



REPORT

Permafrost Monitoring Plan

*Tuktoyaktuk Base Remediation,
Inuvialuit Settlement Region, Northwest Territories*

Submitted to:

Inuvialuit Land Administration

107 Mackenzie Road

Bag Service #21

Inuvik, NT X0E 0T0

Submitted by:

WSP Canada Inc.

237 - 4 Avenue SW, Suite 3300,

Calgary, Alberta T2P 4K3

403 299 5600

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Table of Contents

1.0	INTRODUCTION	1
1.1	Site Location and History	1
1.2	Site Description	1
2.0	PROJECT SUMMARY	1
2.1	Contaminated Soil Excavations	2
2.2	North and South Landfills	2
2.3	Draining and Reclamation of Former Sewage Lagoon	2
2.4	North and South Docks	3
2.5	Concrete Pads.....	3
3.0	SITE CONDITIONS	3
3.1	Permafrost.....	3
3.2	Site Hydrogeology	3
3.3	Thermokarst Development/Progression	4
3.4	Regulatory Framework	4
4.0	PERMAFROST MONITORING/INTEGRITY DURING REMEDIATION	5
4.1	Former Sewage Lagoon.....	6
4.2	North and South Landfills	6
4.3	Surficial Debris	6
4.4	Upper Terrace and Airstrip	7
4.5	Monitoring Activities	7
5.0	CONCLUSIONS	7
6.0	REFERENCES	8

TABLES [in text]

Table A: Thermistor Installation and Observation Details (2024-2025)6

FIGURES [after text]

Figure 1	Site Location
Figure 2	Site Plan
Figure 3	Water Management Details and Permafrost Monitoring Locations

1.0 INTRODUCTION

WSP Canada Inc. (WSP) was retained by Imperial Oil Resources Limited (Imperial) to develop a Permafrost Monitoring Plan for the former Tuktoyaktuk Exploration Logistics Base Camp (Tuk Base or the Site) approximately 1.5 kilometres (km) southeast of the Hamlet of Tuktoyaktuk, Northwest Territories (NWT) (Figure 1).

The monitoring program for permafrost integrity is based on the management strategies outlined in the Remedial Action Plan (RAP; Advisian 2019, amended May 2020) for the remediation activities at the Site (the Project).

1.1 Site Location and History

The Site is at 69°25'35"N latitude and 132°57'20"W longitude on the Beaufort Sea coast approximately 1.5 km southeast of the Hamlet of Tuktoyaktuk, NWT (Figures 1 and 2). The Site is on a lease (ILA85TJ079) held by Imperial from the Inuvialuit Land Administration (ILA). Tuk Base began operations in 1970 and operated as a staging and storage area for oil and gas exploration in the Arctic. In 1980, decommissioning of the Site began. Between 2001 and 2013 almost all major infrastructure on site was decommissioned and removed (Advisian 2019). As of 2018, the only notable features remaining on site include two historic landfills, a sewage lagoon, north and south docks and concrete pads.

1.2 Site Description

The Site covers a land area of approximately 54 hectares and generally comprises the former Tuk Base on the Upper Terrace, transitioning down to a Lower Terrace (created by infilling the low-lying natural topography with dredged ocean sediments) and the surrounding natural tundra as shown in Figure 2.

The Site is bordered by tundra to the north and south, with the Mayogiak Inlet and Tuktoyaktuk Harbour bordering the Site to the east and west, respectively (Figure 2). The former Northern Transportation Company Limited tank farm/lease is located to the north of the Imperial lease on Saviktok Point.

2.0 PROJECT SUMMARY

The Project-specific RAP for the planned remediation works was submitted to the Inuvialuit Water Board (IWB) in March 2019 (Advisian 2019; Golder 2019), approved in July 2019 and amended in May 2020 (Golder 2020). The RAP has been guiding the following Project tasks since 2019 and continuing until 2029.

- Surface debris (including the wood piles from the former wooden wharf) will be collected, removed and disposed of off site at an approved disposal facility.
- Hazardous material (stemming from historical operations) encountered on site will be temporarily stored, transported off site and disposed of at an approved disposal facility.
- Soil impacted with light-end petroleum hydrocarbons (PHCs) will be treated on site and used as backfill.
- Soil impacted with heavy-end PHCs will be treated on site and/or disposed of off site at an approved disposal facility.
- Soils impacted with metals or polychlorinated biphenyls will be excavated and transported to an approved disposal facility.
- The Former Sewage Lagoon will be dewatered, backfilled and regraded/revegetated (as directed by the ILA).

- The North Dock will be utilized for the Project and then will either be repurposed (pending negotiations with the ILA) or demolished.
- The South Dock will be demolished.
- The concrete pads will be transported off-site for re-use or appropriate disposal.
- Site access for personnel and equipment will be via barge and crew boats from the Hamlet of Tuktoyaktuk during the summer field programs, and ice road during the winter field programs.
- Accommodation during the winter and summer field programs may be provided by the 802-barge camp or the Arctic Star barge camp, anchored either at the Site, or close to Tuktoyaktuk; the location of the camp may change between these two locations seasonally, depending on the number of personnel required for the Site.

After Project completion, the Site will be left in a condition that promotes long term geotechnical stability and positive drainage in all disturbed areas. The end land use will be “parkland” as defined by the Canadian Council of Ministers of the Environment (CCME 1999a and updates).

2.1 Contaminated Soil Excavations

Contaminated soil areas that will need to be excavated include the North and South Landfill and multiple locations throughout the former operations area at the Upper Terrace as defined in the RAP (Advisian 2019). Each area will be excavated and, where possible, soil will be treated on site and used as backfill to promote positive drainage. Alternatively, soil that cannot be treated will be transported and disposed of off site at an approved, licenced facility. The disturbed areas will then be revegetated with native species (as directed by the ILA) to match surrounding land cover. The North and South Landfills will be the largest excavations on site.

2.2 North and South Landfills

The North Landfill is north of the lease boundary and contains approximately 2,000 cubic metres (m³) of impacted soil/debris (e.g., construction/demolition debris and general camp debris) that will be excavated, treated and/or removed and disposed of off site. The South Landfill is in the southeast portion of the Upper Terrace (Figure 2). It is considerably larger than the North Landfill and is currently (2025) estimated to contain roughly 18,000 m³ of impacted soil/debris (e.g., drums, domestic debris, rig mats, heavy tangled cables and possible metal decking materials) that will be excavated, treated and/or removed and disposed of off site. Following confirmatory soil sampling, both landfill excavations will be recontoured to promote positive drainage.

2.3 Draining and Reclamation of Former Sewage Lagoon

The former sewage lagoon water will be sampled for water quality parameters to confirm there are no exceedances of applied guidelines. Upon analytical confirmation, the water will be pumped off to the land at a minimum of 30 metres (m) away from the nearest water body and 100 m away from the nearest fish bearing waters. The remaining berms will be used as backfill to re-contour the lagoon area to integrate into the surrounding landscape. The reclaimed lagoon area will then be re-vegetated using a combination of live staking of willows, by harvesting live stakes from the surrounding area, seeding of native species and natural revegetation as approved by the ILA to avoid the establishment of invasive species.

2.4 North and South Docks

Structural assessments of the North and South Docks were completed in 2018 (Advisian 2018) which concluded that the North Dock is in servicable condition while the South Dock was found to be at the end of its servicable life. The North Dock is anticipated to remain intact during the remediation program while the South Dock will be removed. The granular material will be excavated to restore the natural shoreline and then the dock sheet piles will be removed. A Dock Repair and Removal Monitoring Plan was developed to mitigate possible sedimentation effects during South Dock removal (submitted to the IWB in March 2019).

2.5 Concrete Pads

Two concrete pads as well as a number of stockpiled smaller slabs remain on site. These slabs will be excavated and cut to size prior to being removed from Site for reuse or appropriate disposal.

3.0 SITE CONDITIONS

3.1 Permafrost

The region is underlain by continuous permafrost with high ice content in the form of ice wedges, intra-sedimental sills and pingos (ESWG 1995). Permafrost at the Site has been observed through boreholes and test pits from 2007 to 2015 as follows:

- Upper Terrace: depths varying from 0.4 to 3.0 metres below ground surface (mbgs), with an average depth of 1.8 mbgs;
- Airstrip: depths of 1.4 and 1.5 mbgs;
- Lower Terrace: depths range from 0.95 to 2.9 mbgs, with an average of 2.0 mbgs; and
- Natural Tundra: depths ranging from 0.3 to 0.6 mbgs.

These depths are based on the maximum active layer thickness measured in summer months.

It is noted that the depth to permafrost recorded during past investigations is based on visual observations of auger soil cuttings, exposed soil faces (test pits) and equipment performance (e.g., difficult drilling or excavation). Accordingly, visual interpretation of the permafrost interface depth can be affected by many aspects such as groundwater presence, sloughing soils, discontinuous ice and surface organic layer.

3.2 Site Hydrogeology

Shallow groundwater levels across the Site vary between ground surface and 1.0 mbgs on the Upper Terrace and between ground surface and 0.6 mbgs on the Lower Terrace. In general, there is a limited amount of groundwater at Site as evident by the presence of dry monitoring well conditions and very slow groundwater flow in this permafrost environment. Detailed groundwater monitoring results were presented in Advisian (2017a). Groundwater flow direction has not been verified to date due to limited sample data and dry monitoring well conditions. The location of the groundwater monitoring wells is shown in Figure 3.

During site construction/operation, the Lower Terrace was backfilled with dredged ocean sediments from the adjacent Tuktoyaktuk Harbour. The dredged fine sand and silt soils are saturated, possibly by shallow groundwater with saline intrusion or remnants of ocean water from dredging operations and are naturally more saline than the soils of the Upper Terrace. These conditions are likely contributing to the observed increase in depth of permafrost on the Lower Terrace (average of 1.8 and 2.0 mbgs, respectively) in comparison to the Upper

Terrace (1.2 and 1.8 mbgs, respectively) and the remainder of the undisturbed areas of the Site.

The former sewage lagoon located within the natural tundra east of the Upper Terrace is the only significant surface water body within the Imperial lease boundary and was man-made. Based on the 1964 air photo, it appears that organic deposits and minor thermokarst landforms were present at the location of the former sewage lagoon prior to its construction.

3.3 Thermokarst Development/Progression

Thermokarst development/progression is linked to surface disturbance, subsequent thawing of ice-rich permafrost and massive ice, surface subsidence from slope instability, and water impoundment (Grosse et al. 2012). Surface disturbance and water impoundment have occurred at Tuk Base and there is evidence of thawing of ice-rich permafrost (Advisian 2017b).

Given the general higher elevation of the Site within the lease boundary compared to the surrounding land, there are no natural thermokarst lakes identified within the lease. However, ice thaw polygonal landforms with visible ponded water are evident north of the Tuk Base lease boundary, and in the lower-lying topography of the Northern Transportation Company Limited lease. These landforms are typical of the organic peat deposits within thermokarst basins (Rampton 1988).

There does appear to have been similar organic soils and potential thermokarst landforms existing at the location of the Lower Terrace and the sewage lagoon in 1964 prior to any earthworks construction. However, the sewage lagoon was man-made and was not developed through thermokarst progression. Based on historical aerial photographs, the lagoon does not appear to have increased in size since construction; however, interpretation of scale from the photographs is approximate and vegetation growth may be impacting this assessment.

While historical aerial photographs did not indicate evidence of previous polygonal or thermokarst landforms at the location of the two small ponds 50 m north of the northwestern lease boundary), these ponds appear to have been man-made. The impounded surface water may impact degradation of the surrounding permafrost. Based on the above noted conditions, future development and potential impact of thermokarst features in areas to be remediated is minimal (Advisian 2017b).

3.4 Regulatory Framework

The Abandoned Military Site Remediation Protocol (AMSRP) (Vol I, Section 4.7.1) recommends that remediation activities in hydrocarbon areas should avoid disturbing permafrost-sensitive areas (INAC 2008). In compliance with this guidance, the remedial excavation depths defined in the RAP (Advisian 2019; Golder 2019, 2020) have considered depth to permafrost in each proposed remedial excavation area. During remediation, observations of permafrost distribution will be recorded to create a baseline for comparison against future monitoring data.

The AMSRP specifies three phases for post-construction monitoring. The purpose of each of these phases is described in the following sections.

- Phase I of the post-construction monitoring program is considered to be the first five years following construction. The purpose of the Phase I monitoring program is to confirm that thermal equilibrium and physical stability are achieved. As per the AMSRP, monitoring will be conducted in Years 1, 3 and 5.
- Following the Phase I post-construction monitoring program, the data will be reviewed to confirm that thermal equilibrium has been achieved and that no stability issues have been identified. If no significant issues are

identified compared to the baseline conditions, the monitoring program can be discontinued. The potential to discontinue the monitoring program will be discussed with the ILA following a review of the available monitoring data.

- If required, the monitoring program will continue into Phase II. The purpose of the Phase II monitoring program is to verify the equilibrium conditions established during the Phase I monitoring program and can be modified, downgraded or discontinued based on the results of the Phase I monitoring program. If additional monitoring is warranted based on the thermal, groundwater, soil, or physical inspection, it is recommended that the monitoring be conducted in Years 7, 10, 15 and 25.
- The Phase III monitoring program includes monitoring for long term issues such as permafrost stability and significant storm events. After 25 years of post-construction monitoring, the monitoring program should be re-evaluated. There is no specific schedule recommended for this phase of monitoring.

In addition, the Government of the Northwest Territories (GNWT) established a series of guidelines to assist proponents and operators when planning, assessing and undertaking land use activities in the NWT (including development of roads, trails, camps and seismic activities; [GNWT 2015]). The guidelines include information on the mitigation of environmental issues (including permafrost). The guidelines were reviewed and incorporated during the preparation of this document, where applicable.

4.0 PERMAFROST MONITORING/INTEGRITY DURING REMEDIATION

Advisian (2017a) installed a total of six thermistors at the Site to provide information on the presence, nature, vertical distribution and temporal variability of permafrost conditions. Each thermistor string contains 11 temperature sensors positioned at 0.75 m vertical intervals starting at or near ground surface. Each temperature sensor is hermetically sealed on a cable. All thermistors were installed in 2015 to a maximum total depth of 7.5 mbgs. Two thermistor locations, TM-L-01 and TM-K-01, were installed to shallower total depths due to subsurface conditions (soil sloughing). The thermistor strings for TM-L-01 and TM-K-01 consequently contain one or more sensors which are positioned above ground surface inside the thermistor standpipes (Advisian 2017a). The installation of thermistor strings was targeted at areas with varying settings and spatial distribution across the Site as shown in Figure 3. Thermistor installation details are summarized in Table A.

Each thermistor string is connected to a Lakewood Systems Ltd. model RX-16 Ultra-Logger data storage unit. Each unit is programmed using Lakewood Systems Ltd.'s Prolog 2 software.

Observations of permafrost conditions from 15 June 2024 to 31 July 2025 are summarized in Table A. The depth to permafrost is characterized as the depth at which the ground temperature is below 0°C throughout the year.

Table A: Thermistor Installation and Observation Details (2024-2025)

Thermistor	Installation Area	Top Sensor Depth (mbgs)	Bottom Sensor Depth (mbgs)	Depth of Observed <0°C Conditions (mbgs)	<0°C Conditions Observed Since
TM-D-01	West Upper Terrace	0	7.50	2.25	15 June 2024 to 31 July 2025
TM-G-01	Upper Terrace	0	7.50	2.25	15 June 2024 to 31 July 2025
TM-K-01	Lower Terrace (South Landfill)	Above ground	7.20	2.7	15 June 2024 to 31 July 2025
TM-L-01	South Lower Terrace	Above ground	5.75	2.75	15 June 2024 to 7 March 2025
TM-N-01	North Upper Terrace	0	7.50	Between 1.5 and 3.0	15 June 2024 to 8 March 2025
TM-S-01	East of Sewage Lagoon	0	7.50	2.25	15 June 2024 to 31 July 2025

Historic access roads, gravel pads and the airstrip have been affected by thermal permafrost degradation, slumping and subsidence. The sections below highlight specific areas at the Site where remediation activities will be completed in consideration of permafrost integrity.

4.1 Former Sewage Lagoon

Timely backfilling and regrading of the dewatered sewage lagoon will reduce the likelihood of permafrost degradation created by the impounded surface water. Regrading would require the use of both sand and gravel borrow material and fine-grained soils, such as the surrounding natural silt and clay that was previously excavated during their construction. Soils from the tank farm berm, airstrip or crushed concrete may also be considered for use as backfill material. The reclaimed former sewage lagoon area will then be re-vegetated using a combination of live staking of willows, by harvesting live stakes from the surrounding area, seeding of native species and natural revegetation as approved by the ILA to avoid the establishment of invasive species.

4.2 North and South Landfills

Remediation will include landfill excavation, contaminant screening, and off-site debris disposal. The two man-made ponds will be backfilled to promote positive drainage and prevent future ponded water following remediation activities which will reduce the likelihood of further permafrost degradation created by the impounded surface water.

4.3 Surficial Debris

Some surficial and partially buried debris is still present which will be removed for off-site disposal. Special consideration will be given to debris that is partially or wholly located within the permafrost layer. If the noted debris is inert, it may cause more damage than benefit to remove said debris and it will be left in place. However, if debris has the potential to create future contamination (i.e., barrel with liquid contents), it will be removed regardless of its permafrost proximity.

4.4 Upper Terrace and Airstrip

A limited volume of suitable sand and gravel borrow material is available from the Upper Terrace and airstrip areas. Any excavation of these materials for remediation purposes will be limited as much as practically possible to prevent the existing permafrost active layer moving deeper into the underlying native soils.

4.5 Monitoring Activities

The majority of soil impacts have been sufficiently delineated in the RAP document; however, some vertical delineation is still required for some contaminants of concern and associated areas of potential environmental concern. The maximum depth of excavations will not exceed the depth to permafrost. To remediate areas with PHC impacts, soils will be excavated to the bottom of the impacted zone or the base of the active layer of the permafrost.

Future soil remediation and demolition activities may require the decommissioning of thermistors currently installed. Thermistor TM-K-01, at the South Landfill and TM-S-01, east of the former sewage lagoon will need to be removed prior to excavation activity.

The following measures will be employed to minimize permafrost degradation during excavation activities to prevent excessive thawing:

- ongoing thermal monitoring and installation of new thermistors may be required pending an identified approval period;
- maintaining well-established vegetation growth, these areas should also be monitored in retaining permafrost integrity;
- excavations will be backfilled as soon as possible to minimize permafrost deterioration and to prevent the accumulation of water; if water does accumulate, it will be sampled to confirm it meets release criteria and pumped out in accordance with the applicable regulatory requirements (at a minimum of 30 m to the nearest water body and 100 m to the nearest fish bearing waters) prior to backfilling and recontouring;
- any water generated through permafrost melting, precipitation, or surface water runoff should be directed to accumulate in one localized area through grading excavated areas;
- surface water run-on will be sampled to confirm it meets release criteria and will be redirected away from work areas using diversion ditches, berms, or grading to promote positive drainage; water that does not meet release criteria will be collected and pumped through the onsite water treatment system prior to release; and
- restrict equipment usage to existing tracks and in disturbed areas where possible.

5.0 CONCLUSIONS

Ongoing monitoring activities are required to ensure the integrity of permafrost is maintained during remediation and post-remediation. During the remedial excavation, exposed permafrost will be covered as soon as practical. Impacted soil will be excavated from several areas and excavations will be backfilled with on-site fill material. Excavations will be graded and re-contoured upon completion.

Excavation area floors will be sloped away from the side walls. If necessary, drainage ditches will be installed. Any water that may be collect in excavation areas will be tested, treated (if required) before released.

An existing thermistor system at the site will be used to monitor temperatures below and at ground level. Thermistors TM-K-01 and TM-S-01 will need to be removed prior to excavation activities. Additional thermistor installation may be required pending construction activity.

6.0 REFERENCES

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Figures



LEGEND

LEASE BOUNDARY

02505001,000

METRES

NOTE(S)
1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
2. COORDINATE SYSTEM IS UTM ZONE 8 NAD 83.

REFERENCE(S)
1. BASE MAP: VANTOR

CLIENT
IMPERIAL OIL LIMITED

PROJECT
TUKTOYAKTUK BASE REMEDIATION, INUVIALUIT SETTLEMENT
REGION, NORTHWEST TERRITORIES

TITLE
SITE LOCATION



CONSULTANT	YYYY-MM-DD	2026-03-09
DESIGNED	J.REDSTONE	
PREPARED	J.REDSTONE	
REVIEWED	V.ANDERSON	
APPROVED	B.SUEN	

PROJECT NO.
CA-GLD-18105460

YEAR/DOC
2026/IWB

REV.
0

FIGURE
1

PATH: S:\Client\Imperial_Oil\tuktoyaktuk\99_PROJ\18105460_IDL_2026\40_PROJ\0002_IBP\CA-GLD-18105460-2026-IWB-XXXX.dwg PRINTED ON: AT: 12:00:42 PM

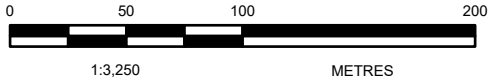
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm



LEGEND

— CURRENT ROAD EDGE



NOTE(S)

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.

2. COORDINATE SYSTEM IS UTM ZONE 8 NAD 83.

REFERENCE(S)

1. PRE-CONSTRUCTION SURVEY CONDUCTED BY INUKSHUK GEOMATICS INC. DATED: AUGUST 25-29, 2015.

2. RECORD SURVEY CONDUCTED BY INUKSHUK GEOMATICS INC., SUMMARIZING CONSTRUCTION ACTIVITIES UP TO AUGUST 10, 2022. PROVIDED BY GOLDER, RECEIVED: OCTOBER 13, 2022.

3. AERIAL IMAGERY SUPPLIED BY INUKSHUK AND COLLECTED ON AUGUST 26, 2024 BY THE PLEIADES SATELLITE CONSTELLATION.

CLIENT

IMPERIAL OIL LIMITED

PROJECT

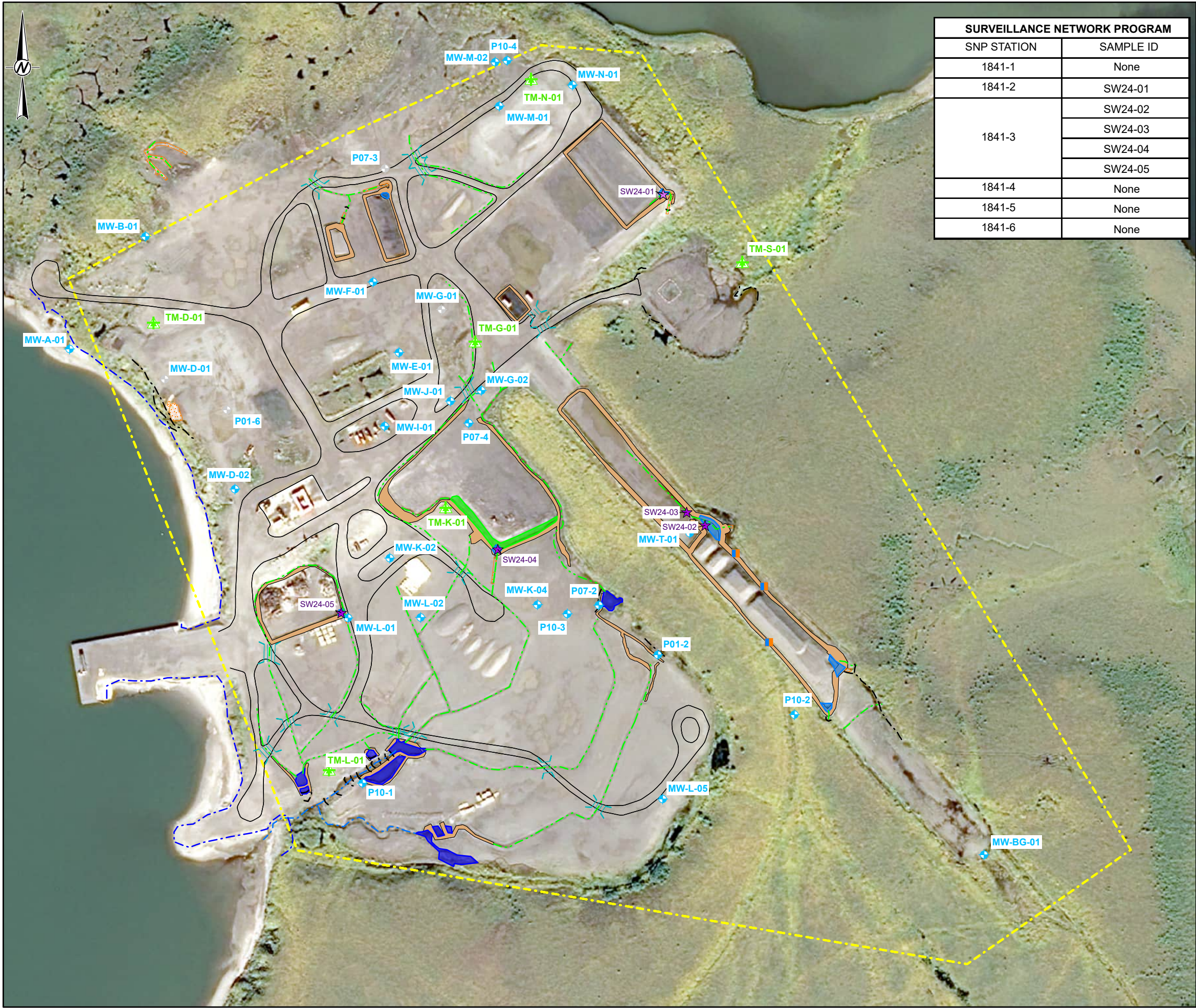
TUKTOYAKTUK BASE REMEDIATION, INUVIALUIT SETTLEMENT REGION, NORTHWEST TERRITORIES

TITLE

SITE PLAN

	CONSULTANT	YYYY-MM-DD	2026-03-09
	DESIGNED	J.REDSTONE	
	PREPARED	J.REDSTONE	
	REVIEWED	V.ANDERSON	
	APPROVED	B.SUEN	

PROJECT NO.	YEAR/DOC	REV.	FIGURE
CA-GLD-18105460	2026/IWB	0	2



SURVEILLANCE NETWORK PROGRAM	
SNP STATION	SAMPLE ID
1841-1	None
1841-2	SW24-01
1841-3	SW24-02
	SW24-03
	SW24-04
	SW24-05
1841-4	None
1841-5	None
1841-6	None

LEGEND

REMEDICATION MANAGEMENT BERM

EROSION CONTROL MAT

CONTAINMENT SUMP

WATER MANAGEMENT CATCH

WATER MANAGEMENT POND

LEASE BOUNDARY

CREEK

OBSERVED HIGH WATER MARK

SILT FENCE

WATER MANAGEMENT SWALE

REMOVED CULVERT

CURRENT ROAD EDGE

EROSION CONTROL FEATURE

GROUNDWATER MONITORING WELL LOCATION

DESTROYED OR DECOMMISSIONED MONITORING WELL

THERMISTOR

WATER SAMPLE LOCATION (SNP: 1841-2)

WATER SAMPLE LOCATION (SNP: 1841-3)



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REFERENCE(S)
1. PRE-CONSTRUCTION SURVEY CONDUCTED BY INUKSHUK GEOMATICS INC. DATED: AUGUST 25-29, 2015.
2. RECORD SURVEY CONDUCTED BY INUKSHUK GEOMATICS INC., SUMMARIZING CONSTRUCTION ACTIVITIES UP TO AUGUST 10, 2022. PROVIDED BY GOLDER, RECEIVED: OCTOBER 13, 2022.
3. AERIAL IMAGERY SUPPLIED BY INUKSHUK AND COLLECTED ON AUGUST 26, 2024 BY THE PLEIADES SATELLITE CONSTELLATION.

CLIENT
IMPERIAL OIL LIMITED

PROJECT
TUKTOYAKTUK BASE REMEDIATION, INUVIALUIT SETTLEMENT REGION, NORTHWEST TERRITORIES

TITLE
WATER MANAGEMENT DETAILS AND PERMAFROST MONITORING LOCATIONS

	CONSULTANT	YYYY-MM-DD	2026-03-09
	DESIGNED	J.REDSTONE	
	PREPARED	J.REDSTONE	
	REVIEWED	V.ANDERSON	
	APPROVED	B.SUEN	

PROJECT NO.	YEAR/DOC	REV.	FIGURE
CA-GLD-18105460	2026/IWB	0	3

