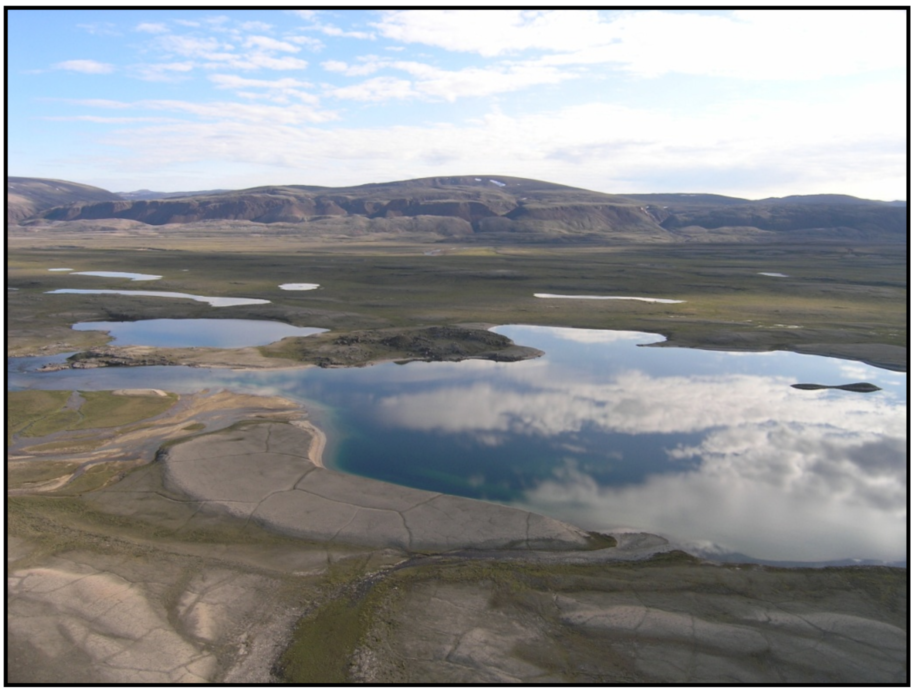
APPENDIX 6C

VEGETATION BASELINE REPORT

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

VEGETATION BASELINE STUDY REPORT



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BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

VEGETATION BASELINE STUDY REPORT

EXECUTIVE SUMMARY

Vegetation baseline studies were conducted in proximity to the Baffinland Iron Mines Corporation's (Baffinland) Mary River Project (Project) during the summers of 2005, 2006, 2007, and 2008. The 2005 studies were scoping studies, and the 2006 - 2008 studies built on the information learned in 2005, taking into account changes to the Project in subsequent years. A total of 760 plots were surveyed, covering the deposit and proposed mine infrastructure area, the tote road and proposed rail route to Milne Inlet, and the proposed south rail routes to Steensby Inlet. Locations within the proposed Steensby and Milne Port area were also surveyed.

Based on the information compiled from the vegetation plots, a vegetation classification system was developed and a species list was compiled. No plant species considered to be "rare" in Canada were found to occur in the survey locations. Plant species abundance data derived from the vegetation plots was utilized in the Ecological Land Classification (ELC) work that is presented under a separate cover. To help develop an understanding of Inuit Qaujimajatuqangit regarding the traditional use of plants by Inuit, studies were carried out with elders in Pond Inlet. Metals analysis of surface soil and plant foliage from 56 baseline stations in the Local Study Area was conducted to establish a baseline of metal concentrations in plants and soil.

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

VEGETATION BASELINE STUDY REPORT

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SECTION 1.0 - INTRODUCTION

The Mary River Project (Project) is an iron ore exploration project in the North Baffin Region of Nunavut. The Project is located about 160 km south of Pond Inlet and 270 km southeast of Arctic Bay at approximately Latitude 71º20’ north and Longitude 79º14’ west. The Mary River Project site is located in the centre of Baffin Island, as shown on Figure 1.

Baffinland Iron Mines Corporation (Baffinland) has been conducting mineral exploration on a seasonal basis since 2004, on known high-grade iron ore deposits that were originally staked and explored in the 1960s.

1.1 LOCATION OF STUDIES

The study area for this vegetation survey encompasses a portion of North Baffin Island extending approximately 250 km from Milne Inlet south to Steensby Inlet, with a width of approximately 10 to 50 km, dependant on the proposed Mary River Project components.

The vegetation baseline studies were divided into Local Study Areas (LSA) described below.

- The proposed Mary River Project mine area.
- The existing Milne Inlet Tote Road.
- An alternative rail corridor leading north from Mary River to Milne Inlet.
- Milne Port site.
- An alternative rail corridor (and associated road) which extends south from Mary River to Steensby Port.
- An alternative rail corridor extending from the Mary River site down the west side of Angajurjualuk Lake.
- Steensby Port site.

The Regional Study Area extends from Milne Inlet southeast to Steensby Inlet and is approximately 75 to 150 km in width.

1.2 BACKGROUND

Vegetation refers to the plants growing in an area, and the communities and associations that are typical of the region. Plants are of great importance in the natural world. They provide food and shelter for animals, stabilize the soil, produce oxygen, and modify the local environment. They form the base of the food chain, and are consumed by herbivores, which are in turn eaten by carnivores. Humans enter this food chain at several levels, using plants directly, and, in their consumption of “country foods” by utilizing the animals that feed on the plants.

Vegetation baseline studies are detailed studies of the plant species in an area, and the relationships of these plants with the terrain. Vegetation baseline studies provide a snap shot of the study area prior to project activities, so that future conditions can be assessed against the baseline information. In relation to this Project, these changes will include removal of vegetation as a result of preparation activities for infrastructure (i.e. railway lines, roads and buildings) and mine development. Impacts may also include deposits of metals or other materials in the environment, commonly by the deposition of wind-blown dust or potentially by metals or materials carried in water that can then get absorbed into soil (Greger, 2004). For this reason, is important to collect baseline data for vegetation and soils prior to the construction and operating phases of a mining project so that future comparisons of vegetation and soil in locations surrounding mining activities can be monitored for the proper development of mitigation and reclamation plans.

1.3 OBJECTIVES OF BASELINE STUDY

The objectives for this baseline study were as follows:

- To determine what plant species occur in the area of the Project
- To develop a fine scale vegetation classification system
- To identify the possibility of plants considered "rare in Canada" or plants on the COSEWIC list occurring in the area
- To use field data from this baseline study and Inuit Qaujimajatuqangit to determine the species that occur in the LSA and that are important to Inuit people
- To establish baseline information regarding the concentration of metals in plant foliage and soil.

1.4 ACKNOWLEDGEMENTS

Page Burt conducted the field data collection and interpretation, and prepared this report. Several people have assisted with the collection of field data for this project. In 2005, Page Burt was assisted by Debra Stokes of Knight Piésold Vancouver. In 2006, Maret Tae of Elagu Ecosurveys ran parallel plots, and Katie Fry of Knight Piésold Vancouver assisted. In 2007, Peter Quinby and Maret Tae of Knight Piésold North Bay assisted. Peter Quinby has analyzed the data for the Ecological Land Classification system. In 2007 and 2008, Page was joined by soil scientist Hugo Veldhuis, who conducted soil studies which have paralleled the vegetation field work and contribute to the Ecological Land Classification system.

Traditional knowledge studies (Inuit Qaujimajatuqangit) were initiated in 2007 with field work with elders in Pond Inlet. Shelly Elverum and Sarahme Akumilik assisted with this work, and the elders consulted included Theresa Ootoova, Elisapee Maktar, and Ham Kadloo. A report on the Inuit Qaujimajatuqangit work is attached as Appendix G.

Various Inuit field assistants have helped, particularly in 2008. Thanks are due to Steven Tagak, Charley Uttak, Joshua Akavak, and Scott Kadlutsiak for their patience and assistance in the studies at Steensby Inlet.

SECTION 2.0 - STATE OF KNOWLEDGE

2.1 ECOLOGICAL LAND CLASSIFICATION OF THE AREA

Existing knowledge of the North Baffin region with respect to vegetation can be described in ecozones and ecoregions.

2.1.1 Ecozones and Ecoregions

The Baffinland Iron Mines Mary River Project area is located in the "Northern Arctic Ecozone", defined in the Ecological Land Classification of Canada system. It is part of two main ecoregions, and extends slightly into a third. These ecozones and ecoregions are fully described on the Environment Canada website as "An Ecological Land Framework for Canada" (Environment Canada, 2010). Portions pertinent to this study area have been extracted below:

"The Northern Arctic ecozone extends over most of the non-mountainous areas of the Arctic Islands, and portions of northeastern District of Keewatin and northern Quebec. It incorporates the coldest and driest landscapes in Canada."

"Climate. The climate is very dry and cold. The mean annual temperature ranges from - 17°C in the northern islands to -11°C in northern Quebec. The mean summer temperature ranges from -1.5°C in the north to 4°C in the south, and mean winter temperatures range from -31°C in the north to -20°C in northern Quebec. Winters pass in darkness. The mean annual precipitation ranges from 100-200 mm, the lowest in Canada. This ecozone is often referred to as a polar desert. Snow may fall any month of the year and usually persists on the ground for at least 10 months (September to June)."

"Vegetation. A harsh climate, high winds and shallow soils result in sparse and dwarfed plant life. Herb- and lichen-dominated communities constitute the main vegetative cover. The latter is closely associated with the rock fields and hilly upland areas. Common herbs are purple saxifrage, mountain avens, and arctic poppy, often mixed with shrubs such as arctic willow. The size of shrubs decreases rapidly as one moves north. Vegetative cover tends to be greater on wetter sites confined to coastal lowlands, sheltered valleys and moist nutrient-rich corridors along streams and rivers."

"Landforms and Soils. East of Prince of Wales and Somerset islands, the terrain is composed mainly of Precambrian granitoid bedrock, and tends to consist of plateaus and rocky hills. The permafrost is continuous and may extend to depths of several hundred meters. Cryosolic soils (i.e., those affected by permafrost-related processes) predominate."
"Within the Northern Arctic Ecozone, the transect of Baffin Island in which the Mary River Project and both proposed road and rail routes occurs is part of three ecoregions. The northwestern area around Milne Inlet and including the western edge of the graben through which Philip's Creek flows is in the Borden Peninsula Plateau Ecoregion."

"The Borden Peninsula Plateau Ecoregion covers the Borden Peninsula of north-central Baffin Island and the southwestern coast of Bylot Island along Navy Board Inlet. The mean annual temperature is approximately -13°C with a summer mean of 1°C and a winter mean of -25°C. The mean annual precipitation ranges from 100 mm to over 200 mm with the higher values falling in the centre of the peninsula."

"This ecoregion is classified as having a high arctic ecoclimate. It supports a very sparse vegetative cover of moss and mixed low-growing herbs and shrubs such as purple saxifrage, *Dryas*, arctic willow, *Kobresia*, sedge, and arctic poppy. The inland plateau, formed on flat-lying Palaeozoic and late Proterozoic carbonate rocks, slopes gently southward, ranging from about 765 to 300 m asl. Regosolic Turbic Cryosols with Regosolic Static Cryosols are dominant soils that have developed on a variety of undulating glacial deposits. Permafrost is deep and continuous with medium ice content."

The second ecozone which just touches the eastern edge of the Mary River Project study area is the Baffin Island Uplands Ecoregion. According to the description on the Environment Canada website:

"The Baffin Island Uplands Ecoregion in the central uplands of Baffin Island has a very sparse (up to about 15%) vegetative cover of moss, and mixed low-growing herbs and shrubs such as purple saxifrage, *Dryas sp.*, arctic willow, kobresia, sedge, and arctic poppy. Wet sites can develop up to about 60% cover of wood rush, wire rush, and saxifrage, along with a nearly continuous cover of mosses."

"The mean annual temperature is approximately -11.5°C, although higher elevations are considerably colder than this. Lower elevations within the ecoregion have a mean summer temperature of 1°C and a mean winter temperature of -23°C. This ecoregion gets more precipitation than do surrounding adjacent ecoregions to the southwest, with mean annual precipitation ranging from 200 mm in the north to 400 mm in the south, and 300-400 mm at the southern tip. This ecoregion is classified as having a high arctic ecoclimate."

"The general aspect of Baffin Upland is one of a broad, gently warped, old erosion surface, shallowly etched by erosion along joint systems and zones of weakness. Its surface slopes gently to the southwest to an elevation of about 915 m asl near Barnes Ice Cap. Bare bedrock is common, and Turbic Cryosols developed on sparse, thin, colluvial and morainal deposits are the dominant soils. The ecoregion is underlain by continuous permafrost with low ice content. Wildlife includes arctic hare, arctic wolf, arctic fox, and caribou."

The third, and main ecoregion represented on this project is the Melville Peninsula Plateau Ecoregion. The project iron ore deposits are in this ecoregion, as are most of both road and rail routes, and the general area surrounding Steensby Inlet. From the Environment Canada website:

"The large Melville Peninsula Plateau Ecoregion includes the western half of Melville Peninsula and much of northwestern coastal Baffin Island as far south as Nettilling Lake."

“The mean annual temperature is approximately -13°C with a summer mean of 0.5°C and a winter mean of -25°C. The mean annual precipitation ranges 100-200 mm. This ecoregion is classified as having a mid-arctic ecoclimate. Vegetation is discontinuous, and dominated by purple saxifrage, *Dryas sp.*, and arctic willow, along with alpine foxtail, wood rush, and saxifrage. Dry sites are very sparsely vegetated, whereas wet areas have a continuous cover of sedge, cottongrass, saxifrage, and moss.”

“The ecoregion takes in the mainland part of Melville Plateau physiographic region, a broad, gently warped, old erosion surface composed of crystalline Precambrian rocks that rise to about 460-610 m asl. It also takes in the very similar western portion of the uplands of Baffin Island where drainage begins to flow southwestward towards Foxe Basin.”

“Bedrock outcroppings are common, and Turbic Cryosols developed on hummocky, thin, discontinuous sandy moraine are the dominant soils. Organic and Static Cryosolic soils also occur in this ecoregion. Most of the ecoregion is underlain by continuous permafrost with low ice content, although, in the area between Foxe Basin and Borden Peninsula, permafrost with medium ice content bisects the ecoregion north to south. Characteristic wildlife includes caribou, muskox, arctic hare, arctic fox, snowy owl, polar bear, seal, whale, and seabirds.”

2.1.2 <u>Development of Subgroups for each Ecoregion.</u>

Under the Ecological Land Classification System for Canada, ecoregions are further divided into ecodistricts (Environment Canada, 2010). Ecodistricts have been named but not yet fully described for Nunavut; this baseline work may contribute to the development of such a system.

In addition, ongoing remote sensing work by Ian Olthof has been used to contribute to the understanding of the vegetation changes and classification. This work is ongoing, and correspondence with Dr. Olthorp and access to work in progress has been very helpful (Olthof, 2008, and Olthof, Latifovic, and Pouliot, 2000). The Toolik-Arctic Geobotanical Atlas (Alaska Geobotany Centre, 2007) was also of great assistance.

In designing the vegetation classification system described in this report, categories were developed that are as meaningful as possible to the people of the north in terms of wildlife utilization of the land, as well as being recognizable without resorting to statistical analysis. The categories are based on the principle that the various plant communities and associations should be recognizable by direct observation.

SECTION 3.0 - METHODS

Inuit elders often express the concern that those who do the environmental studies should actually spend time on the land. It is their tradition to walk the land, to understand the relationship of the animals to their environment by direct observation. This tradition was honoured in all plant studies conducted for the Mary River Project. Consultation with elders in Pond Inlet regarding traditional Inuit use of plants was well received, with enthusiastic appreciation expressed at being updated on vegetation field studies on the Project and at being consulted out on the land where they could show many of the plants used in the past.

The general goal of the vegetation baseline study was to survey as much of the proposed Project area as possible, sampling the vegetation (and, in some cases, the soil) by setting up plots and recording the information from each, then using the data to describe the plant communities as completely as possible. Inuit Qaujimajatuqangit studies were initiated in 2007 to obtain information from elders as to traditional use of plants. These have been enhanced by land use studies conducted by the traditional knowledge teams in the communities, and by the publication of *Walking with Aalasi* (Ziegler, Joamie, and Hainnu, 2009), a useful introduction to plant use on Baffin Island.

3.1 AERIAL SURVEYS

Aerial surveys by helicopter were done in conjunction with transport to each day's work site, and in cooperation with the wildlife and water sampling work. At all times when in the air, observers were alert to the possibility of finding a "new" plant community or association, something that looked "different" from the air, and might be unusual.

Only one unexpected example of a plant association was found in the Local Study Area for the development of the Baffinland Iron Mines Mary River Project. This is an unusual willow shoreline shrub association with Richardson's willows growing to a height of 2.5 m, and is located in a lateral moraine at the south end of Cockburn Lake. A more detailed treatment of this association is included under the "Riparian Shoreline Shrub" description in Appendix E1.

3.2 FIELD STUDIES

Prior to each day's work, areas of focus for the day were selected. Using maps that included the proposed project infrastructure, as well as candidate transportation routes, vegetation plots were located in areas that could potentially be impacted by development.

Plots were selected visually, from the ground, with attempts made to ensure that each occurred within a single plant association, as opposed to straddling the edges of two adjacent associations. Each 5 m x 5 m plot was paced off and the corners marked with yellow plastic stakes with orange flagging tape attached, to ensure that the plot showed up in the photos.

Using a GPS unit, coordinates (eastings and northings) were obtained for each plot, and each plot was photographed from the ground beside the plot. Two photos were taken of each plot, one photo including all the corner stakes, and one which provided a more close-up view, and did not include the entire plot. Physical and biotic data were recorded for each plot, using the data form included in Appendix A. All plot locations completed from 2005 - 2008 are shown on the maps in Figures 2 through 10. Spreadsheets of the 2005 - 2008 plot locations are included in Appendix B. Also included in Appendix B are the locations and descriptions of baseline stations that were used for the metal analysis of vegetation and soil samples.

The plant species occurring in each plot were recorded on the form, and the percent cover by species was recorded. Many species were identified in the field, and any for which identification was uncertain were collected for later determination.

Specimens of willows, grasses, sedges, cotton grasses, and rushes were collected for identification by specialists. These were bagged by plot, and later preserved in plant presses.

Incidental sightings of wildlife or signs of wildlife use of the area were recorded, including visual sightings, bird calls, scats, feeding damage to vegetation, trails, fur or feathers, nests or burrows, or bird calls/songs. Any archaeological information (structures or artefacts) noticed was noted on the data forms, and later passed on to the archaeology team.

Each plot was tentatively identified in the field as to community or association, comments were recorded, and a sketch was made if needed. Figure 2 shows the approximate location of vegetation studies over the entire LSA.

Approximately every third day the coordinates of the plots completed were entered in an Excel file and a map with all plots completed was produced, in order to avoid focusing heavily on a given area to the exclusion of other areas.

3.3 IDENTIFICATIONS AND TAXONOMY

Plant specimens collected and brought back to camp were identified using the following aids:

- *Vascular Plants of the Continental Northwest Territories* (Porsild and Cody, 1980)
- *Eastern North America as Seen by a Botanist: Pictorial. 1. The Arctic Region.* (Chung, 1989)
- *Barrenland Beauties* (Burt, 2000)
- *A Photographic Field Guide to Mosses, Lichens, and Ferns of Northwest North America* (Vitt, Marsh, and Bovey, 1988)
- *Lichens of North America* (Brodo, Sharnoff, and Sharnoff, 2001)
- *Flora of the Canadian Arctic Archipelago* as downloaded and printed from the website
- And, in 2008, *Flora of the Canadian Arctic Archipelago* as published on CD-ROM (Aiken, Dallwitz, Consaul, et.al. 2007)
- In 2008, a representative collection of specimens of sedges, grasses, and willows as identified and provided by specialists were used to aid in identification in the field

While many plants were identified in the field or while they were fresh, several groups (sedges, cottongrasses, rushes, grasses, and willows) are so complex and hybridize so readily that it is advisable to rely on specialists for their identification. These specimens were labelled, pressed, and sent to the following three specialists for identification:

- Dr. George Argus (recently retired from the National Museums of Canada, and a member of the COSEWIC team): Genus *Salix* (willows)
- Dr. Laurie Consaul (Canadian Museum of Nature), a grass taxonomist who has been deeply involved in the development of the "*Flora of the Canadian Arctic Archipelago*" website: Poaceae (formerly Graminae) (grass family) and miscellaneous
- Dr. Jeff Saarela (Canadian Museum of Nature): Cyperaceae (sedges and cottongrasses) and Juncaceae (rushes)

Taxonomy has become an issue in doing vegetation baseline studies in the North. In the past, botanists were able to utilize the superb *Vascular Plants of Canada's Northwest Territories* (Porsild and Cody, 1980) as the "authority" for all nomenclature of vascular plants, keeping identification and names used very simple. However, there have been so many taxonomic changes that this 1980 publication is outdated. Therefore, the taxonomy for all plants collected from 2005 - 2008 has been checked online, using several major authorities: the *PLANTS Database* (USDA, NRCS, 2010), the *Flora of North America* database (2010) (for a few families), and the *Integrated Taxonomic Information System* (ITIS, 2010) database. These databases are updated on an ongoing and sporadic basis, so their information may not be completely up-to-date. Also, as time passes, the information in this paper may also be superseded by further changes due to ongoing taxonomic research.

Another important source of current taxonomy for the study is the *Flora of the Canadian Arctic Archipelago* website (Aiken, et al., 1999 onwards) and CD-ROM (Aiken, et al., 2007).

3.4 SPECIALIST IDENTIFICATIONS

Information from specialists is returned in the form of lists of species keyed to plot numbers, and the identifications are entered on the hard copy of the plot forms as well as in the database. Because they are experts in their fields, the taxonomy used by the specialists has been accepted for the purpose of this report.

3.5 VEGETATION CLASSIFICATION SYSTEM

The vegetation classification developed for this project was based on field observations and on baseline classifications developed for other arctic projects such as the Bathurst Port and Road Project (O'Leary, Bentz, and Burt, 2002) and the Meadowbank Gold Project. This classification system was tailored to suit local conditions, species, and surficial geology.

3.6 DATABASE

Abbreviated data files for 2005-2008 are attached in Appendix B. These have the coordinates, locations of the plots, plus a condensed description of the vegetation and an assignment as to vegetation association.

The plot data for 2005 and 2006 was entered in Outcrop's "Nunavut Plants Database" for digital storage of data for this project. This database has been developed by a team at Outcrop in Yellowknife and is based on elements of the VENUS system, used in BC and elsewhere, but is customized to be much simpler and more practical for vegetation baseline use in the Arctic.

The “Nunavut Plants Database” can be accessed online as “read-only” files. Using an Internet browser, go to http://npd.outcrop.com/project_bimmr.asp. No password is required to view this database, but authorization and a password are required to change it. A printed sample of the plant species database is included as Appendix C.

The data, including data from 2007 and 2008, has also been entered in an Excel spreadsheet maintained by Knight Piésold, designed to facilitate statistical analysis of the data to assist with the mapping of the elements of an Ecological Land Classification system.

3.7 BASELINE SAMPLING OF SOILS AND PLANT TISSUE FOR METALS

Baseline sampling of surface soils and plant tissues for the purpose of metal analysis is a relatively recent addition to environmental baseline studies being carried out in the North. Baseline sampling of soils and plant tissue for metals for this study was in part modelled after the studies done for Wolfden Resources’ High Lake and Ulu Project in the western central arctic (Wolfden Resources/Zinifex Draft EIS, 2007).

Baseline sampling of plant tissue and soils for analysis began with the establishment of a series of marked plots located in the project development area for the mine, Steensby Port, and proposed rail route. Data was collected from these plots as for the plots used to establish the vegetation classification system, but, in addition, surface soil samples and samples of foliage from 2-3 plant species in each plot were taken. The samples from each plot were analysed by species for a suite of metals, which becomes the baseline for metals concentration in soils and foliage from the plants.

These permanent plots have been marked by a metal spike holding an aluminium tag, and a small inukshuk painted orange. The monitoring plots differ from the classification plots in that they are permanently marked, and in that plant tissue and surface soil samples were collected from the vicinity of each plot.

Soil and vegetation samples were taken from 56 plots during the field season of 2008. These plots are located around the mine site itself, and around the planned mine infrastructure area, including the ore crushing and storage areas, car loading facilities, and in a number of places where dust could be generated by construction. Plots were established along the rail corridor from Mary River south to Steensby Inlet, and around the infrastructure area at Steensby, including around the rail yard, the car dumping site, airstrip, camp/accommodations area, and on the island where the ore will be loaded onto the ships.

Foliage samples were not collected from inside the 5 m x 5 m boundary of the plot, but from the general area around the plot, so that the removal of plant material would not have an effect on the vegetation in the plot itself. Two to three species were selected per plot, mostly plant species that are important to wildlife or humans. Vegetative material from these species was collected, a single species per sample, bagged and frozen, and later analyzed at ALS Environmental Laboratories in Edmonton. Soil samples from close to the surface in about three places in each plot were collected, mixed to provide a representative sample, and chemically analyzed. Samples were sent to ALS Environmental Laboratories in Edmonton for analysis.

Vegetation and soil samples were chemically analyzed for a suite of metals, including:

Aluminum (Al)	Mercury (Hg)
Arsenic (As)	Molybdenum (Mo)
Barium (Ba)	Nickel (Ni)
Beryllium (Be)	Potassium (K)
Bismuth (Bi)	Selenium (Se)
Boron (B)	Silver (Ag)
Cadmium (Cd)	Sodium (Na)
Calcium (Ca)	Strontium (Sr)
Chromium (Cr)	Sulfur (S)
Cobalt (Co)	Thallium (Tl)
Copper (Cu)	Tin (Sn)
Iron (Fe)	Titanium (Ti)
Lead (Pb)	Uranium (U)*
Magnesium (Mg)	Vanadium (V)
Manganese (Mn)	Zinc (Zn)

* Plant samples did not yield results for Uranium

Tests for leachable anions and nutrients, Total Kjeldahl Nitrogen (TKN), were also performed on selected soil samples.

3.8 LIFE OF PROJECT VEGETATION MONITORING

The permanently labelled vegetation plots established in 2008 can provide a baseline for vegetation monitoring into the future. A vegetation monitoring plan is included in the EIS.

3.9 SOIL STUDIES

Soil studies, including soil pits and soils analysis were carried out in 2007 and 2008 in conjunction with the vegetation baseline studies. Soil studies are described in a separate report and the Executive Summary to the Soils Report is included in this report as Appendix D.

SECTION 4.0 - RESULTS

Based on field studies, a vegetation classification system has been developed, a species list of plant species occurring in the area has been completed, occurrence of rare plants has been checked, and baseline levels of metals in plant foliage and soils has been established.

4.1 VEGETATION CLASSIFICATION

The vegetation classification units developed and described on the Mary River Project include the following categories. The codes describe the vegetation association and are subsequently used to identify photos.

Vegetation associations were generally named by the type of vegetation (Sedge community, non-tussock sedge association, or, Moss community, mossy shoreline). However, when dealing with some associations such as the "Disturbed Sites" it is more logical to consider the causes of the disturbance when naming these (example: Disturbed Sites, Animal-caused, Den sites).

Class	**Community**	**Association**	**Codes**	
Wetlands				
	Sedge Community		S	
		Emergent association		Se
		Non-tussock sedge association		Snt
		Tussock association		St
		Sedge-moss wet meadow		S-Mwm
	Moss communities		M	
		Mossy shorelines		Ms
		Mossy cliff bases		Mcb
	Willow communities		R	
		Willow shrublands		Wsh
		Riparian willow association		Rw
		Riparian shoreline shrub association		Rss
Uplands				
	Heath tundra community		HT	
		Blueberry heath association		HTb
		Cassiope heath association		HTc
		Cassiope – dry moss association		HTr
		Mixed heath association		HTm
	Snowbank association		SB	
		Heath snowbank association		SBh
		Forb snowbank association		SBf

Class	Community	Association	Codes	
	Miscellaneous			
		Shrub-sedge tundra association		Tss
		Grassy slope		Gsl
		Dry slope with forbs		Fsl
		Cliff ledges		Lcl
	Barrens		B	
		Purple mountain saxifrage barrens		Bps
		Avens and xeric sedge associations		Bax
		Luzula association		Bl
	Lichen-rock community		LR	
		Lichen-rock bedrock		LRr
		Lichen-rock scree slopes		LRs
		Lichen rock boulder fields		LRb
		Lichen-rock felsenmeer		LRf
		Lichen-rock iron deposits		LRi
Coastal			C	
		Rocky shorelines		Cr
		Gravel shorelines		Cg
		Sandy shorelines		Cs
		Sandy marine backshore		Csb
		Sand/silt flats		Csf

DISTURBED SITES — DS

Some sites are affected by processes that disrupt the "normal" progression of succession of plant communities over time. Some of these processes are natural, including geological and animal-caused, and some are caused by humans. Disturbance causes temporary changes in vegetation, mostly the occupation of the area by an association with grasses, which changes over time to the type of vegetation typical for that area. Attention to the vegetation that comes in on disturbed sites is important in that these species are pioneer plants, and potentially could be used in reclamation.

Geologic processes		
	Solifluction	DSsol
	Landslides and thaw slumps	DSls
Animal-caused		
	Den sites	DSd
	Raptor perches or "bird stones"	DSbs
	Bird nesting sites	DSn
	Caribou trails	DSt

Human-caused	
Old road systems, airstrips	DSr
Sampling sites	DSs
Old Inuit camps	DSi
Inuit caches and carcasses	DSc

Complexes

Certain vegetation units were more easily described as "complexes" when several associations were present in recognizable features on the land. The complexes and their component parts are outlined below.

Valley Complex		VC
	Bedrock slopes/cliffs	
	Talus or scree slopes	
	Sedge associations in valley floor	
	Avens associations	
	Willow riparian	
	Snowbank associations	
Limestone "Slot" Canyon Complex		SC
	Caprock (usually LR bedrock)	
	Cliff ledges	
	Heath tundra slopes	
	Sedge associations in valley floor	
	Avens associations	
	Riparian willow associations	
	Snowbank associations	
Esker (or ridge) complex		EC
	Crest – sand or cobble	
	Windward slope (heath tundra)	
	Lee slope (snowbank)	
	Esker pond banks	

Glaciofluvial plain complex			GF
	(surficial units):	Associations in GF:	
	Glaciofluvial terraces	Heath tundra	
	Deep water proglacial	Sedge associations	
	Alluvial	Snowbanks	
	Lacustrine	Riparian associations	
	Marine terraces	Lichen rock	
	Modern river floodplain		

Mega-Polygons (on non-calcareous till deposits)		MP
	Heath tundra associations	
	Sedge associations	
	Riparian associations	
	Avens associations	
Calcareous till uplands (till veneer)		TV
	Forb barrens	
	Purple saxifrage barrens	
	Avens associations	
Cockburn Lake cliff complex		CLC
	Heath tundra associations	
	Sedge associations	
	Cliff ledges	
	Lichen-rock associations	
	Snowbank associations	
	Moss communities	
	Riparian associations	
	Grassy slope	
	Avens association	
Open plain felsenmeer/sedge		F/S
	Sedge associations	
	Moss associations	
	Lichen-rock associations	
	Heath tundra associations	
	Avens associations	
	Willow shrublands	

A descriptive summary of all vegetation units mentioned above is included in Appendix E1 with representative photos of all units included in Appendix E2.

Each plot was photographed digitally at approximately 1 MB during 2005 and 2006, and at 2.5 MB in 2007 and 2008. At least two photos were taken of each plot. All photos are coded and all have been archived on the Knight Piésold by Outcrop Ltd.

4.2 <u>PLANT SPECIES ENCOUNTERED</u>

During these baseline studies, 155 vascular plant species were found. There are an additional 8 species for which the classification is uncertain due to either a lack of flower structures or other diagnostic characters or due to the specialists having doubts about them (e.g. possible hybrids, revision of the taxonomy of the genus, etc.). This compares with 147 species on the online list for Bylot Island in Sirmilik National Park (Parks Canada, 2004).

As plant species are described, each is given a Latin name that can be recognized worldwide. These names comply with the complex International Rules of Binomial Nomenclature. As taxonomic work is done on plant families or genera, the names of species can change. For example, the star chickweed, *Stellaria monantha*, was recently combined with *Stellaria longipes*. *Stellaria longipes* was the older of the two names, so *S. monantha* became *S. longipes*, thus being removed as a distinct species for our list.

A list of species encountered and species expected is attached in Appendix F. Based on a review of literature on collection records from the North Baffin area, a list of potential species has been developed, and is the "working list" for field work. As the presence of species is confirmed, their presence is indicated on the list.

The species marked with an "X" in the first column have been found on this project, and have been identified in the field or by experts. Those without an "X" likely are present (per the literature), but have not yet been encountered. Several species that have a high potential to be accidentally introduced into the area are also included in the list, with notes indicating the possibility of introduction.

The Project area is important to the collective knowledge of the flora of the Canadian Arctic in that no field work has been done in this part of the interior of Baffin Island in the past. The field studies done during the baseline vegetation work for this project contribute significantly to the knowledge of the flora of the Arctic, and is appreciated by the scientists at the National Museum of Nature (Consaul, 2009).

4.3 RARE PLANTS

Rare plants are always of concern in any project that affects vegetation. It is important to identify whether there are rare plants in an area, and then important to identify where these are, in order to protect or mitigate impacts to their microhabitats.

There are several references that are of considerable value in determining just what constitutes a "rare" plant. These include McJannet, Argus, and Cody (1995), McJannet, Argus, Edlund, and Cayouette (1993), and Cody (1979). The list of potential plants has been checked against an unpublished list entitled *Draft General Status Ranks of Vascular Plants in Nunavut* (Govt. of Nunavut, 2005). None of the plants on the list (potential and encountered) for the area appears in anything other than the "Secure" category on the draft list.

Lists of species of special concern, threatened, or endangered have also been developed as a part of the COSEWIC (Committee on the Status of Endangered Wildlife In Canada), and are posted on the COSEWIC website (COSEWIC, 2010) or on the "Species at Risk" website (SARA, Species at Risk Public Registry, 2010).

According to the *Atlas of Canada* (Natural Resources Canada, 2010), "some plants are rare because they naturally occur in very specialized habitats or in very low numbers; others may be rare because they have suffered setbacks because of natural processes or pressures from human activities”. This has been interpreted as reserving for “rare” status those plants that occur in small numbers in Canada, not those that occur in small numbers in a specific area of Canada, or are at the limits of their range in the study area.

No “rare plants” as described in any of the above references were found within the LSA’s during field surveys for this baseline study. In addition, while working on the land, or while in transit from one site to another, the team was constantly on the lookout for species not already seen and for unusual groupings of plants. No “rare plants” were identified during these incidental activities.

One species that had not previously been reported from North Baffin was found. This is the yellow mountain saxifrage (*Saxifraga azoides*). It occurs on frost-scarred terrain where there is some solifluction, and is common along the northern road and rail routes. *Saxifraga aizoides* is not rare in the rest of the arctic and is not rare here; it is just the first time it has been found, due to the fact that the vegetation of this study area was not well known previous to this work. It simply represents a significant range extension for that species.

Another significant range extension has been found for the sedge *Carex chordorrhiza*, which was found in 2007 near Steensby Inlet. Dr. Jeff Saarela and Dr. Julian Starr of the Canadian Museum of Nature have both looked at the specimen and concur that it is *Carex chordorrhiza* (Saarela and Starr, 2008).

The small arctic fireweed (*Epilobium arcticum*) was found in a moss association on the north road route at approximately kilometer 56, on a gentle calcareous slope downstream from the “tote” road where it passes by the face of a limestone cliff. It has been recorded from plots 07_VN080 and 07_VN252, both of which are located in the same area. According to Porsild and Cody (1980), the arctic fireweed is rare. However, range maps in Porsild and Cody reveal that it has been found in Greenland and in many places in the Canadian Arctic Archipelago, as well as around Hudson Bay. According to McJannet, Argus, and Cody (1995), *Epilobium arcticum* was considered for rare status and rejected due to the fact that it is of widespread distribution across the Arctic. This species does not appear in any of the other publications on rare plants, nor is it on the COSEWIC or SARA lists. It is listed as “Secure” in the Draft Status of Nunavut Plants database.

During a return visit to the RSA to attempt to ascertain plant numbers for *Epilobium arcticum*, more than 80 plants were found in moss associations in the immediate area. In 2008, it was found again, in Plot 08-VS008 in the proposed Steensby port site area, indicating a larger range than originally expected. *Epilobium arcticum* should not be considered a “rare” species, but can be considered “uncommon” within the Regional Study Area.

4.4 OBSERVATIONS APPLICABLE TO RECLAMATION

Approximately 20 plots were established on the old road surface or adjacent to it in sites disturbed in the past. These plots contribute to the knowledge of natural succession and the plant species that can become re-established without intervention. These species may be considered good candidates for use in re-vegetation.

Observations applicable to reclamation are summarized below:

- Natural re vegetation in this general environment is slow, but not as slow as expected. Based on observations on an old silver mine near the Doris North Project in the Kitikmeot Region, we expected little re vegetation in the Mary River study area thirty years after use, but were surprised to find that considerable re vegetation had occurred along the old tote road, particularly in damp areas. The difference is that much of the area traversed by the tote road is on sandy soils, whereas the Roberts Bay Silver Mine is located mostly on fractured gravels (Burt, 2003).
- Colonization of dry areas along the old roads, paths, and campsite areas is occurring slowly, so slowly as to be almost immeasurable in the time since the disturbance.
- Plant communities around the old mining camp near Sheardown Lake have been slightly affected by the addition of nutrients, and are, as expected, richer than normal, with more lush growth and more species of grasses and forbs.
- This colonization (around the old camp) may be on the wane, due to depletion of nutrients and lack of enrichment in the ensuing years.
- There are plenty of local species that can be utilized for reclamation; it is neither necessary nor advisable to obtain plant stocks for reclamation from elsewhere. Use local/regional plant stocks and seed sources for any re vegetation being done on this Project.

4.5 TRADITIONAL INUIT USE OF PLANTS

A traditional knowledge component of the vegetation study was initiated in the summer of 2007 with consultation with elders in Pond Inlet. An illustrated report on the results of this 2007 consultation is attached as Appendix G. The local Inuit have a rich tradition in the use of plants, for many purposes.

Although it is indirect, the most important plant use in this area, as far as Inuit are concerned, is undoubtedly the use of grazing land by caribou. During certain times of the year, the people depended almost entirely on caribou, and arranged their lives around interception of the herds so they could hunt these animals for food, clothing and tools. The direct use of plants such as berries and roots was incidental to caribou hunting, fishing and hunting of marine mammals in the area; the people moved to take advantage of the availability of caribou, geese, seals, or fish, and used the local plants according to their season.

In winter, caribou feed mainly on lichens, especially *Cladonia* and *Cetraria or Flaviocetraria*. In summer, their diet is much more varied, including herbs, especially legumes, grasses, sedges, and cottongrasses, plus the leaves of willows and dwarf shrubs (Chernov, 1985). Based on field observations, important areas for caribou foraging in the Project area include the following (see wildlife reports for more detailed information):

- Megapolygons, which consist of domed centres and lower margins. According to the wildlife team, caribou use these heavily in spring, when the centres are appearing from under the snow.

- Barrens, including purple saxifrage barrens and the avens/xeric sedge association, which often blow clear early in the spring and provide accessible forage.
- Sedge wetlands, which provide essential fresh forage for caribou when the sedges are greening up, and seem to be most important during peak lactation time.

The entire transportation route across the island from Milne Inlet to Steensby Inlet has for centuries been a traditional travel route for Inuit. Historically, people travelled by dog team or by walking and spent extended periods of time in small camps on the land. In addition to hunting, they utilized what plants were available, seasonally. In many cases these were berries, especially blueberry or kigutangirnait (*Vaccinium uliginosum*) and crowberry or paungait (*Empetrum nigrum*), almost always called “black berry”, locally.

The lowlands around Steensby Inlet, Cockburn cliffs, and many of the glaciofluvial terraces along both the north and south routes support a rich crop of blueberries, and, in the south, crowberries. The traditional use of plants has occurred on an opportunistic basis. In the past, people likely did not move long distances simply to access rich crops of berries, but travelled into an area to hunt caribou or geese, or to fish, and readily picked berries while they were there. They still do this today, camping along the coasts and hunting and berry picking in the area.

Consultation with elders during the traditional knowledge studies in Pond Inlet, and conversations with Inuit field assistants throughout the project have revealed that Inuit traditionally used much more than berries. They consumed the leaves of the willows (uqaujat, *Salix arctica*, and, to a lesser extent, avaalaqiat, *Salix richardsonii*), and the roots of the yellow crazyweed or airaq (*Oxytropis maydelliana)*, bistort or tuqlak (*Persicaria vivipara)*, and various louseworts, especially the woolly lousewort (*Pedicularis lanata*). The fleshy leaves of mountain sorrel or qunguliq (*Oxyria digyna*) were (and are) eaten wherever found, and the stems and leaves crushed to make a refreshing juice. Several plants, including blueberry or kigutangirnait, purple mountain saxifrage (aupilattunnguat or *Saxifraga oppositifolia*) and prickly saxifrage (kakillaqnait or *Saxifraga tricuspidata*) and large-flowered wintergreen (Pyrola grandiflora) were used to make “tea”, especially after the introduction of commercial tea, and particularly when the group had run out of tea purchased from the trading posts. In many cases, it was the men who ate significant quantities of plant material while out hunting and away from the cooking skills of their wives.

The activity that uses the largest quantity of plants is the gathering of “firewood”, which is not necessarily large pieces of wood, but a mixture of arctic heather (qijuktaat, *Cassiope tetragona*), Labrador tea (qittiqsuut or *Ledum palustre*), and small willows, scraped up and piled, then used twig by twig in small fires. Dry lichens were often used to make fires as well and driftwood was used whenever found.

The silky white flowers and seed heads of the arctic cotton (kangujait or pualunnguat or *Eriophorum* sp.) and the seed-bearing fluff (siputiksaq) of the willows (sometimes mixed with dry moss) were used as the wick in the qullit or soapstone lamp. Willow fluff was mixed with dry cushion moss and used to stop bleeding in wounds.

4.6 BASELINE METALS IN SOILS AND PLANT TISSUE

For this project, the main emphasis was to establish baseline levels of different metals and elements before any work was done that disturbed the surface of the land or created dust or runoff that might carry metals or other elements.

The results for selected metals in plant species foliage are summarized in Table 1 and for soils in Table 2 below. The complete results for both plant tissue and surface soils analysis are presented in Appendix H (Table H1 and H2).

Table 1 - Baseline Metal Concentrations in Vegetation Foliage

Common Name	No. of Samples	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
White Arctic Heather	12	<0.05 – 0.06	0.6 – 14.2	0.2 – 0.8	3.2 – 6.6	101 - 1650	0.17 – 2.75	0.9 – 7.8	14.8 – 25.3
Blueberry	34	<0.05 – 1.40	0.4 – 13.1	<0.1 – 0.6	3.8 – 11.8	16 - 539	<0.2 – 0.92	0.8 – 6.4	15.9 – 78.6
Alpine Holygrass	1	<0.05	4.9	0.2	2.4	243	0.33	2.7	23.7
Bluegrass	1	<0.05	3	0.1	2	58	0.07	1.8	17.3
Unknown Small Grass	1	0.17	0.6	0.5	5.6	33	0.02	0.8	102
Crowberry	7	<0.05 – 0.41	0.3 – 7.9	<0.1 – 1.2	4.6 – 5.7	12 – 2010	<0.02 – 1.01	0.7 – 12.9	7.9 – 64.8
Alpine Holygrass	1	<0.05	2.2	<0.1	2.3	53	0.08	1.7	17.2
Alpine Foxtail	1	<0.05	157	2.9	6.2	4810	3.03	84.2	15.5
Northern Pike Sedge	2	<0.05 – 0.05	28.7 – 36.0	0.5 – 0.7	4.2	506 - 1490	0.67 – 0.85	16.0 – 18.0	17.8 – 23.7
Shortleaved Sedge	2	0.10 – 0.51	27.9 – 32.6	1.8 – 2.2	11.2 – 52.2	1570 - 3220	2.07 – 3.09	16.2 – 19.1	15.5 – 22.7
Fragile Sedge	2	<0.05	1.5 – 18.9	<0.1 – 0.5	3.4 – 4.6	264 - 819	0.03 – 0.53	1.9 – 9.9	33.6 – 44.8
Spike Sedge	1	<0.05	6.7	0.2	3.8	387	0.37	3.2	20
Curly Sedge	1	0.06	1.5	0.1	6.6	86	0.28	1.2	20.7
Mutiple-Flowered Cottongrass	2	0.05 – 0.15	3.7 – 11.3	0.3 – 1.2	3.3 – 16.2	690 - 794	0.51 – 0.65	5.0 – 6.1	25.3 – 39.6
Sheathed Cottongrass	2	<0.05	1.1 – 3.6	0.1 – 0.2	2.5 – 3.4	285 - 341	0.05 – 0.27	0.7 – 2.1	28.5 – 44.7
Arctic willow	40	<0.05 – 16.6	0.5 – 19.6	<0.1 – 5.5	1.9 – 8.0	33 - 448	0.02 – 1.11	0.5 – 23.9	48.5 - 393
Richardson's Willow	2	0.46 – 6.28	0.6 – 2.1	1.1 – 2.0	5.4 – 7.1	45 - 203	0.04 - 0.33	3.4 – 14.3	188 - 371
Purple mtn. Saxifrage	1	0.1	28.7	2.3	9.3	1970	3.78	18.4	28.3

Common Name	No. of Samples	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Nickel (Ni)	Zinc (Zn)
		(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Yellow crazyweed	6	<0.05 – 0.15	1.0 – 26.8	0.3 – 1.2	2.6 – 4.9	85 – 3310	0.08 – 3.30	1.5 – 15.5	15.5 – 22.7
Alpine Milkvetch	1	<0.05	30.6	0.9	6.8	721	0.78	15.7	16.8
Mountain Avens	8	<0.05 – 0.10	1.4 – 51.2	0.3 – 2.1	2.5 – 6.5	189 - 3360	0.43 – 2.50	1.2 – 24.0	15.5 – 37.0
Mountain Sorrel	2	<0.05 – 0.09	2.1 – 2.5	1.4 – 2.2	4.0 – 4.4	126 - 181	0.37 – 1.62	4.5 – 9.8	18.1 – 31.4
Grey Cushion Moss	7	<0.05 – 1.99	15.2 - 183	0.5 – 4.1	2.4 – 26.9	859 - 7060	1.38 – 10.6	8.6 – 99.9	10.2 – 37.4
Crinkles Snow Lichen	3	<0.05 – 0.10	1.9 – 23.4	0.2 – 0.7	1.7 – 2.6	165 - 1170	0.74 – 1.74	1.2 – 11.4	17.1 – 21.7

Table 2- Baseline Metal Concentrations in Soil

Plot Location	Steensby Inlet	Steensby Port Island	Mine Infrastructure Area	Deposit #1	Cockburn Lake	Steensby Airstrip	Steensby Ikpikitujua
No. of Samples	20	6	3	7	5	4	4
Arsenic (As; mg/kg)	0.1 - 1.5	0.1 - 12.6	0.2 - 0.8	0.5 - 1.1	0.1 - 1.5	0.2 - 1.5	0.4 - 0.8
Cadmium (Cd; mg/kg)	<0.1	<0.1 - 0.4	<0.1	<0.1 - 1	<0.1 - 0.8	<0.1 - 0.2	<0.1 - 0.2
Chromium (Cr; mg/kg)	1.5 - 50	2.1 - 10.7	4.7 - 6.1	11.5 - 65.6	4.3 - 29.4	4.3 - 55.1	0.9 - 9.1
Cobalt (Co; mg/kg)	1.0 - 7.7	1.4 - 3.5	1.0 - 2.2	3.1 - 18.5	1.2 - 10.4	2.3 - 11.2	0.8 - 3.9
Copper (Cu; mg/kg)	1.2 - 41.3	1.6 - 62.0	2.5 - 6.6	5.8 - 283	4.1 - 50.1	3.8 - 25.8	4.6 - 26.8
Iron (Fe; mg/kg)	26000 - 1900	23700 - 2600	4100 - 2300	35400 - 6300	24600 - 4500	40900 - 6200	6800 - 1100
Lead (Pb)	1.5 - 15.9	1.6 - 6.8	2.5 - 4.3	5.3 - 66.5	4.3 - 13.6	2.9 - 21.9	2.0 - 8.7
Mercury (Hg; mg/kg)	<0.05 - 0.13	< 0.05 - 0.71	<0.05	<0.05	<0.05 - 0.11	<0.05 - 0.20	<0.05 - 0.13
Nickel (Ni; mg/kg)	1.4 - 27	1.7 - 6.5	3.9 - 8.3	8.3 - 45.2	2.1 - 21.9	2.8 - 20.2	2.4 - 6.1
Zinc (Zn; mg/kg)	9 - 49	11 - 32	9 - 17	14 - 188	32 - 84	13 - 61	18 - 122

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