The following sections describe the mixing zone, effluent quality, effluent disinfection, toxicity and land application environmental assessment studies.

2.3.1 Mixing Zone

The mixing zone in groundwater arising from discharge of effluent is not subject to Water Quality Objectives. The mixing zone is not specifically defined, but Water Quality Objectives are to be met at property line boundaries and are implied in Section 3.3.

2.3.2 Effluent Quality

Table 2-2 describes minimum treatment requirements for effluent application to land or for reuse as reclaimed wastewater. The effluent quality to be met is for both a 30 consecutive day average, and the maximum 7 consecutive day average within each month.

2.3.3 Effluent Disinfection

Table 2-2 sets out minimum disinfection requirements for different reuse and application to land alternatives. Where disinfection is required, the median coliform values for 7 consecutive tests must be less than the values shown. For higher class and public use applications, no two consecutive tests are to exceed 10 times the value shown.

TABLE 2-2
CRITERIA FOR DISCHARGES TO LAND*

	Exfiltration Basin (2)	Surface Disposal (1)(2)			Parameter (11)
		Class A (3)(6)	Class B (4)(6)	Class C (5)(6)	
Treatment	Secondary (7)	Advanced (8)	Secondary (7)	Secondary (7)	Treatment
Effluent Quality Prior to Application	30; 45	5; 10	30; 45	30; 45	BOD_5 mg/L - 30 day avg.; max. 7 day avg.
	30; 45	5; 10	30; 45	30; 45	TSS mg/L - 30 day avg.; max. 7 day avg.
	6-9	6-9	6-9	6-9	pH
	No	<2.2/100 mL	<200/100 mL	<200/100 mL	Disinfection; fecal coliform (9)(10)
	-	-	10	-	Effluent storage, days
	-	-	6 - milk cows 3 - other cattle	-	Lag time in days between end of application and use on land

	Subsurface Disposal (12)(16)							
	Number of metres of drainage pipe for each 10 m^3/d of design effluent flow for percolation rates shown							
	2 (13)(14)	5 (13)	10	15	20 (15)	25 (15)	30 (15)	Percolation rate; minutes/25 mm
Effluent Quality Prior to Application (17)(7) - typical septic tank effluent - no disinfection	120	215	280	320	360	400	430	m/10 m^3/d
Effluent Quality prior to application (18) - BOD_5 = 10 mg/L - TSS = 10 mg/L - no disinfection	50	75	100	110	120	135	150	m/10 m^3/d

* Numeric values in parentheses refer to numbered explanation in the explanatory notes to Table 2-2.

$\geq$ Means greater or equal to.

$<$ Means less than.

Explanatory Notes to Table 2-2

1. Maximum application equals the average seasonal potential evapotranspiration divided by the application efficiency of the sprinkler system.

   (a) Average seasonal potential evapotranspiration shall be based on calculations by Coligado and Sly using a Baier and Robertson formula. These values are available from the Soils and Engineering Branch of the Ministry of Agriculture and Fisheries (Table 2-5, B.C. Sprinkler Irrigation Manual (1989)). The application efficiency should not be less than 72%.

   (b) In some cases where the land is composed of fine textured soils, such as clays, or where slopes exceed 10%, it may be required that lesser amounts of water be applied as determined by site-specific studies.

   (c) Where the soil has sufficient porosity and there is an exceptional depth of unsaturated soil to prevent ground or surface water pollution, greater amounts of water may be applied provided it can be shown that slope breakout, instability or flooding will not result.

2. See Section 6.2.4 for applicable criteria.

3. Class A land use includes parks, boulevards, schoolyards, playgrounds, cemeteries and other high use public areas. Class A land use also includes surface and drip (but not spray) irrigation on orchards and vineyards.

4. Class B land use includes surface or spray irrigation on pasture. Lag time for milking cows is 6 days and for other cattle is 3 days. Storage requirements may be waived if filtration is provided to remove worm eggs.

5. Class C land use includes surface or spray irrigation of forage, fibre and seed crops, golf courses, freeway landscapes and turf farms; and includes surface or spray irrigation of forests, silviculture, and rangeland.

6. Where land use is in doubt, the more stringent class land use restrictions are to apply.

7. Secondary treatment is any form of wastewater treatment meeting the tabulated effluent quality criteria, and providing not less than 85 percent removal of BOD_5 and TSS. The BOD_5 and TSS effluent concentrations are the 30 consecutive day average and the maximum 7 consecutive day average within each month. Average annual values may be acceptable for land application for Class B use, where storage reservoirs are used over the non irrigation season.

8. Advanced treatment is additional following secondary treatment and shall comprise coagulation, clarification and filtration. The advanced treatment steps may be combined. Filtered effluent is not to exceed 5 NTU turbidity units in any 24 hour period. Coagulation plus clarification is required to ensure virus, helminth and protozoa removal when passed through filters.

9. Disinfection levels are to be achieved at point of application (sprinkler head). Values shown are geometric (log) mean. Fecal Coliforms (FC) < 200 MPN/100 mL shall be measured as a running log mean based on 5 samples taken over not more than a 30 day period nor shall more than 10% of total samples during any 30 day period exceed 400 MPN/100 mL. The median number of fecal coliform bacteria shall not exceecd 2.2 MPN per 100 millilitres, as determined from the bacteriological results of the last seven days for which analyses have been completed, and the number of fecal coliform bacteria does not exceed 23 MPN per 100 millilitres in any two consecutive samples.

10. Where extensive buffer zones are provided, public access is restricted, and provided the operation ensures that the health of workers is not compromised, it is possible to irrigate forests and range land with secondary effluent which does not meet these coliform requirements and in some cases may not be disinfected, particularly from long term storage lagoons (ie: in excess of 120 days with no short circuiting).

11. See Section 3.3 regarding additional quality criteria which may be included. In addition, removal of nutrients may be required unless any one of the following three conditions can be substantiated:

    (a) The groundwater table will remain at least 3 m below the surface (or below the drainage pipe invert for sub-surface disposal) and percolation rates are longer than 10 minutes per 25 mm.

    or

    (b) The discharge will neither contribute to eutrophic conditions in surface water nor adversely affect the quality of groundwater outside the boundaries of the disposal areas.

    or

    (c) Total wastewater discharges to land in the groundwater drainage area are not considered to be significant in relation to groundwater flows.

12. This part of the table refers to discharges exceeding 22.7 m^3/d and applies to drainfields constructed with 0.6 m wide trenches and 3 m spacing. The drainage pipes are normally to be provided in two fields with a third field being retained as a standby area. Each of the two developed fields is to have at least the length of drainage pipe indicated in Table 2.2.

    The bottom of the seepage trench is to be 1 m above the maximum water table. The trench bottom is to be at least 600 mm below the pipe invert. Pipe cover is to meet local frost protection requirements but shall not be less than 150 mm. Drainage pipe diameter will normally be 100 mm or greater unless a pressure distribution system is shown acceptable.

13. In recognition of Note 11, where groundwater depth is greater than 1.0 m below the deepened drainage trench, deeper and narrower trenches may be considered in well drained soils, and drainage pipe length may be reduced to a value equal to the product of Table 2-2 pipe length and a factor of $1/\sqrt{H}$ or 0.8 (whichever factor is greater), where H is the drainage pipe depth in metres. Seepage beds, including mounds, where large trenches carrying several drains are constructed, will not normally be permitted.

14. Percolation rates less than 2 minutes per 25 mm are too fast for adequate renovation and drainfields will not be permitted, unless hydrogeotechnical studies show that local groundwater quality can be reasonably met at the property boundary.

15. Percolation rates more than 20 minutes per 25 mm require a tile field length equivalent of 2 times the Table 2-2 value to account for construction disturbances to soil permeability. This requirement will be waived if the construction is certified by a professional engineer to have been carried out in a manner which has not reduced the trench wall permeability.

16. Drainfields shall not be located within:

    (i) 6 m (20 feet) of a parcel boundary;
    (ii) 30 m (100 feet) or the groundwater mound effect, whichever is greater, of any house;
    (iii) 91.5 m (300 feet) or the groundwater mound effect, whichever is greater, of any water well;
    (iv) 305 m (1,000 feet) of a water well drawing from an aquifer affected by the field which is located within the zone of lower groundwater potential, and where it is also substantiated that nitrate-nitrogen levels will remain at acceptable levels in the well water. Lesser separation distances in (iii) and (iv) may be allowed where it is demonstrated conditions so warrant.

17. Septic tank treatment requires a hydraulic capacity of at least two times the design maximum daily flow.

18. The use of a drainfield in this category requires the addition of microstrainers, sand filters, intermittently dosed sand filters, or other acceptable filtration facilities following secondary treatment.

2.3.4 Toxicity

Protection of human health and vegetation from toxic effluent is to be undertaken through treatment and monitoring to assure that specific toxicants are maintained below a level consistent with the handling and use of the effluent. It is the responsibility of the discharger to determine the quality of effluent discharge, background concentrations, degradation rate and persistence of principal toxicants, and site specific variables which may alter or impact toxicity in the discharge.

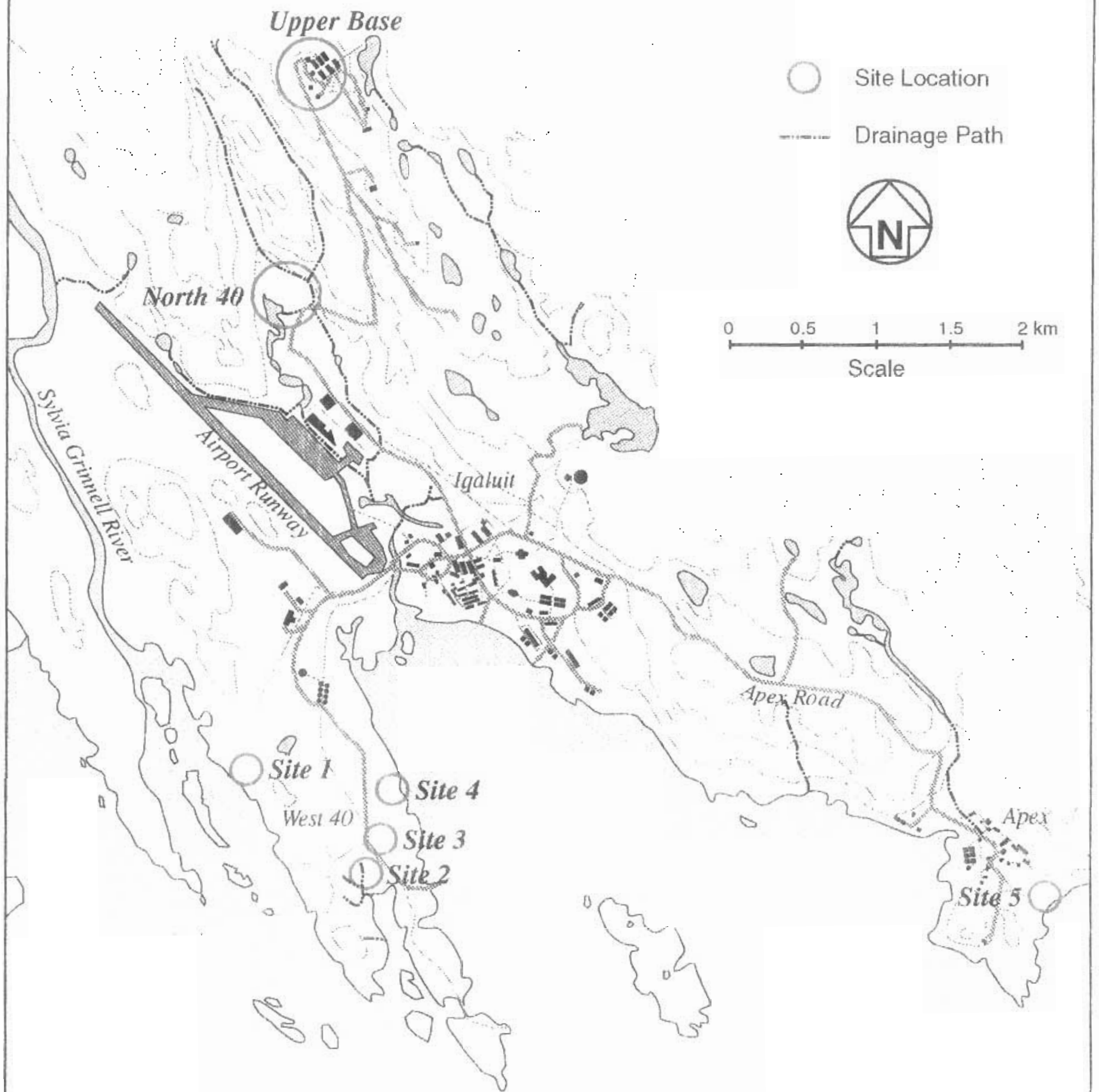
2.3.5 Land Application Environmental Assessment Studies

Section 3.3 describes environmental assessment study requirements for application of effluent to land.

V. RESULTS AND RECOMMENDATIONS

The results of the current environmental assessment of the military installation and six dump sites located near the town of Iqaluit (Map V-1), and recommendations based on the assessment of each site, are presented in this chapter. The assessment has been broken down into seven sections - one for each site - designated as the Upper Base, the North 40 Dump, Dump Sites #1 - #4 in the West 40, and the Apex Dump, in that order. Included in each section is a general overview of the location and history of the site, a summary of the sampling program undertaken there, and a discussion of the results of analyses conducted on soil/sediment, plant and water samples. Cleanup recommendations conclude each section. These are based on requirements for Arctic sites as outlined in the DEW Line Clean Up (DLCU) Protocol, and are made in consideration of the degree of ecosystem impact incurred, through comparison of analytical results to the applicable criteria (see Chapter IV), the use of plants as indicators, and visual inspection of each site.

Map V-1: Locations of the Military Installation and Waste Disposal Sites Near Iqaluit



A. Background Contaminant Concentrations in Soils and Plants

1. General

Soil and plant samples were collected from areas which were not directly impacted by operation of the Upper Base, the dumps or the town of Iqaluit itself, termed *background* locations. By comparing the concentrations of compounds in samples from potentially impacted areas to those from background locations, a distinction can be made between elevated concentrations of compounds which have resulted from local human activity and those resulting from the geological makeup of an area or from atmospheric transport.

Many of the dump sites studied in the current investigation are in close proximity to the marine environment. Marine and estuarine sediment samples were collected near Dump Sites #1, 2, 4 and 5 as part of the concurrent Historical Ocean Disposal (HOD) study (Bright et al. 1995). The results from analyses of these samples are discussed in the context of the current terrestrial study where applicable. Contaminant concentrations in sediment have been compared to concentrations in additional HOD study sediment samples collected in unimpacted marine locations off the coast of Baffin Island.

2. Sampling Program

Eight background soil samples, including one field duplicate, were collected from seven locations near Iqaluit between August 9th and 17th, 1994. Five samples of vegetation were collected, one from each of five of the seven background locations. Detailed descriptions of individual sampling locations, and vegetation collected and surveyed are provided in Section A, Chapter IV of the Appendices.

A total of 20 marine sediment samples was collected from various background locations along the east coast of Baffin Island as part of the HOD study (Bright et al. 1995). Four of these were collected in relatively unimpacted areas of Frobisher Bay.

3. Analytical Results

The analytical results for background samples can be found along with the results for all other sites in Chapter V of the Appendices.

i. Inorganic Elements

All eight background soil samples, including the field duplicate, were analyzed for inorganic elements. Mean and maximum background soil concentrations are presented in Figure V-1. Since cadmium and lead were not detectable in any of the background soil samples, their means are presented as half their detection limit - 0.5 ppm for cadmium and 5.0 ppm for lead - and indicated in the figure by a hollow bar.

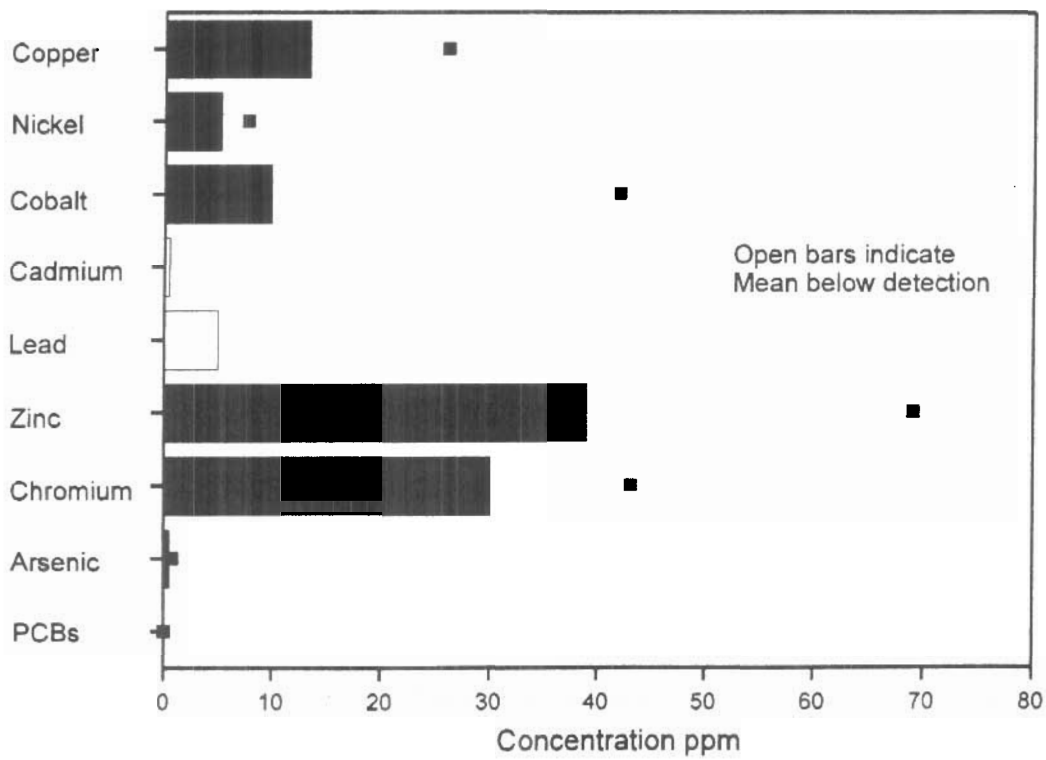


Figure V-1: Mean and Maximum Concentrations of Inorganic Elements and PCBs in Background Soil

The mean concentrations of inorganic elements detected in background soils collected near Iqaluit were comparable to trace element concentrations found elsewhere in

Canadian soils (McKeague & Desjardins 1979). The mean background concentrations of all elements except chromium were comparable to or below the CCME Assessment Criteria for Soils (see Chapter IV). The mean concentration of chromium in background soils (30 ppm) and the concentration of chromium in all individual background soil samples, but one, exceeded the CCME Assessment Criterion (20 ppm). A maximum concentration of 43 ppm was detected in a background soil sample. Concentrations of zinc were elevated above the Assessment Criterion in two background soils, but the mean for backgrounds did not exceed that level. All other inorganic elements were detected at concentrations below the assessment criteria in all background samples.

Five background plant samples were also analyzed for inorganic elements. Mean and maximum background plant concentrations are presented in Figure V-2.

The mean concentrations of all inorganic analytes except zinc were lower for background plant samples than for background soils. The mean concentration of zinc in background plants (252 ppm) was 6.5 times the mean background soil concentration (39 ppm). The elevated concentrations of zinc detected in the background plants can be attributed to the fact that the long-lived species sampled, *Salix arctica* (Arctic willow), has a tendency to accumulate this inorganic element, as shown in previous studies (Reimer et al. 1993a).

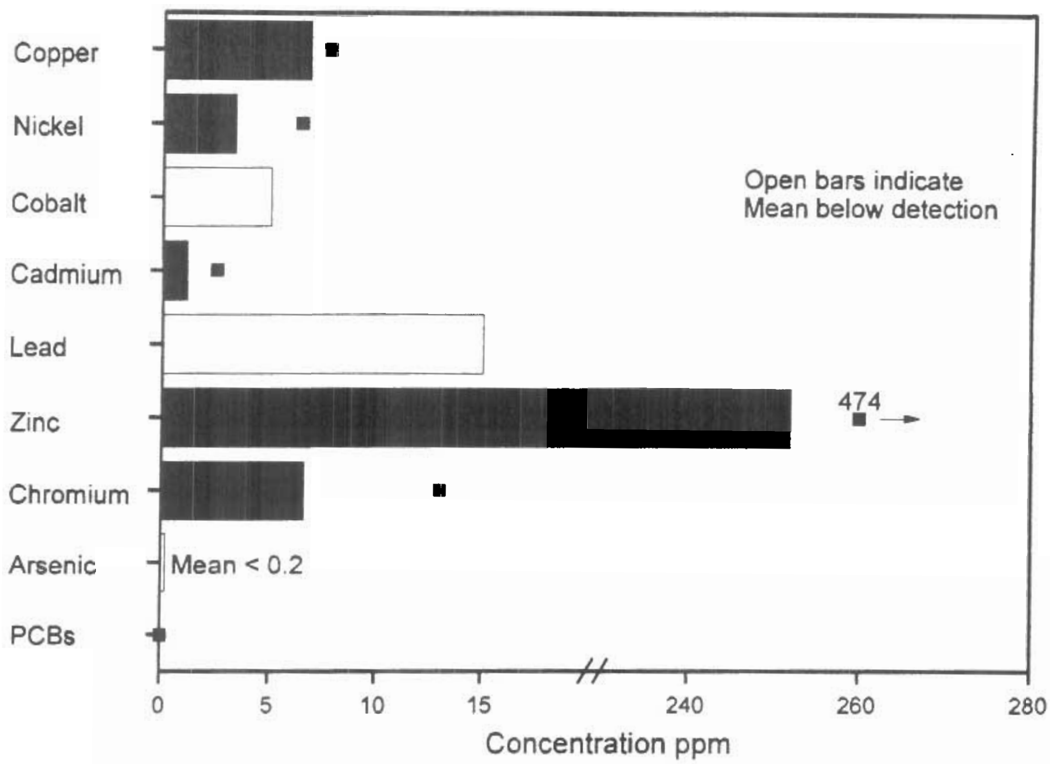


Figure V-2: Mean and Maximum Concentrations of Inorganic Elements and PCBs in Background Vegetation

For the purpose of the current study, mean background concentrations of inorganic elements for plants in the Iqaluit region are either the mean of the five results (calculated using half the detection limit for those elements not detected) or the analytical detection limit for those compounds not detected in any of the plant samples (cobalt, lead and arsenic). Those plants, collected from the Upper Base or from the dump sites, that contained more than twice the mean background concentration of an inorganic element are considered in the following assessment to indicate environmental impact. The inorganic element Impact Criteria, developed specifically for Iqaluit and defined in the current study as twice the mean background plant concentration, are presented in Table V-1.

Table V-1: Impact Criteria for Inorganic Elements in Plants Collected near Iqaluit

Element	Copper	Nickel	Cobalt	Cadmium	Lead	Zinc	Chromium	Arsenic
Concentration (ppm)	14	13	10	2.2	30	500	13	0.4

Eight of the 20 background marine sediment samples were analyzed for inorganic elements. Concentrations of cadmium, lead and arsenic were below the limits of detection in all sediment samples analyzed. Mean concentrations of all other analytes in the sediments were less than the Interim Draft Environment Canada Marine Sediment Quality (ECMSQ) Criteria.

In summary, levels of chromium and zinc in background soils were elevated above the CCME Assessment Criteria, but did not approach the DCC. Levels of all inorganic analytes in background marine sediments were not elevated above the ECMSQ criteria. Background plants contained zinc at concentrations significantly elevated above background soil concentrations. The concentrations of all other inorganic analytes in background plants were below those detected in background soils. Impact criteria for the current investigation were established based on inorganic element concentrations in background plants.

ii. Polychlorinated Biphenyls (PCBs)

All eight background soil samples were analyzed for PCBs as Aroclors by high resolution mass spectrometry. The mean concentration of PCBs in background soils (0.0013 ppm) was two orders of magnitude lower than the CCME Assessment Criterion (0.1 ppm, see Figure V-1). The maximum concentration of PCBs detected in a background soil sample (0.007 ppm) was 14 times lower than the assessment criterion.

All five background plant samples were analyzed for PCBs by high resolution mass spectrometry (Figure V-2). The mean concentration of PCBs detected in the background plants (0.00059 ppm) was less than half the mean for background soils (0.0013 ppm). Under the current assessment, environmental impact is exhibited by plants containing PCBs at a concentration greater than twice the mean concentration in background plants (0.0012 ppm).

All 20 background marine sediments were analyzed for PCBs. Six of the twenty samples did not contain PCBs at detectable levels, based on the Aroclor analyses. The remaining samples had a total Aroclor concentration in the range of 0.05 to 4.5 ppb. The mean concentration of PCBs as Aroclor calculated for the background marine sediments (0.77 ppb) did not approach the threshold effect level of the EC Marine Sediment Quality Guidelines.

The concentration of PCBs in background soils did not approach the CCME Assessment Criteria. PCB concentrations in background marine sediments were much lower than threshold effect level of the marine quality criteria. The concentration of PCBs detected in background plant samples was lower than the concentration detected in background soils. Based on PCB concentrations in plants collected from locations near Iqaluit not influenced by human activities, plants collected from the sites currently under investigation containing PCBs at a concentration over 1.2 ppb will be considered to demonstrate environmental impact.

B. Upper Base

1. General

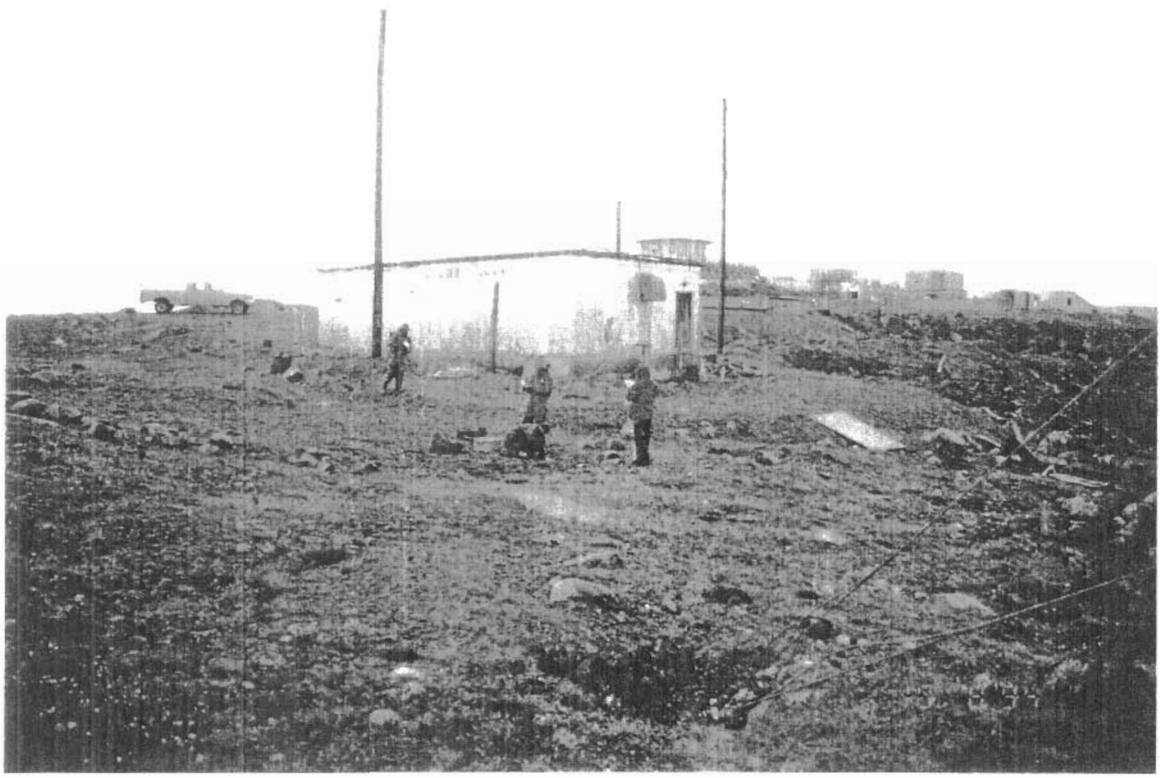
The Upper Base is situated atop a mountain overlooking the town of Iqaluit 3.5 km to the southeast (63° 47' N, 68° 33' W, 180 m asl; Map V-1). The former Pole Vault communications facility and long-range radar station occupy about 220 hectares which can be accessed from the only road traveling north out of town, through the North 40 and up to the top of the steep slope. The site is surrounded by rolling hills which are covered with vegetation typical of tundra heath. In areas where the substrate consists of more than just exposed granite bedrock, there is a thin peat-like layer over a thin soil layer, which supports the more common species of plants, including willows (*Salix* spp.), sedges (*Carex* spp.), heather (*Cassiope tetragona*) and blueberries (*Vaccinium* sp.). Caribou are a common sight on the hills surrounding the site, particularly in winter.

In 1951 the US Air Force returned to the air base established at Frobisher Bay during W.W.II as part of the North Atlantic Ferry Route (Fletcher 1990). The perceived threat to North America from Soviet airborne attack during the early stages of the Cold War had increased awareness of the vulnerability of the polar regions; in the eyes of American strategists the Arctic represented the Achilles tendon of North American defence (Grant 1988). Development of operations like Strategic Air Command (SAC), a web of international defensive air bases operated by the US Air Force (Anderton 1975), and the Distant Early Warning Line, a series of radars surveying the northern skies for enemy aircraft (Fletcher 1990), was undertaken in the forties and fifties as a result. The air base at Frobisher Bay, which had been maintained after the war by the Royal Canadian Air Force, was expanded and upgraded with the return of USAF in '51 (DND 1958). Integration of DEW Line and northern SAC operations required reliable communication with southern operations. The Pole Vault Tropospheric Scatter Line, a series of communications facilities extending from Frobisher Bay to Gander, Newfoundland, was installed in 1954 and 1955 to meet this requirement. Military facilities at Frobisher Bay expanded with the construction of six communications buildings including Pole Vault Building 222 (Photograph V-1), Building S-28 (Photograph V-2) and two remote receiver and transmitter sites above the base (Map V-2). These facilities permitted reliable voice and teletype communication with the South through the use of ultra-high frequency FM radio signals (Fletcher 1990). The round, 9 m diameter dishes present outside Pole Vault Building 222 acted as antennae for the transmission of signals. The rectangular billboards previously present at the site were highly sensitive receivers of transmissions from the South (Fletcher 1990).

With the construction of long-range radar stations along the Pole Vault Line in 1955, the Upper Base, which consisted of the six original Pole Vault communications facilities and the new radar station (the Main Site), became one of the four largest stations in the Pole Vault system (Photograph V-3). The Main Site had both search and height-finding radars under geodesic domes elevated on towers (Photograph V-4) and were manned by approximately 130 men (Fletcher 1990). The rectangular buildings connected by long heated passageways that make up the Main Site were fashioned after the design for older radar sites constructed in Alaska. These included the radar facilities, power plant, administration building, post exchange (PX), sleeping quarters (BQ), an eating mess, warehouses, recreation and laundry facilities (see Map V-3). Additional facilities included a sewage system consisting of a pipeline, a holding tank and outfall, a water supply lake and its associated pump house and a POL tank with pumphouse to fuel the generators. A landfill for waste disposal was located off the edge of a cliff just outside the main gate to the site. With the advent of satellite communication, the facilities along the Pole Vault Line became obsolete and were abandoned in 1974. The facilities at the Upper Base were left intact.

After its abandonment the site became a focus of local interest. Scavenging of materials from the Upper Base is a common method of obtaining construction materials for small projects. Complete buildings have also been removed from the site and transported into town to serve as residences or storage buildings (Photograph V-5). The remaining buildings make a maze in which regular paint ball games are held. The site is often used for target shooting and the buildings are pock-marked with many bullet holes. Picnics and berry-picking include some of the more social activities that occur at the Upper Base (Paul Smith, personal communication)

Photograph V-1: Aerial view of Pole Vault Building 222 located to the southeast of the Main Site at the Upper Base



Photograph V-2: Communications Building S-28 situated on the southeast edge of the Main Site, Upper Base.