GOVERNMENT OF NUNAVUT

ENVIRONMENTAL MANAGEMENT OF CHROMIUM IN SOIL

IQALUIT INTERNATIONAL AIRPORT IMPROVEMENT PROJECT

NOVEMBER 2014

WSP

ENVIRONMENTAL MANAGEMENT OF CHROMIUM IN SOIL

IQALUIT INTERNATIONAL AIRPORT IMPROVEMENT PROJECT

Government of Nunavut

Report (final)

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Mr. Barry Reimer
Government of Nunavut

Subject: ENVIRONMENTAL MANAGEMENT OF CHROMIUM IN SOIL

Dear Mr. Reimer,

You will find below a comprehensive look at the issue of Chromium concentrations in soil at the Iqaluit Airport. The report was built on both previous studies and guidance documents that are referenced in the bibliography. One figure is included along with the text to show the locations of previous environmental sampling exercises that have taken place on the site.

The report compares background concentrations of Chromium to concentrations on site, describes the various valence states of Chromium, and it describes the challenges of managing this soil in accordance with the current regulatory guidance.

The report provides proposed methods for overcoming these challenges while maintaining the priority of protecting the environment.

Yours truly,

Steven Dawson
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WSP (2014). *Environmental management of chromium in soil, Iqaluit International Airport Improvement Project.* Report produced for the Government of Nunavut. 15 p. and figure and appendix.

EXECUTIVE SUMMARY

In June of 2014, during the construction of the Iqaluit Airport redevelopment project, soil samples were collected on site and were determined to contain chromium in excess of Canadian Council of Ministers of the Environment (CCME) guidelines as adopted by the Department of Environment for the Government of Nunavut for general use. A series of environmental investigations have since been conducted to determine the source of the chromium, and the optimal method for managing the soil.

Background research was conducted to determine the source of the chromium. The most pertinent information source was a 2005 study conducted by the Geological Survey of Canada. The study analyzed hundreds of samples for a number of physical and chemical parameters to describe the geomorphology and geochemistry of the South Baffin Island region. Samples from the study show that not only chromium, but nickel and copper are naturally present in soils at concentrations above the CCME guidelines. This is not unusual given that this area is part of the Canadian Shield. The Canadian Shield's igneous, metamorphic, and sedimentary rocks contain high concentrations of iron, nickel, copper, lead, zinc, uranium, gold, and silver.

Chromium exists in different valence states in nature. Naturally occurring chromium is present in the trivalent state, chromium (Cr III). The valence state, hexavalent chromium (Cr VI) is produced from high temperatures that result from manufacturing activities. The different valence states of chromium also result in very different risk factors to both human health and the natural environment. Cr III is stable in nature, insoluble in water, and innocuous. In contrast, Cr VI is unstable and highly toxic.

Due to the geologic history of the South Baffin Island region and the difference between the known valence states of chromium, additional laboratory analysis was conducted. Results determine the concentration of both valence states of chromium in the (Total Chromium) sample results from the Airport site. These results would indicate if whether chromium results reflect naturally occurring chromium or chromium that has been introduced into the natural environment by manufacturing, and the potential for it to have a deleterious effect on the lands and waters in proximity to the airport site.

Because there is no specific laboratory method for analyzing Cr III, analysis of Cr VI must be conducted and then subtracted from total chromium results to determine Cr III concentrations. Cr VI was not detected in any of the samples collected on site. This report describes how the analysis confirms that the source of chromium in soil is Cr III and the result of natural deposition of eroded Canadian Shield bedrock.

This report also discusses the challenge going forward with respect to the interpretation of the appropriate environmental standards given the site specific conditions. It is our opinion that CCME guidelines do not provide clear guidance regarding how to manage Cr III in soil when the background concentrations exceed the criteria. The guidelines, however, provide a rationale for looking at background concentrations and suggest considering other Canadian jurisdictions to consider standards that would be more relevant.

This report reviewed and considered the guidance in Ontario, much of which also contains Canadian Shield geology. It is our view that the standards applied by Ontario provide the relevant risk based standard concentrations for total chromium based on Cr III as well as helpful measures for proceeding.

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1 CURRENT SITE CONDITIONS

1.1 SITE BACKGROUND

The Iqaluit Airport was originally built in 1942 and used as an air base for the United States and Canadian military for industrialized transport during and after WWII. The military base was closed in 1963 and the airport was converted for civilian use. In September 2013, Arctic Infrastructure Partners was awarded a contract through a Public Private Partnership to construct a new airport terminal, a new combined services building, and to conduct major infrastructure improvements to the runways, taxiways, and apron structures at the airport.

As is the case with all military complexes constructed and operated during the mid-20th century, the Iqaluit Airport was known to contain areas of contamination. In July 2013, Conestoga Rovers Associates (CRA) completed a Phase II environmental assessment of the site and a Pre Existing Contamination Management Plan. The primary focus of the plan was management of contamination which had been introduced to the site in the course of prior construction and operations.

In May 2014 Arctic Infrastructure Partners hired Qikiqtaaluk Environmental (QEC) to conduct a Phase III environmental site assessment (ESA). The final report was submitted on July 26, 2014 and included an assessment of soil and groundwater conditions in areas of concern as identified in the CRA report. The report and the subsequent QEC Phase III addendum detailed soil sample results containing Total Chromium concentrations above the CCME Soil Quality Guidelines for the Protection of Environmental and Human Health (industrial land use), and the Government of Nunavut's Department of Environment's Environmental Guide for Contaminated Site Remediation quality criteria for commercial/industrial land use. The criterion in both of these guidelines is 87 mg/kg for Total Chromium. The QEC reports stated that the source of the chromium was unknown at the time. Subsequent research has revealed that the chromium concentrations on site are typical for the region.

The following sections of this report provide a deeper understanding of the current situation regarding the soil on site by looking at the following:

- → Geology and glacial deposits of elemental metals
- → Chemistry of Total Chromium – Trivalent Chromium compared to Hexavalent Chromium
- → Managing soil and determining regulatory guidelines

In July 2014 QEC conducted additional investigations to fully delineate chromium in soil on site. *The Addendum to Phase III Report Following Additional Sampling for Chromium Contamination* was submitted on July 16, 2014. *Sampling for Possible Chromium Contamination – Property Located at Combined Services Building (CBS) Site, New Iqaluit Airport Project* was submitted on July 17, 2014. The report, *Chromium under ATB footprint – Further Details* was submitted on July 25, 2014. *Chromium under the ATB footprint* was submitted on July 29, 2014. An approach to continue working was proposed to the Government of Nunavut Department of the Environment, but the concern remained regarding the effect soils may have on water quality. Until this can be determined, the movement of large volumes of stockpiled soil has been stopped until there is a clear path forward.

Following the full delineation of Total Chromium in soil on site and discussions regarding the environmental management of the soil, the Government of Nunavut requested that WSP Canada Inc. (WSP) provide third party consulting services and recommendations for proceeding. On September 4, 2014, WSP submitted *Environmental Memorandum - Iqaluit Airport - Chromium under the ATB footprint*. The purpose of this document was to provide environmental recommendations regarding the current state of the Airport construction project. This memorandum was submitted to the Nunavut Water Board on September 5, 2014. Comments were received on September 16, 2014 and included a number of questions requesting further clarification regarding the source of native Chromium at the Iqaluit Airport and the proposed use of the soil. WSP provided *Environmental Memorandum – Iqaluit Airport – Chromium* on September 23, 2014 to further explain the historic geochemistry and to propose recommendations for soil use at the Iqaluit Airport site.

1.2 SAMPLING AND ANALYSIS

As part of the investigations, 31 soil samples were collected in July 2014 and were analyzed for metals. Of the first of those results, seven samples contained concentrations that exceeded the Canadian Council of Ministers of the Environment (CCME) criteria for chromium (combined total of Cr III and Cr VI), but which were not atypical for the general South Baffin region based on the 2005 study conducted by the Geological Survey of Canada.

Chromium was initially detected above criteria in a soil stockpile (which represents material excavated during construction) from another area of the site that was previously undeveloped land (according to the previous environmental property assessments). Each sample result represents a large volume of soil on site. The stockpile of soil contains approximately 8,000m^3 of soil. WSP has calculated averages using each of these areas to provide a more comprehensive look at the overall concentrations. Additionally, one sample (labeled SP) was analyzed for Cr VI. Cr VI was not detected. Subsequent testing for CR VI on all samples that exceeded the CCME criteria for total Chromium was conducted. Those results also confirmed that no CR VI was present in the samples.

The Pre Existing Environmental Contamination Management Plan details sampling in 2013 for total chromium as well as Cr VI. Cr VI was not detected above laboratory detection limits in any of these samples. Table 1 summarizes the results of the July, 2014 sampling exercise. WSP has modified the order in which the samples are presented to show results from the stockpiled soil separately from the other samples.

Table 1 Results summary – July 2014

7/17/2014	Sample ID	Total Cr (mg/kg)	Cr VI (mg/kg)
Stockpile Average 65 mg/kg	S1	59	-
	S2	34	-
	S5	42	<0.50
	S6	20	-
	S9	**107**	<0.50
	S12	55	-
	S13	61	-
	S16	**109**	<0.50
	S17	27	-
	S20	**113**	<0.50
	S21	49	-
	S24	58	-
	S25	58	-
	S28	**88**	<0.50
	S31	**100**	<0.50
	SP	-	<0.50
7/17/2014	**Sample ID**	**Total Cr (mg/kg)**	**Cr VI (mg/kg)**
Soil Average 54 mg/kg	S3	25	-
	S7	24	-
	S10	39	-
	S11	61	-
	S14	32	-
	S15	37	-
	S18	20	-
	S19	22	-
	S22	**105**	<0.50
	S23	41	-
	S26	42	-
	S27	**94**	<0.50
	S29	75	-
	S30	83	-
	S32	84	-
	S33	79	-
7/23/2013	**Sample ID**	**Total Cr (mg/kg)**	**Cr VI (mg/kg)**
Soil Average 19 mg/kg	LTU 1	17	<0.20
	LTU 2	21	<0.20
	TP01	34	<0.20
	TP02	19	<0.20
	TP03	17	<0.20

7/17/2014	Sample ID	Total Cr (mg/kg)	Cr VI (mg/kg)
	TP04	23	<0.20
	TP05	17	<0.20
	TP06	30	<0.20
	TP07	18	<0.20
	TP09	22	<0.20
	TP10	13	<0.20
	TP12	28	<0.20
	TP13	15	<0.20
	TP14	11	<0.20
	TP15	20	<0.20
	TP16	17	<0.20
	TP17A	16	<0.20
	TP17B	11	<0.20
	TP18	11	<0.20
	TP19	7.3	<0.20
	TP20	11	<0.20
	TP21	22	<0.20
	TP22	22	<0.20
	TP23	15	<0.20
	TP24	19	<0.20
	TP25	16	<0.20
	TP26	16	<0.20
	TP27	18	<0.20
	TP28	18	<0.20
	TP29	23	<0.20
	TP30	33	<0.20
	TP31	14	<0.20
	TP32	18	<0.20

On July 16, 2014, QEC issued a Phase III addendum that included results from 22 test pits. After receiving these results, an additional analysis exercise was conducted on September 2, 2014 to determine if Cr VI was present in the samples. The basis for this analysis is to determine the source of the chromium. If Cr VI was not detected in the samples, it would confirm that the results for Total Chromium contain only Cr III. This is explained in further detail in Section 1.4. Of the additional 14 samples tested for Cr VI from this area, no Cr VI was detected above laboratory detection limits. WSP examined several other environmental studies and reports conducted for Iqaluit Airport initiatives and none of the prior reports with specific Cr VI testing identified any detectable Cr VI. Locations of previous sampling study areas are shown on the figure in Appendix A. Results from the September 2nd sampling are shown in Table 2 below.

Table 2 September 2nd sampling results

7/16/2014	Sample ID	Total Cr (mg/kg)	Cr VI (mg/kg)
Average 118 mg/kg	TP 200	114	<0.50
	TP 201	76	-
	TP 202	70	-
	TP 203	133	<0.50
	TP 204	102	<0.50
	TP 205	153	<0.50
	TP 206	54	-
	TP 207	170	<0.50
	TP 208	70	-
	TP 209	102	-
	TP 210	190	-
	TP 211	155	<0.50
	TP 212	138	<0.50
	TP 213	96	-
	TP 214	137	-
	TP 215	141	<0.50
	TP 216	138	<0.50
	TP 217	147	<0.50
	TP 218	159	<0.50
	TP 219	129	<0.50
	TP 220	71	-
	TP 223	78	-
	TP-2	-	<0.50
	TP-1 DT1	-	<0.50
	TP 208-D	75	-
	TP 218-D	146	-

The Tier 1 Industrial Guidelines (CCME, 2010; 2011) are used to protect humans and ecological receptors from direct contact with soils. The regulatory limit for chromium concentrations that result in the classification of hazardous waste is 87 mg/kg (ppm). It is advised to look outside of the CCME regulations for more specific standards in order to properly manage soil on site for the following reasons:

- → Results show that concentrations of total chromium reflect a concentration of Cr III, and not Cr VI
- → The CCME does not have separate criteria for Cr III and Cr VI.
- → Based on regional soil results, background averages of chromium are above CCME guidelines

In instances where background concentrations exceed those of the regulatory criteria, it is prudent to conduct risk analyses and look at outside regulations.

1.3 CHROMIUM

Chromium (Cr) is a metal chemical element found in nature. The three most stable forms in which chromium occurs in the environment are the 0 (metal and alloys), +3 (trivalent chromium), and +6 (hexavalent chromium) valence states. In the +3 valence state, the chemistry of chromium is dominated by the formation of stable complexes with both organic and inorganic ligands. In the 6+ valence state, chromium exists as an oxo species such as CrO_3 and CrO_4^{2-} that are strongly oxidizing (USEPA, 1998). Chromium is often targeted as a contaminant of concern in environmental studies due to its association with manufacturing activities such as steel production, aerospace engineering, ore refining, chemical and refractory processing, cement-producing plants, leather tanneries, and catalytic converters. Chromium is also found in paints and plating operations. When chromium is utilized in industrial processes at high temperatures it is converted to hexavalent chromium (Cr VI) through oxidation. Unlike trivalent chromium (Cr III), Cr VI is dangerous to human health and harmful to the natural environment. While Cr III occurs naturally and is ubiquitous in the environment, the principal source of Cr VI in the environment is anthropogenic pollution. Cr III has limited hydroxide solubility and forms strong complexes with soil minerals. It is thermodynamically stable thus making it a very low risk in terms of environmental health and safety. Cr VI is not thermodynamically stable and behaves as a strong oxidizing agent driving the more stringent total chromium standards.

The 1998 US EPA Toxicological Review of Trivalent Chromium explains:

"Hexavalent chromium is widely considered to have significantly greater toxicity than the trivalent form. This results in part from the recognition of hexavalent chromium as a known human carcinogen by the inhalation route of exposure, from the caustic properties of many of the hexavalent compounds, the greater absorption of the hexavalent species following exposure by ingestion and inhalation, and the ability of hexavalent chromium to efficiently traverse cell membranes."

And a 2001 US EPA report for the Resource Conservation and Recovery Act (RCRA), Superfund, and The Emergency Planning and Community Right-to-Know Act (EPCRA) training Module for Solid and Hazardous Waste Exclusions (40 CFR §261.4) has listed numerous cases where wastes from certain industries that exhibit the toxicity characteristic for chromium are excluded from the definition of hazardous waste. The wastes were excluded from the hazardous waste lists for the following reasons:

- The chrome they produce is nearly exclusively trivalent, which is not considered to be hazardous
- Their process does not generate hexavalent chromium (a known carcinogen)
- The waste they produce is handled in a non-oxidizing environment (i.e., the trivalent chrome could not oxidize to hexavalent chrome).

The following sections provide details regarding the geochemistry of soil on the Iqaluit Airport site, as well as a description of the regulatory guidance used to determine how best to manage the soil.

1.4 GEOCHEMISTRY

Geologically, Baffin Island is a continuation of the eastern edge of the Canadian Shield. The surficial landscape dips southwest from the mountainous spine in the east to form the lowlands in the west. The landscape is described as 'Baffin Surface', composed of high-level plains and rolling uplands, represented by plateau remnants and concordant summits and fault-line scarps. Sediments consist of predominantly inorganic cryosols and glacial till.

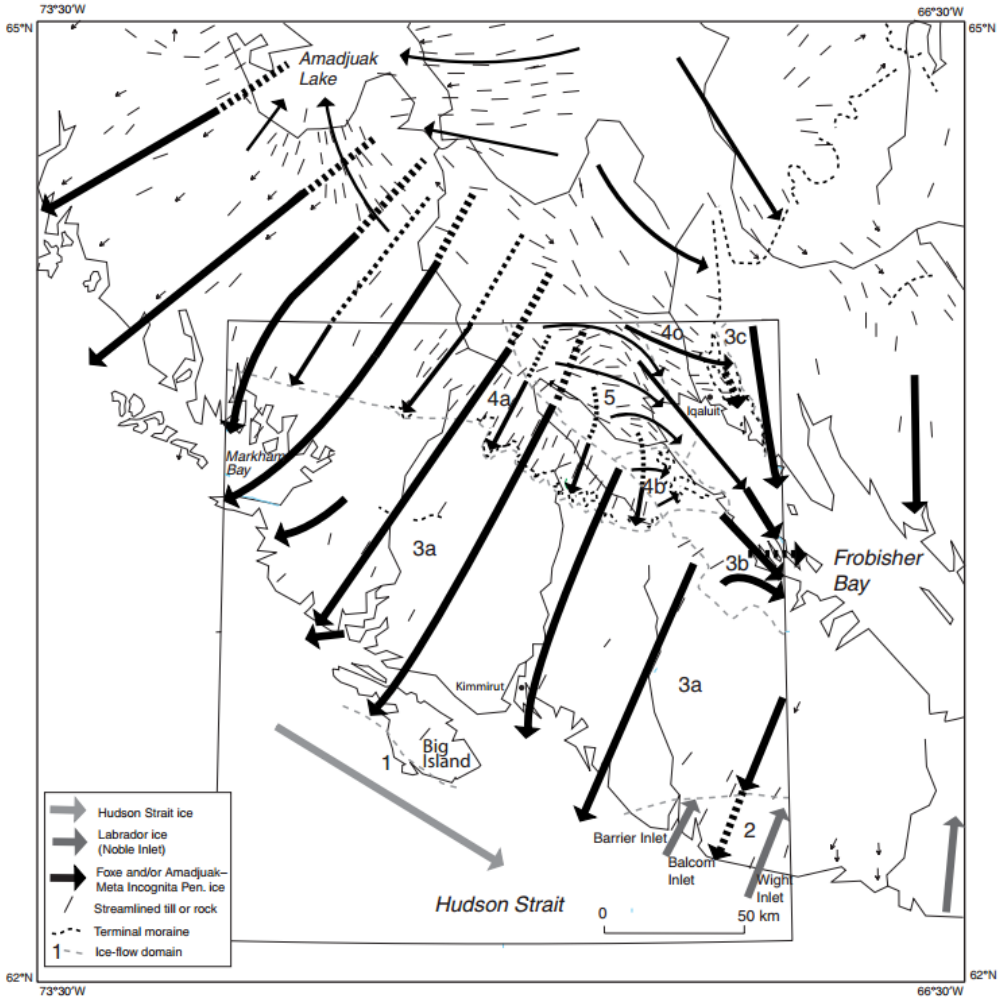
The composition of the till represents the regional bedrock including a wide distribution of Paleozoic limestone overlying Precambrian metamorphic and igneous rocks. The till is more typical of shield composition, even though Paleozoic rocks are exposed. This may be due to chemical erosion of the

Paleozoic limestone as sulfates in shield rocks can generate a lower pH in groundwater and surface water.

One of the defining characteristics of the bedrock across the Canadian Shield is that it is rich with mineral ores including substantial deposits of nickel, gold, silver, and copper. Additionally, the shield (which includes an area of 4.4 million square kilometers) is a source for not only profitable resources, but a plethora of rare earth metals. The surface of the shield has undergone millions of years' worth of erosion caused by the changing climates. The metals that formed nearest to the surface of the earth have been naturally eroded and deposited by rivers, streams, wind, and glaciers and are now part of the inorganic sediment that makes up the soils. Because of this geologic history, the process of identifying metal concentrations in soil is an important method for understanding the geochemistry of individual regions.

The source and distribution of metals including chromium in the South Baffin Island Region are explained in detail in the *Quaternary geology of western Meta Incognita Peninsula and Iqaluit area, Baffin Island, Nunavut*; by D A. Hodgson with the Geological Survey of Canada (Hodgson 2005). The last glacial stage on Baffin Island was the Foxe Glaciation which centered over the Foxe Basin within the Laurentide Ice Sheet. The late Foxe Glaciation substage continued up to 6-5 ka. The following figure shows the generalized ice flow within the last ice age over the Meta Incognita Peninsula. It should be noted that the later flows are represented by thinner arrows. Overrun flows are dashed lines. The figure shows the location of the Frobisher Moraine in the vicinity of Iqaluit, and the recent path of ice flows moving southeast from Sylvia Grinnell Territorial Park toward Iqaluit. This Amadjuak Ice Divide running southeast from Foxe Basin into Meta Incognita Peninsula is referred to as the Meta Incognita Ice Divide branching from the Amadjuak Ice Divide west of the head of Frobisher Bay.

Figure 1 General Ice Flow within the last ice age over the Meta Incognita Peninsula



The Hodgson research included a low-density till sampling program (1 sample/218 km^2) which resulted in the analysis of 123 samples for a suite of 34 elements in order to find patterns in concentrations that could be directly related to ice flows. The samples were also analyzed for grain size, pH and carbonate content. Much of the soils contain particles derived from ultramafic rocks, which contain high concentrations of nickel and chromium (in a trivalent state). One example is Serpentine. Serpentine-rich rock has a mottled, greenish-gray color with a waxy feel to it, and is the rock commonly used for Inuit carvings in Nunavut. As would be expected from sediment that has been derived from this type of bedrock, copper and nickel both exceed the CCME guidelines in the majority of samples included in the Hodgson survey. The highest concentrations of metallic elements in soils and rock are found along the Hudson Strait in the vicinity of Big Island. However, due to the lack of extensive depositional landforms (excluding the end-moraine belt and the Frobisher Bay Moraine System) there is a high variability in geochemistry.

The following table and figure from the Hodgson 2005 research show the location of the samples and the background concentrations of chromium in mg/kg (ppm). It is important to note that the overall average value of all samples taken is 103.3 mg/kg and that sample B62 which is taken from an uninhabited area closest to Iqaluit had a value of 97 mg/kg, both of which are above the CCME guideline for Total Chromium. It is also important to note that laboratories typically report chromium as Total Chromium.

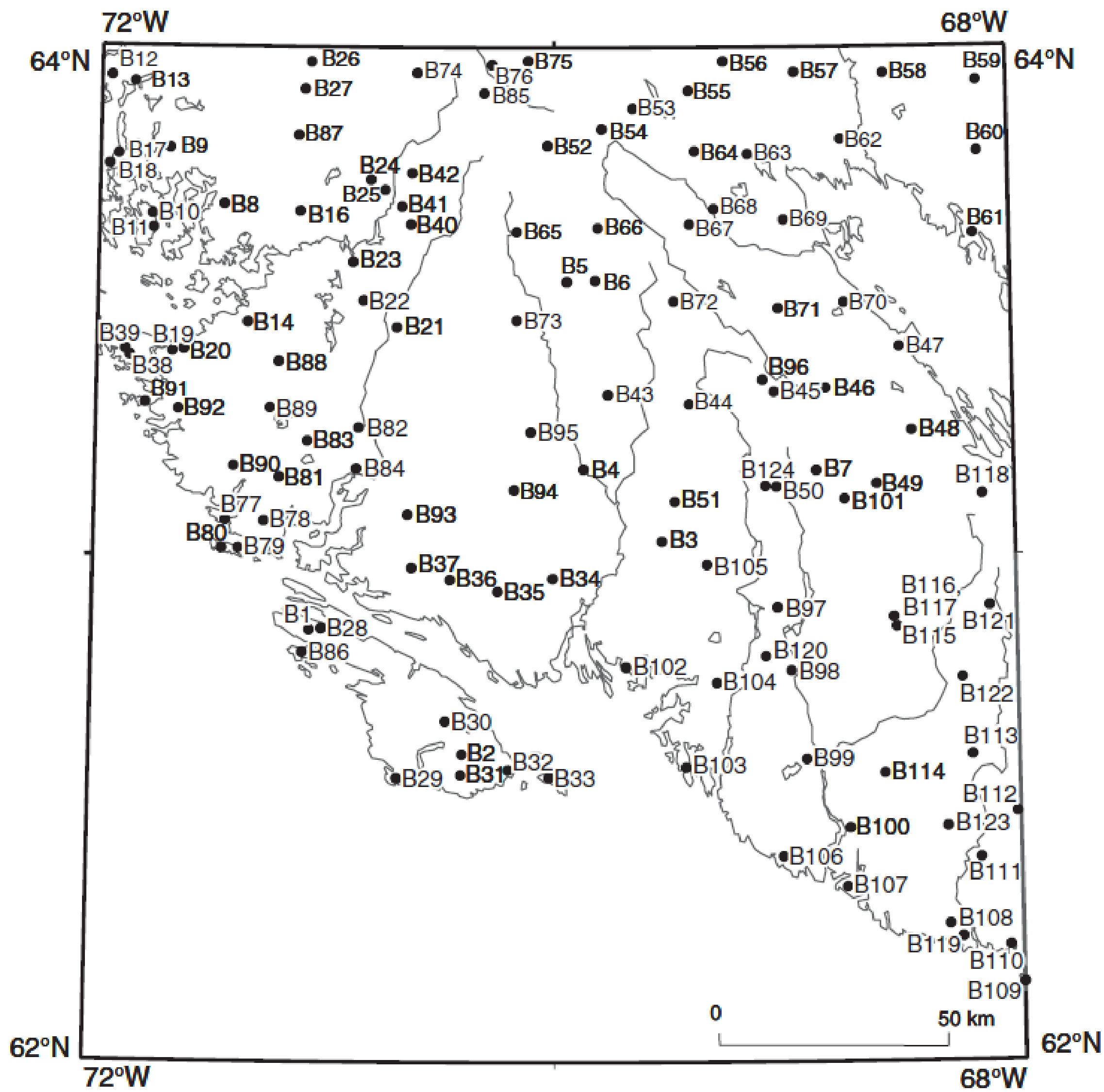
Total Chromium consists of the total sum of Cr III and Cr VI (if Cr VI is present). As there is no recognized analytical method for Cr III, concentrations of Cr III are determined by calculating the difference of Cr VI from Total Chromium.

Table 3 Background concentrations of chromium in mg/kg (ppm) (Hodgson 2005)

Sample ID	**Cr (mg/kg)**	**Sample ID**	**Cr (mg/kg)**	**Sample ID**	**Cr (mg/kg)**	**Sample ID**	**Cr (mg/kg)**
B01	133	B39	76	B77	84	B115	108
B02	103	B40	70	B78	92	B116	136
B03	94	B41	121	B79	53	B117	108
B04	182	B42	78	B80	100	B118	91
B05	85	B43	52	B81	122	B119	64
B06	157	B44	98	B82	117	B120	81
B07	143	B45	69	B83	193	B121	130
B08	146	B46	116	B84	123	B122	358
B09	113	B47	80	B85	125	B123	77
B10	120	B48	109	B86	73	B124	77
B11	129	B49	84	B87	113		
B12	68	B50	81	B88	120	**Total Average mg/kg**	
B13	87	B51	114	B89	74	**103,3**	
B14	109	B52	140	B90	79		
B15	92	B53	231	B91	95		
B16	67	B54	99	B92	95		
B17	103	B55	42	B93	109		
B18	110	B56	39	B94	174		
B19	141	B57	52	B95	142		
B20	95	B58	100	B96	106		
B21	142	B59	85	B97	80		
B22	127	B60	61	B98	107		
B23	120	B61	63	B99	87		
B24	107	**B62**	**97**	B100	135		
B25	67	B63	99	B101	91		
B26	62	B64	87	B102	175		
B27	92	B65	120	B103	139		
B28	74	B66	140	B104	47		
B29	97	B67	90	B105	96		
B30	65	B68	51	B106	104		
B31	106	B69	160	B107	82		
B32	64	B70	138	B108	96		
B33	64	B71	116	B109	97		
B34	107	B72	101	B110	151		

Sample ID	Cr (mg/kg)	Sample ID	Cr (mg/kg)	Sample ID	Cr (mg/kg)	Sample ID	Cr (mg/kg)
B35	73	B73	153	B111	74		
B36	92	B74	167	B112	117		
B37	86	B75	81	B113	169		
B38	105	B76	52	B114	91		

Figure 2 Location of the samples (Hodgson 2005)



1.5 RELEVANT REGULATIONS

The Department of Environment for the Government of Nunavut administers and enforces the *Environmental Protection Act* (Nunavut). The Act defines “contaminant" as including "any substance "where discharged into the environment", endangers the health, safety or welfare of persons, or animal life; interferes with normal enjoyment of life; or causes or is likely to cause damage to plant life or to property. However, Nunavut has not made regulations prescribing contaminants or the concentration of contaminants permissible in the environment. Given the nature of the chromium found onsite, which is naturally occurring, it cannot be determined that the soils would be considered as "contaminant" because it is not being and will not be discharged into the environment, and even if it were, trivalent chromium is innocuous and poses a low risk to environment and human health.

The *Nunavut Waters and Nunavut Surface Rights Tribunal Act* defines “waste” as any substance that, by itself or in combination with other substances found in water, would have the effect of altering the quality of any water to which the substance is added to an extent that is detrimental to its use by people or by any animal, fish or plant, or any water that would have that effect because of the quantity or concentration of the substances contained in it or because it has been treated or changed, by heat or other means and includes any substance or water that is deemed to be waste under the Canada Waters Act; any substance or class of substances specified by the regulations; water containing a substance in a concentration greater than prescribed; and water that has been treated or changed as prescribed**.** All investigations and data confirm that Cr VI is not present on site, and the soil will have no negative impact on the local environment or health and safety. As a result, it is also reasonable to conclude that the nature of the chromium found onsite would not be considered as “waste” within the meaning of the Act.

We have also reviewed the Department of Environment's Environmental Guideline for General Management of Hazardous Waste which provides information and guidance with respect to the management or control of a hazardous waste. The Guideline states that "waste is a term used to describe materials that are no longer wanted or are unusable for their original intended purpose. Many different types of waste are generated by industry and small business, hospitals and health centers, schools and individuals during the normal course of carrying out daily activities. Some types of waste pose greater risks than others because of their chemical, physical and biological properties. These wastes are generally referred to as being a ‘hazardous waste’. Examples of hazardous waste include discarded paint, used solvents, motor and lubricating oil, cleaning compounds, certain building construction and demolition waste and products with an expired shelf life. They will generally exhibit one or more of the following characteristics - ignitable (i.e. flammable), reactive, corrosive or toxic. Hazardous waste often requires that specific management measures be taken to ensure the health and safety of the environment, workers and the general public.”

The GN’s Guideline and its definition of waste indicate that naturally occurring chromium in soil is not waste and would not cause any harm. Indeed, the soil has an objective value, because it can be used for fill without causing any harm.

Finally, the Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada, CCME (1996) defines a contaminant as any chemical substance whose concentration exceeds background concentrations or that does not naturally occur in the environment.

As mentioned above, CCME soil quality guideline of 87 mg/kg (chart below) is based on potential risk factors predominantly stemming from the toxicology of Cr VI. This is also a result of there being no recognized analytical method for measuring the concentration of Cr III. Cr III must be determined by subtracting the concentration of Cr VI from total chromium. Due to these limitations, strict adherence to the CCME guidelines is problematic.

Table 4 CCME Soil Quality guideline

SOIL QUALITY GUIDELINES (MG/KG)

	Land Use			
	Agricultural	**Residential/ Parkland**	**Commercial**	**Industrial**
Total Chromium	64	64	87	87
Hexavalent Chromium	0.4	0.4	1.4	1.4

2 PROJECT CHALLENGE

2.1 CHROMIUM IN NATIVE SOIL

In the 1996 *Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada*, the Canadian Council of Ministers of the Environment and the National Contaminated Sites Remediation Program address the subject of elevated background concentrations in soil.

Although the generic guidelines are appropriate for use under a wide range of environmental conditions, the CCME Subcommittee for Environmental Quality Criteria for Contaminated Sites recognizes that site adapted environmental quality remediation objectives may be necessary under certain circumstances, including situations where background levels of a substance exceed CCME guidelines. The Subcommittee recommends specific procedures for deriving remediation objectives for soil using the guideline-based approach. These recommendations include procedures for evaluating the applicability of the generic guidelines to individual contaminated sites and for modifying these guidelines to account for typical or unique site characteristics. Two basic approaches have been proposed to support the development of site-specific remediation objectives in Canada. The first approach, known as the guideline-based approach, involves:

- Method 1: direct adoption of existing Canadian soil remediation guidelines, or
- Method 2: limited modification of the soil remediation guidelines to reflect site conditions.

The second approach, termed the risk-based approach, relies on:

- Method 3: use of risk assessment procedures to establish the remediation objectives at contaminated sites on a site-specific basis.

At the Iqaluit Airport site it has been shown that chromium exists at concentrations relative to background concentrations. The background concentrations for chromium in the region are higher than the CCME guidelines for contaminated soil. It has also been shown that the valence state of the chromium located at the Iqaluit Airport site is Cr III, not Cr VI. There is no specific regulation for Cr III in the Nunavut or CCME guidelines.

The challenge, therefore, is to arrive at a modified guideline that does not pose a risk to either human health or the environment, but which allows use of the naturally occurring soils on the airport site. Method 2 of the guideline based approach provides a flow chart for setting site specific soil remediation objectives that do not exceed background levels.

As the geology of the Canadian Shield also encompasses a majority of the Provence of Ontario, difficulties with background concentrations of metals such as chromium had to be addressed for that Province. The Ontario Ministry of the Environment has developed specific standards based on both human health risk criteria and background concentrations.

2.2 RELEVANT STANDARDS IN ONTARIO

The Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act* written by the Ontario Ministry of the Environment (April 2011) provide Site Condition Standards (SCSs) that are used for Regulation 153/04 which is used to guide contaminated site cleanup in Ontario. The development of those SCSs are explained in the Rationale for the Development of Soil and Ground Water Standards for use at Contaminated Sites in Ontario developed by the Standards

Development Branch of the Ontario Ministry of the Environment. This guidance for managing soils is a relevant guidance that may be considered as a guide for managing the chromium in soil at the Iqaluit Airport.

The SCSs have been used at contaminated sites in Ontario since 1985 and have been consistently updated based on advances in knowledge and improved procedure development criteria (including CCME protocols). The SCS for total chromium have been established in order to more closely represent the risks associated with Cr III presumably due to its prevalence in the natural environment. These regulations are in place to protect against potential adverse effects or the likelihood of adverse effects to human health, ecosystem health and the natural environment resulting from contamination dude to human activities. The values provided in the Ontario document also provide a level of human health and ecosystem protection consistent with background in order to protect sensitive ecosystems:

TABLE 5: Stratified Site Condition Standards in a Non-Potable Ground Water Condition is applicable to the Iqaluit Airport site as it provides risk based guidance for both surface soil and subsurface soil. Surface soil is typically defined as soil from zero to five centimeters below the ground surface. The surface soil threshold is 160 µg/g (ppm) while the subsurface threshold is (18,000) 11,000 µg/g. The standard in bracket applies to medium and fine textured soils.

TABLE 5: Stratified Site Condition Standards in a Non-Potable Ground Water Condition

Table 5	Soil Standards (other than sediment) µg/g				Non-Potable Ground Water
Contaminant	Residential/ Parkland/ Institutional Property Use		Industrial/ Commercial/ Community Property Use		All Types of Property Use
	Surface Soil	Subsurface Soil	Surface Soil	Subsurface Soil	
Total Chromium	160	(18000) 11000	160	(18000) 11000	810
Hexavalent Chromium	(10) 8	40	(10) 8	40	140

Table 7: Generic Site Condition Standards for Shallow Soils in a Non-Potable Ground Water Condition is also applicable to some areas of the Iqaluit Airport site. The table recommends that soil containing total chromium in Residential/Parkland/Institutional property or Industrial/ Commercial/ Community property follow the standard of 160µg/g (ppm) for shallow soils. Shallow soils are described as soils consisting of less than 2 m of overburden above bedrock. Due to the regional variation in depth of glacial till to bedrock or permafrost, this designation will be applicable in some areas of the site. Table 7 is included below.

TABLE 7: General Site Condition Standards for Shallow Soils in a Non-Potable Ground Water Condition

Table 7	Soil Standards (other than sediment)		Non-Potable Ground Water
Contaminant	Residential/ Parkland/ Institutional Property Use	Industrial/ Commercial/ Community Property Use	All Types of Property Use
Total Chromium	160	160	640
Hexavalent Chromium	(10) 8	(10) 8	110

3 PROPOSED SOLUTIONS

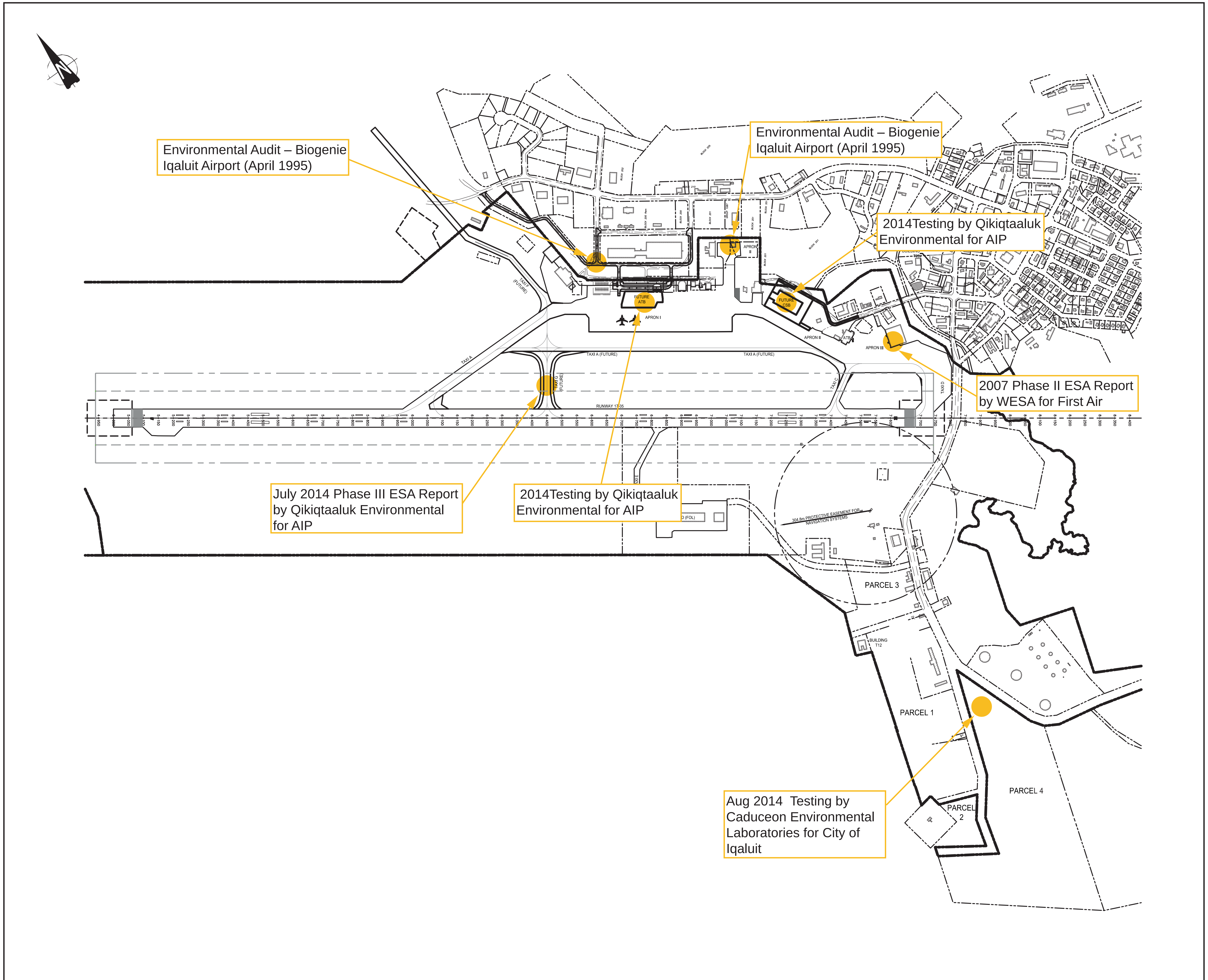
3.1 ENVIRONMENTAL MANAGEMENT

Consistent with MOE Soil, Ground Water Sediment Standards (2011), the reuse of the excavated soil at the site where the soil is excavated is encouraged. This approach limits the amount of excess soil that requires management off site. The MOE also encourages use of the excess soil for a beneficial purpose, provided the use complies with applicable legislation and where the use does not have the potential to cause an adverse effect or impair water quality

In this case, the excavated soil is generally planned to be used as fill throughout the remainder of the project. In order to ensure that the environment is not adversely affected, any soil exceeding the surface soils standard of 160 µg/g (pending volume requirements) could be restricted for use as surface soil and be covered (with soil that does not exceed the standard, concrete, or asphalt). Ongoing soil management should be conducted in accordance with the MOE Soil, Ground Water and Sediment Standards (2011).

Appendix A

FIGURE 1 CHROMIUM SAMPLING AREA



IQALUIT INTERNATIONAL AIRPORT IMPROVEMENT PROJECT Environmental Managment of Chromium in Soil

Figure 1

Chromium Sampling Area

Source:
Iqualuit International Airport Improvement Project, Iqualuitm, Nunavut, Drawing No. GEN-SP005D

Preparation: S. Dawson
Drawing: C. Thériault
Approval: B. Reimer

November 3rd, 2014 121-60109-15

File: 121_60109_15_ChromiumSampling_141103.ai

Appendix B

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