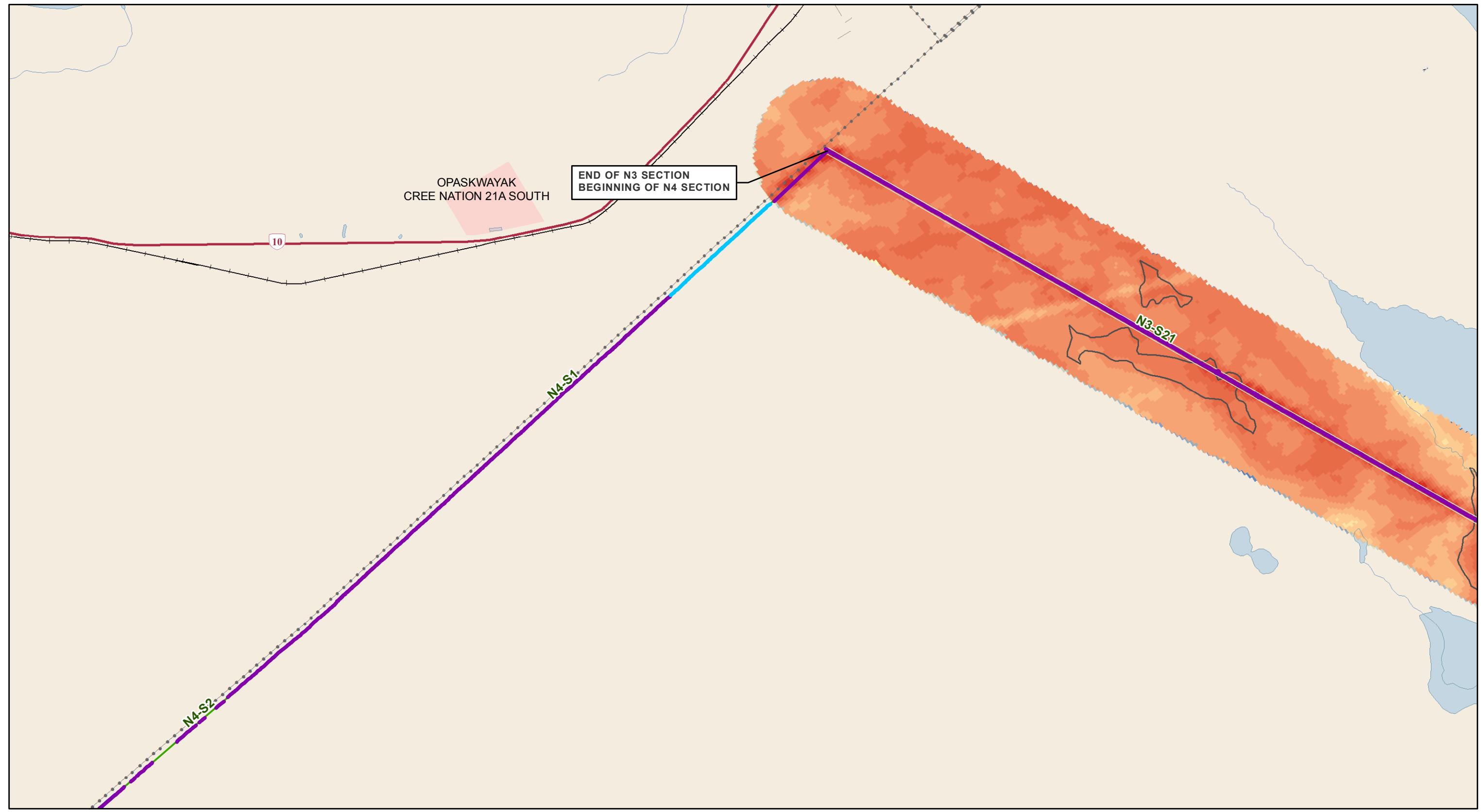
**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

**Project Infrastructure**  
BPIII Final Preferred Route  
66m ROW

**Landbase**  
Provincial Road  
Local Road  
Wildlife Management Area  
Watercourse  
Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**



Coordinate System: UTM Zone 14N NAD83  
Data Source: MB Hydro, ProvMB, NRCAN  
Date Created: November 14, 2016

0 500 1,000 2,000  
Metres  
1:40,000

**Base Data**  
Permafrost  
**ROW Clearing Methods**  
General Clearing  
Low Disturbance Clearing

TIR Summer 2016 (°C)  
High : 46  
Low : 0

Project Infrastructure

Landbase

- Provincial Highway
- Local Road
- Railway (Operational)
- Transmission Line
- First Nation
- Watercourse
- Waterbody

**Bipole III Transmission Project  
Permafrost Monitoring  
Landsat-8 Thermal Data  
Summer 2016**

Available in accessible formats upon request