CAM-E, Keith Bay
Long Term Monitoring Plan

Public Services and Procurement Canada

Project number: 60579368 (400)

December 17, 2019

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AECOM: 2015-04-13

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1. Introduction

1.1 Background

AECOM Canada Ltd. (AECOM) was retained by Public Services and Procurement Canada (PSPC), on behalf of Indigenous and Northern Affairs Canada (INAC), to develop a post-construction monitoring plan for the remediated CAM-E, Keith Bay, former Intermediate Distant Early Warning (DEW) Line site (the "site"). The site is located at 68°15.37' N, 88°10.42' W, on the eastern side of Simpson Peninsula, approximately 75 kilometres (km) east of Kugaaruk, Nunavut (NU), formerly Pelly Bay.

The CAM-E site was operated as an Intermediate DEW Line site by the Department of National Defense (DND). Station operations ceased in 1963, and in 1965 the property was transferred to INAC ownership.

The site is divided into two main areas, Area 1 and Area 2. Area 1 consists of the Main Station Area, a small airstrip, and a freshwater lake. Area 2, located approximately 5.6 km south of Area 1, consists of a larger airstrip (Beach Airstrip), a helicopter landing area, a Non-Hazardous Waste Landfill, and a Tier II Landfill.

The locations of the Non-Hazardous Waste Landfill and the Tier II Landfill are shown on **Figure 1** in **Appendix A**.

1.2 Objective

In January, 2017 the Nunavut Water Board issued Type B NWB Licence No. 1BR-KEI722 for remediation activities to be completed at CAM-E. Part J of the license requires the licensee (INAC) to submit a long-term monitoring plan, including Quality Assurance and Quality Control (QA/QC) requirements to the Board at least 60 days prior to undertaking post-closure, long-term monitoring.

This Long-Term Monitoring Plan outlines the scope and frequency of specific tasks to be completed as required by the 2009 INAC Abandoned Military Site Remediation Protocol (AMSRP) for post-construction monitoring.

1.3 Landfill Monitoring Protocol and Requirements

The general components of the long-term monitoring program at CAM-E include:

- Baseline monitoring
- Visual inspection
- Surface and shallow depth soil sampling and analyses
- Groundwater sampling and analyses
- Ground temperature monitoring

The requirements for long-term monitoring, as laid out in the AMSRP, are summarized in **Table 1**.

Table 1. General Landfill Monitoring Requirements

Landfill Type	Baseline Monitoring	Visual Inspection	Soil Sampling	Groundwater Sampling	Thermal Monitoring
New Non-Hazardous Waste Landfill	Soil, Groundwater	√	As required[1]	√	
Regraded Landfill	Soil	√	As required[1]		
Leachate Contained Landfill	Soil, Groundwater	√	As required[1]	√	√
New Tier II Landfill	Soil, Groundwater	√	As required[1]	√	√

Source: INAC, 2009 AMSRP, Table 7.1

Note 1: Soil samples are to be collected at locations of seepage or staining. See Section 1.3.3 for more information.

1.3.1 Baseline Monitoring

To establish baseline contaminant concentrations as a point of comparison for long term monitoring, a baseline soil collection program was completed for the Non-Hazardous Waste Landfill and the Tier II Landfill.

Baseline sampling was completed in 2017 by advancing five test pits at the Non-Hazardous Waste Landfill and seven test pits at the Tier II Landfill. Each test pit was advanced to 0.5 metres (m) where frozen ground was encountered. Samples were collected at surface and 0.5 m.

The soil samples were analyzed for the following parameters:

- Polychlorinated Biphenyls (PCBs)
- Petroleum Hydrocarbon Fractions, F1 to F4
- Inorganic elements: arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc

None of the soil samples reported the presence of metals, PCBs or Petroleum Hydrocarbons at concentrations above the AMSRP remedial objectives, indicating there were no environmental concerns relative to the baseline geochemistry of the soil at the Non-Hazardous Waste Landfill or Tier II Landfill.

An attempt to collect baseline groundwater samples was made in 2017; however, six of the seven wells were either dry or frozen at the time of sampling. MW17-01 at the Non-Hazardous Waste Landfill had a sufficient volume of water to collect a baseline sample in September 2017. An additional attempt at sampling was made in 2018; however, all wells were again either dry or frozen. The groundwater sample collected in 2017 was analyzed for the following parameters:

- Petroleum Hydrocarbon Fractions, F1 and F2
- Total and dissolved metals: arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc
- Major ions, hardness, total dissolved solids, total suspended solids
- pH and conductivity
- PCBs
- Field parameters: pH, conductivity

As there are no groundwater guidelines in the water licence or AMSRP, the results of this groundwater sample will be used to provide a baseline indication of groundwater characteristics, which will be used to assess potential contaminant migration within groundwater during future monitoring events.

Baseline soil sample and monitoring well locations are shown in **Figure 2** in **Appendix A**.

1.3.2 Visual Monitoring

During future monitoring events, the physical integrity of the landfills should be inspected and reported using annotated drawings, as applicable. Observations relating to the following issues should be documented including:

- Settlement
- Erosion
- Frost action, including changes to patterned ground
- Animal burrows
- Vegetation re-establishment and percentage cover
- Soil or water staining
- Vegetation stress
- Seepage points
- Area and depth of ponded water
- Installation conditions

The visual inspection should note the presence or absence of these items, and the extent, with dimensions as applicable. Photographic records are to be provided to document the general condition of the area and to substantiate all recorded observations. Drawings shall be annotated to show the location of each identified feature, the size, and a photographic reference that notes the scale and directional view point.

1.3.3 Soil Monitoring

Soil sampling during post construction monitoring will be limited to locations where seepage or staining has been identified as part of the visual inspection. Soil samples collected during landfill monitoring events should meet or exceed the following requirements:

- Soil samples should be collected over the interval of 0 to 0.15 m, and 0.35 to 0.50 m depth
- Soil samples are to be analyzed for the following constituents:
  - PCBs (polychlorinated biphenyls – Total Aroclor analysis)
  - Petroleum Hydrocarbon Fractions, F1 to F4
  - Inorganic elements: arsenic, cadmium, chromium, cobalt, lead, nickel, and zinc

1.3.4 Ground Temperature Monitoring

During each monitoring event, thermistor data from the Tier II Landfill will be downloaded and the dataloggers re-set. Manual readings will also be taken at that time as a backup in the event of datalogger malfunction. Data logger batteries will be replaced as required. Monitoring reporting will include a plot of ground temperatures versus depth, with clear indication of the 0 degree isotherm, and discussion related to freeze back and active layer depth within the landfill during the period of maximum thaw.

1.3.5 Groundwater Monitoring

During the construction phase, groundwater monitoring wells are installed at all existing landfills classified as moderate environmental risk (Class B landfills) and new landfills. There are no existing landfills at CAM-E requiring monitoring wells, but wells were installed at the two new landfills constructed; the Non-Hazardous Waste Landfill, and the Tier II Landfill. Groundwater monitoring wells were installed hydraulically up-gradient and down-gradient of the landfills.

For baseline and for future monitoring events, the following physical measurements are recorded prior to the collection of groundwater samples from a monitoring well:

- Water elevation
- Total depth of water
- Height of well stick-up
- Depth to bottom of well
- Presence of hydrocarbons
- Hydrocarbon thickness (if appropriate)

Prior to sampling, monitoring wells are purged until groundwater parameters such as pH, temperature and conductivity stabilize. In the event of low recharge volumes, standing water may be sampled and specifically documented.

Following withdrawal of a water sample, other physical measurements recorded include:

- Colour and odour
- pH, conductivity and temperature

The groundwater samples will be analyzed for the following parameters:

- Petroleum Hydrocarbon Fractions, F1 and F2
- Total and dissolved metals: arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc
- Major ions, hardness, total dissolved solids, total suspended solids
- pH and conductivity
- PCBs

1.3.6 Frequency

Conceptually, the landfill monitoring program consists of three phases, as described in detail below.

Phase I: Monitoring of conditions to confirm that physical stability criteria are achieved.

During Phase I, visual inspections of the remediated landfills will be carried out at Years 1, 3, and 5 following completion of remediation. Minor settlement of the constructed landfill cover is anticipated within the first three years of monitoring. It is expected that changes observed after year three are more likely attributed to changes in the site conditions (e.g. changes in temperature or surface water drainage patterns).

An evaluation of the Phase I information would be carried out at the end of five years to confirm that no stability issues had been identified. If required, the monitoring program may be extended with the implementation of Phase II, as described below.

Phase II: Verification of equilibrium conditions established during Phase I.
At the completion of Phase I monitoring and following a review of the results, the requirements for Phase II monitoring will be established. If no significant issues are identified for landfills of low potential environmental risk, monitoring may be discontinued at the conclusion of Phase I.

If additional monitoring is warranted based on the Phase I results, it is recommended that the monitoring frequency in Phase II be carried out according to the following schedule: Year 7, Year 10, Year 15, and Year 25. Year 25 would mark the end of Phase II monitoring.

Phase III: Monitoring for long term issues such as liner integrity, permafrost stability, and significant storm events.

At the end of Phase II, 25 years after implementation of the remedial actions for a given landfill, a re-evaluation of the monitoring program should be carried out prior to initiating Phase III.

Table 2. Long-Term Monitoring Requirements

Monitoring Type	Frequency	Non-Hazardous Waste Landfill	Tier II Landfill
Visual	Once per year in 2020, 2022 and 2024	√	√
Groundwater	Once per year in 2020, 2022 and 2024	√	√
Soil	As Required[1]	√	√
Thermal	Once per year in 2020, 2022 and 2024		√

Note [1]: Soil samples are to be collected at locations of seepage or staining. See Section 1.3.3 for more information.

2. Monitoring Locations

2.1 Non-Hazardous Waste Landfill

The Non-Hazardous Waste Landfill is a new landfill constructed for the disposal of non-hazardous wastes and debris generated and collected during clean-up activities. The landfill is located at the beach area, approximately 200 m west of the airstrip.

The design of this landfill includes perimeter berms and placement of a cover of compacted granular fill over the landfilled material. Three groundwater monitoring wells were installed around the perimeter of the landfill.

The long term monitoring plan will consist of visual monitoring and periodic collection of groundwater samples. Soil samples will be collected as needed based on field observations.

2.2 Tier II Landfill

A Tier II Disposal Facility has been constructed at the CAM-E site for the disposal of Tier II soil excavated during the clean-up. The facility is adjacent to the Non-Hazardous Waste Landfill.

The Tier II Disposal Facility design is a double containment system. The landfill was constructed with the placement of low-permeability, saturated, compacted berms keyed into frozen/saturated ground below existing ground, the installation of a liner system over the berms and along the landfill base, and the placement of a surface liner system over the landfill contents with the placement of sufficient overlying granular fill to promote freeze back of landfill contents. Four groundwater monitoring wells were installed at the landfill perimeter, and five thermistors will be installed within the landfill to monitor ground temperatures.

The long term monitoring plan consists of visual monitoring, periodic collection of groundwater samples and monitoring of subsurface ground temperatures in the berms and in the main body of the disposal facility. Soil samples will be collected as needed based on field observations.

3. Quality Assurance and Quality Control

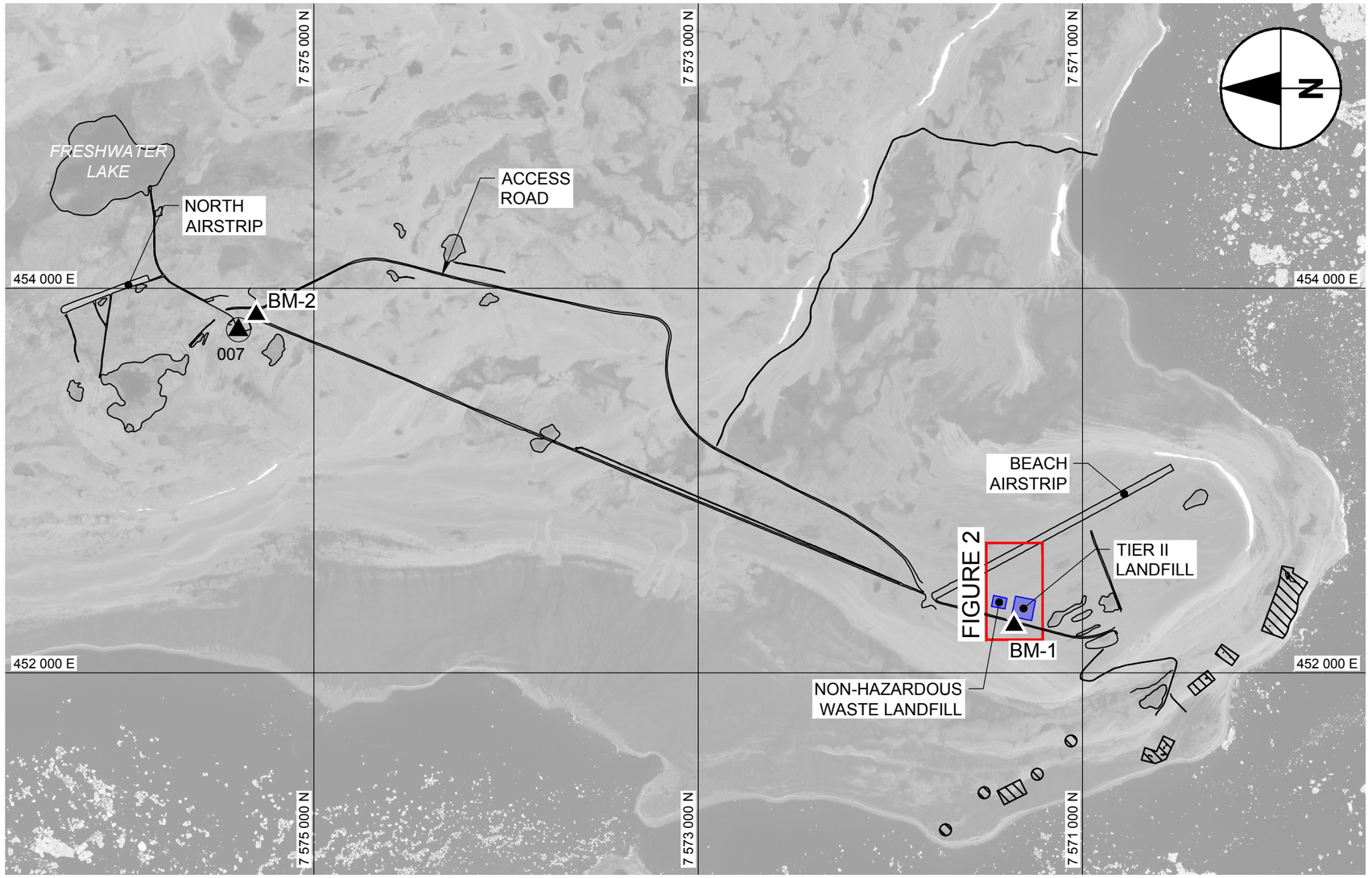
Quality Control (QC) measures used in the collection, preservation, shipment and analysis of samples should include the following:

- Sampling techniques are performed in accordance with standard protocols
- Rigorous field notes are taken during the field work
- All samples are kept cool prior to shipment to the laboratory
- Samples are assigned unique sample control numbers and transported under chain of custody procedures
- The analytical laboratory has proficiency certification issued by the Standards Council of Canada (SCC) for the specific analyses conducted

Standard Quality Assurance (QA) measures established for the remediation included collection of blind duplicate field samples at the rate of approximately 10%. A blind duplicate field sample consists of a second sample collected from the same location as the primary sample and submitted to the analytical laboratory under a separate label such that the analytical laboratory has no prior knowledge that it is a duplicate.

Appendix A

Figures



LEGEND:

- GENERAL LOCATION OF HERITAGE SITE (IDENTIFIED IN ARCHAEOLOGICAL IMPACT ASSESSMENT, GOLDER & ASSOCIATES, 2013)
- EXISTING SURVEY CONTROL MONUMENT
- BM NEW PERMANENT SURVEY CONTROL MONUMENT

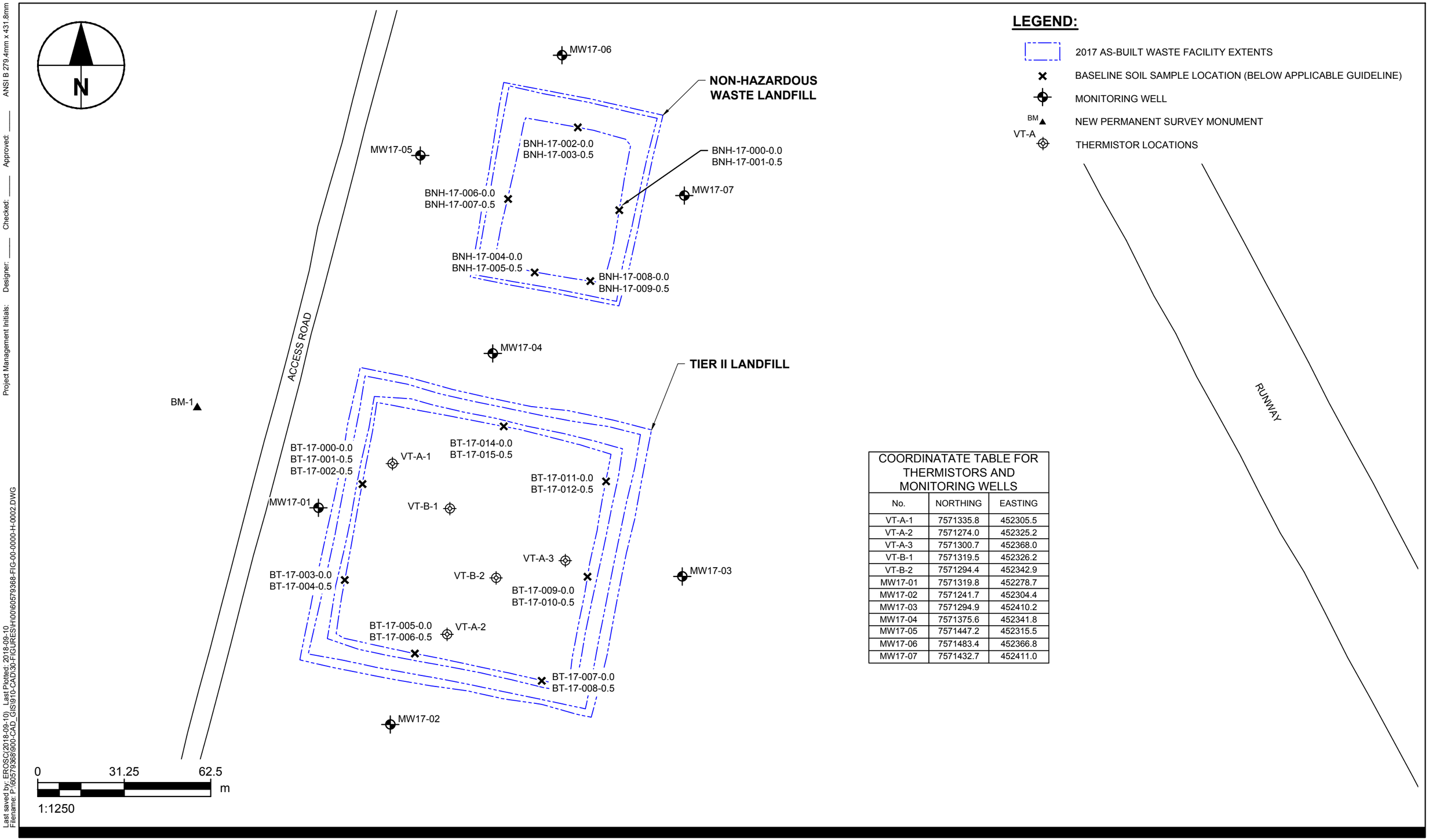
SURVEY CONTROL MONUMENTS		
NO.	COORDINATES	
	LATITUDE	LONGITUDE
007	68°17'16.76" N	88°7'10.13" W
BM-1	68°15'5.54" N	88°9'17.69" W
BM-2	68°17'13.78" N	88°7'3.16" W

CAM-E REMEDIATION PROJECT
LONG TERM MORITORING PLAN
Public Services and Procurement Canada
Project No.: 60579368 Date: 2018-09-12

OVERALL SITE PLAN

AECOM

Figure 1



LEGEND:

- 2017 AS-BUILT WASTE FACILITY EXTENTS
- BASELINE SOIL SAMPLE LOCATION (BELOW APPLICABLE GUIDELINE)
- MONITORING WELL
- BM▲ NEW PERMANENT SURVEY MONUMENT
- VT-A THERMISTOR LOCATIONS

COORDINATATE TABLE FOR THERMISTORS AND MONITORING WELLS

No.	NORTHING	EASTING
VT-A-1	7571335.8	452305.5
VT-A-2	7571274.0	452325.2
VT-A-3	7571300.7	452368.0
VT-B-1	7571319.5	452326.2
VT-B-2	7571294.4	452342.9
MW17-01	7571319.8	452278.7
MW17-02	7571241.7	452304.4
MW17-03	7571294.9	452410.2
MW17-04	7571375.6	452341.8
MW17-05	7571447.2	452315.5
MW17-06	7571483.4	452366.8
MW17-07	7571432.7	452411.0

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CONSTRUCTED FACILITIES
BASELINE SAMPLE AND
MONITORING WELL LOCATIONS

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Figure 2