3.1 Review of Existing Information & Literature Review

Background information on the ecology of the Project area was compiled from broader regional studies done in the NWT. These reports include the following:

- *Ecological Regions of the Northwest Territories – Taiga Shield* (Government of the Northwest Territories 2008).
- *Species at risk in the Northwest Territories, a guide to NWT species legally listed under the federal Species at Risk Act and those under consideration for listing, 2008 edition* (Government of the Northwest Territories 2008).
- *Northwest Territories biodiversity action plan – report two: gap and overlap analysis and recommendations for future actions* (NWT Biodiversity Team 2006).
- *Phase 1 ecological and renewable resources assessment, Caribou Point candidate protected area, Northwest Territories* (EBA Engineering Consultants Ltd. 2006).
- *Ecological Assessment of the Edéhzhíe candidate protected area* (EBA Engineering Consultants Ltd. 2005).
- *Characteristics of tree line plant communities in Alaska* (Viereck 1979).
- *Vegetation classification for the west Kitikmeot/Slave study region* (Matthews, *et al*. 2001).
- *An environmental survey of the Thor Lake area (Golder Associates Ltd. 1998. Saskatoon, Saskatchewan)*
- *Thor Lake Area (NWT) Environmental Baseline Survey (Melville, G., B. Godwin, D. Russell and J. Polson. 1989. Saskatchewan Research Council Publication E-901-1-E-89).*

3.2 Climate Information – (Relevant to Vegetation)

The closest Environment Canada weather station is located in Yellowknife (205.7 m elevation), which is approximately 100 km to the northwest. Data collected between 1971 and 2000 reports average annual precipitation of 280.7 mm, and an average annual snowfall of 151.8 cm (Environment Canada 2000). Temperature information indicates July to be the warmest month with an average temperature of 16.8 C, and January the coldest with -26.8 C, for a yearly average of -4.6 C.

3.3 Background/Available Ecosystem Information

As shown above, a number of regional reports and ecological information was reviewed prior to the implementation of the ecosystem mapping program for this pre-feasibility assessment. Although general vegetation communities were described and discussed in previous reports, no site specific ecosystem mapping information was available for the project area. The mapping program followed the British Columbia Terrestrial Ecosystem Mapping protocols, however the ecosystem types and mapping approach was built upon both the historical biophysical mapping completed in the

Northwest Territories in various projects, and the ecoregional structure developed by the Government of the Northwest Territories.

The ecoregional classification system is described here within:

> *In 2008, the Government of the Northwest Territories and the Ecosystem Classification Group published the Ecological Regions of the Northwest Territories: Taiga Shield. The hierarchy of ecoregion classification places the Thor Lake site within the Level I Taiga Ecoregion. This is the broadest classification level that provides the backdrop to the ecological mosaic of the continent, and provides context at a global or intercontinental scale. The Level II Taiga Shield Ecoregion designation for the study area is useful for national and sub-continental overviews of physiography, wildlife and land use (Commission for Environmental Cooperation 1997). The Level II Taiga Shield Ecoregion is characterized by Precambrian bedrock outcrops with many lakes and wetlands in glacially carved depressions.*
>
> *The third level of ecoregion classification is defined by regional climatic differences within Level II Ecoregions (Ecosystem Classification Group 2008). The Thor Lake Project area Level III Ecoregion classification is Taiga Shield High Boreal which is characterized by exposed bedrock plains with thin boulder till veneers. Jack pine or black spruce stands occupy large areas depending on fire frequency and white spruce/aspen forests are common in low elevation areas to the west where nutrient and water supplies are adequate. Peat plateaus and floating fens are scattered throughout. (Ecosystem Classification Group 2008).*
>
> *Level IV Ecoregions which are characterized by distinctive regional ecological factors. These factors include climate, physiography, vegetation, soil, water and fauna (Marshall, et al. 1996). The Level IV Ecoregion that encompasses this Project is the Great Slave Upland High Boreal Ecoregion. The main characteristics are a nearly level bedrock plain with thin discontinuous till veneers, scattered outwash and lacustrine deposits, and a mosaic of black spruce woodlands and jack pine and paper birch regeneration on burned areas (Ecosystem Classification Group 2008).*

3.4 Pre-Field Bioterrain Mapping for LSA

Initial bioterrain mapping for the local study area (LSA) was completed using 1996, 1:20,000 scale black and white aerial photographs, and viewed in stereo using a HD-MAPP system for the LSA mapping. Following delineation of the polygons the bioterrain line work was transferred into digital format and merged into a seamless map for the LSA. These bioterrain polygons provide a strong foundation for the mapping of vegetation and ecosystems. A detailed description of the bioterrain mapping process and results is provided in the Surficial Geology, Terrain, and Soils Baseline Interim Report.

3.5 Terrestrial Ecosystem Mapping (TEM)

TEM is a hierarchical framework that integrates the topographic, terrain, soils, and vegetative features of a landscape to produce a product that can be used for quantifying the distribution and abundance of ecosystems in a landscape. The mapping product(s) form the basis for various interpretations such as wildlife habitat, tree species and age, and soil modeling.

The methodology used for the LSA ecosystem mapping followed the *Standards for Terrestrial Ecosystem Mapping in BC* (RIC 1998), however only applicable sections were used as it relates to the NWT. Since, there is no established site specific ecosystem classification system for the NWT, the British Columbia TEM mapping approach was relevant and useful for developing a classification system in the Project area. The following information was reviewed and used as a starting point for the detailed ecosystem classification and mapping for the Thor Lake Project:

- *Thor Lake area (NWT) environmental baseline survey* (Melville, et. al. 1989)
- *An environmental survey of the Thor Lake Area* (Golder Associates Ltd. 1998)
- *Environmental data review and requirements, Thor Lake Project* (Highwood Resources 2000).
- *Ecological Regions of the Northwest Territories – Taiga Shield* (Government of the Northwest Territories 2008).

3.6 Regional Ecosystem Mapping

As per the project objectives, a general vegetation classification was created for the RSA using available satellite imagery and National Topographic Data. Remote sensing was used in the RSA as this is the most effective and efficient tool for classifying vegetation over such a large area (44,030 ha). See Appendix A for vegetation classification for the RSA. Remote sensing is the science, technology and art of obtaining information about objects or phenomena from a distance (i.e., without being in physical contact with them) (Natural Resources Canada 2009).

The following section details the methods used to create a vegetation classification for the Thor Lake Regional Study Area (RSA).

LandSat 7, Enhanced Thematic Mapper Plus (ETM+) imagery was used for this classification.

3.6.1 Satellite Dataset

The satellite imagery was acquired from LandSat 7 ETM+ on July 6, 2008. The LandSat 7 ETM+ imagery is composed of eight spectral bands (Table 1). For purposes of the vegetation classification the bands one through four were used. The spatial resolution is 30 m.

Table 1: LandSat 7 ETM+ Characteristics

Band Number	Wavelength Interval (µm)	Spectral Response	Resolution (m)
1	0.45–0.515	Blue-Green	30
2	0.525–0.605	Green	30
3	0.63–0.69	Red	30
4	0.75–0.90	Near-IR	30
5	1.55–1.75	Mid-IR	30

Band Number	Wavelength Interval (µm)	Spectral Response	Resolution (m)
6	10.40–12.50	Thermal-IR	60
7	2.09–2.35	Mid-IR	30
Pan	0.52–0.90		15

NOTE:
The LandSat 7 satellite was launched on April 15, 1999 and is still in operation despite a Scan Line Corrector (SLC) failure May 31, 2003 (NASA, 2009). The LandSat 7 ETM+ currently acquires image data in the "SLC-off" mode. In this project the „SLC-off" effects about one percent of the RSA vegetation classification results and mapping. The problem is most pronounced along the edge of the image and gradually diminishes toward the centre of the image. For the purposes of this study, we have some remnants of the SLC-off, where lines appear on the North-west portion of the RSA classification. However, for the purposes of the work conducted this problem is considered minor and has little impact on the overall mapping product created.

3.6.2 Methods of Analysis

PCI Geomatica software (version 10.1) was used to perform image processing and classification. The original LandSat 7 ETM+ image was clipped to the Regional Study Area (RSA) and all processing was limited to the RSA.

For this study, there were two classifications performed – unsupervised and supervised. The unsupervised classification was performed first, prior to the collection of field data. Unsupervised classification is a useful tool for organizing image information into discrete classes of similar pixel values and it does not require any prior knowledge of the data or image. This classification identified 16 unique classes in the Thor Lake RSA. These classes were then used to guide where to collect data in the field.

Following the collection of field data, a supervised classification was performed on the image. The supervised classification requires input from the user to „train" the dataset. The following sequence of steps outlines the supervised classification process:

1. Create Normalized Difference Vegetation Index (NDVI)

   NDVI was calculated to capture the vegetation characteristics of the study area and improve modeling results. Vegetation is highly reflective in the near infrared (NIR) and highly absorptive in the visible red; as a result, NDVI correlates with the photosynthetic activity of vegetation. NDVI was included as a data source in the supervised classification, along with bands 1 through 4. NDVI is defined as:

   $$NDVI = (NIR - Red) / (NIR + Red)$$

2. Perform Tassel Cap Transformation

   The Tassel Cap Transformation captures the greatest amount of data variability in the fewest number of linearly combined output bands and enhances the interpretability of data sets with respect to the actual image characteristics (Jensen, 2007). In the LandSat 7 ETM+ data, the image characteristics can be captured in 3-dimensions – Brightness, Greenness and

Wetness (Crist and Kauth, 1986). The Brightness, Greenness and Wetness were included as a data source in the supervised classification.

3. Create Training Sites

   Training sites were created from the field data. Similar vegetation types were grouped and assigned a class and the classes were used to generate spectral signatures for the area of interest. The creation of training sites is a critical step as the data collected at the training sites are used to define the statistical limits of the classes that are being defined. These statistics are then used to assign unknown pixels to the appropriate classes.

4. Perform a Supervised Classification using a Maximum Likelihood Method

   Once the classes have been defined, each pixel was assigned to a class using the Maximum Likelihood classifier (an equi-probability classifier) in a supervised classification.

5. Perform an Internal Accuracy Assessment

   A preliminary internal accuracy assessment was conducted for the vegetation classification of the RSA using a portion of the field data. This initial classification followed Story and Congalton (1986), which provides a means for evaluating the reliability of the classification. Producer"s accuracy represents how well a specific area of reclaimed land can be mapped. It is derived by calculating the percentage of reference areas of a particular land cover type were correctly classified and therefore represents the probability that a reference sample will be correctly classified.

   There are also errors of commission, when land cover types are misclassified. User"s accuracy is concerned with how well the maps represent what is actually on the ground. If a user travels to a site indicated on the map as a particular land cover type, the user"s accuracy estimate provides an estimate of the probability that the particular land cover type is actually present at that site.

   These internal accuracy values provide the mapper with an initial estimate of omission error. The final accuracy assessment is to be performed upon the completion of final mapping.

6. Create a Thematic Map

   The classification was exported to ArcGIS v9.2 for thematic map production. Refer to Appendix A for the Regional Vegetation Classification map.

4 FIELD PROGRAMS

Two field programs were conducted in 2009 to determine baseline conditions for vegetation resources in the Thor Lake study areas. These programs involved the following:

- 1:20,000 ecosystem mapping in the LSA, and 1:50,000 regional ecosystem mapping in the RSA
- Rare plant field survey.

4.1 LSA Ecosystem Mapping Field Program

A modified ecosystem sampling plan was developed for the Thor Lake Nechalacho Deposit study areas following the methods developed per the *Standard for Terrestrial Ecosystem Mapping in BC* (RIC 1998). Preliminary delineation of bio-terrain polygons was completed for the LSA prior to the initiation of field work. These polygons were used to pre-select candidate field inspection sites. Field maps were prepared that displayed the bio-terrain polygons and potential inspection sites overlain onto an ortho-photograph. The geo-spatial coordinates of the pre-selected sampling points were loaded into GPS units. Sampling points were selected to capture the range of ecosystem units present within the LSA.

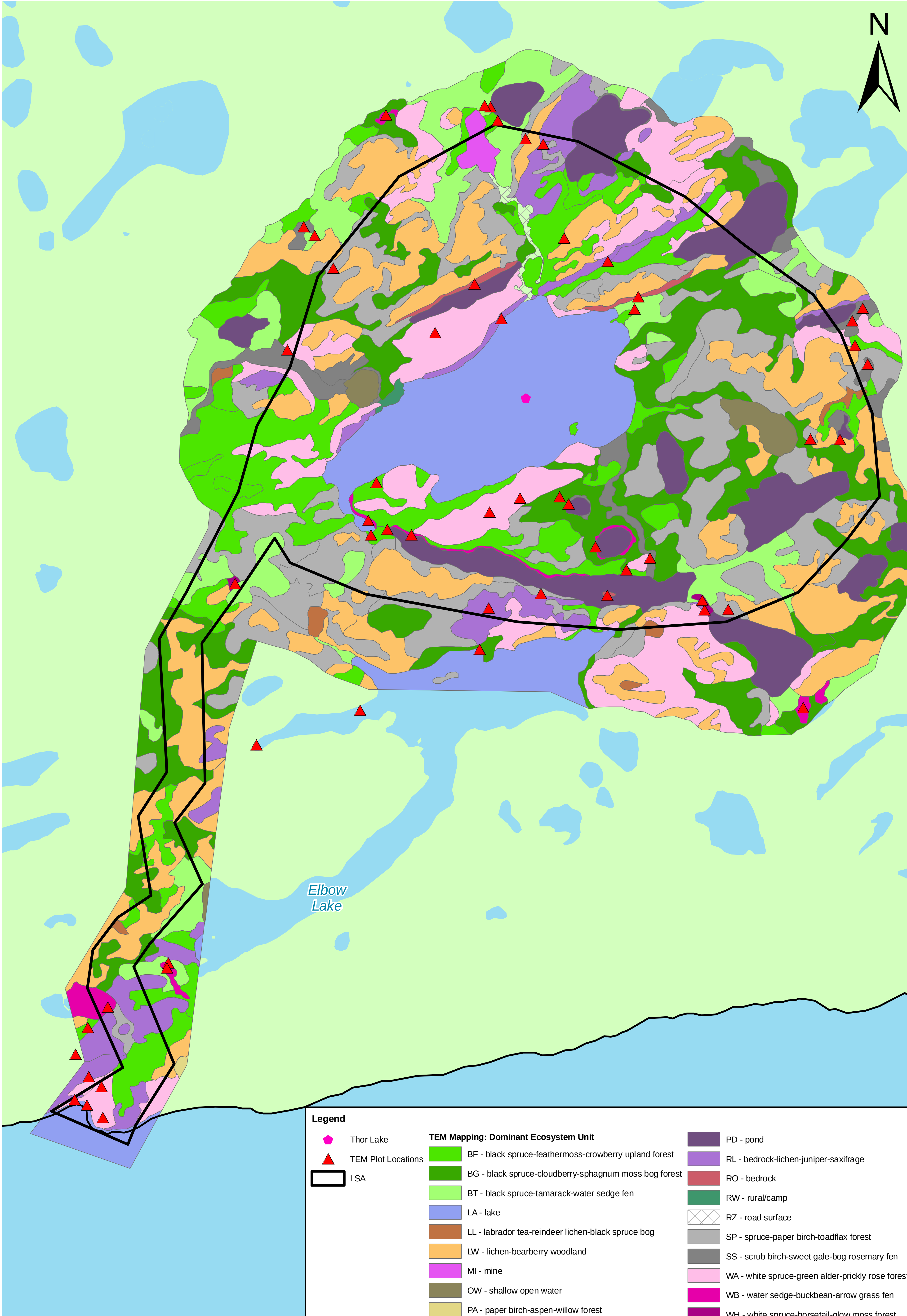
Field work took place from June 22 through June 29, 2009. A field crew consisting of a Senior Vegetation Specialist and rare plant specialist/vegetation ecologist – which carried out field inspections within the LSA and RSA on foot, ATV and also using a helicopter (See appendix B Ecosystem Mapping Field 2009 Survey Locations (RSA & LSA)).

Two types of inspections were completed: ground inspections and visual inspections. The majority of the plots were on-site ground inspections. Visual inspections were done when in transit or from the air, and were done to make notes on ecosystem types that were readily identified from distance. The locations of the ground inspection sites were selectively chosen. (See Figure 3, Thor Lake LSA TEM Map Plot Locations). An effort was made to ensure that the sample site locations were representative of the general ecosystem type with respect to site, soil and vegetation characteristics. The Terrestrial Ecosystem Mapping Ground Inspection Form was used for recording ground inspection data. The Field Manual for Describing Terrestrial Ecosystems (Ministry of Forests and BC Environment 1998) provided a detailed method for data collection at ground inspections locations.

The following information was collected at the each of the ground inspection sites:

- UTM coordinates
- Topographic position (e.g. crest position, lower slope, depression etc)
- Aspect
- Slope
- Drainage
- Soil nutrient regime
- Soil moisture regime
- Plant list
- Dominant trees
- Percent cover by species
- Wildlife notes.

In addition to the above, photographs were taken at the majority of sampling sites, and tree mensuration data (height, diameter, and age) were collected at selected sites.



Thor Lake LSA
Terrestrial Ecosystem Map 2009

AVALON RARE METALS INC.

0 0.2 0.4 0.6 0.8
Kilometers

PREPARED BY
Stantec

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REVISION DATE 18/12/2009		PROJECT 1036222	FIGURE NO. 3
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4.2 RSA Ecosystem Mapping Field Program

In 2009, an initial reconnaissance level survey of the RSA was also conducted at the same time as the field work for the LSA. All of the work conducted in the RSA was completed by helicopter. Eighty-five (85) air calls were completed (see Table 4) following applicable British Columbia field data collection standards and TEM mapping protocols (See Appendix C, LSA Ecosystem Map on Orthophoto). The ecosystems were described following the same protocols and mapping legend as the TEM. See Appendix D for the list of the Thor Lake regional mapping unit definitions.

5 RESULTS

The following section describes the results of the field program and subsequent final ecosystem mapping for the both the LSA and RSA.

5.1 Field Work Results

At total of 163 field inspections were completed within the Project area to support the ecosystem mapping. For the LSA, 79 ecosystem field plots were completed (59 visual inspections and 20 ground inspection plots). In the RSA 85 field inspections were carried out. Refer to Table 2 (below) for a breakdown of TEM field plots by inspection type and ecosystem unit.

Table 2: Summary of 2009 Thor Lake Vegetation Sampling Effort by Plot Inspection Type and Ecosystem Unit

Ecosystem Unit Mapcode[1]	Ground	Visual	Aircall	Total
BF	1	7	17	**25**
BG	1	1	6	**8**
BT	3	5	3	**11**
JH		1	1	**2**
LA		1	2	**3**
LL			3	**3**
LW		8	12	**20**
PA			4	**4**
PD		3		**3**
RL	2	7	9	**18**
RO		1	2	**3**
SH			1	**1**
SP	2	6	8	**16**
SS	4	5	8	**17**
SW	1			**1**

Ecosystem Unit Mapcode[1]	Ground	Visual	Aircall	Total
WA	3	6	2	**11**
WB	2	5	6	**13**
WH	1	3		**4**
Grand Total	**20**	**59**	**85**	**163**

NOTE:
[1] Map codes are described in the ecosystem mapping legend located in Appendix E

The interim results show that the combined RSA (including the LSA portion of the regional classification) is composed of 11,200.0 ha of coniferous forest ecosystems and 4,527 ha of treed fens ecosystems. Wetlands occupy approximately 8761.0 ha and deciduous dominated or mixed forest types cover about 5,693.0 ha. Also, within the RSA there are approximately 8,420.2 ha of the bedrock or bedrock/lichen vegetation type.

Mapping survey intensity level (SIL) is a measure of sampling density and has implications for map accuracy as well as the confidence in the interpretations that are made from the map data. SIL is based on the variables of polygon number, number of plots, and study area size (RIC 1998).

In this project, 79 polygons out of the 329 polygons in the LSA were sampled (24%). By area, there is one ground sampling point for every 23 ha (see Table 3), providing a SIL level of 3 (on a scale of 1 – 5). This level of inspection (SIL 3) is deemed appropriate for insuring the accuracy and confidence in interpretations that are made from the map data (such as ecosystem summaries and wildlife habitat modeling (RIC 1998).

Table 3: Mapping Survey Intensity Levels

Study Area	Area (ha)	Number of Polygons	Number of Polygons with Inspections	Survey Intensity Level	
				% of Inspected Polygons	Hectares per Inspection
LSA	1,797.2	329	79	25.0	22.0

5.2 Interim Final Ecosystem Mapping

Following the completion of the field program all field data was entered into an MS ACCESS database using VENUS (VTEM) software. Using this data the pre-field bioterrain mapping was revised, and final ecosystem maps were produced using methods described in the *Standard for Terrestrial Ecosystem Mapping in BC* (RIC 1998). In the RSA a mapping scale of 1:50,000 was used for vegetation classification using satellite imagery, while a map scale of 1:20,000 was used in the LSA using higher resolution digital aerial photographs. A description of the ecosystem mapping process is provided in the following sections.

5.2.1 Polygon Attribution

Using the field data, plot photos, terrain data and other information, the project ecologists proceeded to assign attributes to map polygons in a GIS environment (ESRI ArcMap).

Polygon attributes including surficial material, texture, surface expression, geomorphological process, and soil drainage were revised in the mapping geodatabase (ArcMap). Ecosystem unit labels were created by the project ecologists. Ecosystem unit labels include an ecosystem unit, site modifier(s) (used to describe physical site characteristics) and a structural stage. Aerial photographs were examined to determine the labels for each polygon. Ecosystem labels may consist of simple units (one ecosystem unit) or be complex and consist of up to three ecosystem units.

Ecosystem unit and bioterrain labels were entered into the map geodatabase. Mapping standards provide a list of the core polygon attribute data that are required. Some of the core data found in the ecosystem database for each polygon include ecosystem labels [decile, site series, modifier(s), and structural stage, recorded up to three times per polygon] and stand composition. Terrain attributes were also entered in the database. Ecosystem labels and attributes are explained below.

Ecosystem maps were created in geodatabase format by combining the polygon digital files and the ecosystem databases. An example of a polygon ecosystem label composed of two components is as follows:

6FCw6C – 4BLw3a

Component 1	**Component 2**
6 = Decile 1	4 = Decile 2
FC = Map code 1	BL = Map code 2
w = Site modifier 1	w = site modifier 2
6 = Structural stage 1	3 = Structural stage 2
C = Stand composition 1	a = Structural stage modifier 2

Each polygon was attributed with a minimum of one to a maximum of three ecosystem units. The ecosystems are ordered in the data based on their relative proportion within the polygons; component deciles indicate the percentage of the polygon occupied by the each ecosystem unit. Hence, in the example shown above the first ecosystem occupies 60% of the polygon area while the second occupies 40%. The deciles total 100% for each polygon.

5.2.2 Site Modifiers

Site modifiers, where used, further denote specific conditions that are associated with individual ecosystem units within map polygons (Table 4). These modifiers describe features such as slope, aspect of terrain features. A slope of 15% was used rather than the standard 25% for an aspect modifier due to the importance of aspect on ecosystem and plant development in the Thor Lake area. The following site modifiers (Table 4) have been used in the Project mapping:

Table 4: Site Modifier Definitions

Symbol	Criteria
a	active floodplain
g	gullying occurring with the ecosystem
h	hummocky terrain
k	cool, northerly or easterly aspect (285-135 degrees, slopes >15%)
n	fan or cone
p	peaty material on surface
r	ridge top
t	terrace
w	warm, southerly or westerly aspect (135-285 degrees, slopes >15%)*

5.2.3 Structural Stage

Structural stage describes the existing dominant stand appearance or physiognomy of the ecosystem unit (Table 5). One of six structural stage categories describing the current development stage is assigned to each ecosystem unit.

Table 5: Structural Stage Definitions

Symbol	Structural Stage	Age Criteria and Descriptions
1	Sparse/ Bryoid	Initial stages of primary and secondary succession; total shrub and herb cover is less than 20%
1a	Sparse	Less than 10% vegetation cover (less than 20 years)
1b	Bryoid	Bryophyte and lichen-dominated communities; >1/2 total vegetation cover (less than 20 years)
2	Herb	Early successional stages, and disclimax or climax sites, dominated by herbaceous vegetation (tree cover <10%, shrub cover <= 20%, herb cover >20% or >= 33% of total cover) (less than 20 years for normal forest succession)
2a	Forb-dominated	Herbaceous communities dominated (>1/2 of total herb cover) by non-graminoid herbs, including ferns
2b	Graminoid-dominated	Herbaceous communities dominated (>1/2 of total herb cover by graminoids [grasses, sedges, reeds, and rushes])
2d	Dwarf woody shrub dominated	Herbaceous communities dominated (>1/2 of total herb cover by dwarf woody species [mountain-heathers, mountain avens, dwarf willows])
3	Shrub/Herb	Early successional stages, and communities dominated by shrub vegetation < 5m in height (tree cover <10%, shrub cover >20% or > = 33% of total cover). Used for communities that will be forested at climax (less than 20 years for normal forest succession)

Symbol	Structural Stage	Age Criteria and Descriptions
3a	Low Shrub	Disclimax or climax communities dominated by shrub cover <2 m in height
3b	Tall Shrub	Disclimax or climax communities dominated by shrub cover 2–5 m in height
4a	Normal Pole/Sapling Succession	Trees greater than 5 m tall with <15cm diameter at breast height (DBH). Densely stocked (up to 80% crown closure) but may still be competing with shrub and herb layers. Self thinning and vertical structure are not yet evident in the canopy. Time since disturbance is usually between 50 and 100 years.
4i	Stagnant Stands	Stands growing on very wet sites (i.e., forested bogs) where moisture conditions and the development of discontinuous permafrost have delayed the successional process creating stagnant stands of stunted trees. Tree heights range from 5-7 m with <10cm DBH. Generally sparse to moderately open stands (occasionally densely stocked stands) that may still be competing with shrub and herb layers. Typical stands are usually greater than 70 years old and occasionally more than 120 years of age.
5	Young Forest	Trees heights range from 10 – 15 m, 10-60% crown closure, DBH <20cm. Self-thinning is usually evident and the forest canopy has begun differentiation into distinct layers. Tree ages are typically range from 80 – 120 years. Also includes older stagnant stands similar to stage 4i described above.
6	Mature Forest	Tree heights generally less than 20 m tall, 10 – 50% crown closure, DBH up to 30 cm. Trees established after the last disturbance have matured and a second cycle of shade tolerant trees may have established. Tree ages range from 100 – 140 years for coniferous stands.
7	Old Forest	Tree heights ranging from 18 – 25 m, DBH >30 cm and 10 – 35% canopy cover. Presence of snags and coarse woody debris, canopy gaps, and often structurally complex stands. Generally >140 years old and coniferous stands.

To summarize the area of each ecosystem unit in the Project study areas, it was necessary to “decompose” complex ecosystem units. For instance, a 10 ha polygon in the forested zone comprised of 50% BT and 50% WA would be broken into 5 ha of each ecosystem type in summary tables. The limitation of this approach is that it is not possible to be spatially explicit about where the component ecosystem types are located within a given polygon. In describing and summarizing Baseline conditions, it was necessary to reduce the ecosystem areas based on the disturbances present at Baseline. These disturbances include the features such as existing roads, exploration trails, seismic lines, drill pads, and trenches. For the purposes of the spatial analyses completed in support of the effects assessment, it is assumed that ecosystem types within a complex TEM polygon are distributed evenly. However, as ecosystem types are typically disproportionately distributed in nature, this assumption may overestimate or underestimate ecosystem Baseline availability in any one area.

5.3 Interim Results of LSA Ecosystem Mapping

Twenty different ecosystem units were mapped in the LSA, including four non-vegetated units: lake, pond, shallow open water, and bedrock (See Appendix E LSA Ecosystem Descriptions). There are 197 ha of lake and 142 ha of pond in the LSA. Two anthropogenic units were also mapped:

rural/camp (1 ha), and mine (6 ha). Fourteen (14) vegetated ecosystems were mapped. The most common unit was LW: lichen - bearberry woodland which occurs on crests and upper slope positions (291 ha).

The second most common unit, with 255 ha, was SP: spruce – paper birch – toadflax forest. Some of the less common ecosystem types were WB: water sedge – buckbean – arrowgrass fen (12 ha); PA: paper birch – aspen – willow forest (1 ha); and WH: white spruce – horsetail – glow moss forest (1 ha) (See Appendix F Ecosystem Mapping Legend and Mapped Hectares). An edatopic grid was developed for ecosites within the LSA and is presented in Appendix G. Also, a landscape profile was created for ecosites with the LSA and is presented in Appendix H. Furthermore, a diagram showing the moisture regimes and ecosites within the LSA is presented in Appendix I.

5.4 Interim Results of RSA Mapping

Eleven broad ecosystem types make up the preliminary vegetation map within the RSA. This preliminary RSA vegetation map and interim results show that the RSA is predominately made up of „Bedrock-Lichen‟, „Deep Open Water‟, „Spruce Upland‟, and „Mixed Upland forest. Refer to Appendix A for an overview map of the current RSA vegetation classification results. Once complete, the final vegetation classification product will be used to support wildlife habitat analysis and assessment.

Table 6: Interim RSA Vegetation Classification Results

Regional Mapping Unit	Hectares	%
Bedrock	1,110	2%
Bedrock Lichen	7,310	16%
Broadleaf Upland	4	0%
Mixed Upland	5,689	12%
Deep Open Water	6,720	15%
Sedge Fen	1,380	3%
Shallow Water	3,709	8%
Shrub Fen	3,671	8%
Spruce Upland	6,770	15%
Spruce Wet	4,429	10%
Treed Fen	4,527	10%
No data	506	1%
Sum within the RSA	**45,827**	**100%**

6 RARE PLANT STUDY

6.1 Methods

The rare plant study was partially completed in 2009, and completed for the LSA only.

6.1.1 Review of Existing Literature

Prior to embarking on the rare plant field survey, a literature review of NWT Government publications and previous reports for the Thor Lake area was conducted. These documents included:

- *Thor Lake Environmental Baseline Survey* (Melville, *et al*. 1989)
- *An Environmental Survey of the Thor Lake Area* (Golder Associates Ltd. 1998)
- *NWT 2006-2010 – General Status Ranks of Wild Species in the Northwest Territories* (Working Group on General Status of NWT Species 2006) [The Department of Environment and Natural Resources (ENR) of the NWT Government is in the process of listing and ranking the status of all species found in the territory, including plants, and has also begun monitoring populations. These listed species with their corresponding ranks are presented in this document].

In the report by Melville, *et al*. (1989), commissioned by the Saskatchewan Research Council, three plants of restricted range are reported to have been found near Thor Lake: *Prunus pennsylvanica, Campanula rotundifolia* and *Chamaerhodos erecta*. By cross-referencing with the current ranking of species mentioned in NWT 2006–2010, an update of the status ranks of these species indicates that of the three species, only the status of *Chamaerhodos erecta* is uncertain, which is ranked as “May be at Risk”. The report by Golder (1998) focused on aquatic and wildlife resources and therefore had no information on rare plant availability.

Rare species are ranked according to their population size, distribution, frequency, threats to existing populations and population trends as well as the amount of information available for them. The NWT 2006 – 2010 list of rare species with their associated rank was consulted prior to embarking on the summer 2009 rare plant survey. The complete list was edited to include only those species ranked as At Risk, May Be At Risk, Sensitive, Undetermined and Presence Expected. The definitions of the species rank categories are presented in Table 7.

Table 7: Definitions of Species Rank Categories

Rank	Definition
At Risk	Species for which a detailed assessment has already been completed (e.g., by COSEWIC or jurisdictional status reports) that determined the species to be at risk of extirpation or extinction. This is a special category that may be used only for species that have been assessed as “Endangered” or “Threatened” according to COSEWIC, or according to a similar future committee in the NWT
May Be At Risk	Species that may be at risk of extinction or extirpation, and are therefore candidates for detailed risk assessment. This is the highest rank that can be given to a species using the General Status Ranking system independent of a more detailed assessment as noted in the At Risk category
Sensitive	Species that are not at risk of extinction or extirpation but may require special attention or protection to prevent them from becoming at risk. These species are ranked with a medium priority for a detailed assessment
Secure	Species which are not at risk or sensitive. These species have the lowest priority for a detailed assessment
Undetermined	Species for which insufficient information, knowledge, or data is available to reliably evaluate their general status
Presence Expected	Species not yet recorded in the NWT, but are expected to be present. These species are expected in the NWT due to their presence in adjacent jurisdiction(s), the presence of appropriate habitat in the NWT, and other evidence. The status rank forms a “Look For” species list

The NWT 2006-2010 plant list was further distilled to include plants found only in the Taiga Shield, and for which suitable habitat was thought to be available in the Project area, and the results are presented below in Table 8.

Table 8: Potential Rare Plants of the Taiga Shield, NWT

Scientific Name	Common Name	Family	NWT Status Rank
Acorus americanus (Acorus calamus)	Several vein sweetflag	*Acoraceae*	May Be At Risk
Atriplex dioica (Atriplex patula)	Thick-leaved orache	*Chenopodiaceae*	May Be At Risk
Callitriche heterophylla (Callitriche anceps)	Large water starwort	*Callitrichaceae*	Undetermined
Cardamine parviflora	Small-flower bitter cress	*Brassicaceae*	May Be At Risk
Carex arcta	Northern clustered sedge	*Cyperaceae*	May Be At Risk
Carex trisperma	Three-seed sedge	*Cyperaceae*	May Be At Risk
Cirsium foliosum	Leafy thistle	*Asteraceae*	May Be At Risk
Cornus suecica	Swedish dwarf dogwood	*Cornaceae*	May Be At Risk
Crassula aquatica	Water pigmy-weed	*Crassulaceae*	May Be At Risk
Cypridedium acaule	Pink lady's-slipper	*Orchidaceae*	Undetermined

Scientific Name	Common Name	Family	NWT Status Rank
Elatine triandra	Long-stemmed waterwort	*Elatinaceae*	Undetermined
Lobelia dortmanna	Water lobelia	*Campanulaceae*	May Be At Risk
Lycopus uniflorus	Northern bugleweed	*Lamiaceae*	Undetermined
Malaxis monophyllos (Malaxis brachypoda)	White adder's mouth	*Orchidaceae*	May Be At Risk
Moehringia macrophylla (Arenaria macrophylla)	Large-leaved sandwort	*Caryophyllaceae*	Sensitive
Nymphaea tetragona	Pygmy white waterlily	*Nymphaeaceae*	Sensitive
Orthocarpus luteus	Yellow owl's clover	*Scrophulariaceae*	May Be At Risk
Polydodium virginianum	Rock polypody	*Polypodiaceae*	Undetermined
Salix pyrifolia	Balsam willow	*Salicaceae*	Secure
Scirpus atrocinctus	Blackgirdled bulrush	*Cyperaceae*	Presence Expected
Senecio eremophilus	Desert groundsel	*Asteraceae*	Sensitive
Sibbaldiopsis tridentata (Potentilla tridentata)	Three-toothed cinquefoil	*Rosaceae*	Sensitive
Silene drummondii (Melandrium drummondii)	Drummond's campion	*Caryophyllaceae*	Undetermined
Trientalis borealis	Northern starflower	*Primulaceae*	Undetermined
Vaccinium myrtilloides	Velvetleaf blueberry	*Ericaceae*	May Be At Risk

6.2 Rare Plant Field Program

Prior to embarking on the field survey, digital orthophotos were examined for unique features such as rock outcrops and microhabitats such as wetlands and drainages that might have rare plant potential. Candidate sampling locations were selected and marked. Sites were also chosen within representative areas of some of the common ecosystem types within the LSA.

The 2009 early summer rare plant surveys were conducted within the LSA by vegetation ecologists from June 22 through June 29, 2009. During field work, rare plant surveys were done at the targeted locations which were deemed to have rare plant potential. At each plot, vegetation ecologists followed the procedure set out by the Alberta Native Plant Council (Lancaster 2000) which consists of conducting a “random meander” within a plant community and compiling a species list until no new species are found. Specimens requiring further examination or species confirmation were collected, with the exception of plants where seed heads or flowers required for identification to species level were unavailable or where plant populations were small (i.e., fewer than 20) (Lancaster 2000).

6.3 Results

Fifty six plots were assessed for rare plants, eight of which were solely rare plant survey plots and 48 were done in conjunction with the TEM survey plots. Plot coordinates and site descriptions are provided in Appendix J (Interim: Rare Plant Survey Coordinates and Site Details), and a visual depiction of survey plot locations is provided in Figure 4 (Thor Lake 2009 Rare Plant Survey Locations).

A preliminary list of 147 plant species (including mosses and lichens) were documented during the survey and are listed in Appendix K, Interim: Thor Lake preliminary species list. One rare plant, rock polypody, *Polypodium virginianum* (Figure 5), was discovered approximately 100-150 meters from the eastern shore of Long Lake on a north facing granite outcrop (Rare Plant Plot Number *RPE-015* with UTM coordinates: 417939 E, 6885702 N). The population size of the specimen was deemed sufficient to allow a voucher specimen to be collected (presently housed in the herbarium at the Stantec Sidney office).

Polypodium virginianum (L.) is an evergreen fern which grows to 20 cm tall, with fronds arising singly along a scaly rhizome. In the NWT, *P. virginianum* is occasionally found on mossy ledges and cliffs in wooded parts of the Precambrian Shield area, north to Great Bear Lake; and in the Mackenzie Mountains known only from Mount Coty, opposite Fort Liard. Its general distribution is circumpolar, ranging from Labrador to BC and SW Mackenzie (Porsild and Cody 1980). This species is currently ranked as “undetermined”, therefore it is not necessarily rare in the NWT, but not enough is known about its frequency or abundance.

Legend

- Rare Plant Survey Location
- LSA
- Watercourse
- Waterbody

Ecosystem Map Unit

- BF - black spruce-feathermoss-crowberry upland forest
- BG - black spruce-cloudberry-sphagnum moss bog forest
- BT - black spruce-tamarack-water sedge fen
- LA - lake
- LL - labrador tea-reindeer lichen-black spruce bog
- LW - lichen-bearberry woodland
- MI - mine
- OW - shallow open water
- PA - paper birch-aspen-willow forest
- PD - pond
- RL - bedrock-lichen-juniper-saxifrage
- RO - bedrock
- RW - rural/camp
- RZ - road surface
- SP - spruce-paper birch-toadflax forest
- SS - scrub birch-sweet gale-bog rosemary fen
- WA - white spruce-green alder-prickly rose forest
- WB - water sedge-buckbean-arrow grass fen
- WH - white spruce-horsetail-glow moss forest

Structural Modifier

e.g. 6WA4m

a = low shrub
b = tall shrub
i = iregular canopy
m = multistoried canopy
s = single canopy
t = two storied canopy

Thor Lake Rare Plant Survey Locations 2009

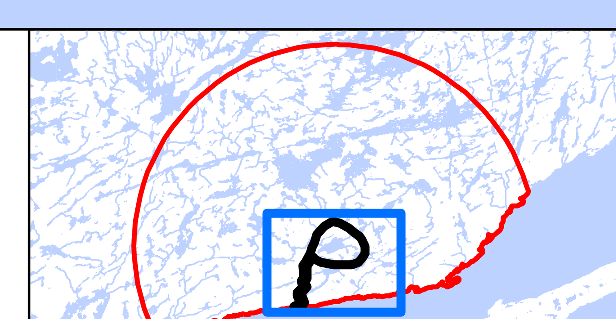

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Figure 5: *Polypodium virginianum* on a granite outcrop at the east end of Long Lake within the Thor Lake Local Study Area

6.4 Summary

In June of 2009, a rare plant survey was conducted in the Thor Lake Project area. Of 147 species identified during the survey, one species, rock polypody (*Polypodium virginianum*), a plant of "undetermined status rank", was found at one of the 56 surveyed sites. With regard to rare ecosystems, the Northwest Territories do not currently maintain a listing of rare ecosystems.

7 CLOSURE

Stantec has prepared this report for the sole benefit of Avalon Rare Metals Inc. for the purposes of documenting baseline conditions in anticipation of an environmental assessment under the Federal *Environmental Assessment Act*. The report may not be relied upon by any other person or entity, other than for its intended purposes, without the express written consent of Avalon Rare Metals Inc. and Stantec. Any use of this report by a third party, or any reliance on decisions made based upon it, are the responsibility of such third parties.

The information provided in this report was compiled from existing documents and data provided by Avalon Rare Metals Inc., field data compiled by Stantec (formerly Jacques Whitford AXYS Ltd.), and by applying currently accepted industry and governmental standards. This report represents the best professional judgment of our personnel available at the time of its preparation. Stantec reserves the right to modify the contents of this report, in whole or in part, to reflect any new information that becomes available. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

8 REFERENCES

Commission for Environmental Cooperation. 1997. Ecological Regions of North America – Toward a common perspective. Montreal, Canada.

Crist, E.P. and Kauth, R.J. 1986. The tassled cap-de-mystified. Photogrammetric engineering and remote sensing. 52:81-86.

Ecosystem Classification Group. 2008. Ecological regions of the Northwest Territories – Taiga Shield. Dept. of Env. and Nat. Res., Government of the Northwest Territories.

Environment Canada. 2000. Yellowknife A weather station climate normals and averages from 1971 – 2000. Environment Canada National Climate Data and Information Archive. Accessed online at www.climate.weatheroffice.gc.ca December 18, 2009.

Golder Associates Ltd. 1998. An environmental survey of the Thor Lake area. Saskatoon, Saskatchewan.

Jensen, J.R. 2007. Remote sensing of the environment: An Earth resource perspective. 2nd Ed., Upper Saddle River, NJ: Prentice Hall.

Lancaster, J. (ed.). 2000. Guidelines for rare plant surveys. Alberta Native Plant Council. Edmonton, Alberta.

Lu, D., Batistella, M., Moran, E., Mausel, P. 2004. Application of spectral mixture analysis to Amazonian land-use and land-cover classification. International Journal of Remote Sensing. 25:23.5345-5358.

Marshall, I.B., Smith, C.A.S., Selby, C.J. 1996. A national framework for monitoring and reporting on environmental sustainability in Canada. Environmental Monitoring and Assessment 39: 25-38.

Melville, G., B. Godwin, D. Russell and J. Polson. 1989. Thor Lake Area (NWT) environmental baseline survey. Saskatchewan Research Council Publication E-901-1-E-89.

Ministry of Forests & BC Environment. 1998. Field manual for describing terrestrial ecosystems in the field. Res. Inv. Branch, B.C. Min. of Env., Lands & Parks and B.C. Min. of For., Victoria B.C.

NASA, 2009. National Aeronautics and Space Administration, Landsat 7 technical details. Accessed online at http://landsat.gsfc.nasa.gov December 16, 2009.

Natural Resources Canada. 2009. Canada Centre for Remote Sensing, glossary of remote sensing terms. Accessed online at http://ccrs.nrcan.gc.ca/glossary/index_e.php?choice=B December 21, 2009.

Porslid, E.A., and W.J. Cody. 1980. Vascular plants of continental Northwest Territories, Canada. Nation. Mus. Can., Nation., Mus. Natur. Sci., Ottawa, Canada, 667 p.

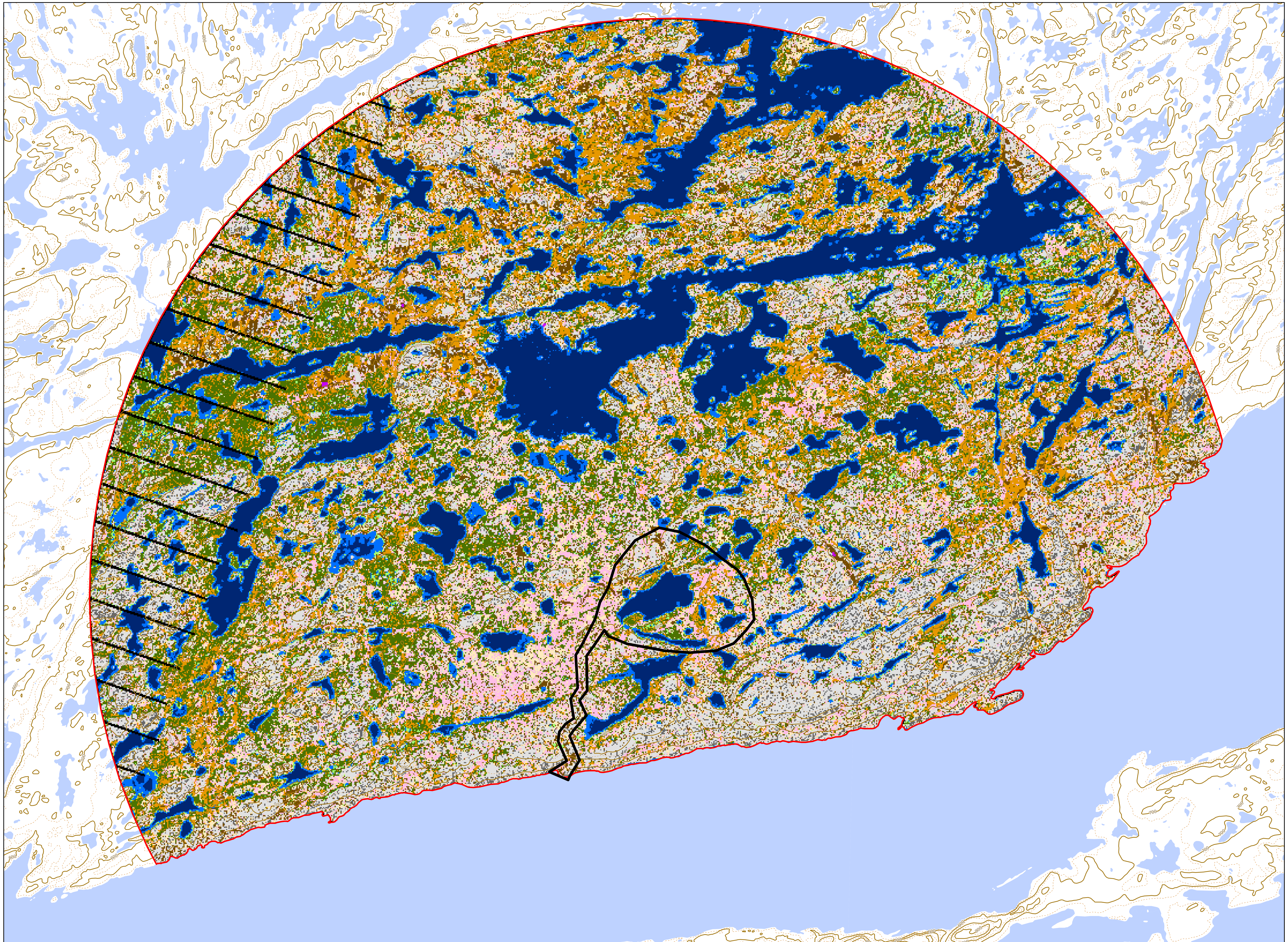
Resources Inventory Committee. 1998. Standard for Terrestrial Ecosystem Mapping in British Columbia. Ecosystems Working Group of Terrestrial Ecosystems Task Force. Victoria, BC.

Story, M. and R. Congalton. 1986. Accuracy assessment: A user"s perspective. *Photogrammetric Engineering and Remote Sensing.* Vol. 52, No. 3. pp. 397-399.

Working Group on General Status of NWT Species. 2006. NWT Species 2006-2010 – General status ranks of wild species in the Northwest Territories, Department of Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, NT.

APPENDIX A

Interim RSA Vegetation Classification



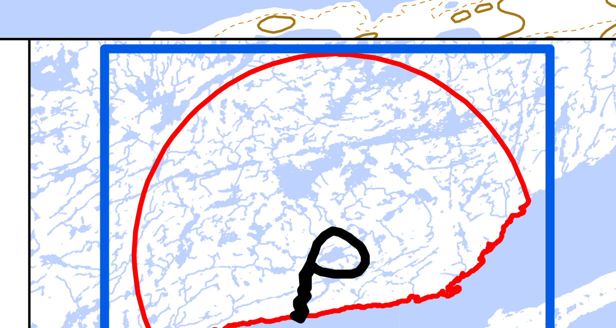
Legend

- Regional Study Area (15km buffer)
- LSA Boundary
- Contour - Intermediate
- Contour - Index (50 Feet)

Class

- Open Water
- Shallow Water
- Spruce Wet
- Sedge Fen
- Shrub Fen
- Treed Fen
- Broadleaf Upland
- Mixed Upland
- Spruce Upland
- Bedrock Lichen
- Bedrock
- No Data

Vegetation Classification for the RSA 2009



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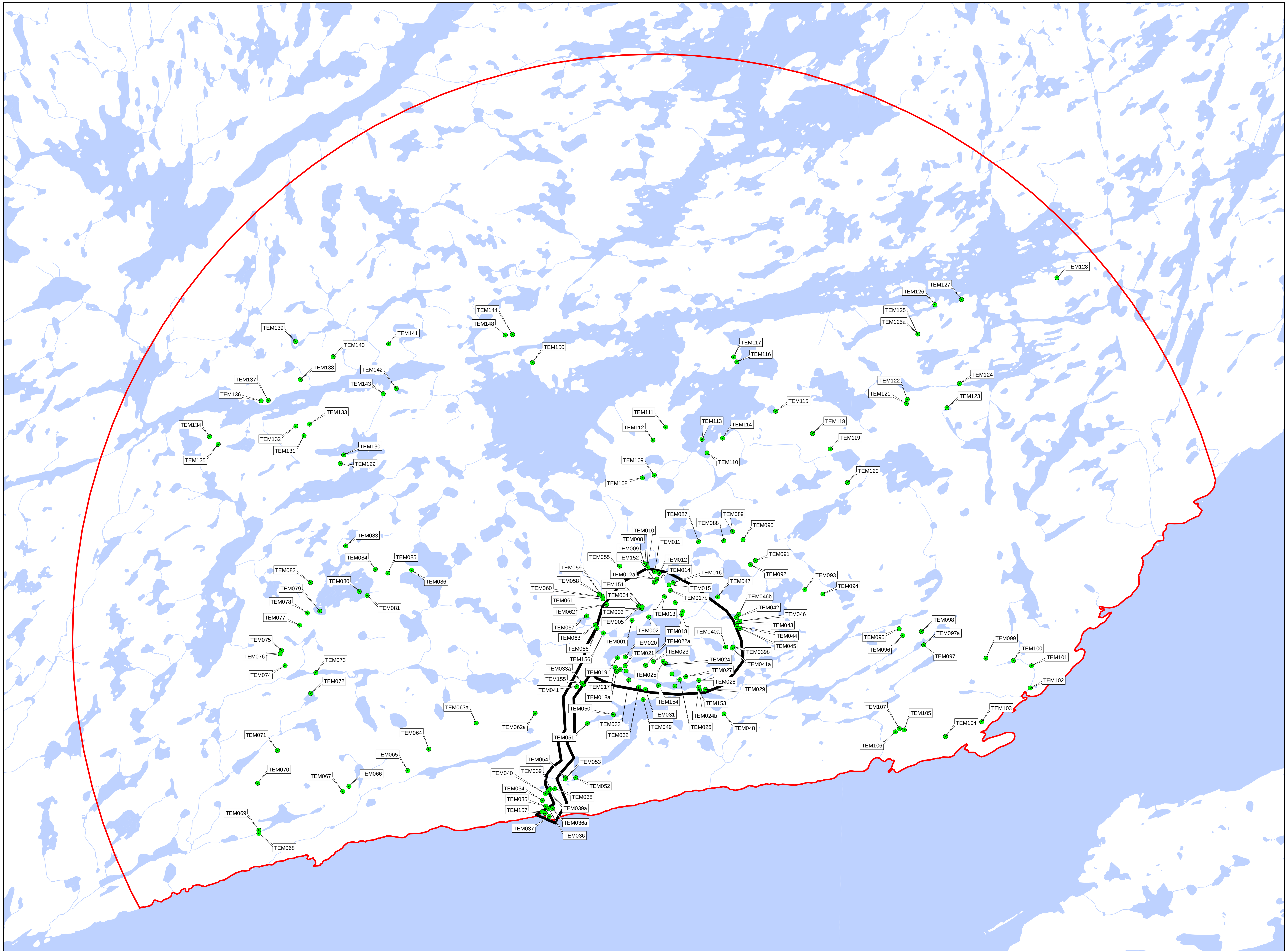
APPENDIX B

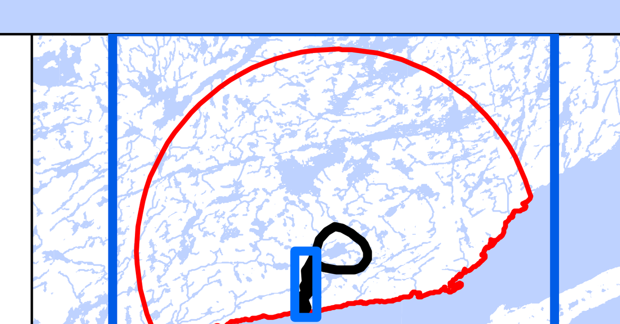
Ecosystem Mapping Field Survey 2009 Locations (RSA &LSA)



Legend

- Field Survey Locations 2009
- LSA
- Regional Study Area (15km buffer)

THOR LAKE
Ecosystem Mapping
Field Survey Locations 2009
(RSA and LSA)



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