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Public Services and Procurement Canada

2017 ENVIRONMENTAL MONITORING PROGRAM - CAMBRIDGE BAY AIRPORT FTA LTU

Cambridge Bay Airport, NU

February 22, 2018

2017 ENVIRONMENTAL MONITORING PROGRAM - FTA LTU

CAMBRIDGE BAY AIRPORT
VICTORIA ISLAND, NU

Elliott Holden, B.Eng.
Environmental Engineer in Training

Maurenia Lynds, M.A.Sc., P.Eng.
Environmental Engineer/Project Manager

Troy Austrins, P.Eng., PMP
Senior Reviewer

Prepared for:
Public Services and Procurement Canada
Environmental Services - Western Region
Suite 1650, 635 - 8th Ave SW
Calgary, Alberta T2P 3M3

Prepared by:
Arcadis Canada Inc.
329 Churchill Avenue North
Ottawa, ON, K1Z 5B8
Tel (613) 721-0555
Fax (613) 721-0029

Our Ref.:

102089-002

Date:

February 22, 2018

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ACRONYMS AND ABBREVIATIONS

Arcadis	Arcadis Canada Inc.
BTEX	Benzene, Toluene, Ethyl Benzene and Xylenes
CCME	Canadian Council of Ministers of the Environment
CCME FWAL	Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life
COC	Contaminant of Concern
DWSV	Drinking Water Screening Value
ESA	Environmental Site Assessment
FCSAP	Federal Contaminated Sites Action Plan
FIGQG	Federal Interim Groundwater Quality Guidelines
FTA	Fire Training Area
HC	Health Canada
km	kilometre(s)
kg	kilogram
L	litre(s)
LTU	Land Treatment Unit
m	metre(s)
m asl	metre(s) above sea level
m bgs	metre(s) below ground surface
NWB	Nunavut Water Board
OVM	Organic Vapour Measurement
PAH	Polycyclic Aromatic Hydrocarbon
PFAS	Poly-and-perfluoroalkyl Substances
PHC	Petroleum Hydrocarbon
ppm	parts per million
PWGSC	Public Works and Government Services Canada
RDL	Reportable Detection Limit
TC	Transport Canada
TOR	Terms of Reference

EXECUTIVE SUMMARY

Arcadis Canada Inc. (Arcadis) was retained by Public Services and Procurement Canada (PSPC) [formerly Public Works and Government Services Canada (PWGSC)] on behalf of Transport Canada (TC) to conduct an Environmental Monitoring Program at the Cambridge Bay Airport Fire Training Area (FTA) Land Treatment Unit (LTU) in Cambridge Bay, Nunavut. The 2017 field activities were completed from July 24 to August 10, 2017.

The FTA LTU was constructed between 2014 and 2015 to treat petroleum hydrocarbon (PHC) impacted soil excavated from an area where fire training exercises were conducted. Approximately 4,300 cubic metres (m^3) of PHC impacted soil was removed from the FTA excavation. This volume was less than the original assessment's estimate of 7,000 m^3. As a result, approximately 25% of the LTU remains unused. The FTA LTU has two sumps: one located in the LTU's northwest corner and one located in the LTU's southeast corner.

The 2017 Environmental Monitoring Program included:

1. A groundwater and soil monitoring program that met the requirements of Nunavut Water Board (NWB) License 1BR-FTA1217. This included modifying the soil sampling requirements to a single sampling event at the FTA LTU as no active soil treatment is currently occurring at the site. Soil (7 samples), sump water (2 samples), seepage water (1 sample) and groundwater (3 samples) samples were collected and submitted for analysis;
2. The repair of damaged monitoring wells;
3. A geochemical assessment to confirm a potential seepage issue outside the FTA LTU's northwest corner;
4. A Class A cost estimate for future proposed work (under separate cover); and,
5. The comparison of historical and current monitoring data from the various sampled media to assess for natural attenuation and the integrity of the LTU.

Sump Water

In 2017, similar sump water results to 2016 were observed. Both sump water samples met the NWB Licence requirements and applicable CCME guidelines. Concentrations of oil and grease, dissolved lead, total zinc and BTEX in both sump water samples, FTASUMP01 and FTASUMP02, were either below the laboratory RDLs or at least 2.5 times less than the applicable criteria.

However, both sump water samples contained concentrations of multiple perfluorinated compounds including PFHpA, PFHxS, PFHxA, PFOA and PFPeA above the applicable HC DWSVs. The concentrations of these perfluorinated compounds ranged between 0.35 and 89 µg/L. In some cases, the exceedances were greater than 100 times the applicable HC DWSVs. Furthermore, the concentration of PFOS in sump water sample FTASUMP02 (12 µg/L) exceeded both the applicable HC DWSV (0.6 µg/L) and ECCC FEQG (6 µg/L). Our recommendation remains similar to 2016, that the sump water should not be discharged to ground surface as it contains PFAS exceedances.

Soil Hydrocarbon Remediation

In 2017, similar soil results to 2016 were observed. All seven soil samples had concentrations of BTEX and PHCs that met the NWB Licence requirements. However, these soil sample results apply to the upper 0.35 metres (m) of the impacted soil profile in the LTU; lower soil depths have not been assessed to date. The average depth of the soil profile in the LTU is one metre (1.0 m).

The PHC concentrations in five (FTA1702, FTA1703, FTA1704, FTA1705 and FTA1706) of the seven soil samples collected ranged from concentrations below the laboratory RDLs to detections that were less than the applicable guideline values. One soil sample, FTA1701, and its duplicate, FTADUP01, both had a concentration of PHC fraction F2 (540 mg/kg) above the CWS-PHC guideline of 230 mg/kg for commercial/industrial land use.

Assessment of the 2017 soil nutrient results indicate that the phosphorous concentration in the upper 0.3 m of the impacted soil is below the optimal range for hydrocarbon degradation.

Groundwater Monitoring Program

The 2016 groundwater samples were the first full round of groundwater samples collected as part of the NWB Licence requirement. In 2017, groundwater samples were collected from three of the eleven monitoring wells (MW15-1, MW15-5 and MW15-8). In addition, similar to 2016, the concentration of BTEX, PHCs and PAHs were all below the applicable guidelines and the concentration of BTEX and PAHs for MW15-1 and MW15-5 were below the laboratory RDLs.

However, several parameters reported concentrations above the CCME FWAL guidelines including: phenols, dissolved arsenic, dissolved iron, dissolved uranium, and dissolved chloride. Several of these elevated groundwater parameters are likely a result of naturally elevated background concentrations.

Geochemical Assessment

As part of the Geochemical Assessment, water samples were collected from the northwest sump area in the FTA LTU, ponded water in the suspected seepage area outside the FTA LTU's northwest corner, a groundwater monitoring well adjacent to the northwest corner of the FTA LTU (i.e., monitoring well MW15-1), ponded water in areas unaffected by seepage, and from a groundwater monitoring well located outside any impacted area (monitoring well MW13-8 was selected). These water samples were analyzed for major cations and anions, PHCs, per- and polyfluoroalkyl substances (PFAS), and trace metals. In addition, field parameters including pH, conductivity, and total dissolved solids were collected at each sampling location. The inorganic and organic chemical signature of each water sample was then compared.

Based on the analytical results from the Geochemical Assessment, it was shown that similar PFAS compounds were present in the Northwest Sump Area (FTA SUMP01) and the Ponded Water in the Northwest Seepage Area (FTA-SW-NW01). As well, the concentrations of PFAS in the water collected from the Northwest Seepage Area were of the same order of magnitude, but lower than those in the northwest sump and that Perfluorobutanioc acid, PFHxA, and PFPeA was confirmed to be present in the groundwater collected from MW15-1, located adjacent to the northwest corner of the FTA LTU, but at lower concentrations than in FTA SUMP01 and FTA-SW-NW01. Finally, in addition to low concentrations

of PFAS, the groundwater in MW15-1 showed other indications of possible flow from beneath the LTU when the data from this well was compared to MW13-8, the monitoring well located outside the impacted area.

With the exception of the PFAS results, it is difficult to draw direct comparisons/contrasts between the parameters in the sump water, the ponded water in the suspected seepage area, and 'unaffected' pond water, as the effects of recent precipitation events and the variability in area contributing surface run-off to the ponds etc. may have an impact (e.g. chloride in the sump is lower than in either pond). However, there were other geochemical indicators (i.e., TDS and pH) that suggest the ponded water in the northwest seepage area (FTA-SW-NW01) has been impacted by seepage and/or groundwater discharge from beneath the FTA LTU.

In summary, the surface water pond and shallow groundwater in the northwest corner appear to be showing evidence of FTA LTU-derived impacts.

Recommendations

Arcadis proposes the following future work at the FTA LTU:

1. To confirm the initial results of the seepage assessment, it is recommended that a second set of seepage water samples be collected with the analytical list expanded to include metals, anions, dissolved nutrients including ammonia, and total and dissolved organic carbon (TOC and DOC) in the surface water and sump samples. This extra data will facilitate further evaluation of the link of seepage to sump water. As well, confirming the initial correlations with a second set of seepage samples will allow more knowledgeable decisions to be made regarding more expensive alternatives for investigating liner integrity, the extent of seepage and/or risk management and/or remedial approaches, as detailed in Arcadis report entitled, "*Assessment Options Analysis, Fire Training Area Land Treatment Unit*", dated November 2016.

2. Complete a groundwater monitoring program at the FTA LTU and excavation area to assess the parameters listed in the license. Attempts should be made to sample the monitoring wells during freshet conditions and warmest weeks at Cambridge Bay, when liquid groundwater conditions are more probable and when groundwater levels are presumed to be at their highest to further evaluate groundwater trends. Based on temperature statistics obtained from ECCC, this sampling period would best occur in mid-July.

3. Arcadis recommends that an evaluation of background conditions be conducted to confirm the source of the elevated phenols, dissolved arsenic, dissolved iron and dissolved uranium concentrations

4. Complete a soil sampling program to assess the level of biodegradation and confirm that soil concentrations remain below the NWB Licence requirements. Select soil samples should be analyzed for nutrients, moisture, pH, bulk density, BTEX, and PHC Fractions F1 to F4. Additionally, tilling of the soils will aid in decreasing soil compaction and increase the rate at which water can infiltrate into the soil during future dewatering activities, as required.

Once active treatment re-commences, Arcadis recommends the number of soil samples submitted for laboratory analysis from the upper 0.3 m bgs of the soil in the FTA LTU be increased to 15 samples to better assess the effectiveness of hydrocarbon degradation. In addition, Arcadis recommends 15 additional soil samples from the soil located below 0.3 m bgs be submitted for laboratory analysis.

5. Arcadis recommends a phosphorous-dominant fertilizer be thoroughly mixed into the soil once active treatment at the FTA LTU is re-commenced.

1 INTRODUCTION

Arcadis Canada Inc. (Arcadis) was retained by Public Services and Procurement Canada (PSPC) [formerly Public Works and Governments Services Canada (PWGSC)] on behalf of Transport Canada (TC) to conduct an environmental monitoring program at the Cambridge Bay Airport Fire Training Area (FTA) Land Treatment Unit (LTU) in Cambridge Bay, Nunavut.

This report is submitted under Northern Standing Offer Contract Number EW699-141143/001/NCS and conducted in according with the Terms of Reference (TOR) Amendment entitled, "*Apron and Fire Training Area Site Remedial Activities Supervision and Environmental Monitoring Program, Cambridge Bay Airport, Victoria Island, Nunavut"* and the Arcadis proposal entitled, "*Fire Training Area (FTA) LTU, Site Remedial Activities Supervision and Environmental Monitoring Program, Cambridge Bay Airport, Victoria Island, Nunavut"* dated, July 13, 2017. Throughout this report the FTA LTU and FTA excavation area will be referred to as "the site."

1.1 Project Objectives

The objectives of the 2017 Environmental Monitoring Program were to:

1. Complete an environmental monitoring program that meets the Nunavut Water Board (NWB) License 1BR-FTA1217 requirements. This included modifying the soil sampling requirements to a single sampling event at the LTU, as no active soil treatment is currently occurring at the site;
2. Complete a groundwater monitoring program at the FTA LTU (four monitoring wells) and FTA excavated area (seven monitoring wells), in accordance with Part J, Item 7 of NWB license 1BR-FTA1217;
3. Repair damaged monitoring wells, if required and/or feasible;
4. Conduct geochemical assessment to confirm the source of seepage outside the FTA LTU identified in 2016. In addition, identify potential mitigative measures to remediate the issue;
5. Submit soil, sump water, seepage water, and groundwater samples for laboratory analysis and analyze data;
6. Provide a Class A cost estimate for future proposed work, if warranted (under separate cover); and,
7. Prepare draft and final reports of the above investigations.

2 BACKGROUND INFORMATION

As part of the airport operations transfer agreement between TC and the Government of Nunavut (GN), two areas of environmental concern (AECs) were identified for remediation at the Cambridge Bay Airport:

1. AEC 1: an area on the apron near the airport terminal where airplanes are refueled, hereafter referred to as the Apron excavation area; and,
2. AEC 2: a fire training area (FTA) located at the northwest end of the airport runway, hereafter referred to as the FTA excavation area.

The location of the Apron and FTA excavation areas are shown in **Figure 1**.

Previous investigation confirmed petroleum hydrocarbon (PHC) impacted soil and dissolved metal impacted groundwater in both AECs. To address these impacts, TC developed remedial action plans for both AECs that involved excavation of the impacted soil and placement into constructed LTUs located near the northwest end of the airport runway.

TC obtained an operating license (IBR-FTA1217) through the Nunavut Water Board (NWB) in 2011, in anticipation of construction activities.

The FTA remediation program was completed by the contractor Uplogiaq Inc., owned by GPEC International. The FTA LTU was constructed from 2014 to 2015 and occupies a footprint of approximately 75 metres (m) x 250 m. The FTA LTU is located immediately north of the FTA excavation area at the northwest end of the airport runway. The base of the FTA LTU was graded to direct captured water towards two sumps: one located in the LTU's northwest corner and one located in the LTU's southeast corner. A 0.25 m thick demarcation layer (base layer) of granular material was compacted over the LTU's geomembrane liner. Similar granular material was used to cover the portion of the geomembrane liner that extends over the berm walls.

As indicated in previous reports, a drum cache was uncovered during grubbing activities along the south side of the LTU footprint. The soil from the drum cache area was excavated to an extent where remaining soils did not exhibit contaminants of concern above the selected soil remediation standards, with the exception of one south wall sample (exceeding PHC fraction F1 criteria). The remaining impact at this location was not considered significant as it was isolated below the ground surface and was covered with clean material.

Approximately 4,300 m^3 of impacted soil was removed from the FTA excavation. This volume was less than the original assessment's estimate of 7,000 m^3. The maximum achieved depths of the excavation were limited by permafrost levels that ranged from 1.7 to 2.0 metres below ground surface (m bgs). All confirmatory samples were below applicable remediation criteria. Subsequently, the impacted soil occupies an area approximately 66 m x 180 m (approximately 75% of the LTU). In the remaining area of the LTU, the granular demarcation layer remains exposed. Four groundwater monitoring wells (MW15-1 to MW15-4) were installed around the LTU and seven groundwater monitoring wells (MW15-5 to MW15-11) were installed through and around the FTA excavation area.

Dillon Consulting Ltd. (Dillon) performed the remediation oversight, data gap analysis and sampling in 2014 and 2015 at the FTA LTU. Concurrently with the 2015 remediation activities, several soil and groundwater samples were collected and analyzed for poly– and perfluoroalkyl substances (PFASs);

specifically, perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). This was done to characterize current site conditions with regard to the previously identified contaminants of potential concern associated with the FTA and to develop an understanding of potential fate and transport considerations to support future assessment of environmental risks as warranted.

Review of the laboratory results of the PFAS samples indicated two groundwater samples and two soil samples exhibited concentrations that exceed criteria for the protection of freshwater aquatic receptors. These results suggest that PFAS migration through soils and seasonal groundwater may have been facilitated by the presence of PHCs. The FTA remedial activities removed both PHC and PFAS-impacted soils from the FTA thus reducing potential risks to downgradient receptors.

3 ENVIRONMENTAL QUALITY GUIDELINES

Analytical results for the soil samples collected were evaluated against the Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines, specifically the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQGs) and the Canada-Wide Standards for Petroleum Hydrocarbons in Soil (CWS-PHC) for commercial/industrial land use and fine grain size. Soils were also compared against the Nunavut Water Board Licence No. 1BR-FTA1217, Part J, Remediation Requirements.

As per the NWB Licence, groundwater analytical results, as well as analytical results for surface water samples collected from the two LTU sumps, were evaluated against the Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (freshwater and marine), hereafter referred to as CCME FWAL. Canadian water quality guidelines are intended to protect freshwater and marine life from anthropogenic stressors such as chemical inputs or changes to physical conditions. Surface water samples collected from the sumps were also evaluated against the NWB Licence, Part D, Effluent Quality Limits.

The following summarizes the site conditions in support of the guidelines selected:

- Grain size analysis of soils samples collected by Dillon in 2014 and 2015 indicate that the soil at the site is fine grained (based on the predominant soil texture).
- The FTA LTU and excavation area are on airport land that has been classified as commercial.
- Groundwater is not used as a source of potable water on-site or in the area. The Hamlet of Cambridge Bay obtains potable water from a surface water body located over four kilometers northeast of the site.
- Freshwater waterbodies are located north and northwest of the FTA LTU and excavation area (within 300 m). The marine waterbody of Cambridge Bay is located to the south of both the Apron LTU and excavation area (within 200 and 100 m respectively),
- Groundwater elevations measured in monitoring wells within around the FTA LTU suggest groundwater flows south towards Cambridge Bay.

PFOS and other PFASs are anthropogenic chemicals that have been introduced to the environment through their broad application including manufacturing products and consumer products. Based on risk assessment activities under the Canadian Environmental Protection Act, 1999, it was concluded that PFOS and its associated salts and precursors may be entering the environment in concentrations that may have an immediate or long-term harmful effect on the environment or biological diversity. Historically, PFOS and other PFASs were used in aqueous film forming foams which were typically used during fire fighting training activities.

There are currently no Canadian environmental quality guidelines for PFAS. The United States Environmental Protection Agency has developed health advisories for Perfloro-n-Octanoic Acid (PFOA) and PFOS, but these are not legally enforced standards and are subject to change as new information becomes available. In the absence of definitive guidelines, Health Canada (HC) and Environment and Climate Change Canada (ECCC) have taken steps to develop PFAS screening values, until such time that environmental quality guidelines are developed.

HC has derived drinking water screening values (DWSVs) for PFAS, as well as soil screening values (SSV) for PFOS and PFOA. Screening values are developed at the request of a federal department in the event of a spill, leak or other unforeseen event and are based on readily-available scientific studies. They have not been subjected to as thorough a review as actual guideline values. They are designed for the protection of human health through direct exposure through drinking water. It should be noted these drinking water screening values have not considered other exposure pathways such as the protection from consumption of fish or irrigation of food crops.

In 2013, ECCC developed draft ecological receptor Federal Environmental Quality Guidelines (FEQGs) for PFOS. They were revised in 2015 but have not been finalized. These FEQGs are summarized in Table 3-1. The values are based on laboratory toxicity studies. If concentrations are detected above these values in the environment, ECCC presumes that adverse effects may occur.

Table 3-1: Draft FEQG for PFOS in the Environment in Canada (from ECCC, 2013)

Water (µg/L)	Fish Tissue (ng/g wet weight)	Wildlife Diet (ng/g wet weight food)		Bird Egg (ng/g wet weight)
		Mammalian	Avian	
6	8,300	4.6	8.2	1,900

For the purposes of the PFAS assessments at FTAs on TC properties, the more applicable of either the Health Canada screening values or the FEQGs should be used for the human health evaluation (e.g. based on land use scenarios and lowest applicable screening values). In October 2015, the National Guidelines and Standards Office, Environment Canada, issued Version 1.3 of the Director General-approved Federal Soil Quality Guidelines (FSQGs) for PFOS available to the Federal Contaminated Sites Action Plan (FCSAP).

Analytical results for surface water samples collected by Arcadis in 2016 were compared to the HC drinking water screening values and the draft FEQGs for PFOS.

4 PROGRAM METHODOLOGY

The following sections outline the scope of work and methodology implemented during the 2017 Environmental Monitoring Program. The field activities were completed between July 24 and August 10, 2017.

4.1 Site Specific Health and Safety Plan

Arcadis prepared a site-specific health and safety plan (HASP) prior to the field activities. The HASP included the documentation of all foreseeable work hazards and mitigative actions. It also contained a list of emergency contact numbers and protocols to follow in the event of an incident. Arcadis ensured that the HASP was communicated to all site personnel and that all field staff were aware of all contaminants of concern, associated precautions, and required personal protective equipment.

A health and safety kick-off meeting and daily tailgate meetings, including task specific job safety analyses, were conducted to inform on-site personnel of the potential risks and appropriate safety controls. The HASP has been retained on file by Arcadis.

4.2 Nunavut Water Board Licence Requirements

In accordance with the NWB Licence (1BR-FTA1217), the sampling plan developed by Arcadis and implemented during the 2017 site visit was reviewed by Maxxam Analytics Inc. (Maxxam). Maxxam is certified by the Canadian Association for Laboratory Accreditation Inc. (CALA). **Appendix A** contains the letter from Maxxam in response to their review of Arcadis' 2017 sampling plan.

4.2.1 Sump Water Sampling

Arcadis collected grab samples from the surface water around the FTA LTU sumps on July 25, 2017. Sump water sample FTASUMP01 was collected from the sump located in the northwest corner of the LTU and sump water sample FTASUMP02 was collected from the sump located in the southeast corner of the LTU. In accordance with the NWB Licence, Part D, Number 4, the samples were submitted for the following analyses: pH, oil and grease, dissolved lead, total zinc, dissolved lead, and benzene, toluene, ethylbenzene and xylene (BTEX), and petroleum hydrocarbon fraction F1 (PHC F1).

All sump water sample containers were placed in a cooler with ice immediately after they were collected and then stored in a refrigerator prior to their shipment. Sump water samples were shipped in coolers with ice packs to the Maxxam depot in Yellowknife, NT on July 26, 2017. Analysis of the samples was completed by the Maxxam laboratory in Edmonton, AB. Copies of the Certificate of Analysis laboratory reports are attached in **Appendix B**.

4.2.2 Soil Sampling

Arcadis conducted FTA LTU soil sampling in accordance with the NWB Licence requirements. All soil samples were analyzed for BTEX and PHC Fractions F1 to F4. A total of six soil samples (FTA1701 to FTA1706) and one duplicate sample (FTADUP01) were collected on August 6, 2017. Soil samples were collected after the 2017 tilling activities.

Sample locations were chosen by dividing the FTA LTU into six sections of approximately equal area (approximately 50 metre by 30 metre areas), as shown in **Figure 3**. Samples were collected in the centre each area at a depth of approximately 0.3 metres below ground surface (m bgs). **Figure 3** also shows sample locations.

All sampling equipment was decontaminated between each sample location with Alconox and distilled water. A new pair of nitrile gloves were worn for the collection of each sample. LTU field conditions and soil descriptions, including approximate grain size, colour, moisture content, and nature and extent of apparent contamination, were documented for each soil sampling location. The GPS coordinates of each soil sample were also collected using a Garmin eTrex 10, with an accuracy of 3 metres.

All soil sample containers were placed in a cooler with ice immediately after they were collected and then stored in a refrigerator prior to shipment. The samples were shipped in coolers with ice packs to the Maxxam depot in Yellowknife, NWT on August 8, 2017. Analysis of the soil samples was completed by the Maxxam laboratory in Edmonton, AB. Copies of the Certificate of Analysis laboratory reports are attached in **Appendix B**.

4.2.3 Groundwater Monitoring and Sampling at the FTA LTU and Excavation Area

Arcadis conducted groundwater monitoring and sampling during the 2017 field program at the FTA LTU and the FTA excavation area. Eleven groundwater monitoring wells are located at the site: four wells located around the FTA LTU (MW15-1 to MW15-4) and seven wells in the FTA Excavation Area (MW15-5 to MW-15-11), as shown in **Figure 2**.

Arcadis collected groundwater samples from all wells with a sufficient volume of water present. One blind duplicate sample was also collected. Before sample collection, a minimum of three well volumes were purged. Purge water was disposed of in the FTA LTU following completion of all sampling. Groundwater could only be collected from three of the eleven monitoring wells (MW15-1, MW15-5 and MW15-8). The groundwater in eight of the monitoring wells (MW15-2, MW15-3, MW15-4, MW15-6, MW15-7, MW15-9, MW15-10, and MW15-11) was frozen.

Sampling and purging was conducted using low-flow sampling techniques via a peristaltic pump and dedicated tubing. Volatile organic compound levels inside each monitoring well were measured with a MiniRae 3000 immediately after removing the well cap. Physical chemistry parameters including pH, oxidation-reduction potential, conductivity, turbidity, dissolved oxygen, total dissolved solids and temperature were monitored using a calibrated Horiba U-52. Water level drawdown was monitored using a Heron oil/water interface probe. Where the recharge was not sufficient to conduct low flow sampling techniques, the well was purged dry three times before sampling. All sampling equipment was decontaminated between sample locations with Alconox and distilled water. A new pair of nitrile gloves were worn prior to each sampling event.

In accordance with the NWB Licence requirements, Part J, Number 7, the groundwater samples were submitted for BTEX, PHC F1-F4, polycyclic aromatic hydrocarbons (PAHs), total alkalinity, nitrate-nitrite, ammonia nitrogen, oil and grease, total phenols, calcium, magnesium, sodium, potassium, chloride,

sulphate, dissolved metals, total suspended solids and total dissolved solids analysis. Copies of the Certificate of Analysis laboratory reports are attached in **Appendix B.**

All groundwater sample bottles were placed in a cooler with ice packs immediately after they were collected. The groundwater samples were then stored in a refrigerator prior to their shipment. Groundwater samples were shipped in coolers with ice packs to the Maxxam depot in Yellowknife, NWT. Analysis of the groundwater samples was completed at the Maxxam laboratory in Edmonton, AB.

4.3 Per- and Polyfluoroalkyl Substance (PFAS) Sampling

Arcadis collected one grab surface water sample from the FTA LTU northwest sump (FTASUMP01) and one grab surface water sample from the FTA LTU southeast sump (FTASUMP02) on July 26, 2017 for PFAS analysis.

All PFAS surface water sampling procedures adhered to TC's February 2016 PFAS Field Sampling Guidance Document. Arcadis applied the following procedure to reduce the potential PFAS contamination during sampling:

- A pencil was used to label sample containers;
- Each sample container was transported in an individual-sealable plastic bag;
- All samples were kept in their own cooler separate from other sample containers;
- Field notes were taken on non-waterproof paper on an aluminum clip board with a pencil;
- A new pair of nitrile gloves were worn prior to each sampling round;
- 100% cotton clothes were worn during sampling (the items were put through a wash cycle without detergent, air dried, and stored in a cotton pillow case);
- A pillow case was used on the driver's seat of the truck used to transport samples as a barrier between vehicle seating materials; and,
- Steel-toed boots were worn but contact with any soil to be collected for PFAS analysis was prevented.

The PFAS analysis was completed by the Maxxam laboratory in Mississauga, ON. Copies of the Certificate of Analysis laboratory reports are attached in **Appendix B.**

4.4 Geochemical Assessment

Arcadis completed a Geochemical Assessment to assess the potential seepage issues suspected of occurring at the northwest corner of FTA LTU. As part of this assessment, water samples were collected from the northwest sump area in the FTA LTU (FTASUMP01), ponded water in the suspected seepage area (FTA-SW-NW01, refer to photo 5 in Appendix C), a groundwater monitoring well adjacent to the northwest corner of FTA LTU (MW15-1), ponded water in areas unaffected by seepage (SW1701 refer to photo 6 in Appendix C), and a groundwater monitoring well located outside any impacted area (MW13-8). A sample of rain water was not collected due to insufficient precipitation during the 2017 field program. These water samples were analyzed for major cations and anions, PHCs, per- and polyfluoroalkyl substances (PFAS), and trace metals. In addition, field parameters including pH, conductivity, and total dissolved solids were collected at each sampling location. The inorganic and organic chemical signature of each water sample was then compared.

5 QUALITY ASSURANCE AND QUALITY CONTROL

To assess the reliability of the laboratory analytical data, one duplicate sample was taken for approximately every ten samples collected. Arcadis generated the duplicate soil samples by alternately placing approximately 10% of the sample volume into the primary sample container and then placing the same amount into the duplicate container. Arcadis continued placing aliquots of approximately 10% of the container volume into each container until both containers were filled. Parent and duplicate samples collected for BTEX/F1 analysis were collected side by side by inserting a plunger into an undisturbed area of the soil column and placing the soil from the plunger in their respective methanol vials. A trip blank and field blank were collected during the groundwater sampling program. Duplicate groundwater samples were collected by filling the duplicate sample bottles immediately after the primary sample was collected.

Analytical data quality was assessed by submission of the following soil and groundwater samples:

- Soil sample FTA 1701 (primary) and FTADUP01 (duplicate) were analyzed for BTEX and PHC fractions F1-F4;
- Groundwater sample MW15-8 (primary) and FTADUP01 (duplicate) were analyzed for PHC fractions F1-F4, BTEX, PAHs, total alkalinity, nitrate-nitrite, ammonia nitrogen, oil and grease, total phenols, calcium, magnesium, sodium, potassium, chloride, sulphate, dissolved metals, total suspended solids and total dissolved solids analysis; and,
- The Trip Blank and Field Blank were analyzed for BTEX and PHC fractions F1-F4.

For each set of duplicates, the relative percent difference (RPD) was calculated using the following formula:

$$RPD = \frac{|X_1 - X_2|}{X_{average}} \times 100$$

where, X_1 and X_2 are the duplicate concentrations and $X_{average}$ is the mean of these two values. Results for duplicate analyses of field duplicate samples were considered acceptable where RPD values were <50% for soil duplicate analyses and <50% for water duplicate analyses, consistent with common industry practices.

RPDs can be calculated only when the compound is detected in both the original and the duplicate sample at a concentration above the method detection limit. Alternative criteria are used to evaluate duplicate pairs where one or both of the results is less than five times the detection or quantitation limit, or where one or both of the results is less than the detection or quantitation limit (i.e., nd or ‘not-detected’).

6 ENVIRONMENTAL MONITORING PROGRAM RESULTS

The following sections summarize the analytical results for all samples collected during the 2017 Environmental Monitoring Program.

6.1 Nunavut Water Board Licence Requirements Sampling Results

6.1.1 Sump Water Analytical Results

Arcadis collected a grab sample from the standing water in each FTA LTU sump on July 25, 2017. Sump water sample FTASUMP01 was collected from the sump located in the northwest corner of the LTU and sump water sample FTASUMP02 was collected from the sump located in the southeast corner of the LTU.

Both sump water samples met all NWB Licence requirements and applicable CCME guidelines. Concentrations of oil and grease, dissolved lead, total zinc and BTEX in both sump water samples, FTASUMP01 and FTASUMP02, were either below the laboratory's reportable detection limits (RDLs) or at least 2.5 times less than the applicable criteria.

The Sump Water analytical results are presented in **Table 7**. Laboratory certificate of analysis including lab QA/QC results are included in **Appendix B**.

6.1.2 Soil Analytical Results

A total of seven soil samples (including one duplicate sample) were collected from the FTA LTU and submitted for the laboratory analysis of BTEX and PHCs. They were identified as: FTA1701, FTA1702, FTA1703, FTA1704, FTA1705, FTA1706 and FTADUP01.

All seven soil samples had concentrations of BTEX and PHCs that met the NWB Licence requirements.

The PHC concentrations in five of the soil samples (FTA1702, FTA1703, FTA1704, FTA1705 and FTA1706) ranged from concentrations below the laboratory RDLs to detections that were less than the applicable guideline values.

BTEX concentrations in all seven soil samples were below the laboratory RDLs.

However, the following soil exceedance was detected:

- Soil samples (FTA1701 and its Duplicate FTADUP01) both had a concentration of PHC fraction F2 (540 mg/kg) above the CWS-PHC guideline of 230 mg/kg for commercial/industrial land use.

The soil analytical results are presented in **Table 9**. Exceedances are shown on **Figure 3**. Laboratory certificate of analysis, including lab QA/QC results, are included in **Appendix B**.

6.1.3 Groundwater Conditions

The casing and riser on all groundwater monitoring wells around the FTA LTU and excavation area were found to be in good condition with the exception of monitoring wells MW15-8 (refer to Photos 1 in Appendix C). Monitoring well MW15-8 is located south of the FTA excavation area adjacent to an Airport access road refer to Figure 2). Arcadis made repairs to monitoring wells MW15-8 during the 2017 field program (refer to photo 2 and 3 in Appendix C). These repairs did not impact the riser height on monitoring wells MW15-8. No damage was noted and no repairs were needed on all other monitoring wells. No measurable thickness of light non-aqueous phase liquid (LNAPL) was identified in any of the monitoring wells. No sheens were observed in the purged groundwater or from the groundwater samples after collection.

During the 2017 field program, the groundwater table was found at depths ranging between 1.588 to 2.204 metres below top of casing (m btc). Groundwater elevations ranged between 23.527 to 25.659 metres above sea level (m asl). The interpreted shallow horizontal groundwater flow direction is towards the south at the FTA LTU and excavation area. The groundwater monitoring data is presented in **Table 1.**

6.1.4 Groundwater Analytical Results

Groundwater samples were collected from three monitoring wells (MW15-1, MW15-5 and MW15-8); one located adjacent to the FTA LTU (MW15-1) and two were in the excavation area (MW15-5 and MW15-8). The analytical results for the groundwater samples were compared to the CCME FWAL guidelines.

The concentration of BTEX, PHCs and PAHs were all below the applicable guidelines. The concentration of BTEX and PAHs for MW15-1 and MW15-5 were below the laboratory RDLs.

However, the following exceedances were detected:

- Concentrations of dissolved arsenic, dissolved iron and dissolved uranium was reported above the CCME FWAL long-term effect guidelines of 0.005 mg/L, 0.3 mg/L and 0.015 mg/L at 0.011 mg/L, 2.2 mg/L and 0.018 mg/L, respectively, for MW15-1;
- MW15-5 reported concentrations of dissolved iron and dissolved uranium just above the CCME FWAL guidelines of 0.3 mg/L and 0.015 mg/L, respectively at 0.48 mg/L and 0.028 mg/L;
- MW15-8, and its Duplicate (FTADUP01) reported concentrations of dissolved iron above the CCME FWAL guideline of 0.3 mg/L at concentrations of 1.8 mg/L and 2.1 mg/L;
- Dissolved chloride was reported at concentrations above CCME FWAL long-term and/or short-term effects guidelines in all four groundwater samples. The exceedance factors ranged from 2 to 13 times the short-term guideline of 120 mg/L; and,
- Phenols reported concentrations above the CCME FWAL guideline of 0.004 mg/L for all four groundwater samples. The exceedance factors ranged from 4 to 35 times the guideline.

The groundwater analytical results are presented in **Tables 2 to 5.** Exceedances are shown on **Figure 3**. Laboratory certificates of analysis including lab QA/QC results are included in **Appendix B**.

6.2 Per- and Polyfluoroalkyl Substance (PFAS) Sampling Results

For the PFAS sampling, Arcadis collected a grab sample from the standing water in each FTA LTU sump on July 25, 2017. The following exceedances were detected:

- Exceedance of multiple perfluorinated compounds were detected in both sump water samples. Both samples had concentrations of Perfluoroheptanoic Acid (PFHpA), Perfluorohexane Sulfonate (PFHxS), Perfluorohexanoic Acid (PFHxA), Perfluoro-n-Octanoic Acid (PFOA), and Perfluoropentanoic Acid (PFPeA) above the applicable HC DWSVs.
- Concentrations of these perfluorinated compounds ranged between 0.35 and 89 µg/L. In some cases, exceedances were greater than 100 times the applicable HC DWSVs.
- The concentration of Perfluorooctane Sulfonate (PFOS) in sump water sample FTA SUMP02 (12 µg/L) exceeded both the applicable HC DWSV (at 0.6 µg/L) and ECCC FEQG (at 6 µg/L).

The Sump Water PFAS analytical results are presented in **Table 8**. Exceedances are shown on **Figure 3**. Laboratory certificate of analysis including lab QA/QC results are included in **Appendix B**.

6.3 Geochemical Assessment Results

For the Geochemical Assessment, water samples were collected from the northwest sump area in the FTA LTU (FTASUMP01), ponded water in the suspected seepage area (FTA-SW-NW01), a groundwater monitoring well adjacent to the northwest corner of FTA LTU (MW15-1), ponded water in areas unaffected by seepage (SW1701), and a groundwater monitoring well located outside any impacted area (MW13-8). The results are presented in **Tables 10 to 14**. Based on the analytical results, the following was observed:

- Similar PFAS compounds were present in the Northwest Sump Area (FTA SUMP01) and the Ponded Water in the Northwest Seepage Area (FTA-SW-NW01). The concentrations in the water collected from the Northwest Seepage Area were of the same order of magnitude, but lower than those in the Northwest Sump;
- Perfluorobutanioc acid, PFHxA, and PFPeA was confirmed to be present in the groundwater collected from MW15-1, located adjacent to the northwest corner of the FTA LTU, but at lower concentrations that FTA SUMP01 and FTA-SW-NW01;
- In addition to low concentrations of PFAS, the groundwater in MW15-1 showed other indications of possible flow from beneath the LTU when the data from this well was compared to MW13-8 (the monitoring well located outside the impacted area);
- With only one exception, BTEX and PHCs were not detected in any of the water samples. PHC F3 was detected in MW15-1 but only at the RDL concentration of 200 µg/L;
- There was evidence of reducing conditions, including lower sulphate, lower ORP, and predominance of reduced nitrogen species (ammonia) versus oxidized forms (nitrate) in MW13-8, the well located outside the impacted area; and,
- There was a higher concentration of chloride and TDS in MW15-1.

7 QUALITY ASSURANCE AND QUALITY CONTROL

Arcadis quantitatively assessed the analytical quality of the data through calculating the relative percent difference (RPD) between each sample and its duplicate. A summary of the analytical results for the original and duplicate samples, along with the calculated RPDs, are included in the analytical results.

7.1 Soil Duplicates

In general, RPD value below 50% are considered acceptable for soil results. The calculated RPDs for soil sample FTA 1701 (parent sample) and its duplicate, FTADUP01, ranged from 2% to 18%, below the upper limit of 50% for soil, and were therefore deemed acceptable by Arcadis.

Arcadis considers that the results of the QA/QC analysis indicate that soil samples can be considered representative of site conditions.

7.2 Groundwater Duplicates

In general, RPD values below 50% are considered acceptable for groundwater results. The calculated RPDs for groundwater sample MW15-8 (parent sample) and its duplicate, FTA DUP01 DUP01, ranged from 2.75% to 31%. Arcadis considers that the results of the QA/QC analysis indicate that groundwater samples can be considered as representative of site conditions.

Additionally, a trip blank and a field blank were submitted for analyses of BTEX and PHCs. Both reported non-detect concentrations. The trip blank results determined that no cross-contamination occurred from other samples, ambient conditions, or other sources that samples may have been exposed to. The field blank results determined that no field or transporting environments have impacted the samples.

8 DISCUSSION AND RECOMMENDATIONS

8.1 Sump Water

In 2016, the sump water concentrations met the NWB Licence requirements for pH, oil and grease, dissolved lead, total zinc and BTEX. However, PFASs analytical results for the surface water samples collected from both sumps reported concentrations of PFHxA, PFHpA, PFHxS and PFPeA above their respective DWSVs, as developed by HC. Surface water sample FTASUMP02 collected from the sump located in the southeast corner of the FTA LTU also reported concentrations of PFOA and PFOS above the HC DWSV and/or and EC FEQG for PFOS. Given these PFAS exceedances, it was recommended that the sump water should not be discharged to ground surface.

In 2017, similar sump sampling results were observed. Both sump water samples met the NWB Licence requirements and applicable CCME guidelines. Concentrations of oil and grease, dissolved lead, total zinc and BTEX in both sump water samples, FTASUMP01 and FTASUMP02, were either below the laboratory RDLs or at least 2.5 times less than the applicable criteria.

However, both sump water samples contained concentrations of multiple perfluorinated compounds including PFHpA, PFHxS, PFHxA, PFOA and PFPeA above the applicable HC DWSVs. The concentrations of these perfluorinated compounds ranged between 0.35 and 89 µg/L. In some cases, the exceedances were greater than 100 times the applicable HC DWSVs. Furthermore, the concentration of PFOS in sump water sample FTASUMP02 (12 µg/L) exceeded both the applicable HC DWSV (0.6 µg/L) and ECCC FEQG (6 µg/L). Again, as in 2016, it is recommended that the sump water not be discharged to ground surface due to these PFAS exceedances.

8.2 Soil Hydrocarbon Remediation

In 2016, the soil samples collected by Arcadis were the first soil samples collected as part of the NWB Licence requirements. In 2016, a total of seven soil samples were collected and the BTEX and PHC concentrations met the NWB Licence requirements. Furthermore, only one soil sample reported a concentration of PHC fraction F2 above the CWS-PHC guideline of 230 mg/kg for a commercial/industrial land use.

In 2017, similar results were observed in comparison to previous 2016 sampling as all seven soil samples had concentrations of BTEX and PHCs that met the NWB Licence requirements.

The PHC concentrations in five of the soil samples (FTA1702, FTA1703, FTA1704, FTA1705 and FTA1706) ranged from concentrations below the laboratory RDLs to detections that were less than the applicable guideline values. One soil sample, FTA1701, and its duplicate, FTADUP01 both had a concentration of PHC fraction F2 (540 mg/kg) above the CWS-PHC guideline of 230 mg/kg for a commercial/industrial land use.

The moisture content detected in the upper 0.35 m of soil in the FTA LTU in 2017 ranged between 4.2% and 16%. These levels are below the lower limit of moisture content of 20% typically required to support healthy microbial populations (USEPA, 1994). The optimal moisture content for PHC biodegradation ranges between 40% and 80% (GC, 2006). Arcadis recommends the continued practice of sump water recirculation to elevate soil moisture levels and help promote microbial growth in the FTA LTU's soil.

Nitrogen and phosphorus are essential for promoting the microbial activities needed for hydrocarbon degradation; however, excessive concentrations of these nutrients have been found to decrease the biodegradation rate (USEPA ,1994). Federal guidelines for landfarming petroleum contaminated hydrocarbon soil recommends the carbon-to-nitrogen-to-phosphorus ratio remain between 100:10:1 and 100:1:0.5 to encourage effective biodegradation. Table 8-1 shows average nitrogen and phosphorus concentration in the FTA LTU's soil along with the estimated effective nutrient ranges.

Table 8-1: Average Nutrient Concentrations for the FTA LTU's soil

Petroleum Hydrocarbons	Effective Nutrient Range for FTA LTU(1)(2)	2017 Average Concentration
Nitrogen (mg/kg)	75 - 8	264
Phosphorus (mg/kg)	8 - 7	2

Note:
(1) Carbon content used to derive the effective nutrient ranges for the FTA LTU was based on the average total petroleum concentration in the FTA LTU in 2017.
(2) The effective nutrient range is based on the Federal Guidelines for Landfarming Petroleum Contaminated Hydrocarbon (GC, 2006) and does not consider site-specific climatic conditions.

The average nitrogen concentration in the upper 0.3 m of soil in the FTA LTU is above the estimated effective nitrogen range. Conversely, the average phosphorous concentration is below the lower limit of the estimated effective phosphorous range. Arcadis recommends a phosphorous-dominant fertilizer be thoroughly mixed into the soil within the FTA LTU. Nutrient concentration should continue to be monitored during future monitoring programs.

Arcadis recommends the number of soil samples submitted for laboratory analysis from the upper 0.3 m bgs of the soil in the FTA LTU be increased to 15 samples to better assess the effectiveness of hydrocarbon degradation. In addition, Arcadis recommends 15 additional soil samples from the soil located below 0.3 m bgs be submitted for laboratory analysis. Select soil samples should be analyzed for nutrients, moisture, pH, bulk density, BTEX, and PHC Fractions F1 to F4.

8.3 Groundwater Monitoring Program

In 2016, the groundwater samples collected and analyzed were the first full round of groundwater samples collected as part of the NWB Licence requirements. During the 2016 field program, groundwater samples could only be collected from four of the eleven monitoring wells (MW15-1, MW15-4, MW15-5 and MW15-8) due to frozen conditions. At that time, several parameters reported concentrations above the CCME FWAL guidelines including: phenols, dissolved nitrites and nitrates, dissolved copper, dissolved chloride, dissolved iron, dissolved uranium, and dissolved zinc. BTEX, PHC F1 – F4 and PAHs were either below the laboratory RDLs or below the CWS-PHCs standards and the CCME FWAL guidelines.

In 2017, groundwater samples were collected from three of the eleven monitoring wells (MW15-1, MW15-5 and MW15-8). As well, similar to 2016, the concentration of BTEX, PHCs and PAHs were all below the applicable guidelines and the concentration of BTEX and PAHs for MW15-1 and MW15-5 were below the laboratory RDLs.

However, several parameters reported concentrations above the CCME FWAL guidelines including: phenols, dissolved arsenic, dissolved iron, dissolved uranium, and dissolved chloride.

8.4 Geochemical Assessment

Based on the analytical results from the Geochemical Assessment, it was shown that similar PFAS compounds were present in the Northwest Sump Area (FTA SUMP01) and the Ponded Water in the Northwest Seepage Area (FTA-SW-NW01). As well, the PFAS concentrations in the water collected from the Northwest Seepage Area were of the same order of magnitude, but lower than those in the Northwest Sump and, Perfluorobutanioc acid, PFHxA, and PFPeA was confirmed to be present in the groundwater collected from MW15-1, located adjacent to the northwest corner of the FTA LTU, but at lower concentrations that FTA SUMP01 and FTA-SW-NW01. Finally, in addition to low concentrations of PFAS, the groundwater in MW15-1 showed other indications of possible flow from beneath the LTU when the data from this well was compared to MW13-8, the monitoring well located outside the impacted area.

With the exception of the PFAS results, it is difficult to draw direct comparisons/contrasts between the parameters in the sump water, the ponded water in the suspected seepage area, and ‘unaffected’ pond water, as the effects of recent precipitation events and the variability in area contributing surface run-off to the ponds etc. may have an impact (e.g. chloride in the sump is lower than in either pond). However, arguably there are other geochemical indicators that the ponded water in the northwest seepage area (FTA-SW-NW01) is showing effects of seepage and/or groundwater discharge from beneath the FTA LTU. Specifically,

- The TDS in this ponded water was similar to that measured in MW15-1, the NW well, and were higher than that in the unaffected pond (SW1701); and,
- The pH in the Sump and Ponded water in Suspected Seepage Area appeared similar, and was higher than that in the unaffected ponded water.

In summary, the surface water pond and shallow groundwater in the northwest corner appear to be showing evidence of FTA LTU-derived impacts.

8.5 Recommendations

Arcadis proposes the following future work at the FTA LTU:

1. The sump water contains concentrations of multiple PFAS compounds above the applicable HC DWSVs. Based on this PFAS information and the results from the Geochemical Assessment, there appears to be evidence that the FTA LTU is impacting the areas outside the LTU. However, with the exception of the PFAS results, it is difficult to draw direct comparisons/contrasts between the parameters in the sump water and those in other areas exterior to the LTU.

   To confirm the initial results from this 2017 monitoring program, it is recommended that a second set of seepage water samples be collected with the analytical list expanded to include metals, anions, dissolved nutrients including ammonia, and total and dissolved organic carbon (TOC and DOC) in the surface water and sump samples. This extra data will facilitate further evaluation of the link of seepage to the sump water. As well, confirming the initial correlations with a second set of seepage samples will allow more knowledgeable decisions to be made regarding more expensive alternatives for investigating liner integrity, the extent of seepage and/or risk management and/or remedial approaches, as detailed in Arcadis report entitled, "*Assessment options Analysis, Fire Training Area Land Treatment Unit*", dated November 2016.

2. To continue to be in compliance with the NWB License requirements and identified chemicals of concern, a groundwater monitoring program must be completed at the FTA LTU and excavation area to assess the parameters set out in the license. Attempts should be made to sample the monitoring wells during freshet conditions and warmest weeks at Cambridge Bay, when liquid groundwater conditions are more probable and when groundwater levels are presumed to be at their highest to further evaluate groundwater trends. Based on temperature statistics obtained from ECCC, this sampling period would best occur in mid-July.

3. Several of the groundwater parameters; such as dissolved arsenic, dissolved iron and dissolved uranium, are likely a result of naturally elevated background concentrations. Arcadis recommends that an evaluation of background conditions be conducted to confirm this.

4. Complete a soil sampling program to assess the level of biodegradation and confirm that soil concentrations remain below the NWB Licence requirements. Select soil samples should be analyzed for nutrients, moisture, pH, bulk density, BTEX, and PHC Fractions F1 to F4. Additionally, tilling of the soils will aid in decreasing soil compaction and increase the rate at which water can infiltrate into the soil during future dewatering activities, as required. Once active treatment re-commences, Arcadis recommends the number of soil samples submitted for laboratory analysis from the upper 0.3 m bgs of the soil in the FTA LTU be increased to 15 samples to better assess the effectiveness of hydrocarbon degradation. In addition, Arcadis recommends 15 additional soil samples from the soil located below 0.3 m bgs be submitted for laboratory analysis.

5. Arcadis recommends a phosphorous-dominant fertilizer be thoroughly mixed into the soil once active treatment at the FTA LTU is re-commenced.

9 LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by Arcadis Canada Inc. (Arcadis) for Public Services and Procurement Canada (PSPC) / Transport Canada (TC). It is intended for the sole and exclusive use of PSPC/TC. Any use, reliance on or decision made by any other person other than PSPC/TC based on this report is the sole responsibility of such other person. PSPC, TC and Arcadis make no representation or warranty to any other person with regard to this report and the work referred to in this report and they accept no duty of care to any other person or any liability or responsibility whatsoever for any losses, expenses, damages, fines, penalties or other harm that may be suffered or incurred by any other person as a result of the use of, reliance on, any decision made or any action taken based on this report or the work referred to in this report.

This report has been prepared in accordance with generally accepted engineering and environmental practices for the exclusive use of PSPC/TC. This report is based on the historical information provided and information obtained during this work program.

Third party information reviewed and used to compile the data and conclusions contained in this report is assumed to be complete and correct. Arcadis used this information in good faith and will not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.

The investigation undertaken by Arcadis with respect to this report and any conclusions or recommendations made in this report reflect Arcadis' judgment based on the site conditions observed at the time of the site inspection on the date(s) set out in this report and on information available at the time of preparation of this report. This report has been prepared for specific application to the site and it is based, in part, upon visual observation of the site, subsurface investigation at discrete locations and depths, and specific analysis of specific chemical parameters and materials during a specific time interval, all as described in this report. Unless otherwise stated, the findings cannot be extended to previous or future site conditions, portions of the site which were unavailable for direct investigation, subsurface locations which were not investigated directly, or chemical parameters, materials or analysis which were not addressed. Substances other than those addressed by the investigation described in this report may exist within the site, substances addressed by the investigation may exist in areas of the site not investigated and concentrations of substances addressed which are different than those reported may exist in areas other than the locations from which samples were taken. Notwithstanding these limitations, this report is believed to provide a reasonable representation of activities completed and site conditions as of July and August 2017.

If site conditions or applicable standards change or if any additional information becomes available at a future date, modifications to the findings, conclusions and recommendations in this report may be necessary.

Other than by PSPC/TC, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of Arcadis. Nothing in this report is intended to constitute or provide a legal opinion.

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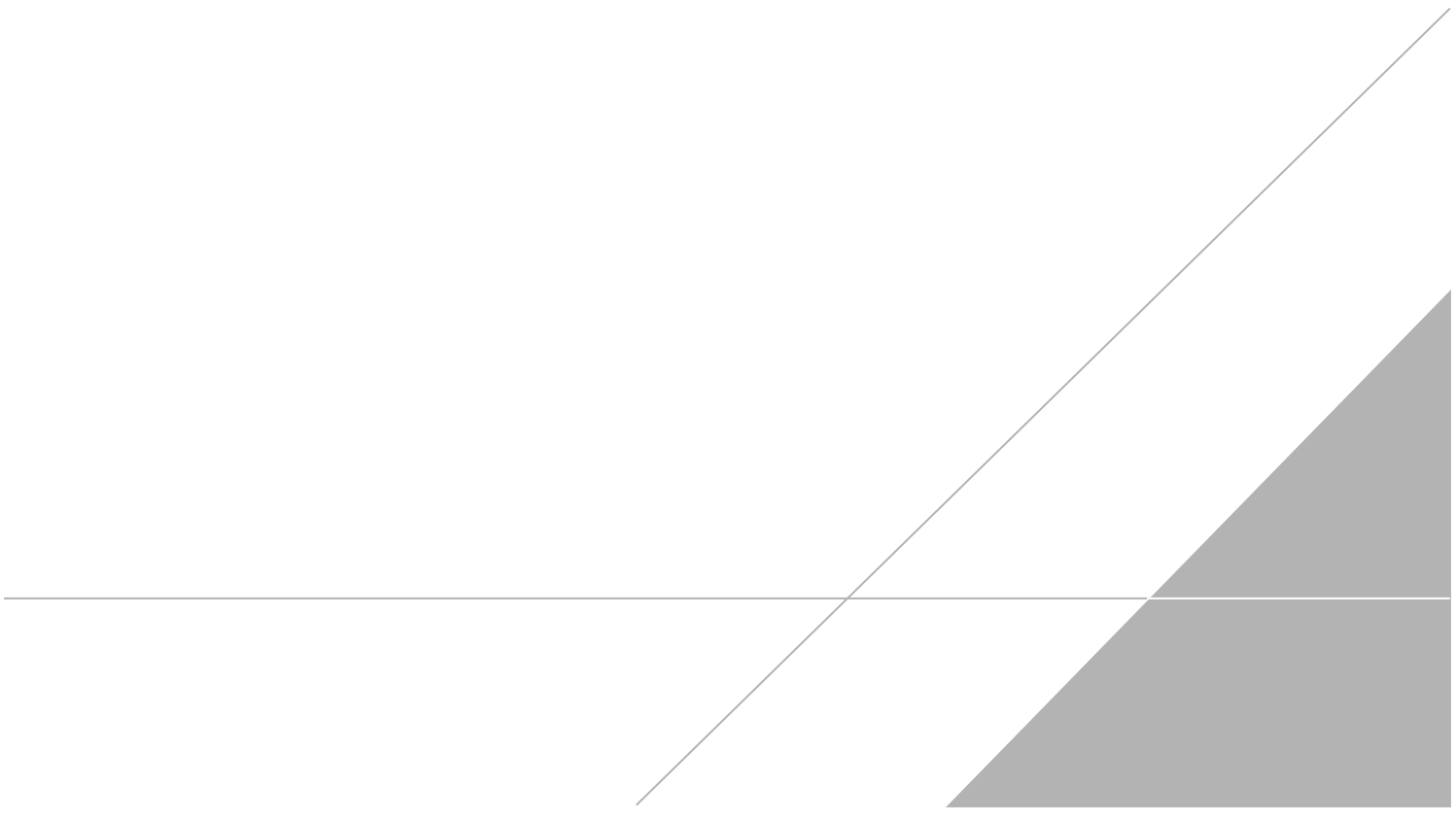
TABLES

FIGURES

APPENDIX A

Laboratory Response to Sampling and Quality Control Protocols



APPENDIX B

Laboratory Certificates of Analysis

APPENDIX C

Site Photographs

Arcadis Canada Inc.

329 Churchill Avenue North

Suite 200

Ottawa, Ontario K1Z 5B8

Tel 613 721 0555

Fax 613 721 0029

www.arcadis-canada.com