Defence Construction Canada

Water Use License Amendment and Renewal FOX-3, Dewar Lakes Landfill Monitoring

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This Statement of Qualifications and Limitations is attached to and forms part of the Report.

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1. Post Construction Monitoring Program

1.1 Introduction

FOX-3 Dewar Lakes is a land-locked site located in central Baffin Island, roughly 10 km south of the confluence of the MacBeth River and the Dewar Lakes system. The nearest community is Clyde River, approximately 220 km to the northeast. FOX-3 has been converted to a North Warning System (NWS) Long Range Radar site, and NWS now holds the reserve on the site. Because of ongoing facilities use, most of the infrastructure was not slated for demolition, and no remedial activities were completed within operational areas.

1.2 Background

FOX-3 was originally a main site within the original DEW Line system and was decommissioned in 1991. A Long Range Radar (LRR) station occupies the site. The cleanup included the closure and remediation of the existing landfills. A new landfill for the disposal of non-hazardous wastes generated from demolition and collection of site debris was constructed. In addition, a DCC Tier II Disposal Facility was constructed for disposal of Tier II contaminated soil. The existing and new landfills, as shown on the overall site plan, Figure FOX-3.1, include:

- Station West Landfill
- West Landfill
- Non-Hazardous Waste Landfill
- Tier II Disposal Facility

Landfills that were remediated by complete excavation include the Airstrip Landfill and Site Debris 12, which are not shown.

The Department of National Defence (DND), in cooperation with Nunavut Tunngavik Incorporated (NTI), developed a landfill monitoring plan to address post closure monitoring requirements for the landfills at the DEW Line Sites (Appendix B). Defence Construction Canada (DCC) is managing the cleanup and monitoring programs on behalf of DND.

The objective of the landfill monitoring program is to collect sufficient information to assess the performance of the landfills from a geotechnical and environmental perspective. The landfill monitoring plan specifies the requirements for visual inspection, and chemical and thermal monitoring of landfills at the DEW Line sites under DND's jurisdiction.

Table 1 provides the landfill monitoring schedule for the FOX-3 site.

Table 1- MONITORING SCHEDULE – FOX-3 Dewar Lakes

No. of Years After Construction	Monitoring Event Number	Year
Prior to/During:	Baseline	2005, 2009-2011
1	1	2012
2	2	2013
3	3	2014
4	4	2015
5	5	2016

7	6	2018
10	7	2021
15	8	2026
25	9	2036

1.3 Program Components

The post-construction landfill monitoring program consists of four main components to measure the performance of the landfills, depending on the remediation plan for each landfill. These components are visual, soil, groundwater and thermal monitoring. Details on each of the monitoring components are provided below.

1.3.1 Visual Monitoring

The physical condition of each landfill is inspected in accordance with the Visual Inspection Checklist provided in the Environmental Provisions of the NTI-DND Agreement. Documented observations include evidence of settlement, ponding, frost action, erosion, and lateral movement, as well as sloughing of berms, and thermal contraction cracks. Documentation of observations is supported using hand drawn sketches, as applicable. Photographic Records are provided to document the general condition of the landfill and to substantiate all recorded observations.

1.3.2 Soil Monitoring

Baseline conditions refer to existing soil chemistry at the landfill area prior to and during remediation. The baseline landfill monitoring program consists of two phases: samples collected as part of the landfill assessment program which determined whether the landfill posed a potential environmental risk, and samples collected during the construction/closure of the landfill. The results of subsequent landfill monitoring events are compared to baseline and background values to evaluate any potential changes in environmental conditions.

As part of the baseline sampling program, soil samples are collected in areas upgradient and downgradient of each landfill. Upgradient samples are targeted to areas near the landfill, but not influenced by migration of contaminants through the landfill. Upgradient samples are meant to be representative of contaminant input conditions to the landfill and serve as the primary basis upon which to compare the downgradient contaminant concentrations.

Downgradient soil samples are collected at surface/shallow depths from designated areas at the toe of each landfill and from areas of preferential drainage. These soil samples are collected and analyzed to document whether there has been migration of contaminants from the landfill area. Although contaminants are primarily transported in water (surface and groundwater), they have a tendency to adsorb to soil particles the water is migrating through. Therefore the soil still retains information regarding the historical input of contaminants.

Analytical results of soil samples collected downgradient of landfills are compared to contaminant concentrations of samples collected upgradient of landfills. Downgradient samples are also compared to overall site background contaminant levels because they help in establishing a more broad level of contaminant concentrations that can be found at the site, particularly where different soil or rock types are

present. Contaminant concentrations in downgradient samples that are significantly higher than background or upgradient concentrations, particularly where there have been changes over time; provide evidence of contaminants having migrated to, possibly beyond the soil sampling location. These data, in conjunction with other site-specific information, were used in the assessment of the environmental status of the landfill and the determination of an appropriate remediation solution.

Samples collected during baseline and subsequent landfill monitoring are analyzed for the following parameters:

- Inorganic elements: arsenic, cadmium, chromium, cobalt, copper, lead, nickel, and zinc.
- Mercury.
- PCBs (polychlorinated biphenyls – total Aroclor).
- TPH (Total Petroleum Hydrocarbons) – as represented by the sum of F1 (nC_6 to nC_{10}), F2 (nC_{10} to nC_{16}), and F3 (nC_{16} to nC_{34}), as defined by the CCME Tier I Method – Rev. 5, Analyses of Total Petroleum Hydrocarbons in soil.

The requirement for the analyses of baseline samples is to provide record information on the environmental status of the landfill should potential problems be identified during the monitoring program.

1.3.3 Groundwater Monitoring

During the construction phase, permanent groundwater monitoring wells are installed at all existing landfills classified as a moderate environmental risk (Class B landfills) and at new landfills built to support site remediation. At FOX-3, this includes the Non-Hazardous Waste Landfill (new) and the Tier II Disposal Facility (new). Groundwater monitoring wells were installed hydraulically upgradient and downgradient of the landfills. Surface and shallow depth soil samples are also collected adjacent to monitoring well locations. Analytical data from water samples collected from wells up and downgradient are reviewed in conjunction with soil analytical data to evaluate potential impacts associated with the landfill.

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

- Water elevation.
- Total water depth.
- 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. Water samples are not filtered.

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

- Colour, odour.
- pH, conductivity and temperature.

Groundwater samples are analyzed for the following parameters:

- Inorganic elements (total concentrations): arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc.
- Mercury.
- PCBs (polychlorinated biphenyls – total Aroclor).
- TPH (Total Petroleum Hydrocarbons) – C_6 to C_{32}.

1.3.4 Thermal Monitoring

For Class B landfills and Tier II Soil Disposal Facilities where a component of the design includes the placement of sufficient fill to promote aggradation of permafrost through the landfill contents, geothermal modeling is conducted to determine the maximum depth of active layer at the landfill, and the amount of fill required on the landfill surface to ensure that the active layer does not penetrate into the landfill contents following freeze-back. Modeling also determines the length of time required for the landfill contents to freeze-back following the placement of additional surface fill. Geothermal modeling considers the following:

- soil type
- soil thermal properties
- presence or absence of insulating cover (vegetation or snow drift)
- measured ground temperatures at the site or at nearby sites
- measured air temperature and climatic data
- an estimated 1 in 100 warm year air temperature
- an estimated ten consecutive years of 1 in 100 warm years, and
- an estimate of the effect of global warming (based on estimates of temperature change reported by the Panel on Energy Research and Development for Environment Canada – PERD – in 1998).

During landfill construction, vertical thermistors were installed within the landfill to record ground temperatures. Measured ground temperatures will be compared to the active layer depth and freeze back time modelled during design. It is anticipated that all landfills where freeze back is an integral part of the design will reach thermal equilibrium within approximately five years following closure. If thermal equilibrium is not achieved within five years, it may be necessary to increase the term of the thermal monitoring.

1.4 Frequency

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

1.4.1 Phase I

Phase I involves monitoring of conditions to confirm that equilibrium is achieved. The frequency of monitoring events during Phase I is dependent on the closure or remediation design at specific landfills. The five-year term was selected on the basis that ground-temperature thermal regimes will require three to five years to reach equilibrium.

An evaluation of all Phase I data is carried out at the end of five years to confirm that thermal and chemical equilibrium is achieved, and that no stability issues are identified. The Phase I monitoring program may be extended, if required, to provide sufficient data to establish equilibrium conditions.

The first year of the Phase I post-construction monitoring is completed by the Environmental Sciences Group (ESG) of the Royal Military College of Canada, who are part of the DEW Line Clean Up Project Team. Subsequent landfill monitoring events are carried out by independent contractors, who successfully win the competitive tender.

1.4.2 Phase II

Phase II monitoring is the verification of equilibrium conditions established in Phase I. The monitoring frequency in Phase II is downgraded from Phase I and will be carried out according to the following schedule: year 7, 10, 15 and 25. Year 25 marks the end of Phase II monitoring.

1.4.3 Phase III

Phase III involves the monitoring for long-term issues such as liner integrity, permafrost stability and significant storm events. At the end of the Phase II program, 25 years after construction, a re-evaluation of the landfill monitoring program will be carried out prior to initiating any Phase III program. The scope of the Phase III monitoring program is not included here, but is anticipated to be based on a 10 year monitoring interval.

1.5 Review and Evaluation Process

An Environmental Working Group (EWG) was established to provide a technical report and to support the DLCU Steering Committee. This working group is comprised of qualified engineering and environmental scientists with expertise in environmental remediation and clean up in northern climates. The EWG has four designated representatives, two from each of the Owner (DND) and the Inuit (through the NTI), respectively.

During the monitoring program, the EWG reviews the results of the monitoring program in accordance with the methodology as described previously. The results of the review and any recommendations regarding changes to the monitoring plan and/or remediation requirements are reported to the DND/NTI Steering Committee.

The requirement for further monitoring after 25 years is evaluated. Monitoring may be terminated if the performance of the landfill was satisfactory over the period of monitoring from an environmental, geotechnical and thermal perspective, as appropriate. The assessment of satisfactory performance is carried out jointly by the NTI and DND.

2. Detailed Landfill Monitoring Requirements

Site figures documenting the monitoring locations at each landfill are provided in Appendix A. Table 2 provides a summary of the general landfill monitoring requirements at the DND DEW Line sites following construction.

Table 2 - General Landfill Monitoring Requirements

Landfill Classification	Visual Inspection	Groundwater Sampling	Soil Sampling	Thermal Monitoring
Existing Landfills, High Potential Environmental Risk (Class A)	Not required, as landfill to be excavated			
Existing Landfills, Moderate Potential Environmental Risk (Class B)	√	√	√	√
Existing Landfill, Low Potential Environmental Risk (Class C)	√		√	
New Landfill, Non-Hazardous Waste Landfill	√	√	√	
New Landfill, DCC Tier II Disposal Facility	√	√	√	√

A summary of these requirements, as related to the specific landfills at FOX-2, is provided in Table 3. The rationale for the monitoring requirements is provided in the landfill-specific sections.

Table 3 – FOX-2 Landfill Monitoring Requirements

Landfill Designation	Visual Inspection	Groundwater Sampling	Soil Sampling	Thermal Monitoring
Tier II Disposal Facility	√	√	√	√
Non-Hazardous Waste Landfill	√	√	√	
Station West Landfill	√		√	
West Landfill	√		√	

2.1 Non-Hazardous Waste Landfill

The Upper Site Landfill is 200 m east of the warehouse. It was the main disposal area for station operations, beginning in the 1950s. The size and approximate depth of the lobe is 4040 m2 and up to 2.0 m deep. There were several areas of Tier I and Tier II contamination on the landfill surface, as well as downgradient noted during the site investigation. Localized TPH impacts were also present. Surface contamination was generally associated with debris, but some of the contamination along the toe may be due to landfill leachate. Four groundwater monitoring wells were installed at the landfill perimeter, and four thermistors were installed within the landfill.

Based on the evaluation of the landfill as a potential source of contamination, this landfill was classified as a moderate potential environmental risk. Remediation included excavation of surface hazardous soils and leachate containment.

The long term monitoring plan consists of visual monitoring, the collection of soil and groundwater samples, and monitoring of subsurface ground temperatures of the landfill. Approximate locations for the collection of soil and groundwater samples, and thermistor installation locations are identified on Figure FOX-3.5.

2.2 Station West Landfill

The Station West landfill is located approximately 150 m west of the main station building northwest and west of the old station access road. It comprises a number of individual lobes, some of which were identified during previous investigations and labelled as independent landfills. The lobes range in size from 5440 m^2 (lobe A) to 100 m^2 (lobe I2), and generally are consistent with the areas identified during previous investigations. No surface contamination was detected, nor was there any evidence of contaminant migration from the landfill.

The long term monitoring plan consists of visual monitoring, and the periodic collection of soil samples. Approximate locations for the collection of soil and groundwater samples are identified on Figure FOX-3.2.

2.3 Tier II Soil Disposal Facility

The Tier II Disposal Facility is located adjacent to Borrow Area 2. The landfill cell was constructed with the placement of low-permeability, saturated, compacted berms, 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 overlying sufficient granular fill to promote freezeback of landfill contents. Four groundwater monitoring wells were installed at the landfill perimeter, and four thermistors were installed within the landfill.

The long term monitoring plan consists of visual monitoring, the collection of soil and groundwater samples, and monitoring of subsurface ground temperatures of the landfill. Approximate locations for the collection of soil and groundwater samples, and thermistor installation locations are identified on Figure FOX-3.4.

2.4 West Landfill

The West Landfill is located approximately 1.3 km west of the station, and 0.5 km beyond the DEW Line Reserve boundary, in a former borrow area. There is an old access road leading to the area from the north end of the module train, although the former access point from the immediate station area has been cut-off by the placement of the SGT domes.

Geophysics identified two adjacent anomalies: lobe A – to the west – was identified as 980 m^2, and lobe B - to the east - was identified as 680 m^2. While the geophysical survey shows the lobes to be distinct, there is only about 3 m separating the two areas. As a consequence, they were regraded as one continuous area.

The long term monitoring plan consists of visual inspection, and the periodic collection of soil and groundwater samples. Approximate locations for the collection of soil and groundwater samples are identified in Figure FOX-3.3

Table 4: Summary Of Landfill Monitoring Installations/ Sampling Locations
FOX-3 Dewar Lakes

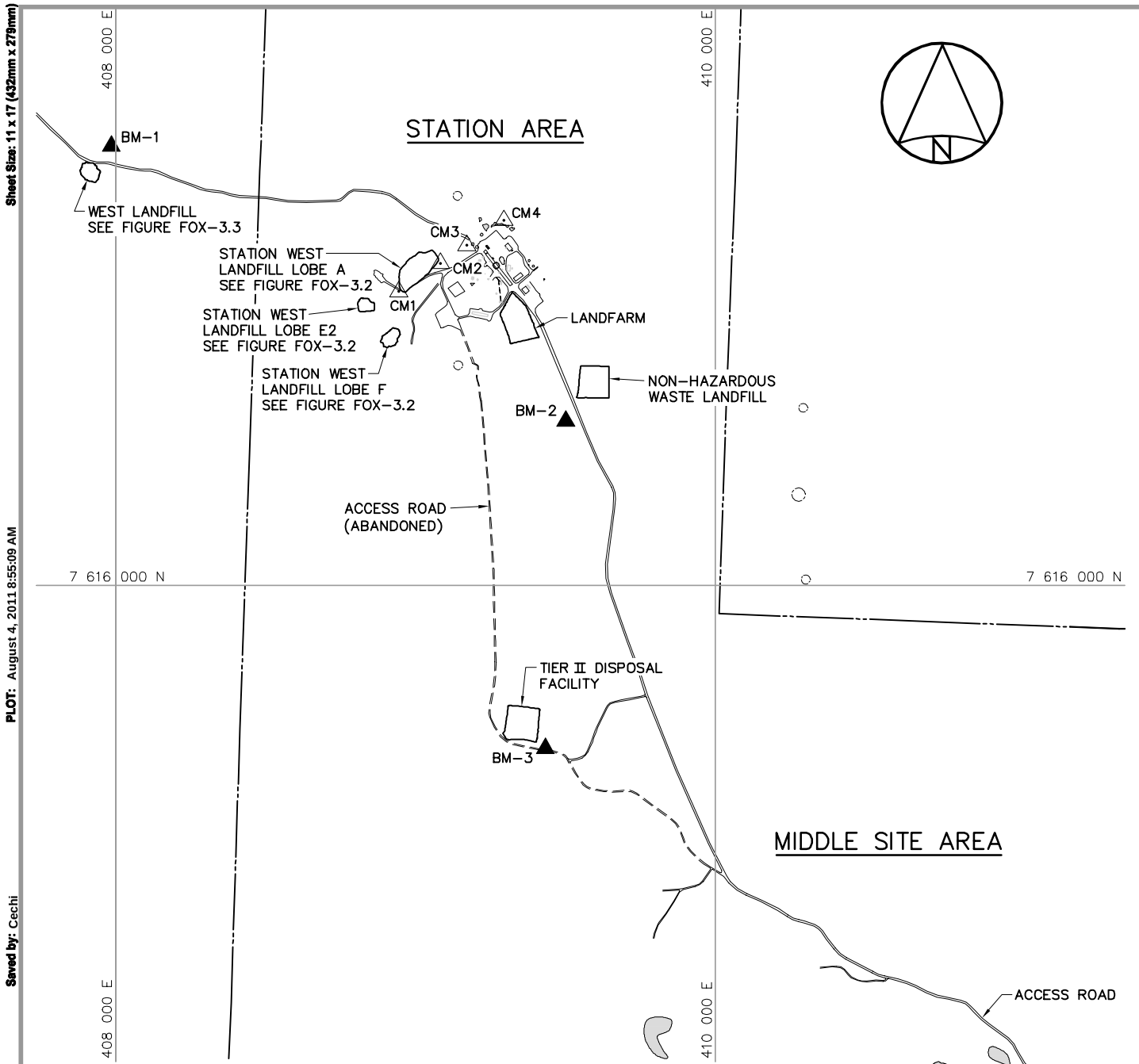
	Coordinates		Elevation
Landfill Designation/Monitoring Locations	North (m)	East (m)	(masl)
West Landfill			
Sample Location 1 (soil)	TBD	TBD	-
Sample Location 2 (soil)	TBD	TBD	-
Sample Location 3 (soil)	TBD	TBD	-
Non-Hazardous Waste Landfill			
MW-05 (soil and groundwater)	7616728.0	409555.9	510.7

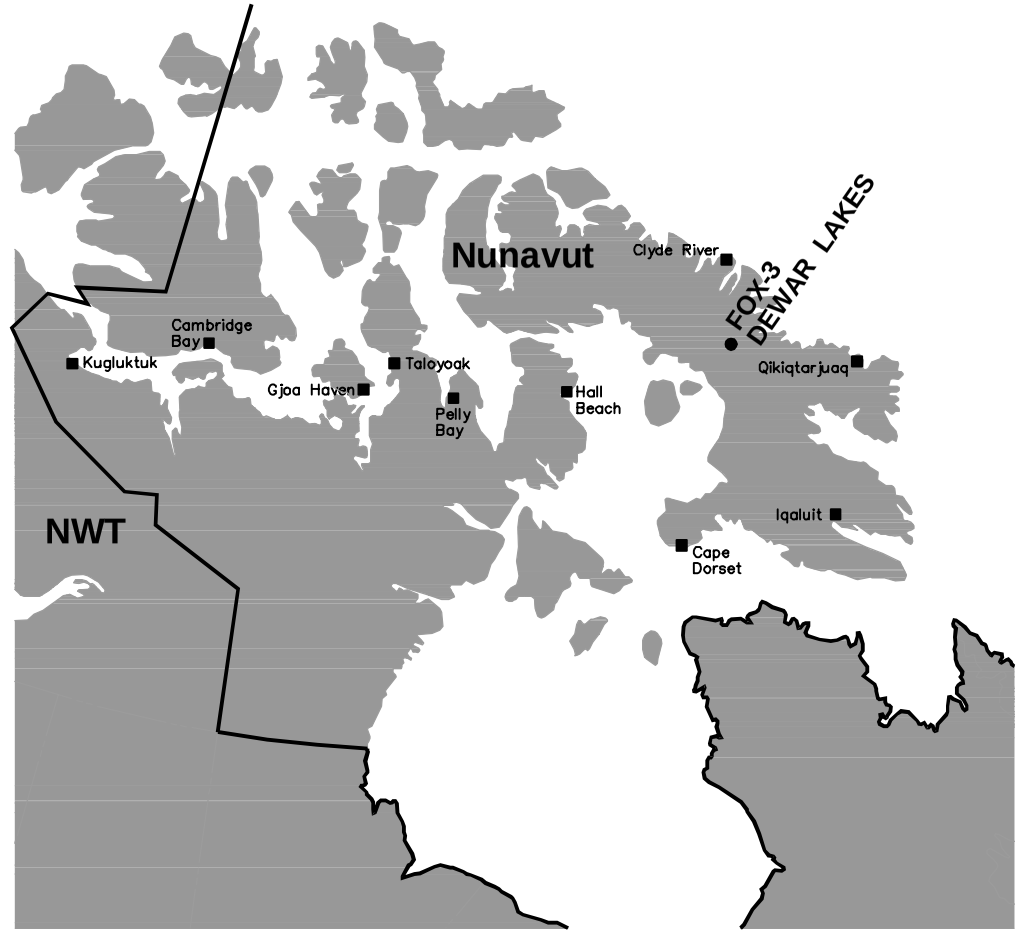
Table 4: Summary Of Landfill Monitoring Installations/ Sampling Locations
FOX-3 Dewar Lakes

	Coordinates		Elevation
Landfill Designation/Monitoring Locations	North (m)	East (m)	(masl)
MW-06 (soil and groundwater)	7616725.0	409635.7	510.9
MW-07 (soil and groundwater)	7616640.2	409632.4	507.6
MW-08 (soil and groundwater)	7616643.0	409552.5	507.5
Station West Landfill			
Sample Location 4 (soil)	TBD	TBD	-
Sample Location 5 (soil)	TBD	TBD	-
Sample Location 6 (soil)	TBD	TBD	-
Sample Location 7 (soil)	TBD	TBD	-
Sample Location 8 (soil)	TBD	TBD	-
Sample Location 9 (soil)	TBD	TBD	-
Sample Location 10 (soil)	TBD	TBD	-
Sample Location 11 (soil)	TBD	TBD	-
Tier II Disposal Facility			
VT-1 (temperature)	TBD	TBD	-
VT-2 (temperature)	TBD	TBD	-
VT-3 (temperature)	TBD	TBD	-
VT-4 (temperature)	TBD	TBD	-
MW-01 (soil and groundwater)	7615513.9	409428.3	417.0
MW-02 (soil and groundwater)	7615610.9	409290.7	418.2
MW-03 (soil and groundwater)	7615540.3	409278.3	417.7
MW-04 (soil and groundwater)	7615620.8	409430.7	418.4

Note 1. Monitoring well coordinates as provided by the cleanup contractor (survey). Coordinates referenced to UTM Zone 14N, NAD83.

STATION AREA





LOCATION OF DEWAR LAKES WITHIN NUNAVUT TERRITORY
SCALE: NTS

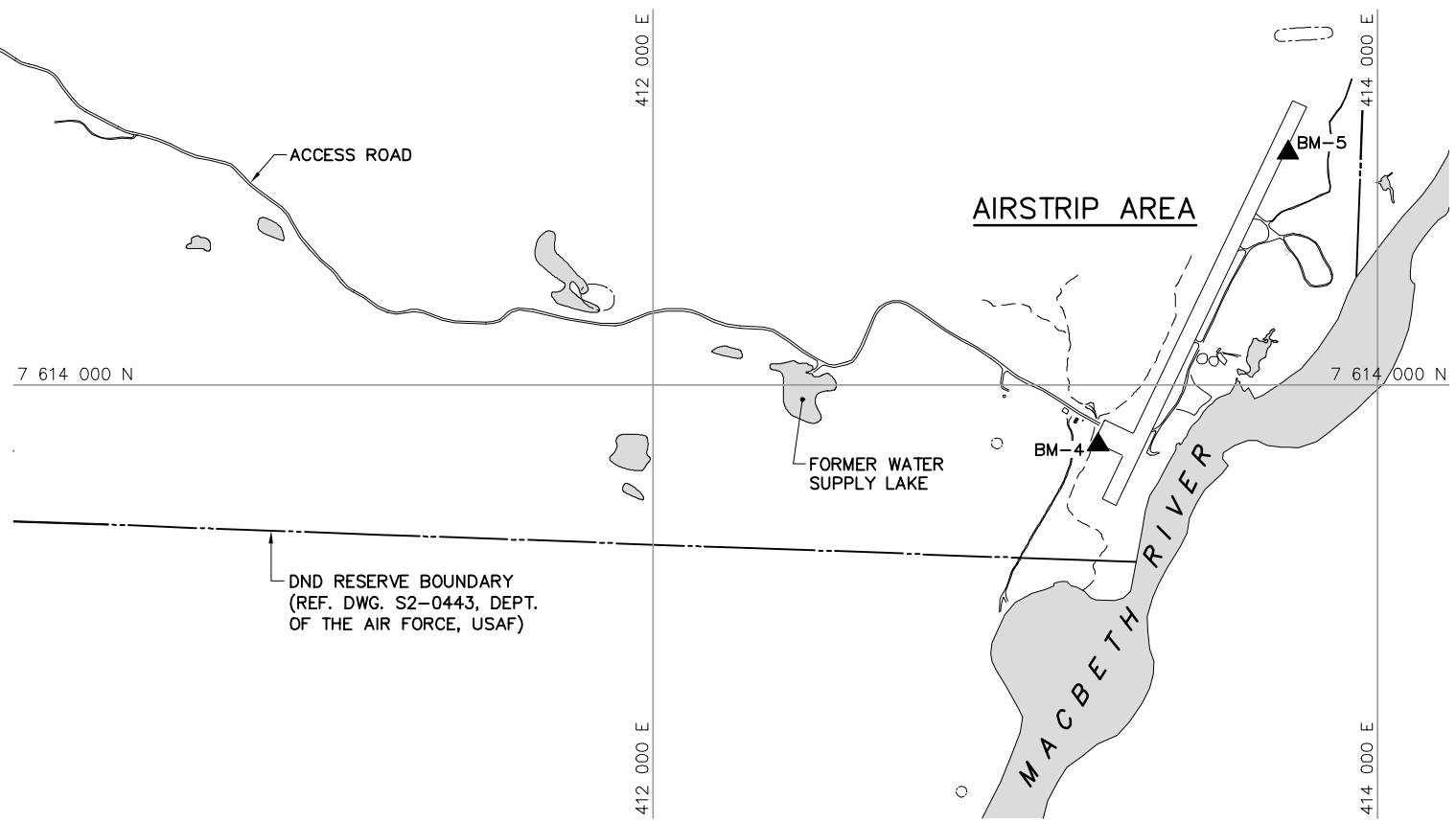
GENERAL NOTES:

1. ALL COORDINATES ARE REFERENCED TO NAD83 (CSRS), UTM ZONE 19N. ALL ELEVATIONS REFER TO GEODETIC DATUM.
2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

LEGEND:

- CM1 — SURVEY CONTROL MONUMENT (4)
- BM-1 — APPROXIMATE PERMANENT BENCHMARK LOCATION (5)
- ARCHAEOLOGICAL FEATURES
- APPROXIMATE LOCATION OF PROPERTY BOUNDARY
- BODY OF WATER

MIDDLE SITE AREA



SURVEY CONTROL MONUMENTS				
NO.	UTM COORDINATES		ELEV.	DESCRIPTION
	NORTHING	EASTING		
CM1	7 616 981.903	408 942.460	513.650	FOX-3 BASELINE STA. 0+00
CM2	7 617 076.152	409 081.577	517.980	FOX-3 BASELINE STA. 5+51.73
CM3	7 617 135.904	409 169.961	518.382	FOX-3 BASELINE STA. 9+01.38
CM4	7 617 219.128	409 293.072	516.486	FOX-3 BASELINE STA. N/A

NOTE: BASELINE STATIONS SHOWN ARE IN IMPERIAL UNITS.

RECORD DRAWING
NOT FOR CONSTRUCTION

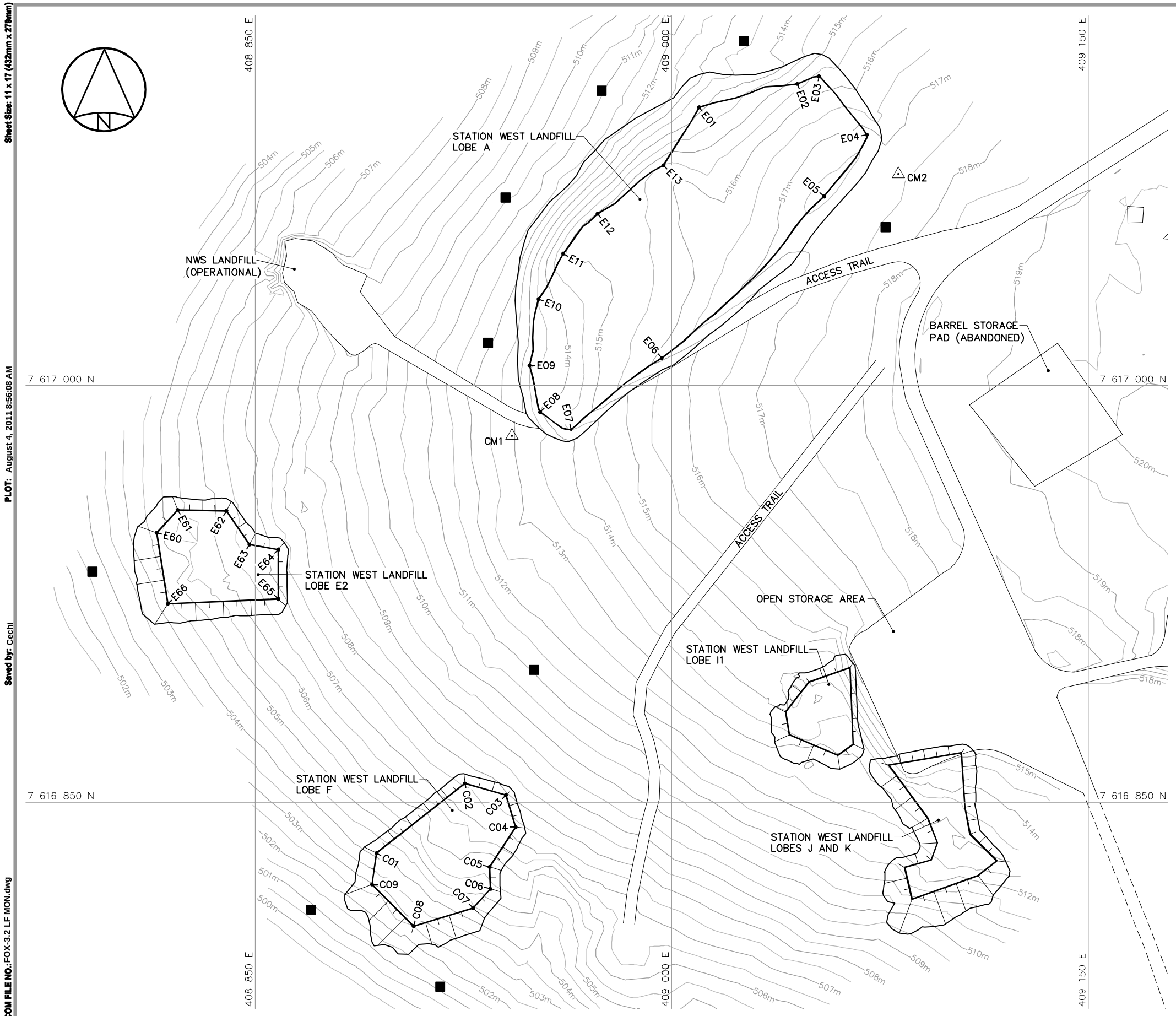
0 200 400 m SCALE 1:20000

DEW LINE CLEAN UP
LANDFILL MONITORING PLAN

FOX-3 DEWAR LAKES

LOCATION PLAN
FIGURE FOX-3.1

AECOM



GENERAL NOTES:

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2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

LEGEND:

- CM1 — SURVEY CONTROL MONUMENT (2)
- C01 — COORDINATE POINT
- ■ — MONITORING SOIL SAMPLE LOCATION (9)

SURVEY CONTROL MONUMENTS				
NO.	UTM COORDINATES		ELEV.	DESCRIPTION
	NORTHING	EASTING		
CM1	7 616 981.903	408 942.460	513.650	FOX-3 BASELINE STA. 0+00
CM2	7 617 076.152	409 081.577	517.980	FOX-3 BASELINE STA. 5+51.73

NOTE: BASELINE STATIONS SHOWN ARE IN IMPERIAL UNITS.

STATION WEST LANDFILL LOBE F REGRADING (DESIGN)		
NO.	UTM COORDINATES	
	NORTHING	EASTING
C01	7 616 831.7	408 893.7
C02	7 616 856.8	408 925.5
C03	7 616 852.6	408 940.3
C04	7 616 841.0	408 943.8
C05	7 616 826.7	408 934.4
C06	7 616 818.8	408 934.7
C07	7 616 811.8	408 928.5
C08	7 616 805.4	408 907.0
C09	7 616 820.4	408 892.1

STATION WEST LANDFILL LOBE E2 REGRADING (DESIGN)		
NO.	UTM COORDINATES	
	NORTHING	EASTING
E60	7 616 947.0	408 814.5
E61	7 616 955.2	408 822.1
E62	7 616 954.9	408 839.6
E63	7 616 942.7	408 847.9
E64	7 616 940.9	408 858.3
E65	7 616 923.1	408 858.3
E66	7 616 921.4	408 818.5

STATION WEST LANDFILL LOBE A REGRADED (AS-BUILT)			
NO.	UTM COORDINATES		ELEV.
	NORTHING	EASTING	
E01	7 617 100.2	409 009.9	513.9
E02	7 617 108.6	409 045.2	515.3
E03	7 617 111.3	409 053.0	515.6
E04	7 617 090.3	409 070.3	517.2
E05	7 617 068.1	409 054.9	517.7
E06	7 617 009.9	408 996.4	516.1
E07	7 616 984.1	408 963.8	514.5
E08	7 616 990.4	408 952.6	514.0
E09	7 617 007.3	408 948.8	513.5
E10	7 617 031.2	408 952.0	513.6
E11	7 617 047.5	408 960.9	515.0
E12	7 617 061.9	408 973.3	515.0
E13	7 617 079.3	408 997.0	515.5

RECORD DRAWING
NOT FOR CONSTRUCTION

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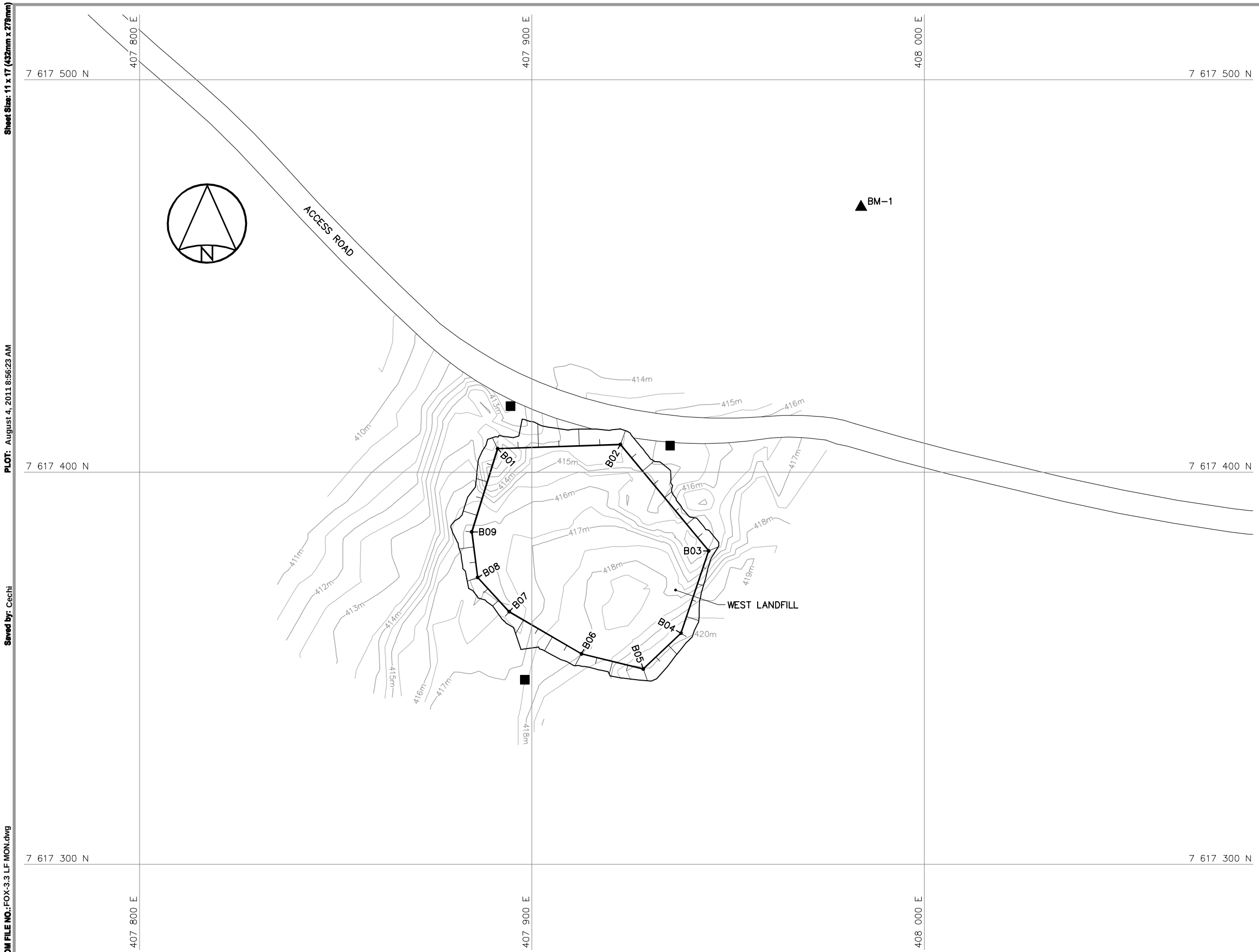
DEW LINE CLEAN UP
LANDFILL MONITORING PLAN

FOX-3 DEWAR LAKES

STATION WEST LANDFILL

FIGURE FOX-3.2

AECOM



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2. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.

LEGEND:

- ▲BM-1 — APPROXIMATE PERMANENT BENCHMARK LOCATION (1)
- •B01 — COORDINATE POINT
- ■ — MONITORING SOIL SAMPLE LOCATION (3)

WEST LANDFILL REGRADING (DESIGN)		
NO.	UTM COORDINATES	
	NORTHING	EASTING
B01	7 617 405.9	407 891.3
B02	7 617 407.0	407 922.5
B03	7 617 379.9	407 945.0
B04	7 617 358.9	407 938.0
B05	7 617 349.8	407 928.4
B06	7 617 353.7	407 912.6
B07	7 617 364.4	407 894.2
B08	7 617 373.2	407 886.2
B09	7 617 384.8	407 884.7

RECORD DRAWING
NOT FOR CONSTRUCTION

0 10 20 m SCALE 1:1000

DEW LINE CLEAN UP
LANDFILL MONITORING PLAN

FOX-3 DEWAR LAKES

WEST LANDFILL

FIGURE FOX-3.3

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