CAPE CHRISTIAN
LONG TERM MONITORING PLAN

Revised February 28, 2017

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Appendices

1.0 Introduction

From 1954 to 1974, the United States Coast Guard operated a Long Range Navigation (LORAN) communications station at the Cape Christian site. The site was abandoned in 1975 without decommissioning. There were some remedial works carried out at the site in the past. However, there still exist significant environmental concerns at the site.

INAC has completed the site assessment of the site, developed a Remediation Action Plan (RAP), tendered and awarded contract for the RAP implementation and remediated between 2008 and 2010. The remediation involved the demolition and disposal of buildings, structures and other debris; the clean up of hazardous materials; and the excavation and disposal of metals and petroleum hydrocarbon contaminated soils.

1.1 Location

The Cape Christian site is located at Latitude 70° 31' N and Longitude 68° 17' W, near the mouth of the River Clyde, on the northeast coast of Baffin Island, in the Territory of Nunavut. It is situated approximately 16 km northeast of the Hamlet of Clyde River (Figure 1 a & b)

1.2 Site Characteristics

The Cape Christian station comprised of five (5) buildings (the main station, garage, hazmat building, terminal building, and the survival hut). Six (6), Aboveground Storage Tanks (AST) (102,600L each) were also installed at the site for fuel storage. The ASTs are connected to the main station with pipes. Several oil barrels were also supplied to the station during its years of operation. The barrels, following the use of oils in them, were buried at the site. The station was abandoned in 1974.

Senes Consultants Limited conducted a Human Health Risk Assessment (HHRA) (Screening Level) and Ecological Risk Evaluation (ERE) on Cape Christian site and produced reports in November 2003 to characterize the risk levels at the site. The HHRA report shows high risk levels for the adult and composite receptors for carcinogenic contaminants, namely PCBs. The report also suggested that the Cape Christian site may pose a potential safety risk to human receptors. The ERE score is also high, showing that Cape Christian, could potentially pose some chemical and physical hazards to the humans and the environment.

A number of Environmental Site Assessments (ESAs) have been carried out at the site by Environmental Services group (ESG), PWGSC and Earth Tech. The site assessments identified 5 deteriorating buildings, 6 ASTs, power poles with associated cables, and piping, an equipment yard containing several abandoned equipment, 2 surface dumps containing partially buried /surface placed debris, a water supply reservoir, and about 8 worked areas containing fully/partially buried barrels and debris.

Other environmental issues identified at the site include hazardous materials (lead acid batteries, compressed gas cylinders, asbestos, and building materials painted with polychlorinated biphenyls (PCBs) amended paints, soils contaminated with metals, soils contaminated with petroleum hydrocarbons (PHC), and soils contaminated with PCB's.

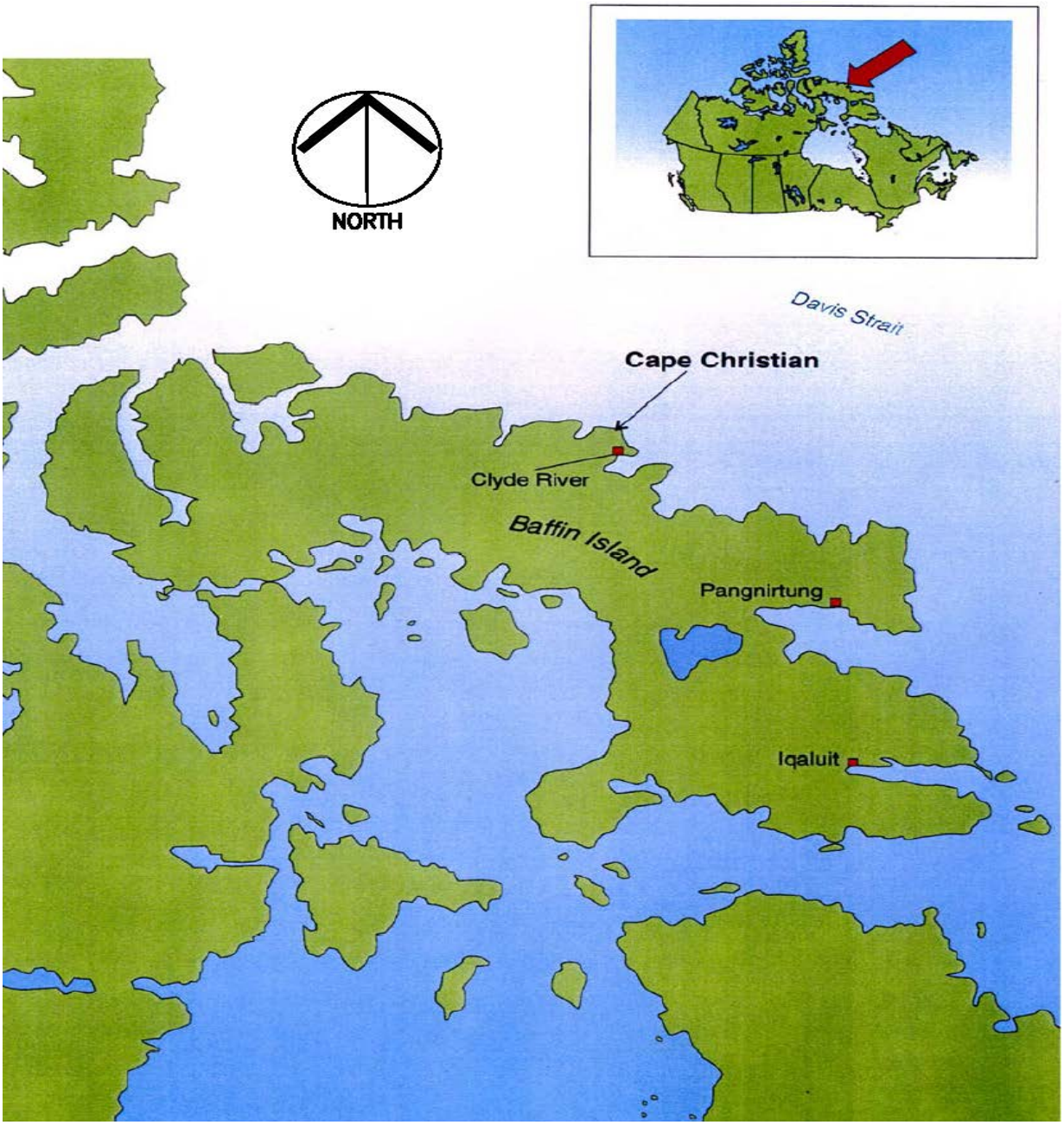


Figure 1a: Cape Christian Location Map

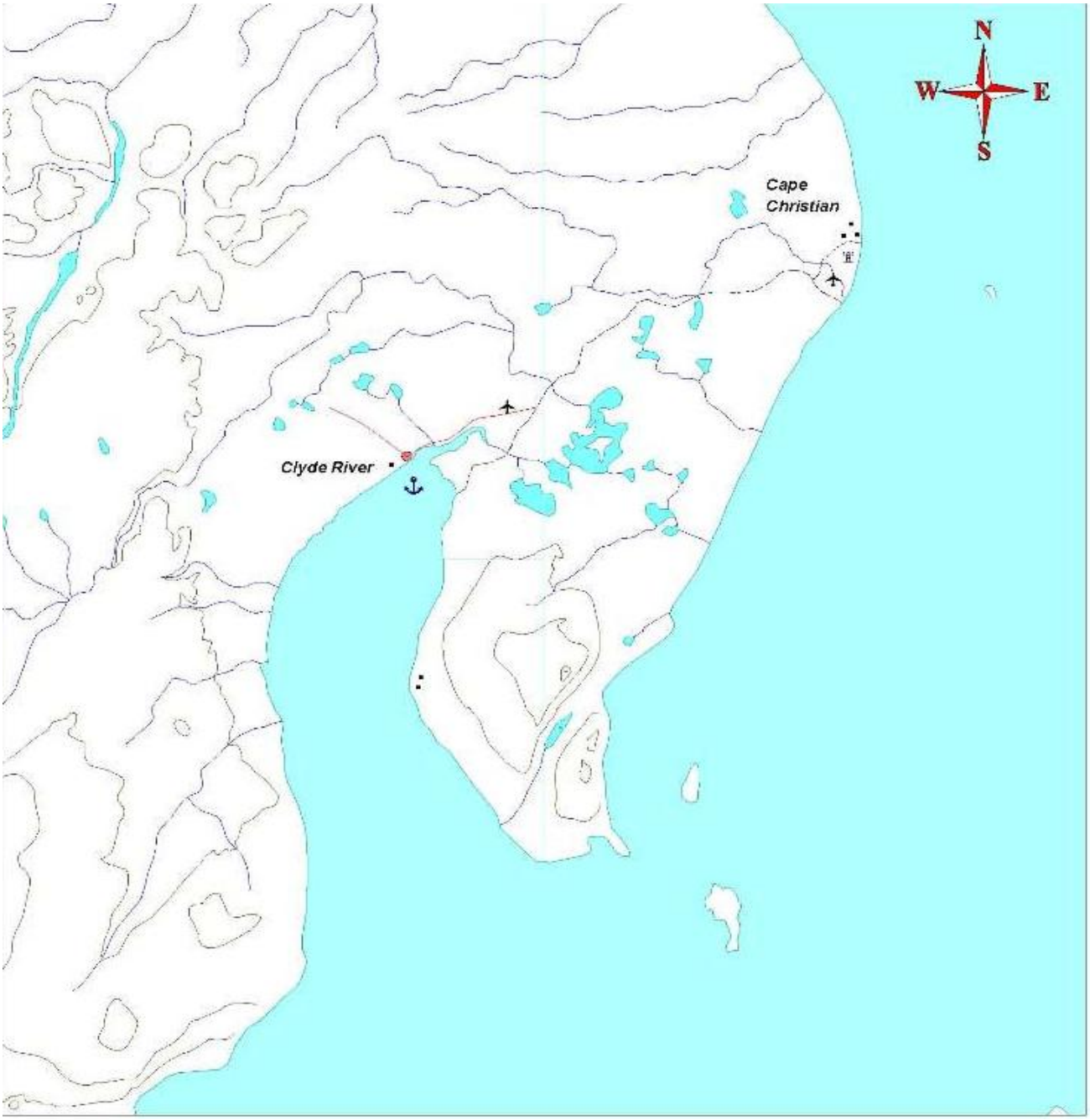


Figure 1b: Cape Christian Location Map – Cape Christian relative to Clyde River

1.3 Climate

The Cape Christian Site has a humid, cold arctic climate, marked by short cold summers and long winters. Meteorological data collected at Clyde River between 1933 and 1990 identify mean daily temperatures ranging from -28oC in February to +4.2oC in July. The average mean daily temperature over the year is 12.4°C. The annual precipitation of 225.6 mm falls in this area, 87% of which is in the form of snow.

1.4 Flora and Fauna

The flora in this region is characterized by a sparse vegetative cover of mixed low-growing herbs and shrub. Typical plants found in this region include moss, purple saxifrage, arctic willow, kobresia, sedge, and arctic poppy.

The wildlife typically found in this region includes arctic hare, arctic fox, lemming, and caribou. Marine mammals, such as walrus, seal, whale, and polar bears are also common. King eider, rock ptarmigan, northern fulmar, plover, hoary redpoll and snow bunting are representative birds, which can be found in this area.

2.0 Monitoring Program

After the completion of remediation at the Cape Christian site the only structure that was constructed and remains at the site is the Non-Hazardous Waste Landfill (NHWL). Due to the small amounts of metals and PCB contaminated (TIER II) soils at the site, there will not be any need for a Secure Soil Disposal Facility (SSDF).

The monitoring program for the Cape Christian site will be in accordance to the INAC's Abandoned Military Site Remediation Protocol, AMSRP (2008) involving (i) baseline and post-closure monitoring of the NHWL; and (ii) the natural environment monitoring of the site.

2.1 Non-Hazardous Waste Landfill Monitoring

2.1.1 Baseline Monitoring

The baseline monitoring procedure recommended by INAC AMSRP (2008) involved soil monitoring and groundwater monitoring.

- ***Soil Monitoring:***

  INAC AMSRP (2008) specifies that, for baseline monitoring, soil samples be taken at a grid spacing of 50 m x 50 m. For the Cape Christian Site, a minimum of four samples were taken around the perimeter of the proposed landfill taking into consideration, the site topography. The locations of these soil samples are included in Appendix C. Refer to the 2011 Long Term Monitoring Report for more information.

  The samples were analyzed for:

  - Inorganic elements: arsenic, cadmium, chromium, cobalt, copper, lead, nickel, and zinc;
  - Polychlorinated biphenyls (PCBs); and
  - Hydrocarbon Fractions, F1, F2, F3 and F4.

These data supplements the soil information collected during the assessment phase of the site and is used as the baseline soil data to which subsequent monitoring data would be compared.

- ***Water (Runoff) Monitoring:***

  Water samples were collected (following spring melt) from locations that could hold water during spring melt.

  Water samples were analyzed for:

  - Petroleum Hydrocarbon Fractions, F1 and F2
  - Total and dissolved metals
  - Major ions, hardness, total dissolved solids, total suspended solids
  - pH and conductivity
  - PCBs

These data supplements the surface water information collected during the assessment phase of the site and is used as the baseline surface water data to which subsequent monitoring data would be compared.

2.1.2 Post –closure monitoring of the NHWL

- ***Design***

  The NHWL was designed to contain non-hazardous materials only. It was constructed on native ground with the organic matter stripped and consists of four perimeter berms constructed of granular material. The non-hazardous waste was placed in the landfill in layers consisting of 0.5 metre lifts of waste covered by 0.15 metres of granular fill. Once all the layers were completed a final cover consisting of a minimum of 1.0 metres of granular fill was used to cap the landfill. See Appendix B for a detailed schematic of the design.

- ***Contents***

  The NHWL at Cape Christian contains the following:

  - Tier I contaminated soil (see Table 1)
  - F3 and F4 fraction hydrocarbon contaminated soil
  - Non-hazardous demolition debris, such as timbers, plywood, and sheet metal
  - Non-hazardous site debris, such as scrap metal and wood
  - Non-hazardous debris/soil excavated from landfills
  - Creosote timbers

- Double-bagged asbestos

Table 1: DEW Line Cleanup Criteria Tier I Contaminant Criteria

Parameter	Criteria
Lead	200 to 500 ppm
PCBs	1 to <5 ppm

- ***Monitoring Requirements***

The NHWL will be monitored by:

1) Visual Monitoring
   - This will check the physical integrity of the NHWL and look for evidence of settlement, erosion, frost action, animal burrows, vegetation, staining, vegetation stress, seepage points, exposed debris, and condition of monitoring instruments (Appendix E contains a Visual Monitoring Checklist).
   - Photographs will be taken to document the condition of the NHWL and substantiate the recorded observations.

2) Active Layer Water Monitoring
   - Samples will be taken from the 4 monitoring wells (Appendix D) installed around the NHWL. These samples will be analyzed and the results will be compared to those from background samples. The parameters that will be analyzed include:
     - Petroleum Hydrocarbon Fractions, F1 and F2
     - Total and dissolved metals
     - Major ions, hardness, total dissolved solids, total suspended solids
     - pH and conductivity
     - PCBs

3) Soil Monitoring (as required)
   - Soil sampling will be limited to locations where seepage or staining has been identified as part of the visual inspection. When required soil samples will be collected over the interval of 0 to 0.15 metres and 0.35 to 0.50 metres depth. The parameters that will be analyzed include:
     - Petroleum Hydrocarbon Fractions, F1 to F4
     - Arsenic, Cadmium, Cobalt, Chromium, Lead, Nickel, and Zinc
     - PCBs

2.2 Natural Environment Monitoring

The natural environment was assessed immediately after site remediation. Both site specific and regional information were collected. Full details of the site specific data and

regional data that are required can be found in the INAC AMSRP (2008). For the Cape Christian site, the required natural environment monitoring data have been incorporated into Appendix E – the Visual Monitoring Checklist.

The natural environment monitoring data was collected at the first visual inspection, completed immediately after site remediation and will be collected during subsequent site visits.

2.3 Monitoring Frequency

The post construction monitoring frequency will follow the schedule recommended in the INAC AMSRP (2008). The three phases recommended by the protocol are:

- Phase I: years 1, 3 and 5
- Phase II: years 7, 10, 15 and 25
- Phase III: beyond 25 years *(if required)*

Monitoring at the Cape Christian site began in 2011. Phase I monitoring took place in years 2011, 2013, and 2015. An evaluation of phase I monitoring data was carried out at the end of the 2015 program and phase II monitoring was recommended. The results can be found in monitoring reports submitted with annual reports under the Nunavut Water Board Water Licence.

Phase II will be carried out during the years 2017, 2020, 2025 and 2035. At the completion of the 25 year monitoring program another evaluation will take place and the need for continued monitoring (phase III) will be assessed.

The monitoring schedule is outlined in Table 2 below.

Table 2: Monitoring Schedule

Year	Site Monitoring Scheduled (X)	Year	Site Monitoring Scheduled (X)
2011	X	**2024**	
2012		**2025**	X
2013	X	**2026**	
2014		**2027**	
2015	X	**2028**	
2016		**2029**	
2017	X	**2030**	
2018		**2031**	
2019		**2032**	
2020	X	**2033**	
2021		**2034**	
2022		**2035**	X
2023			

2.4 Monitoring Plan Summary

The monitoring plan at Cape Christian began in 2011. The area to be monitored is the NHWL; the parameters that will be monitored include visual characteristics and groundwater. The monitoring requirement for the NHWL is summarized in the tables below:

Table 3: General Monitoring Requirements

Area	Monitoring Parameter			
	Visual	Groundwater	Soil	Temperature
NHWL	X	X	As required	

Table 4: Specific Monitoring Requirements

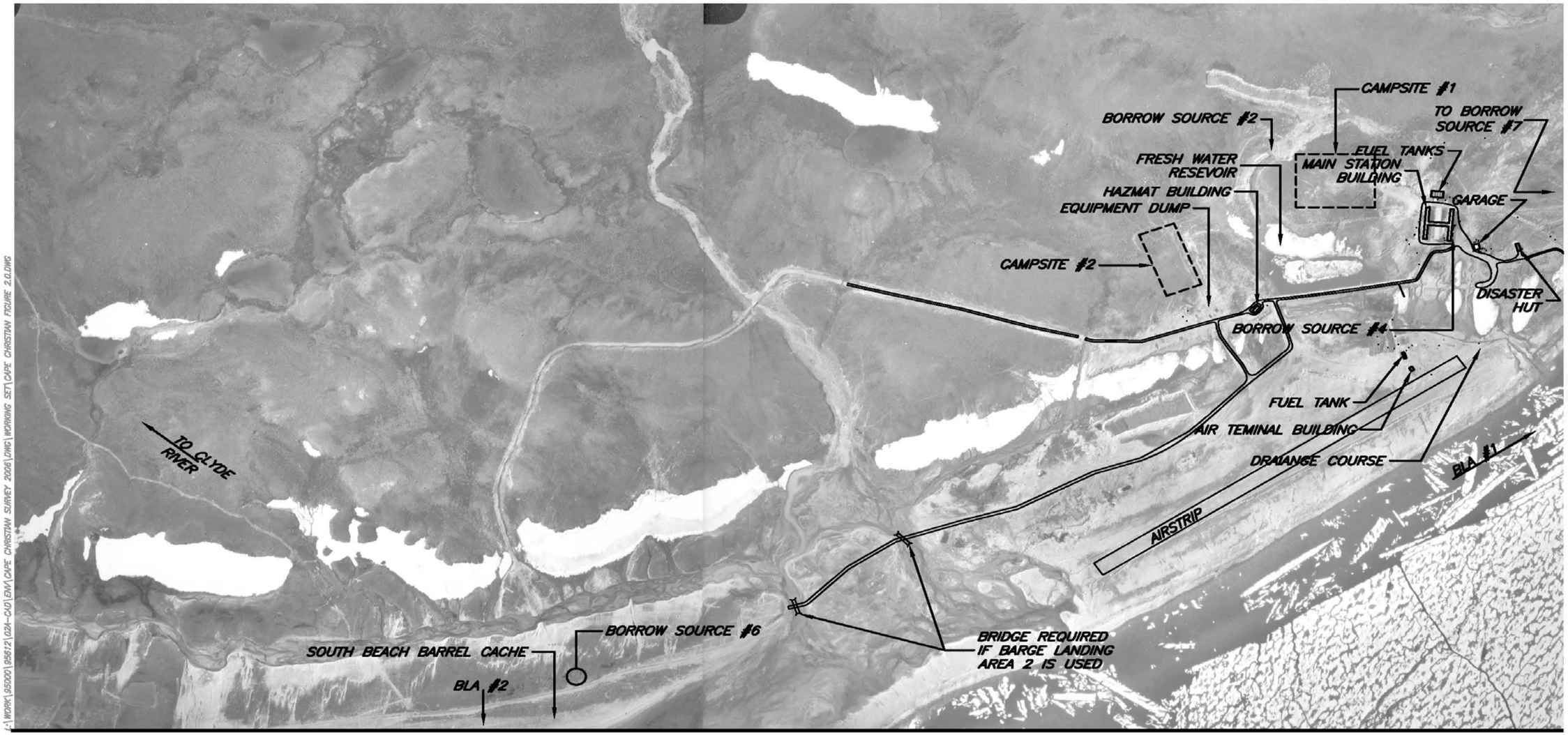
Area	Groundwater		
	ID	Notes	Install Date
NHWL	MW-1	Down-gradient	2009
	MW-2	Down-gradient	2009
	MW-3	Up-gradient	2009
	MW-4	Up-gradient	2010

3.0 Quality Assurance/Quality Control

All sampling, sample preservation and analyses will be conducted in accordance with methods prescribed in the current edition of "Standard Methods for the Examination of Water and Wastewater". All analysis will be performed in a Canadian Association of Environmental Analytical Laboratories (CAEAL) Accredited Laboratory.

Quality Assurance/Quality Control (QA/QC) will be consistent with CAEAL regulations and guidelines. At least 20% of samples will be taken and analyzed in duplicate and all appropriate QA/QC data will be generated and reported.

Appendix A: Cape Christian Site Layout



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Date: January, 2006
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EarthTech
A Tyco International Ltd. Company

NOTE: BLA = BARGE LANDING AREA

INDIAN AND NORTHERN AFFAIRS CANADA

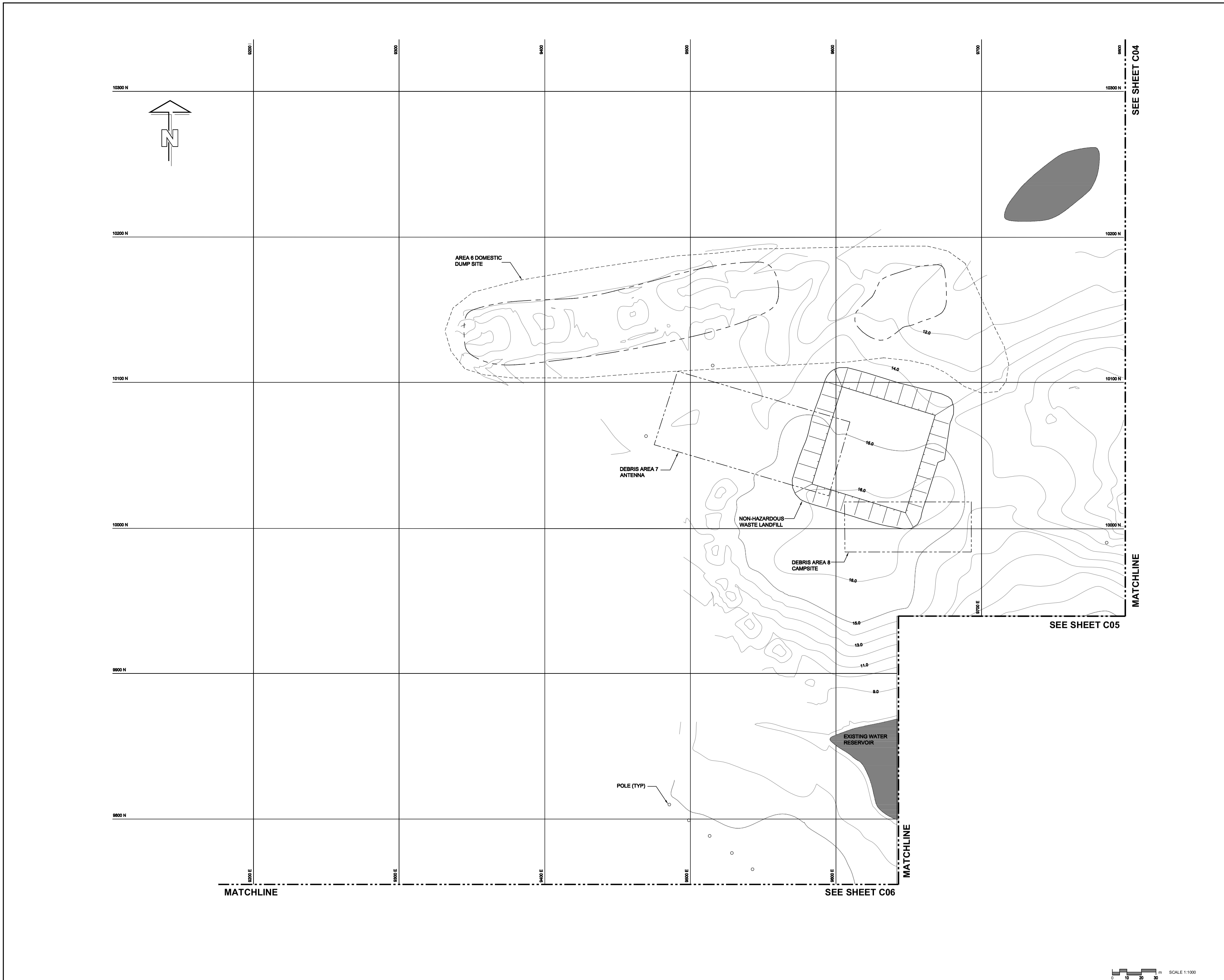
CAPE CHRISTIAN LORAN STATION

OVERALL SITE PLAN

FIGURE 2.0

Appendix B: Non-Hazardous Waste Landfill Location Map


N
STATION AREA WEST
MAIN STATION AREA
AIRSTRIP AREA
BEACH AREA NORTH
BEACH AREA SOUTH
DAVIS STRAIT
DOMESTIC WASTE DUMP
MAIN STATION ASTS
PROPOSED LANDFARM
ARCHAEOLOGICAL AREA
DISASTER HUT
GARAGE
MAIN STATION BUILDING
PROPOSED NON-HAZARDOUS WASTE LANDFILL
EXISTING WATER RESERVOIR
AIRPORT TERMINAL BUILDING
WORKED AREA 1
HAZARDOUS MATERIALS BUILDING
BEACH AST
EXISTING ROAD
EQUIPMENT DUMP
AIRSTRIP
WORKED AREA 7
EXISTING ROAD



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Western Region

Indian and Northern Affairs Canada / Affaires indiennes et du Nord Canada

Canadä

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GENERAL NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.
2. SITE PLANS AND TOPOGRAPHIC INFORMATION ARE BASED ON AIR PHOTOS AND SURVEY PROVIDED BY EARTH TECH CANADA INC. CURRENT CONDITIONS MAY NOT BE EXACTLY AS SHOWN.
3. INFORMATION REGARDING DELINEATION AND ANALYTICAL TESTING OF CONTAMINATED SOIL PROVIDED BY EARTH TECH CANADA INC.
4. DO NOT SCALE DRAWING.

LEGEND

- BODY OF WATER
- DEBRIS AREA
- DUMP BOUNDARY

UMA | AECOM

REVISIONS	DESCRIPTION	DATE
C	TENDER SUBMISSION	07/03/28
B	99% DESIGN SUBMISSION	07/03/28
A	90% DESIGN SUBMISSION	07/03/02

A detail number / number du detail
B source drawing no. / de dessin no.
C detail on drawing no. / detail sur dessin no.

project title / titre du projet
CAPE CHRISTIAN REMEDIATION PROJECT NUNAVUT

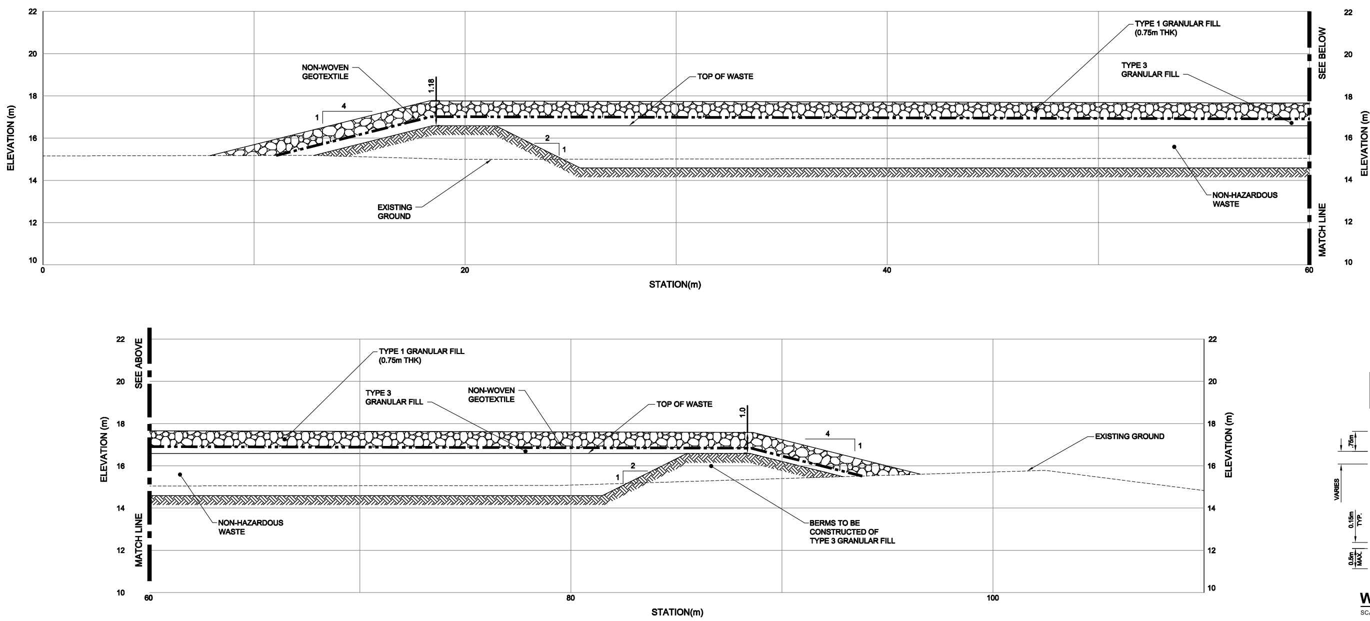
drawing title / titre du dessin
STATION AREA WEST

designed by / concu par: N. OKE
drawn by / dessine par: N. PFEFFERLE
approved by / approuve par: R. SCHMIDTKE
PWGSC Project Manager / Administrateur de Projets TPSGC: B. THOMPSON
scale / echelle: 1:1000
project no. / projet no.: 419818
date: MARCH 2007
sheet / feuille: C03 OF 10

B1 1000 x 707

2577-340-00_05-B-1003_RA

Appendix C: Non-Hazardous Waste Landfill



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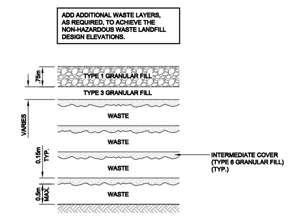

WASTE PLACEMENT DETAIL

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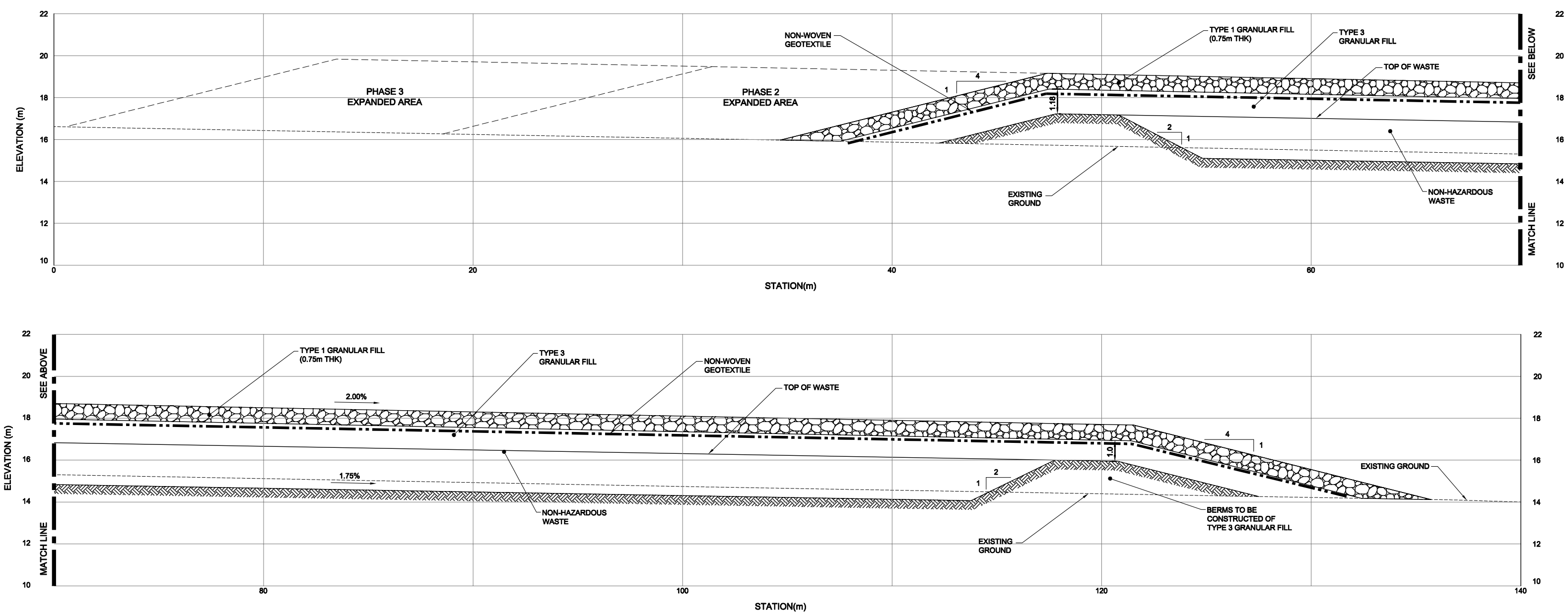

SECTION B C08

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project title / titre du projet: CAPE CHRISTIAN REMEDIATION PROJECT NUNAVUT

drawing title / titre du dessin: NON-HAZARDOUS LANDFILL SECTIONS

designed by / concu par: D. GILBERTSON
drawn by / dessine par: B. HASSLER
approved by / approuve par: R. SCHMIDTKE
PWGSC Project Manager / Administrateur de Projets TPSGC: B. THOMPSON
scale / echelle: AS SHOWN
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date / date: FEBRUARY 2007
sheet / feuille: C09 OF 10

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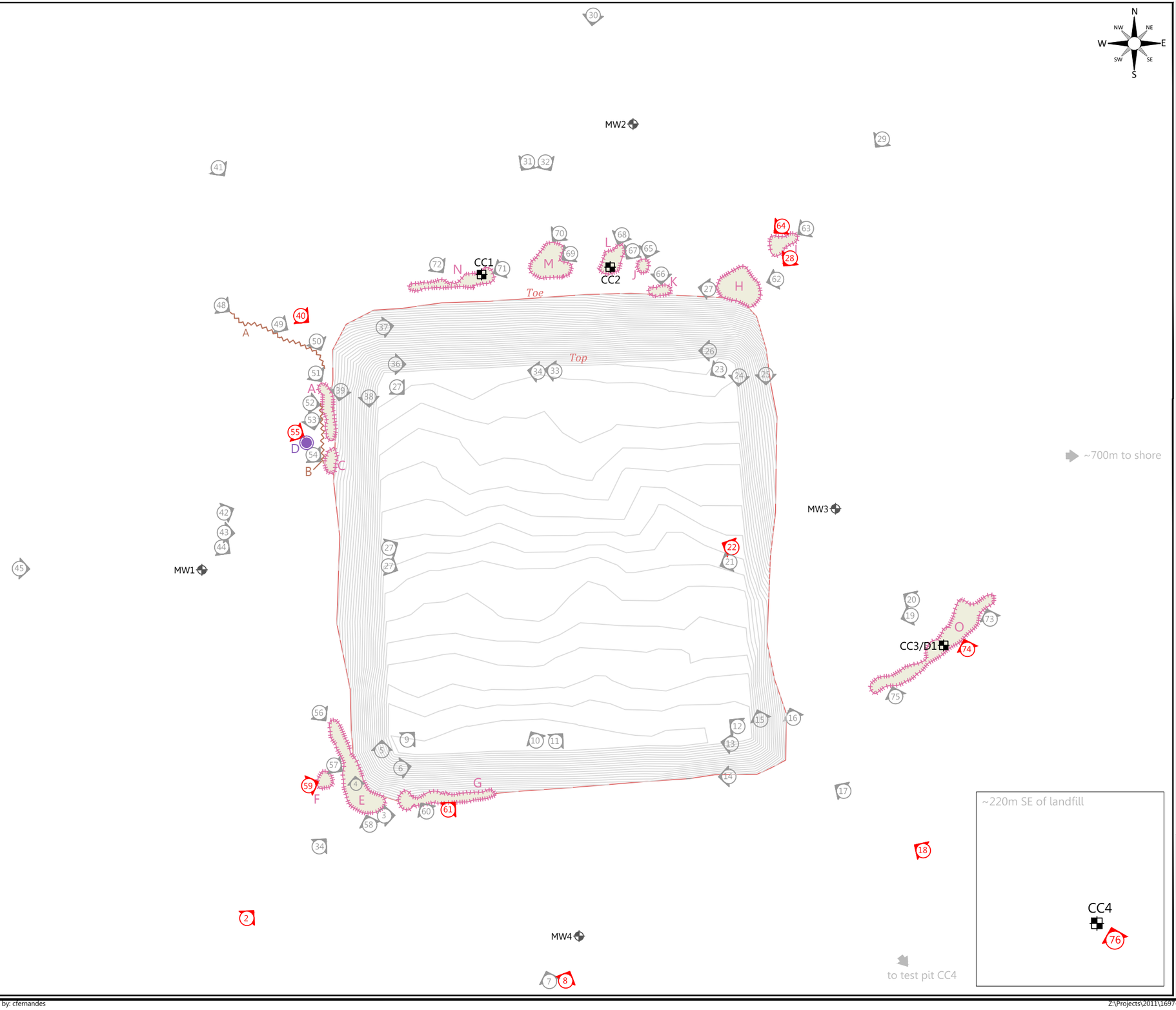

Legend

- MW — Monitoring Well Locations
- TP — Test Pit Locations
- 25 — Picture Viewpoint Number
- 8 — Viewpoint Photograph Included in Appendix F
- A — Staining or Seepage
- Sinkhole
- Settlement
- A — Feature Reference Letter

Note:
Picture numbers refer to photograph names as they appear on the attached cd-rom.

Title:
Non-Hazardous Waste Landfill

FRANZ ENVIRONMENTAL INC.
CONSULTING ENGINEERING TECHNOLOGIES

Project:
Cape Christian
1697-1101

Date:
January 2012

Client:
Aboriginal Affairs and Northern Development Canada

Scale 1:750
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metres

Figure A-1

last saved by: cfernandes

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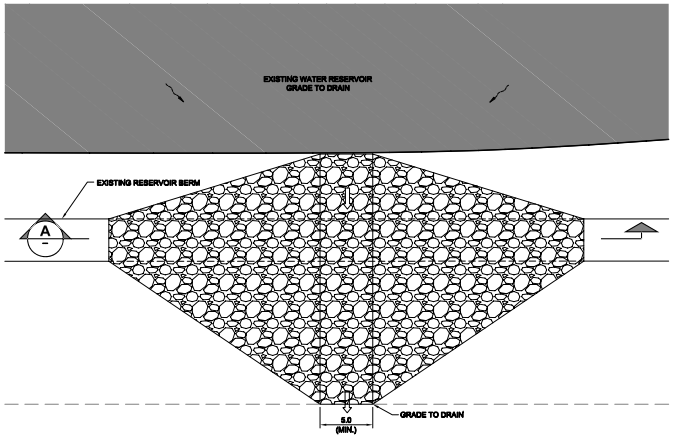
Appendix D: Monitoring Wells



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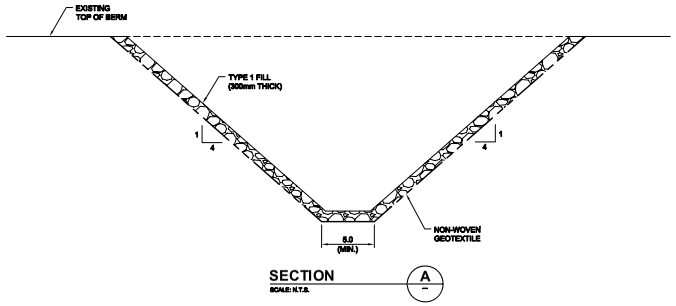

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WATER RESERVOIR PERMANENT BREACH DETAIL
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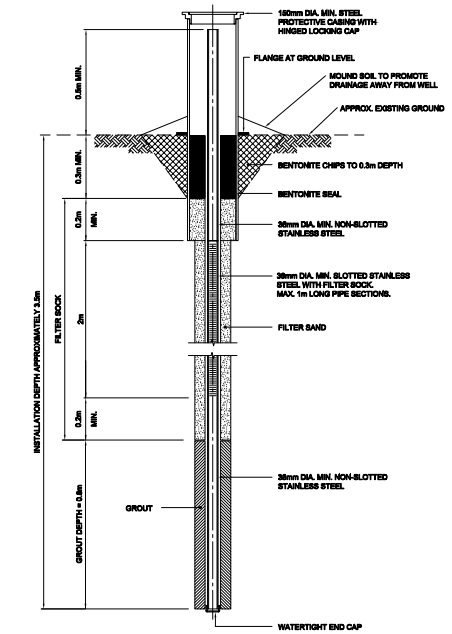

TYPICAL MONITORING WELL / BACKGROUND MONITORING WELL
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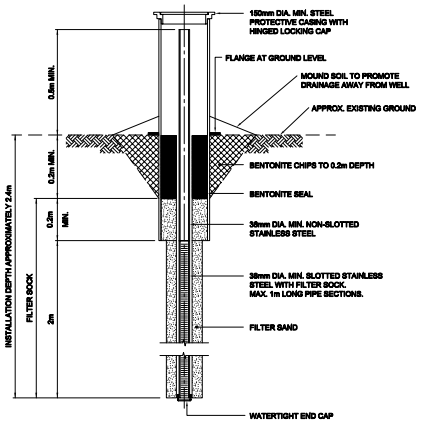

TYPICAL MONITORING WELL / BACKGROUND MONITORING WELL
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SCALE: N.T.S.

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project title / titre du projet
CAPE CHRISTIAN REMEDIATION PROJECT NUNAVUT

drawing title / titre du dessin
GENERAL DETAILS

designed by / conçu par	N. OKE
drawn by / dessiné par	N. PFEIFERLE
approved by / approuvé par	R. SCHMIDTKE
PWGSC Project Manager / Administrateur de Projets TPSGC	B. THOMPSON
scale / echelle	AS SHOWN
project no. / projet no.	419818
date	MARCH 2007
sheet / feuille	C10 OF 10

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Appendix E: Visual Monitoring Checklist

Cape Christian
VISUAL MONITORING CHECKLIST

Date:	
Landfill:	

Visually assess the landfill for the following items & provide a photograph record

1. Erosion	Answer
a) Is erosion occurring on the surface or berms of the landfill?	
i) Are there preferred drainage channels?	
ii) Is there sloughing of material?	
b) What is the extent of the erosion? *(percentage of surface area)*	
i) Is it localized or continuous?	
c) Where is the erosion occurring? *(i.e. along the toe, on the surface, through the berms)*	
d) Explanation: *(i.e. evidence of significant surface water run-off, poor material)*	

2. Settlement	Answer
a) Is there differential settlement occurring on the surface?	
i) Are there low areas or depressions?	
ii) Are voids forming?	
b) What is the extent of the settlement? *(percentage of surface area)*	
i) Is it localized or continuous?	
ii) How deep is it?	
c) Where is the settlement occurring? *(i.e. near berms, near the centre of the facility)*	
d) Explanation: *(i.e. evidence of significant surface infiltration, water ponding, snow drifting)*	

3. Frost Action	Answer
a) Is there frost action/damage to the landfill?	
i) Is there exposed debris due to uplift?	
ii) Is there tension cracking along the berms?	
iii) Is there sorting of granular fill?	
b) What is the extent of the frost action? *(percentage of surface area)*	
i) Is it localized or continuous?	
c) Where is the heaving/cracking occurring? *(i.e. along the toe, on the surface, through the berms)*	
d) Explanation: *(i.e. poor material, poor compaction, high water/silt content in cover material)*	

4. Monitoring Instruments

a) What is the condition of the monitoring wells

5. Others - Confirm presence or absence, extent and description of the following

Animal Burrows:

Vegetation:

Staining:

Vegetation Stress:

Seepage Points:

Exposed Debris:

Other observed features:

6. Sketch

7. General Comments