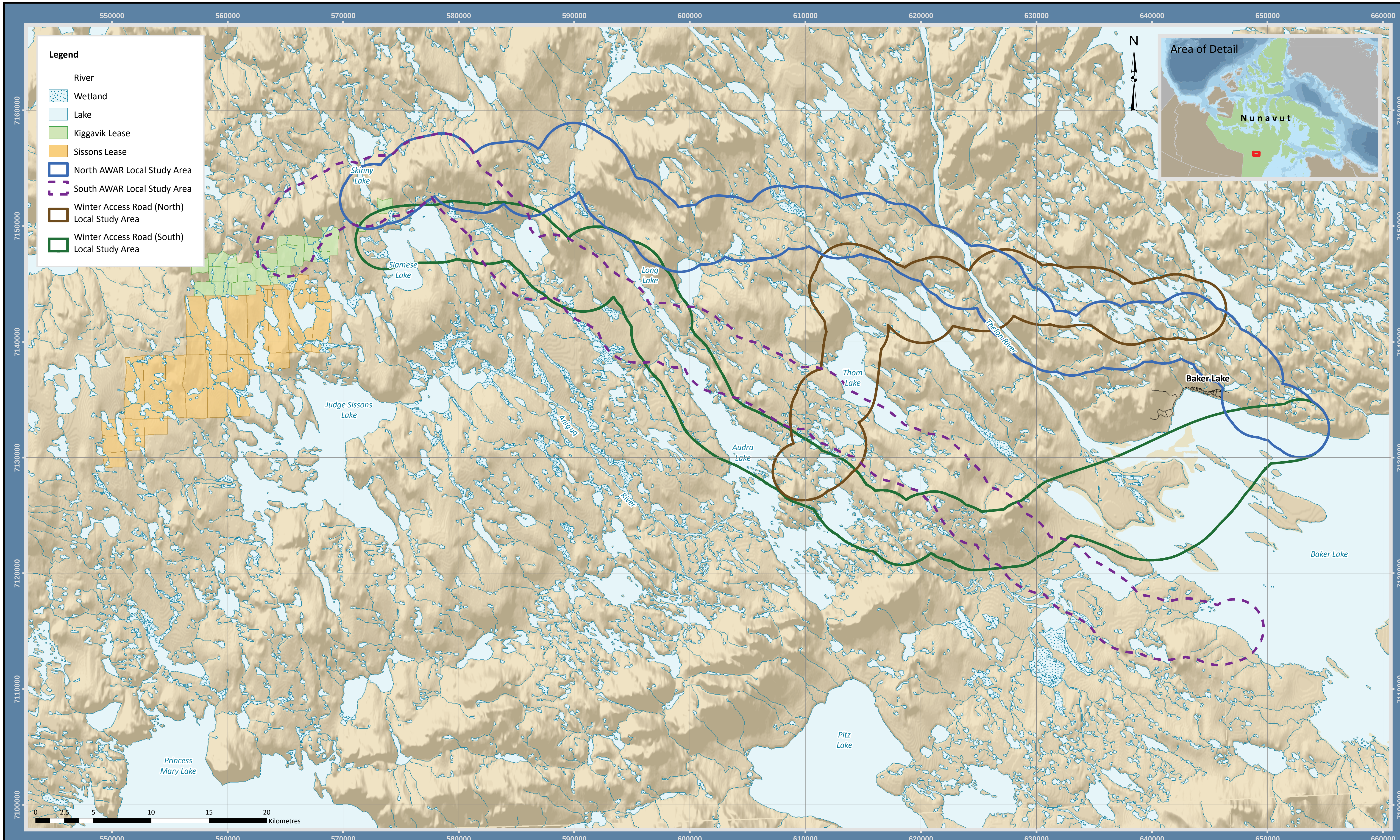

Projection: NAD 1983 UTM Zone 14N
Creator: CASLYS CONSULTING LTD.
Date: 1/13/2011 Scale: 1:300,000
File: 3.2-2_Access_Road_and_Facility_LSAs.mxd
Data Sources: Natural Resources Canada, GeoBase®, National Topographic Database, AREVA Resources Canada Inc., and Gebauer & Associates.

FIGURE 3.2-2
BOUNDARIES OF LOCAL STUDY AREAS FOR ACCESS ROADS AND ASSOCIATED FACILITIES

KIGGAVIK PROJECT - EIS

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4 Vegetation

4.1 Methods

4.1.1 Literature Review

Historical studies in the area around the Kiggavik Project, largely investigations initiated by Urangesellschaft, were integrated as much as possible in the characterization of baseline vegetation conditions for the Mine Local Study Area (LSA), road LSAs and Regional Study Area (RSA). Wherever possible, comparable historical data were used to describe baseline conditions. Differences in study area, design and methodologies, as well as incompleteness of some datasets, prevented direct comparisons with baseline data collected from 2007 to 2010. At a minimum, the availability of historical data is discussed prior to presentation of baseline data, to provide additional context. A summary table of historical studies related to vegetation resources is provided in Table 4.1-1 (including current baseline studies).

The recent development and proximity of the Agnico-Eagle Mine (AEM) Meadowbank Project located east of the Kiggavik Project and north of Baker Lake makes it a useful source of regional data. Terrestrial baseline studies were completed at Meadowbank from 1999 to 2005 and long-term monitoring studies have been completed from 2006 to 2010. Wherever possible this information was used to provide additional regional context (AEM 2009, 2010; Cumberland 2005). Other available information on vegetation resources included information on plant uses from Inuit Quajimajatuqangit (IQ) studies, as well as Ecological Land Classification (ELC) data collected in the RSA by the Government of Nunavut (GN), which was provided under a data-sharing agreement with AREVA.

Table 4.1-1 Summary List of Available Baseline and Historical Data on Vegetation Conditions

Year (reference)	Reconnaissance	Land Classification	Species Inventory	Vegetative Cover	Plant Tissue Chemistry
1979 (Speller et al. 1979)	-	-	LSA RSA	LSA RSA	LSA RSA
1980 (URG 1981)	-	-	LSA RSA	LSA RSA	-
1983 (Kershaw et al. 1983)	-	-	-	-	LSA
1985 (Svoboda et al. 1985)	-	-	-	-	LSA RSA

Table 4.1-1 Summary List of Available Baseline and Historical Data on Vegetation Conditions

Year (reference)	Reconnaissance	Land Classification	Species Inventory	Vegetative Cover	Plant Tissue Chemistry
1986-1989 (Beak 1988; Wickware 1990)	Mine LSA LSAs (BL) RSA	Mine LSA RSA	Mine LSA	Mine LSA	LSA RSA
1990 (Geomatics 1990)	-	Sissons LSA	Sissons LSA	Sissons LSA	-
1991 (Geomatics 1991)	-	-	LSA LSAs (BL)	LSA LSAs (BL)	LSA
2007	-	Mine LSA RSA	-	-	LSA
2008	LSAs RSA	LSAs RSA	LSAs RSA	LSAs RSA	LSA
2009	LSAs RSA	LSAs RSA	LSAs RSA	LSAs RSA	RSA

NOTES:
'-' = type of survey was not included
BL = Baker Lake dock facility; LSAs = refers to North and South AWAR, and/or Winter Access Road (North or South) LSAs (note that RSA/LSA pre-2007 boundaries are different than presented herein)

4.1.2 Field Surveys

4.1.2.1 Ecological Land Classification

The ELC process delineates unique and distinguishable habitat types on the landscape using a combination of satellite imagery, map analysis and field surveys. Initial ELC was completed in 2007 using satellite images to identify vegetation communities. A more rigorous ELC was completed beginning in 2008. Important collaboration and data sharing with the Nunavut Department of Environment (DoE; Mitch Campbell) also contributed to the ELC, as did additional ground data and mapping methodologies developed by the Nunavut Department of Sustainable Development.

Prior to field surveys, a preliminary (or unsupervised) classification was completed using Landsat 7 satellite image data and PCI Geomatica 10.0.3 imaging software to detect and extract unique land cover features and to identify areas for site visits during field surveys. Algorithms compared the spectral signatures of individual pixels on satellite images to the signatures of computer-determined classes and assigned each pixel to one of these classes. The preliminary classification yielded 67 unique classes, which were then examined against the imagery and grouped into similar ELC types. The resulting 16 potential ELC units were subsequently used as the basis for the delineation of the field survey plots used to ground truth the information.

Field surveys are critical for refining the ELC units and their boundaries. Survey plots were selected using the preliminary ELC classification to ensure that all potential ELC units would be adequately surveyed. Features easily identifiable at a scale of 1:50,000 were preferred. Field logistics, including access, timing and terrain, were also taken into consideration. Because DoE field survey data covering the full extent of the RSA and beyond were available, 2008 field surveys were concentrated along the North All-Weather Access Road (AWAR), while 2009 field surveys were concentrated in the Mine LSA and the potential quarry sites. These particular study areas were chosen for ELC field surveys because of preferred design alternatives identified by AREVA. The refinement of the classification used DoE field survey data for the RSA and 2008/09 field survey data from LSAs to assess the accuracy of the classification. Although the field surveys focused on the Mine LSA and North AWAR, these field data were used to refine the ELC for the larger area.

A total of 374 plots was surveyed (Figure 4.1-1). Of the 374 plots, 183 were from the DoE ELC program, 107 were from the 2008 field program and 84 were from the 2009 program. For each 20 by 20 m plot, detailed information relating to landform characteristics (e.g., slope, hummocks, tussocks, etc.), moisture regime, substrate (e.g., peat, moss, boulder, bedrock, etc.) and vegetation composition were collected. Photographs were also taken at each plot.

4.1.2.2 Vegetation Survey

As noted, vegetation species were recorded at each of the above ELC field survey plots (Figure 4.1-1), using 20 by 20 m plots for sampling. Data forms created by the DoE were used to ensure compatibility between AREVA and GN field programs. An effort was made to survey all plant associations.

Habitats that could potentially harbour rare plant species (e.g., rock faces, seep sites, etc.) were investigated opportunistically during the ELC plot sampling surveys. Vegetation survey plots would have been completed around any rare plants observed; however, no rare plants were encountered during the field surveys (see Section 4.2.4 for discussion on rare plant presence).

Biologists were constantly on the lookout for rare plants and rare plant associations during any vegetation and wildlife survey work. Three major publications on rare plants in the North were referred to (Cody 1979; McJannet et al. 1993, 1995). Information on rare plant species posted by the federal Species at Risk Act (SARA) and Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was also accessed (COSEWIC 2009, internet site; SARA 2009, internet site).

4.1.2.3 Plant Tissue Chemistry Sampling

The sampling strategy called for the collection of plant tissue from 12 sampling locations around the RSA and Mine LSA for chemical analysis of specimen tissue (Figure 4.1-2). Different plant tissues were collected including berries (mostly crowberry [*Empetrum nigrum*]), sedges (*Carex* sp.) and lichen (*Cetraria* sp. and *Cladina* sp.).

In 2007, six ‘near-field’ locations were identified as permanent sample plots in the Mine LSA and tissue samples were collected from each location (KIG1, KIG2 and KIG3, and SIS1, SIS2 and SIS3; see Figure 4.1-2). Based on analysis of preliminary data, recommendations were made to increase the number of sampling locations both inside and outside the Mine LSA to obtain better representation of pre-Project conditions. Consequently, four additional near-field locations were identified in the Mine LSA (KIG4 and KIG5, and SIS4 and SIS5; see Figure 4.1-2). Tissue samples were collected at all 10 of the sampling locations in 2008. In 2009, two ‘far-field’ locations were identified in the RSA in areas outside of the potential influence of mine facilities, as indicated by air dispersion models. Additional lichen tissue samples were collected from three locations (i.e. KIG4, SIS1, REF2) in 2011 that were analyzed for radionuclide concentrations of Cesium-137 and Strontium-90. In addition to documenting baseline conditions on terrestrial food sources within both the Mine LSA and the RSA, ongoing monitoring of plant tissue chemistry from near-field and far-field sampling locations will help evaluate any observed changes as Project activities proceed. Soil samples (see Section 5 below), and insect and small mammal/bird tissues were collected at the same locations.

At each of the 12 sampling locations, five sample sites were selected within a 200 to 300 m radius, with a minimum distance of 150 m between sample sites. Coordinates of sampling sites at each of the 12 sampling locations are provided in Attachment A. Within each sample site, five grab samples of plant tissue were collected within a five metre radius. Plant tissues were collected by randomly selecting and grabbing or pulling representative plants (i.e., sedges, lichens, and berries). For berries, approximately two cups were targeted for collection at each site.

Standard sampling procedures were followed for quality assurance/quality control (QA/QC) including: delineating the sampling area prior to collection (i.e., to avoid trampling material), collecting only aboveground material, and cleaning samples to remove all non-target species and debris. Field staff wore latex gloves. Samples were placed in Zip-Loc bags, stored in a cooler, and shipped on ice directly to the laboratory.

In 2007 and 2008, 180 samples were collected in the Mine LSA, including 50 berry samples, 56 sedge samples and 56 lichen samples. In addition to these samples, 18 samples of foliage from birch, willow and blueberry bush were also collected in 2007. The total number of samples collected in the RSA in 2009 (i.e., future reference sites) was 22, consisting of two berry samples, 10 sedge samples, and 10 lichen samples.

4.1.3 Laboratory Analysis

Plant tissue samples were sent to Saskatchewan Research Council (SRC) Analytical Laboratories (Saskatoon, SK) and analyzed for moisture content, total metals on a wet weight basis, and radionuclides. In 2007, all samples were analyzed individually for metals and radionuclides (except Thorium-232). In 2008, all samples were analyzed individually for metals. However, due to minimum weight requirements for radionuclide analysis, berry samples were composited into 10 samples, and sedge/lichen samples were combined into 35 composite and 20 individual samples for radionuclide analysis. In 2009, all samples from the RSA were analyzed individually for metals and radionuclides. Details on analytical methods are provided in Attachment B. Particular parameters were analyzed as follows:

- Elemental analysis by ICP Atomic Emission Spectroscopy (ICP-AES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS);
- Radium-226, Thorium isotopes and Polonium-210 by Alpha Spectroscopy;
- Lead-210 by Beta Counting of the Bismuth-210 Successor Product;
- Strontium-90 by counting on a low background gas-flow proportional counter; and
- Cesium-137 by Gamma spectroscopy.

4.1.4 Data Analysis

4.1.4.1 Ecological Land Classification

A final, or supervised, ELC classification was completed to refine the results of the preliminary classification using field survey data collected from the DoE field program. Field information from each plot (e.g., substrate, vegetation, etc.) was examined and assigned an ELC unit based on the dominant biotic and abiotic features. These representative plots were then overlaid on the preliminary ELC classification to compare attribute assignments. Any preliminary unit that contained multiple ELC units (i.e., based on the survey plots) was then extracted and a final supervised classification was performed on this subset. During the final classification, clustering algorithms were used to assign each subset pixel to pre-defined ELC units, as defined by the representative plots surveyed in the field program. This method facilitates the separation of similar types of units. The ELC units identified in the final classification and the details concerning the survey plots for each of these units are provided in Table 4.1-2.

The accuracy of the final classification was assessed by comparing the ELC mapping to the 191 plots from the Kiggavik field survey program completed in 2008 and 2009. The assessment extracts all the values within 50 m of the survey plot and then compares them with the unit of the plot. This approach overcomes the spatial inaccuracies of the GPS-derived locations for the survey plots and the spatial resolution of the Landsat imagery, and accounts for the scale differences. The overall accuracy of the classification was 82%. Typically, the accuracy threshold for a satellite classification is 80%; therefore, the accuracy of this classification exceeds this threshold by 2%. The units that have lower accuracies (<75%) are typically the transitional units. For example, the accuracy of the Shrub/Heath Tundra unit is relatively low (73%) because it is the transition between Shrub Tundra and Heath Tundra units.

Table 4.1-2 Frequency of Field Survey Plots by Ecological Land Classification Unit

ELC Units	No. of Survey Plots in ELC Unit	% of Survey Plots by ELC Unit
Water[(a)]	0	0.0
Disturbance[(a)]	0	0.0
Cloud/Shadow[(a)]	0	0.0
Sand	0	0.0
Gravel	5	1.3
Rock Association	19	5.1
Wet Graminoid	42	11.2
Graminoid Tundra	46	12.3
Graminoid/Shrub Tundra	21	5.6
Shrub Tundra	42	11.2
Shrub/Heath Tundra	19	5.1
Heath Tundra	66	17.6
Heath Upland	47	12.6
Heath Upland/Rock Complex	55	14.7
Lichen Tundra	12	3.2
Total	374	100%

NOTES:
(a) These classes are easily extractable with high confidence from the imagery and therefore were not field surveyed

4.1.4.2 Vegetation Survey Data

Basic statistics were used to analyze vegetation survey data from the available baseline database. Calculated measures included total number of species and average number of species per plot for each ELC unit.