Public Services and Procurement Canada

Site Investigation Report: Per- and Polyfluoroalkyl Substances (PFAS) Presence /Absence Study at Iqaluit Airport

Iqaluit, NU

Prepared by:

AECOM Canada Ltd.
101 – 18817 Stony Plain Road NW
Edmonton, AB T5S 0C2
Canada

T: 780 486 7000
F: 780 486 7070
www.aecom.com

Prepared for:

PSPC Environmental Services
1000, 9700 Jasper Avenue
5th Floor, ATB Place
Edmonton, AB T5J 4C3

Date: March, 2020

Project #: 60615382

Distribution List

# Hard Copies	PDF Required	Association / Company Name
	✓	Public Services and Procurement Canada
	✓	AECOM Canada Ltd.

Authors

Mahsashayan

Report Prepared By:

Mahsa Shayan, Ph.D, P.Eng.
Environmental Engineer

REGISTERED PROFESSIONAL ENGINEER
J.D. STEPNEY
LICENSEE
NT/NU
March 30, 2020

Report Reviewed By:

Jessica Stepney, P. Eng
Environmental Engineer
Project Manager

PERMIT TO PRACTICE
AECOM CANADA LTD.
Signature
Date March 30 2020
PERMIT NUMBER: P 639
NWT/NU Association of Professional Engineers and Geoscientists

Executive Summary

Under contract to Public Services and Procurement Canada, Environmental Services, AECOM conducted a limited presence/absence investigation for per- and polyfluoroalkyl substances (PFAS) at the Iqaluit Airport, 1126 Mivvik Street, Iqaluit, NU (the Site). The objectives for the investigation were: (1) to determine the presence or absence of PFAS in groundwater near site boundaries downgradient from areas associated with former Fire Training Areas (FTA) at the Iqaluit Airport, and (2) to assess if PFAS from the base is migrating off-site.

Iqaluit Airport is located at 1126 Mivvik Street, Iqaluit, NU (hereafter referred to as the Site). Iqaluit airport had one (1) FTA site that was conservatively estimated to be active prior to 1957 until 1991. The FTA site was reportedly used from 20 to 25 times a year for fire fighting exercises. In July 1994, Transport Canada issued the National Airports Policy (NAP). The NAP was a major initiative of the federal government, which requires the transfer of regional/local or small airports (ownership and operation) to territorial, provincial, and local governments, airport commissions, private businesses, or other interests. The Iqaluit airport is owned by the Government of Nunavut (GN) and operated, under a 30-year contract, by Nunavut Airport Services. The company is a subsidiary of Winnipeg Airport Services Corporation, which in turn, is a subsidiary of Winnipeg Airports Services Corp. (WASCO, 2019).

Aqueous film-forming foam (AFFF) containing PFAS compounds was reported to be used during fire training operations at this site. PFAS are not currently regulated at the provincial or territorial levels in Canada; however, Health Canada (HC, 2016, 2018, 2019) has established maximum acceptable concentration (MACs) levels for Perfluoro-octanesulfonate (PFOS) and Perfluorooctanoic acid (PFOA) and drinking water screening values (DWSV) for 9 other PFAS compounds to protect against potential risk from exposure to these compounds via drinking water. Also, Health Canada soil screening guideline values are available for the protection of human health (HC SSV-HH) for all the 11 PFAS compounds listed above. Environment and Climate Change Canada (ECCC, 2017) also published federal soil and groundwater quality guidelines (FSQG, FGWQG) for PFOS for different soil types, land use application and different pathways. The HC and ECCC guidelines were considered to define the presence or absence of PFAS at this Site to the best extent practicable.

The site investigation field activities were completed from October 28 to November 5, 2019. Three (3) groundwater monitoring wells were installed near the southeastern site boundary downgradient from the FTA (MW19-01 to MW19-03). Two (2) groundwater samples (MW19-01 was dry), one (1) blind field duplicate, one (1) trip blank and two (2) equipment blank samples were collected for PFAS analysis. Composite soil and groundwater samples (one for each) were also collected and analyzed for investigative derived waste (IDW) characterization. The laboratory analysis was conducted by Eurofins Environment Testing Canada (Eurofins) accredited by the Canadian Association for Laboratory Accreditation (CALA). Samples were collected and analyzed in accordance with Transport Canada guidance documents (i.e., Arcadis, 2017; Stantec, 2018) and site-specific client and/or regulatory requirements. The analytical results and the decision matrix used for waste categorization and selection of disposal options are presented in **Section 4** of this report. A thorough quality control/quality assurance (QA/QC) was conducted on the analytical data.

Groundwater exceedances were observed in monitoring well MW19-03 for PFPeA (with a maximum concentration of 1,000 ng/L compared to the DWSV of 200 ng/L), PFHxA (with a maximum concentration of 290 ng/L compared to the DWSV of 200 ng/L) and for 6:2 FTS (with a maximum concentration of 520 ng/L compared to the DWSV of 200 ng/L). No exceedances were observed at monitoring well MW19-02, however, some PFAS compounds were detected below guidance criteria. Monitoring well MW19-01 was dry during this sampling program. The presence of PFAS in groundwater samples collected from MW19-02 and MW19-03 is an indication that PFAS can be migrating off-site toward to Frobisher Bay based on the inferred groundwater flow direction to the southeast.

The risk of offsite migration is difficult to infer based on the limited data available at this point. PFAS detection in both wells and DWSV exceedance in both monitoring wells MW19-02 and MW19-03 may, however, reflect an existing risk based on knowledge of local water use. Additional sampling and analysis would be required to establish the nature and extent of PFAS for each applicable media and determine if there is a complete exposure pathway. Further evaluation would be required at the airport boundary, near the former FTA and at all potential release locations (PRLs) at the airport, to determine the nature and extent of PFAS contamination. The additional site investigation may warrant no further action (NFA) or lead to remedial investigation and a feasibility study phase. As the immediate next step, additional site investigations and site-specific risk assessment would be required. Identification of existing potential release locations (PRL) and/or elimination of remnants of historical sources (e.g., FTA) could be determined after completion of additional site investigation.

Table of Contents

List of Figures

List of Tables

Appendices

List of Acronyms and Abbreviations

AFFF	aqueous film-forming foam
amsl	above mean sea level
bgs	below ground surface
btoc	below top of casing
COPC	chemical of potential concern
CSM	conceptual site model
DQO	data quality objective
DWSC	Drinking Water Screening Values
ESS	environmental sequence stratigraphy
FS	Feasibility Study
FSS	fire suppression system
FSQG	Federal Soil Quality Guideline
FTA	Fire Training Area
GSL	grain size logs
HC	Health Canada
HEF	High Expansion Foam
HBCD	Hexabromocyclododecane
IDW	Investigation-Derived Waste

IRP	Installation Restoration Program
LOD	limit of detection
LOQ	level of quantitation
m	metre
MCL	Maximum Acceptable Concentrations
MS	matrix spike
MSD	matrix spike duplicate
NA	Not Applicable
NFA	No Further Action
ng/g	nanograms per grams
ng/L	nanograms per litre
NTA	Nozzle Testing Area
PFAS	per- and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutanesulfonate
PFPeA	Perfluoropentanoic Acid
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic Acid
PFHxS	Perfluorohexanesulfonate
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluoro-octanesulfonate
6:2 FTS	6:2 Fluorotelomer sulfonic acid
8:2 FTS	8:2 Fluorotelomer sulfonic acid
PBDEs	Polybrominated diphenyl ethers
PHC	Petroleum Hydrocarbon
PID	photoionization detector
PRL	potential release location
PSPC	Public Services and Produrment Canada
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/ Quality Control
RI	Remedial Investigation
RSL	Regional Screening Levels
SI	Site Inspection
SOP	Standard Operating Procedure
SSV	Soil Screening Values
TC	Transport Canada
THQ	Target Hazard Quotient
UCMR-3	Unregulated Contaminant Monitoring Rule
US EPA	United States Environmental Protection Agency
VOC	volatile organic compounds
WP	Work Plan

1. Introduction

AECOM Canada Ltd. (AECOM) is pleased to provide this site investigation report following the installation of three (3) monitoring wells and completion a limited Per- and Polyfluoroalkyl Substances (PFAS) presence/absence groundwater investigation near site boundaries downgradient from areas associated with former Fire Training Areas (FTA) at the Iqaluit Airport, 1126 Mivvik Street, Iqaluit, NU (hereafter referred to as the Site). A Site location map is shown in **Figure 1**, and **Figure 2** presents the Site Plan, including the airport property boundary, the location of the former FTA and the newly installed monitoring wells.

The detailed Site description is provided in **Section 2** of this report. Description of the field procedures and scope of work performed during this site investigation is presented in **Section 3**. **Section 3** also includes the deviations from the work plan. The scope of work and field procedures were based on the requirements of the Term of Reference (TOR) (PSPC, 2019), the proposal dated September 2019 (AECOM, 2019a), and the Work Plan document dated October 2019 (AECOM, 2019b). Before developing the work plan, AECOM reviewed the Site historical reports, as well as the FTA summary sheet (Golder, 2017) provided by Public Services and Procurement Canada (PSPC) on behalf of Transport Canada (TC).

The Guidance for Presence/Absence Sampling of Indicator Per- and Polyfluoroalkyl Substances (PFAS) at Transport Canada Transferred Airport Property Boundaries (Arcadis Canada Inc., 2017) and Guidance for the Management and Disposal of PFAS-Impacted Waste Materials (Stantec, 2018) were also reviewed and utilized during the preparation of the work plan. The project kick-off meeting occurred on October 4, 2019, with representatives from AECOM, PSPC and TC and the field activities were executed between October 28 and November 5, 2019. Data evaluation and discussion and recommendations are provided in **Section 4** and **Section 5** of this report, respectively. The following subsections will provide an overview of PFAS and its regulatory climate in Canada and the scope and objectives of this site investigation program.

1.1 PFAS Overview

PFAS comprise a diverse group of synthetic chemicals used for over 50 years in various military and industrial applications and consumer products. PFAS are detected in aqueous film-forming foams (AFFF) used for firefighting and fire suppression systems (FSS) starting in the 1970s. Sources of PFAS used by military and commercial airports can include fire training areas, nozzle test areas, hangars, and other buildings equipped with fire suppression equipment, fire stations, AFFF loading, handling and storage areas, aircraft and vehicle crash response areas, and AFFF ponds, sumps, tanks, landfills and/or other areas of disposal.

Properties of some PFAS that were analyzed as part of this site investigation include:

- Limited sorption to soil and sediments
- Highly water-soluble, non-volatile and extremely mobile in water
- Exceptional stability
- Persistent with very little attenuation
- Widely present in the environment, bioaccumulative, and detected in plants, many animals, and humans

Potential health effects are based on toxicological data that is generally limited for most PFAS, with the exception of a few more highly studied compounds.

The PFAS regulatory framework in Canada is discussed in **Section 3.7** of this report. The following timeline list the federal regulatory highlights in Canada driven by Health Canada (HC) and Environment and Climate Change Canada (ECCC):

- **2006** - PFOS screening assessment published
- **2008** - PFOS and Its Salts and Certain Other Compounds Regulations published
- **2009** - PFOS added to Virtual Elimination List
- **2012** - PFOA assessment report released
- **2016** - Prohibition of Certain Toxic Substances Regulations, 2012 amended to include PFOS and PFOA
- **2018** - Updates being considered to further restrict the manufacture, use, sale, offer for sale and import of PFOS, PFOA, long-chain perfluorocarboxylic acids (LC-PFCA), and two brominated flame retardants Hexabromocyclododecane (HBCD) and Polybrominated diphenyl ethers (PBDEs). Consultation is ongoing. Publication proposed for Winter 2020.
- **2016-2019** - Health Canada published maximum allowable concentration (MACs) for PFOA and PFOS in drinking water. Soil screening values (SSV) for different land use applications and drinking water screening values (DWSV) for the protection of human health were also published for 11 PFAS compounds including PFOS, PFOA, PFBA, PFPeA, PFHxA, PFHpA, PFNA, PFBS, PFHxS,6:2 FTS, and 8:2 FTS (HC 2016, 2018, 2019). Moreover, federal soil and groundwater quality guidelines (FSQG, FGWQG) were published for PFOS for different land use applications, different soil types and different pathways (ECCC 2017).
- **2020- onward** - An increased environmental regulatory scrutiny is occurring and is anticipated to continue in Canada. For example, federal environmental quality guidelines (FEQGs) for PFOS in different media (i.e., soil, groundwater, fish, bird eggs, etc.) is under review and is expected to be published by the Canadian Council of Ministers of Environment (CCME) in 2020.

The existing guidelines described above were considered during this site investigation program to define the presence or absence of PFAS at this Site to the best extent practicable.

1.2 Scope and Objectives

The objectives for this investigation are to determine the presence or absence of PFAS in groundwater near the Site downgradient boundary and to assess off-site migration of PFAS. The scope of work involved drilling and installation of three (3) groundwater monitoring wells near the south eastern property boundary of the Iqaluit airport and collect groundwater samples to determine the presence/absence of PFAS near the airport property boundary to detect any potential off-site concentrations. The southeastern property boundary was identified to be located downgradient from the former FTA based on the groundwater flow direction inferred from the historical and current groundwater elevation data. This report presents the results of the groundwater sampling program, waste management activities, and provides conclusions and recommendations based on the results.

2. Site Description and Historical Investigations

Iqaluit Airport is located at 1126 Mivvik Street, Iqaluit, NU (hereafter referred to as the Site). **Figure 1** shows the site location map, and **Figure 2** presents the Site Plan, including the airport property boundary, the location of the former fire training area (FTA). Iqaluit airport had one (1) FTA site that was conservatively estimated to be active prior to 1957 until 1991. The FTA site was reportedly used from 20 to 25 times a year for fire fighting exercises. Due to the emerging nature of concerns regarding PFAS presence as a potential contaminant of concern (PCoC) at airport sites, no historical PFAS investigation was conducted during the previous site assessment activities at this Site. However, environmental site characterization, assessment, audit, and an environmental baseline study were performed at the Iqaluit Airport between 1994 and 1996 (Biogenie 1994a, 1994b, 1995; Dillon, 1996). There are uncertainties regarding the type of AFFF used and the exact duration/frequency of their use at this Site.

The FTA was approximately 1350 m^2 in size, unlined, and located in the northwestern section of the airport, west of the main apron and between the terminal tarmac and runway (**Figure 2**). The nearest downgradient property boundary is approximately 1.1 km southeast of the former FTA. The FTA Site has been previously remediated for hydrocarbons. A soil and groundwater investigation was conducted in the former FTA in 1997 (EBA, 1997) to delineate the extent of hydrocarbon impacted soil and groundwater, and the follow-up supplemental site investigation and environmental baseline study re-audit were conducted in 1999 (GeoEnv, 1999, Dillon 1999). Remedial activities including soil excavation and development of two lined land treatment units (LTUs) were conducted in 2000 (Transport Canada, 2001). Approximately 2,790 cubic meters (m^3) of impacted soils were excavated in the FTA and landfarmed in LTUs onsite. The excavated area was backfilled with clean material. Monitoring wells were historically installed in the FTA area up to the depth of approximately 2 mbgs (intersect permafrost). Historical site maps, borehole logs, and groundwater elevation maps are also provided in **Appendix A.**

Post-remediation environmental site assessment and re-audits were performed at the site (e.g., Dillon, 2005 and CRA, 2014). Since no previous PFAS investigation has been conducted at this site to date, there is uncertainty regarding the presence and extent of remaining PFAS sources following the remedial activities in the former FTA and its vicinity (i.e., there are uncertainties regarding the extent of PFAS-impacted soil that was removed during the remedial excavation).

In addition, the details regarding the historical storage, handling and use of AFFF at the site are unknown to the authors. The potential accidental spills and/or application of AFFF for the emergency response could be considered as a potential release location (PRL) and ongoing sources of PFAS contamination on Site. A PFAS-focused phase I investigation (including interviews with knowledgeable site staff) would be required to investigate where AFFF has been historically stored on-site, and if any spills occurred during the storage and handling of AFFF compounds, or any accidents that required emergency response happened at the site that required the use of AFFF.

The following subsections provide further details on Site geology, hydrogeology, and evaluation of potential receptors.

2.1 Site Surficial Geology and Topography

Iqaluit is located on southeastern Baffin Island at the head of Frobisher Bay. The airport is built on flat terrain surrounded by hills and rocky plateaus of the Precambrian shield (LeBlanc et al., 2015; St-Onge et al., 2006). Geophysical and hydrogeological investigations have been conducted at the airport in response to the degradation of infrastructure caused by permafrost thawing. The surficial geology map of Iqaluit is presented in **Appendix B (**extracted from LeBlanc et al. 2015).

The majority of the site consists of glaciomarine delta deposits that consist of sand, silt, boulders, and gravel which thickness ranged between 2 and 20 m. Portions of the site are, however, characterized by till veneer (diamicton) that consists of sand, stones, and boulders in a silty sand matrix. Thickness ranges between 0.5 to 2 m. Precambrian bedrock topography is evident in some areas of the site and littoral and nearshore sediments that comprise of generally stratified and well-sorted sand, silty sand, gravelly sand, and gravel layers, are evident at some other locations at the site (**Appendix B**). The extended geological studies near Iqaluit Airport indicated glaciomarine delta deposits representing up to four depositional environments underneath the airport infrastructure, resulting in different ground-ice conditions. Near Frobisher Bay, fine-grained and saline sediments, which are dominated by interstitial and segregated ice, were observed at depth. There, as well as in other locations, sand, and gravel, which is dominated by interstitial ice, was observed nearer the ground surface (MathonDufour et al., 2015). As subsequently discussed in **Section 4.1**, a rather consistent site stratigraphy was observed during the drilling of three (3) boreholes during this program.

2.2 Site Hydrogeology

The regional hydrogeology of the Iqaluit region is controlled by the presence of permafrost. Since 2010, a number of publications that characterize Iqaluit’s permafrost conditions, including maps, reports, and scientific papers have been published, many of the publications concern the Iqaluit airport (e.g., LeBlanc et al., 2015; Mathon-Dufour, 2014; Shojae Ghias et al., 2017). The ground temperature data, along with the knowledge gathered in the region, demonstrated that spatial permafrost conditions in Iqaluit are highly variable. The spatial distribution of ice-rich ground is strongly related to the surficial geology. Ground ice was observed in boreholes in areas experiencing thaw settlement. Frozen ground with significant unfrozen water content was also identified from geophysical data in regions with settlement problems. Even when subsurface conditions are similar, the permafrost thermal regimes can be different if the surface conditions, such as water flow, paved embankments, and thick snow cover, inducing warmer ground at depth. Thawing permafrost is a growing problem for the Iqaluit airport. Results from a multidisciplinary study indicate that permafrost conditions in Iqaluit, such as ice-rich soils, are highly variable spatially and with depth. Ground temperatures at three active monitoring sites (2010–2015) and one abandoned site (1988–2004) show that permafrost has warmed at depth, and active layer thickness has likely increased since monitoring was first established in Iqaluit in 1988 (LeBlanc et al., 2015). Climate normals of mean monthly air temperatures for 1981–2010 range from 8.2°C in July to –27.5°C in February, with an annual mean temperature of –9.3°C, and annual precipitation of 404 mm, 49% of which occurred as rain (Environment Canada, 2019).

A review of historical site investigation reports indicated that the water-bearing zone between FTA and downgradient airport property boundary is an unconfined aquifer with a shallow active layer above the permanently frozen ground (permafrost) that inhibits vertical migration. According to the historical reports, the ground is frozen during most of the year, and no groundwater flow occurs except deep in the bedrock below the permafrost. During the summer, groundwater flow occurs in the shallow active layer above the permafrost. Depth to shallow groundwater was reported between 0.9 to 1.8 meters below the ground surface (mbgs). Groundwater has been historically interpreted to flow southeast towards the southeastern property boundary and Frobisher Bay, approximately 1200 m from the FTA, with localized variation in flow direction depending on site topography. Historical groundwater elevation contour maps are provided in **Appendix A**. As subsequently discussed in **Section 3.6.2**, the southeasterly groundwater flow direction was also confirmed by the 2019 groundwater elevations data. The groundwater flow and contaminant transport at the site are expected to be mainly governed within the active layer above the permafrost, which likely has high permeability (no historical hydraulic conductivity data are available for the site). However, the review of historical reports indicated that the shallow groundwater could also be directed into drainage channels that ultimately discharge into Koojesse Inlet and Frobisher Bay. As shown in **Figure 2**, the drainages channels south of the main apron discharge into the main drainage channel, which directs water off-site. There are other existing drainage ditches on-site that direct surface water and groundwater into drainage channels that ultimately discharge into Koojesse Inlet.

2.3 Potential Receptors/ Exposure Pathways

2.3.1 Groundwater

Potential human exposure pathways related to groundwater include the use of any drinking water wells and irrigation wells for public or private water supply or irrigation purposes or source aquifers. Groundwater is not used for domestic drinking water supply in Iqaluit, and no water supply wells were identified within 500 m of the FTA. Therefore, no human exposure pathway exists through direct use of groundwater at this site. However, contaminated groundwater could pose an indirect risk through groundwater/surface water interactions. As indicated above, it is speculated that the shallow groundwater can be directed into drainage channels that ultimately discharge into Koojesse Inlet and Frobisher Bay. Potential human exposures from surface water are described further in the following subsection.

2.3.2 Surface Water and Sediment

Potential human exposures from surface water include the use of surface water for drinking water, recreation, and fisheries. Potential ecological receptors and exposures include sensitive environments and protected species that may be associated with surface water. The Town of Iqaluit obtains its municipal water supply from Lake Geraldine (2 km east of the airport). Lake Geraldine is an engineered reservoir designed to contain the volume of water necessary to satisfy the drinking water needs of the City of Iqaluit (the City). In 2019, the City applied to the Nunavut Water Board to amend its Municipal water license to allow withdrawal of water from the Apex River and an and Unnamed Lake (located 3.5 kilometres north of the Apex River pumping site), to supplement (add to) the drinking water supply in the Lake Geraldine reservoir. The emergency approval came in response to low rainfall and snowfall in 2019, causing Lake Geraldine to be at its lowest level ever for the time of year. Water levels in the Apex River, which is the city's secondary water source, were also reported at a historic low in 2019. The amendment involves temporarily pumping water from Unnamed Lake to the Lake Geraldine reservoir via the Apex River, and it was approved by the minister of Crown-Indigenous Relations and Northern Affairs (CIRNAC), in August 2019. The City is currently searching for other permanent options for adding water to the reservoir, such as obtaining water the Sylvia Grinnell River and a large Unnamed lake northeast of the City (City of Iqaluit 2018,2019; EXP, 2014).

The current water supply intake sources are located cross gradient of the site. Lake Geraldine is located 2 km to the east of the airport site, and APEX River and the Unnamed Lake are located further northeast of the site (**Figure 1**). Since the water intake is located upgradient of the Iqaluit airport, it is expected that the direct human exposure pathway through drinking water is minimal at this time, if any. However, as noted above, factors such as reliance on surface water supply, presence of permafrost, low precipitation, rising consumption, and changes in climate are placing an additional strain on the limited resource of surface freshwater in Iqaluit (NRC, 2011). Therefore, it is important to note that in future drinking water might be supplied from alternate surface water resources that might be located downgradient from the airport site (e.g., the Sylvia Grinnell River). Therefore, drainage of contaminated groundwater to the surface water bodies could be a potential future exposure pathway for humans and wildlife dependent on the drinking water.

The nearest surface water features to the site include an unnamed creek, approximately 1 km downgradient of the FTA, that discharges into Frobisher Bay located along the southeastern site boundary. A small pond that may also be connected to Frobisher Bay and a few other small ponds are located within airport property, to the west of the runway, and are considered downgradient to the FTA. Frobisher Bay support established wetlands or aquatic ecosystems and discharge of PFAS-impacted groundwater into the Bay can lead to potential human exposure (i.e., through activities such as recreation and fisheries) and also could pose a risk to some ecological receptors.

2.3.3 Soil

Humans may be exposed to the surface and sub-surface soils during routine activities or construction and excavation activities. Ecological receptors may also be exposed to soils if sufficient habitat is present to support or attract terrestrial flora and fauna, including burrowing animals. The surrounding area of Iqaluit Airport includes the zoning of Parkland/Forested and commercial land use. The thin or thick snow cover that insulates the ground in winter months is a major influence that affects the soil exposure pathway at the site that includes minimally paved and landscaped areas. Without the snow cover effect, and under normal operating conditions, there may be potential soil exposure pathways, especially during excavations that a worker could be exposed to soil and dust from soil. During periods of snow cover, the soil pathway is not dominant at this Site. As further discussed in **Section 3**, no soil samples have been analyzed for PFAS prior to and during this investigation, and therefore there is uncertainty regarding whether soil could be a potential exposure pathway for PFAS during excavation activities.

To summarize**,** soil and surface water and sediments are potential exposure pathways of PFAS for human and ecological receptors. Groundwater is not a source of drinking water in the area but could indirectly affect the other pathways (i.e., through groundwater/surface water interactions). Since samples were not collected from soil, and sediment in this phase of the investigation, there are uncertainties regarding the significance of these potential pathways. Surface water could be a potential exposure pathway of PFAS at this site, and exposure significance depends on the levels of human activity and critical ecological and aquatic habitats at the Site.
Groundwater flow direction at this site is interpreted southeasterly towards the Frobisher Bay. The shallow groundwater is also directed into drainage channels that ultimately direct the groundwater off-site, discharging it into Koojesse Inlet and Frobisher Bay. Therefore, PFAS may be traveling off-site into Frobisher Bay. Further investigations (i.e., a comprehensive Phase I and extended Phase II Environmental Site Assessment) would be required to assess the potential exposure pathways better.

3. Assessment Methodology

The methodology for the Site Assessment was in accordance with the standard AECOM practices and procedures, the proposed work plan (AECOM, 2019b), and as discussed in the program kick-off meeting. The deviations from the work plan are summarized in **Section 4.4** Field photographs are presented in **Appendix C.**

3.1 Health and Safety and PFAS Sampling Training

Personnel who worked on-site were required to follow the guidelines of a Site-Specific Health and Safety Plan (SSHASP) developed by AECOM and Reviewed by PSPC (AECOM, 2019c). All the personnel on-site during this assessment had AECOM's internal PFAS sampling training certification. The SSHASP was utilized throughout the project and was adapted for changing site-specific conditions and activities, as needed. Key tenets of the SSHASP included:

- Review and sign-off on the SSHASP by all onsite personnel.
- Daily sign-in and tailgate meetings to review daily activities.
- Daily Review and sign-off on AECOM daily PFAS sampling checklist
- Meeting project-specific personal protective equipment (PPE) requirements (i.e., i.e., PFAS-free clothing and safety boots, safety glasses, gloves, hard hats, etc.).

3.2 Utility Clearance

Prior to initiating any subsurface field investigation, all proposed boring/monitoring well locations were evaluated to identify the potential presence of subsurface structures (e.g., utilities and piping), in addition to overhead obstructions. The city of Iqaluit Engineering Department was contacted, and they confirmed that they had no underground utilities at the site. The airport manager also visited the site and confirmed the underground utilities for the airport operation in the identified drilling locations. AECOM retained MultiVIEW Locates Inc. (MultiVIEW, Ottawa, ON), to clear on-site boring locations of utilities and adjust the locations as necessary and identify public utilities present within the investigation area. Identification of private utilities within the facility boundary was the joint responsibility of Iqaluit Airport and MultiVIEW. AECOM maintained a copy of all utility clearance records, which were reviewed by the drilling subcontractors before the start of the intrusive subsurface investigation.

3.3 Decontamination Procedures and Cross-contamination Prevention

No source water was used to decontaminate drilling tools throughout the investigation. As further described in **Section 3.4**, the air rotary drilling method was used for drilling the boreholes at the site. This method uses compressed air and air track drills with down the hole hammers. No drilling fluid was used during the drilling and the generated soil cuttings were minimal. The down-hole hammer was decontaminated prior to and after each use with Alconox, laboratory-provided PFAS-Free water, and a PVC plastic scrub brush. An equipment rinsate blank was collected from the hammer wash and analyzed for PFAS to ascertain the drilling equipment was PFAS-free (see **Section 3.6.4** for QA/QC sample).

During groundwater sampling, non-disposable sampling equipment (i.e., interface probes) was also decontaminated prior to and after each use using Alconox and PFAS-Free water. Dedicated sampling tubing and bailers were used for each groundwater sampling location and was disposed of after use. To reduce potential cross-contamination concerns through media, special care was considered throughout the site investigation. The drilling company and AECOM personnel changed disposable nitrile gloves between the handling of each new soil interval. Nitrile gloves were also changed throughout the collection and handling of field samples. Extra caution was considered in terms of clothing and application of personal care products during this site investigation, as per PFAS sampling training guidances (AECOM, 2018; Arcadis, 2017).

3.4 Drilling Method

AECOM retained Canadrill Ltd.(Canadrill, Iqaluit, NU) to advance three soil borings utilizing air rotary drilling technology to install three (3) monitoring wells (MW19-01 through MW19-03) to support the assessment of PFAS presence/ absence in groundwater near the site boundary and potential off-site migration of if PFAS from the airport. The monitoring wells locations were selected downgradient from the FTA close to the southeastern boundary, based on the review of historical groundwater flow direction data. **Figure 2** shows the location of the new wells installed during the current site investigation program.

Soil sampling was not a requirement of this phase of the site investigation program. Air rotary drilling limited the recovery of soil cutting for comprehensive field screening. No representative soil samples could be recovered from specific depth intervals to be classified in the field to characterize lithology and describe sedimentary features. The limited soil cuttings generated during drilling were logged by AECOM personnel. The recovered soil (mixed soil from various depths) was visually assessed for staining, odour, and other potential signs and noted observations on the field log. Soil descriptions, including grain size distribution, sorting, moisture content, consistency/density, color, visual evidence of chemical impact were recorded on boring logs. No photoionization detector (PID) readings were included in the boring logs.

All soil cuttings generated during the drilling were managed on-site as subsequently discussed in **Section 4.3.1**. The soil cuttings were placed temporarily in buckets. Canadrill was retained by AECOM to pick up the soil cuttings and dispose of in an on-site location identified by the airport management.

3.5 Soil

3.5.1 Soil Screening

Air rotary drilling limited the recovery of soil cutting for comprehensive field screening. The limited soil cuttings generated during drilling was logged by AECOM personnel, as described above. Soil lithology results are included in boring logs included in **Appendix D**. Well construction details are provided in **Section 3.6.1**. No soil samples from monitoring well boring locations were submitted for laboratory analyses.

3.6 Groundwater

3.6.1 Monitoring Well Construction and Development

Soil borings were advanced to total depths between 3.49 and 4.3 mbgs. Monitoring wells MW09-1 through MW09-3 were screened at different depths interval from 0.44 to 3.96 mbgs. Monitoring well completion details and screened intervals are provided in **Appendix D**. All monitoring wells have stick-up well completion with two-inch (2") diameter, 3-m long, 0.25-mm slot size, continuously wrapped polyvinyl chloride (PVC) screens and risers, with the exception of MW19-2 which was completed with a 1.5-m long screened interval. The well screens were installed such that they "straddled" the water table. A silica sand pack was placed around the screen of each monitoring well and extend to approximately 0.30 m above the top of the screen. A 1-m bentonite seal was placed from the top of the silica sand pack and the well was grouted to the ground surface using a cement bentonite mixture, if necessary. All wells were fitted with locking J-Plugs and were completed with stick-up well monuments. The bentonite grout was allowed to set for a period of 48-hours prior to well completion

Wells were developed after a period greater than 48-hours following completion by AECOM. Development was completed using bailors as the use of the peristaltic pump and inertial pump were not feasible due to the freezing of purged groundwater within the tubing and the induced clogging. Groundwater was purged from the well screen until the discharge water had generally cleared of suspended solids. A surge block was raised and lowered across the well screen to flush finer-grained sediments from the surrounding formation and sand pack into the well annulus for removal. Prior to development, the static depth to water and depth to LNAPL (if present) and water quality parameters were recorded. During well development MW19-01 was dry, and respectively 35 L and 50 L of groundwater were purged from MW19-02, MW19-03. Development water was containerized in 20-L buckets for later disposal as discussed in **Section 4.3.1.**

3.6.2 Well Gauging and Surveying

Following installation and 24-hour after the development of new observation wells, depths to water and depth to LNAPL (if present), were measured using an oil-water interface probe for all new wells. Fluid level gauging data were then utilized to interpret horizontal groundwater flow gradients.

AECOM gauged the three (3) newly installed monitoring wells MW19-01 to MW19-03 for fluids levels (LNAPL and groundwater). Well gauging activities were completed in one single episode. The water table elevations are shown on borehole logs in **Appendix D** and data are also shown in **Figure 3**. LNAPL accumulations were not measured in any of the wells. All groundwater (potentiometric surface) elevations computed for the Site were corrected using equation 1 below.

$$groundwater\ elevation = TOC\ elevation - DTW \qquad \textbf{Equation 1}$$

Where: TOC = top of casing elevation, m amsl
DTW = depth to water, meters below top of casing

AECOM retained Canadrill to also provide surveying data for the newly installed monitoring wells. Survey data collected from each well included a latitude and longitude measurement and top of casing and ground surface elevations. Survey results, as well as fluid level gauging data and groundwater potentiometric surface elevations, are included in **Table 1**. Depth to groundwater ranges from dry (MW19-01) to 1.884 mbgs (MW19-02) and 0.563 mbgs (MW19-03). The potentiometric elevation data was not sufficient to provide a potentiometric contour map (only two wells), however, the data confirmed the groundwater flows predominantly towards the southeast (**Figure 3).**

3.6.3 Groundwater Sampling and Analysis

AECOM collected groundwater samples from the new monitoring wells installed in the vicinity of the downgradient property boundary. Low-flow sampling techniques were initially utilized. Dedicated PFAS-compatible high-density polyethylene (HDPE) peristaltic pump tubing was placed at the midpoint of the water-saturated portion of each monitoring well screen. Ideally, groundwater was to be purged until field parameters stabilized (or the well went dry) to ensure that representative groundwater samples were obtained. Samples were supposed to be containerized when water quality parameters stabilized to within the following limits:

- Temperature (±3 percent);

- pH (± 0.1 units);
- Specific conductance (±3 percent); and
- Oxidation-reduction potential (ORP) (± 10 millivolts).

Ideally, water quality parameters were supposed to be measured approximately every five minutes and recorded on the groundwater sampling forms. However, the low-flow sampling did not work during this program as expected due to the extreme cold weather that caused the freezing of groundwater and clogging of the tubing as soon as the water was exposed to the below-zero air temperatures (below -10° C). **Table 2** summarizes the limited water quality data collected during groundwater sampling. As shown, the temperature of purged groundwater was around 0.0 ° C. As per discussion with the client and their approval, AECOM personnel completed the groundwater sampling using PVC bailers. Three (3) well volumes were purged with bailors prior to collecting the samples in the laboratory-provided containers.

Groundwater samples were submitted to Eurofins Environment Testing Canada (Eurofins, Ottawa, ON) under chain-of-custody seal in laboratory-supplied containers packed with ice for analysis of PFAS compounds using the US EPA Method 537 modified version, using isotope dilution (hereafter “Modified Method 537”). The modified method 537 includes analysis of 32 different PFAS compounds. Groundwater analytical results are included in **Table 3 and Figure 4**. Full laboratory reports and Chain-of-custody documentation are included in **Appendix E**.

3.6.4 Quality Assurance and Quality Control (QA/QC) Program

A comprehensive field quality assurance and quality control (QA/QC) program was completed during the October/November 2019 sampling event, including the collection of one blind field duplicate samples (MW19-03/DUP-1) to confirm the reproducibility of sampling and laboratory analysis methods. The measure of the reproducibility or precision of the data was quantified by calculating the Relative Percent Difference (RPD). The QA/QC program also included analysis of one trip blank sample, two Matrix Spike and Matrix Spike Duplicates (MS-GW19-02/ MSD-GW19-02), and two Equipment Rinse Blank, from the water level tape (EB- WLT) and the drilling hammer rinsate (EB-DR). Equipment rinse blank was collected to document adequate decontamination procedures that were used between each well. A field reagent blank was also prepared by pouring the laboratory-supplied PFAS-free water into the container and was shipped to the laboratory to assess the potential for contamination of samples during field handling and transportation. All QA/QC samples were analyzed for PFAS via EPA Method 537 modified.

Eurofins also maintains an internal quality assurance program to assure the integrity of the analytical data generated. This includes analysis of samples in duplicate, analysis of sample preparation blanks, and accuracy checks. Each of these is performed at a minimum frequency of one per every sample set or a level of 10%. Results of the 2019 QA/QC program are included in **Table 3**. Laboratory certificate of analysis including the method detection limits (MDL) for each analysis are included in **Appendix E.** As noted in the certificate of analysis, MDL values vary between samples by less than one order of magnitude due to the differences in the moisture level or size of the samples. The data quality objectives for QA/QC techniques include:

- Relative Percent Difference (RPD) values less than 30%.
- Analytical results below the laboratory detection limits for the trip blank and the field blank.
- Satisfactory laboratory QA/QC results of the duplicate samples, sample blank, and spike analyses.

3.7 Applicable Comparison Criteria

As described in **Section 1.1**, groundwater analytical results are compared against maximum acceptable concentration (MAC) levels for PFOS and PFOA and with the interim drinking water screening values (DWSV) for nine (9) other PFAS compounds including PFBA, PFPeA, PFHxA, PFHpA, PFNA, PFBS, PFHxS, 6:2 FTS, and 8:2

FTS. The Soil Screening values (SSV-E) for industrial land use were used as the comparison criteria for the PFAS compounds. The federal soil and groundwater quality guidelines (FSQG, FGWQG) was also considered for PFOS. Since PFOS and PFOA have similar toxic effects, the recommended additive approach was considered when screening soil and groundwater data. If the relative sum (Hazard Index) ≤1, then soil and groundwater are considered acceptable (**Table 3** and **Table 5a**). It should be noted that 6:2 FtS and 8:2 FtS compounds are likely present in soil and groundwater samples as intermediate biotransformation products (Arcadis, 2017). PFHxA is the longest likely eventual transformation product of 6:2 FtS. PFPeA and PFBA are also likely to form from this compound. PFOA is longest likely eventual transformation product of 8:2 FtS. PFHpA and PFHxA are also likely to form from this compound.

Ontario guidelines were also used for the waste characterization of composite IDW-Soil and IDW-GW samples, for BTEX, PHCs, Fluoride and TCLP analysis. If applicable, the waste disposal facilities in the Province of Ontario were designated recipients of the waste. These guidelines included Ontario Regulation 558/00 Toxicity Characteristic Leaching Procedure (TCLP) Schedule 4 (TCLP criteria for waste characterization) and Table 1, Full Depth Background Site Condition Standards (Table 1 SCS) that is the most stringent soil and groundwater guideline in Ontario. When a parameter was found above Table 1 SCS, it was then compared to Table 3 SCS for Industrial sites, as most waste disposal facilities set their benchmark to Table 3 SCS. However, it should be noted that even Table 3 exceedances do not result in a "hazardous" classification.

Determination of whether or not something is hazardous for disposal is purely based on comparing TCLP data to Schedule 4, and for this specific site is also based on the TC guideline for PFAS waste classification (i.e., Stantec, 2018). The MAC values for PFOA and PFOS, the updated DWSV, and SSV values available for selected PFAS compounds in soil and groundwater, as well as the Ontario guidelines values, are provided in **Table 3** through **Table 5**.

4. Data Evaluation

The data evaluation section includes the following subsections:

- Review the stratigraphy of formation materials near the downgradient property boundary
- Review of GW quality data
- Review of IDW quality data
- Assessment of exposure pathways
- Assessment of whether the concentrations of PFAS are present in quantities that warrant NFA or additional investigation or remedial feasibility studies

4.1 Formation Stratigraphy near the Downgradient Property Boundary

As described in **Section 2.1**, the airport is built on flat terrain surrounded by hills and rocky plateaus of the Precambrian shield. The majority of the site consists of glaciomarine delta deposits that consist of sand, silt, boulders and gravel and portions of the site are characterized by till veneer that consists of sand, stones and boulders in a silty sand matrix. Precambrian bedrock topography is also evident in some areas of the site (**Appendix B**). As subsequently described, a rather consistent site stratigraphy was observed during the drilling of three (3) boreholes during this program.

The three boreholes for MW19-01, MW19-02, and MW19-03 were drilled to 4.3, 3.75, 3.49 mbgs, respectively, with various screened intervals intersecting the observed water table. No water table was observed at monitoring well MW19-01 which was screened between 0.91 and 3.96 mbgs. The screened intervals and water table elevation data are provided in **Table 1**. Soil classification data collected during the installation of the three monitoring wells in the vicinity of the downgradient property boundary indicate subsurface heterogeneity consistent with the literature on the regional geology of Iqaluit Airport (**Section 2.1**). The primary sedimentary facies observed at each well is highlighted in the boring logs provided in **Appendix D**.

Monitoring wells MW19-01 and MW19-02 were screened partially within a silty sand unit underlaid by bedrock**,** where monitoring wells MW19-03 was fully screened within a silty sand unit with some cobbles. No LNAPL impacts (staining, odour, and other potential signs of hydrocarbons) were observed, as indicated on the soil boring logs (**Appendix D)**. No permafrost conditions were encountered during the drilling program. In summary, it seems that a mixture of high and low permeability materials are present near the site downgradient property boundary. Further subsurface investigations are required to support any hypothesis regarding the hydraulic properties of the subsurface material and its impact on off-site migration of the PFAS plume.

4.2 Review of Groundwater Quality Data

4.2.1 PFAS Presence in Monitoring Wells

The potential for groundwater quality impacts off-site was assessed by collecting groundwater samples from the three newly installed wells assuming these wells represent groundwater quality prior to migration off-site. The groundwater samples were analyzed for a suite of 32 PFAS compounds and the MAC and DWSV criteria were used for comparison as discussed in **Section 3.7**.

Groundwater analytical results are included in **Table 3** and **Figure 4.** The boundary well MW19-01 was dry and therefore no groundwater sample was collected at this location. The following PFAS parameters were detected below the comparison criteria in groundwater samples collected one or both of monitoring wells MW19-02 and MW19-03: PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFBS, PFHxS, PFOS, 6:2 FTS, and 4:2 FTS (no DWSV exists for 4:2 FTS).

PFAS exceedances were only observed in the groundwater sample collected from MW19-03. From the 32 PFAS compounds analyzed in MW19-03, 21 compounds were non-detect, eight (8) were detected below DWSV criteria and three (3) compounds exceeded the criteria. The exceedances include:

- PFHpA: Concentration of 1000 ng/L (700 ng/L in duplicate) versus the DWSV of 200 ng/L.
- PFHxA: Concentration of 290 ng/L (270 ng/L in duplicate) versus the DWSV of 200 ng/L
- 6:2 FTS: Concentration of 520 ng/L (350 ng/L in duplicate) versus the DWSV of 200 ng/L

MW19-03 is located in closest proximity to the southeast property boundary located at close vicinity of the west side of the airport, just outside of the airside fence (**Figure 2).** MW19-02 had detectable PFAS parameters below MAC or DWSV criteria as shown in **Table 3**. The analytical data that are J-flagged in Table 3, are those parameters that were detected in concentrations below the level of quantitation (LOQ) (See **Section 4.2.2** for more details). As shown in **Table 3**, The sum of PFOS/MAC$_{PFOS}$ + PFOA/MAC$_{PFOA}$ was less than 1 for all collected groundwater samples.

In summary, the analytical results indicate that exceeded PFAS concentrations exist in the close vicinity of the downgradient property boundary. The exceedance of three (3) PFAS compound in MW19-3 (with concentrations x2 to x3 of the criteria) and detection of more PFAS compounds below criteria in monitoring wells MW19-02 and MW19-03 indicate a risk of PFAS off-site migration toward the southeast into the Frobisher Bay. Additional investigation would be required to better define the extent of PFAS contamination, as further discussed in **Section 5**.

4.2.2 PFAS Data Usability/Validation

Table 3 shows the analytical data for PFAS in the QA/QC samples, including field duplicate, equipment blanks, travel blank, and matrix spike and matrix spike duplicate sample. The laboratory analytical data for PFAS were reviewed to ensure that the precision and accuracy of the data were adequate for their intended use. All analytical data were found to be useable (as qualified). **Appendix F** contains the data validation report, which details the scope, quality assurance/QC sample collection and analysis, and results of the analytical data review and validation.

Detected concentrations below the level of quantitation (LOQ) are reported with a “J” flag. The LOQ is the lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias. During data validation, the J flag was further qualified. The flag “J+” means the analyte is present; however, the reported value may not be accurate or precise, and the result may be biased high. Alternatively, “J-“ means the analyte is present; however, the reported value may not be accurate or precise, and the result may be biased low. Measurements between the detection limit and the LOQ assure the presence of the analyte with confidence, but their numeric values are estimates.

Non-detections are reported as the limit of detection (LOD) followed by a ”U” flag. The LOD is the smallest amount or concentration of a substance that must be present in a sample to be detected at a 99% confidence level. The failure to obtain a detection is reported as “<LOD” because the false-negative rate at the LOD is 1% (DoD, 2009). In the instances where a result was qualified due to a blank detection, the non-detects are reported as the LOD followed by a ‘U*’ flag to indicate the flag was changed during data validation.

The data review and validation performed on the entire data set indicate the overall high quality of the definitive-level data collected for this site. None of the data were qualified as rejected and completeness for these data set is 100 percent. Results qualified as estimated are generally for marginal QC exceedances and blank-qualified results below or near the LOQs, and the qualifications do not significantly affect project objectives.

4.3 Review of IDW Quality Data

All drill cuttings and purged groundwater were temporarily stored in 20-L buckets on-site. A composite sample of investigative derived waste (IDW) from each soil and groundwater were collected and sent to Eurofins for analysis and IDW classification. IDW characterization was conducted following the TC guidelines for waste management (Stantec, 2018) and considering site-specific client and/or regulatory requirements (i.e., territorial guidelines and NWB license).

The composite sample of drill cuttings (IDW-Soil) was analyzed for PFAS, BTEX, PHCs and Fluorine concentrations as well as toxicity characteristics. Toxicity characteristics were analyzed using leaching tests including toxicity characteristic leaching procedure (TCLP) for metals and VOCs and synthetic precipitation leaching procedure (SPLP) for PFAS. A composite sample of purged groundwater (IDW-GW) was analyzed for PFAS, BTEX and PHCs concentrations as well as miscellaneous inorganics such as anions, cations, and nutrients. **Table 3** and **Table 4** summarizes the analytical results of IDW-GW and **Tables 5a and 5b** summarize the analytical results of IDW-soil samples. As discussed in **Section 3.7**, the IDW-GW sample was analyzed for PFAS, BTEX and PHCs, and inorganic compounds, and the IDW-Soil sample was analyzed for PFAS, BTEX, and PHCs, Fluorine and toxicity characteristic (i.e., TCLP and SPLP). MAC and DWSV criteria were used for IDW-GW, and SSV-HH and FSQG criteria for industrial land use were used as comparison criteria for PFAS in the IDW-soil sample. Ontario guidelines were used as comparison criteria for other parameters (e.g., PHCs, TCLP, etc.).

As shown in **Table 3**, in the composite IDW-GW sample, PFAS compounds were non-detect or below the comparison criteria with the exception of PFPeA with a concentration of 450 ng/L vs. the DWSV of 200 ng/L. No PFAS were detected in the composite IDW-Soil sample (**Table 5a)** or the SPLP leachate test (**Table 5b**). As shown in **Table 4** and **5b**, all other parameters analyzed for waste characterization were non-detect or below the Ontario guidelines, with the exception of PHC F2 and some metals that exceeded table 1 SCS. When compared to Table 3 SCS, PHC F2 and Lead were the only parameters with exceedances.

4.3.1 Management and Disposal of Waste Material

The instruction provided in TOR and the Guidance for the Management and Disposal of PFAS-impacted Waste Material (Stantec 2018) were followed for the management of investigation derived waste. Based on the IDW analytical results and the criteria presented at the waste management guidance (Stantec, 2018), the waste was categorized as:

- Category 2 Material: PFAS concentrations< SSVs, PFOS concentration < FSQG, PFAS concentrations> DWSV

No exceedances were found in soil. Based on the decision matrix for solid waste (Stantec, 2018), and the following discussion of results with PSPC, TC and Iqaluit airport management, AECOM retained Qikiqtaaluk Environemntal (QE) to conduct the on-site disposal of the solid waste material by reinstating the waste at a location on-site identified by the airport manager. This was completed in March 2020.

The IDW-water liquid waste (with exceeded concentrations of PFPeA, PHC F2 and lead) will be disposed of at an approved off-site facility for disposal/destruction based on the Decision Matrix for PFAS-Impacted Liquid Waste an as per discussed with PSPC. Liquid waste will be transferred to the Sanexen Environmental Services facility in

Quebec for destruction. Handling and transfer will be conducted by Qikiqtaaluk Environemntal (QE). In February 2020, QE took possession of the liquid waste. QE will handle the transfer of the IDW-GW (<200 L) to the Sanexen waste management facility in Quebec on or after July 2020 (when the barges are back in operation).

4.4 Deviations from the Work Plan

Deviations from the work plan occurred during this investigation. These deviations and the corrective actions are summarized below:

- Monitoring wells were sampled with dedicated disposable PVC bailer, instead of low flow sampling technique. Frozen groundwater in the tubing made low flow sampling not feasible at this site. The change to scope was discussed and agreed to by PSPC. PVC bailers have no PFAS as part of their chemical structure and are not a potential source of cross-contamination. A comprehensive analysis of equipment blank samples (independently conducted by AECOM) has indicated no risk of cross-contamination from many of the field equipment materials, including PVC bailers. To prevent any potential cross-contamination, AECOM personnel were extremely cautious using proper care during the handling of the bailers and used proper decontamination procedures between the wells and frequently changed nitrile gloves during the sampling.
- Turbidity could not be measured during well development because the water quality instrumentation did not include a turbidity probe. A qualitative description of groundwater turbidity was provided in the field notes instead.
- Air rotary drilling limited the recovery of soil cutting for comprehensive field screening.

5. Conclusions and Recommendations

The limited site investigation activities completed in October/November 2019, culminated in the collection of three (3) groundwater samples that were analyzed for the full suite of PFAS consistent with Transport Canada Guideline (Arcadis, 2017). One of the wells (MW19-01) was dry and the two (2) other newly installed monitoring wells had detections of PFAS, but only one (MW19-03) had levels of PFAS exceeding the guidance criteria. PFHpA, PFHxA, and 6:2 FTS were detected above the corresponding DWSV at MW19-03. PFAS were not detected in IDW-soil and were below MAC and DWSV in IDW-GW samples except for PFPeA. PHC F2 and lead were also detected above the Ontario Table 3 SCS in the composite IDW-GW sample.

Due to the presence of PFAS in groundwater samples collected from the newly installed monitoring wells and exceedance of three (3) PFAS compounds in MW19-03 (located at the immediate vicinity of the downgradient boundary), it is recommended that additional investigation takes place at the Site. PFAS detection and exceedances in groundwater could be an indicator of potential residual sources that may lead to potential migration of the resultant PFAS plume off-site. The collection of soil and groundwater samples at the vicinity of the former FTA would be required to confirm any remaining source in that area.

Additional site investigations or sampling programs would also be required to evaluate the risk associated with each potential exposure pathways. Additional sampling and analysis would also be required to establish the nature and extent of PFAS for each applicable media (e.g., soil, sediment, surface water, and groundwater), and determine if there is a complete receptor pathway. Additional sampling and analysis would also be required to come up with the best remedial options to prevent further off-site migration of PFAS.

6. References

AECOM, 2018:
PFAS Sampling Guidance, Internal Training Document, July 2018

AECOM, 2019b:
Proposal for PFAS Investigations for Transport Canada at Two Northern Transferred Airport Locations at Fort Smith, NT and Iqaluit, NU (September 10, 2019)

AECOM, 2019c:
Site-Specific Health and Safety Plan for PFAS Investigations at Iqaluit Airport (October 2019)

AECOM, 2019a:
Work Plan for PFAS Investigations for Transport Canada at Iqaluit Airport, Iqaluit, NT (October 2019)

AN-Geo Environmental Consultants, 1999:
Environmental Site Investigation, February 1999

Arcadis, 2017:
Guidance for Presence/Absence Sampling of Indicator Per- and Polyfluoroalkyl Substances (PFAS) at Transport Canada Transferred Airport Property Boundaries”

Biogenie Inc., 1994a:
Environmental Characterization, Iqaluit Airport, Northwest Territories. November 1994.

Biogenie Inc., 1994b:
Environmental Assessment, Iqaluit Airport, Northwest Territories. December 1994

Biogenie Inc., 1995:
Environmental Audit - Iqaluit Airport, Volume II: Environmental Characterization. April 1995

C8 Science Panel, 2018:
http://www.c8sciencepanel.org/index.html as accessed on 13 May 2018.

City of Iqaluit, 2018, 2019:
Application to amend City of Iqaluit Water License, Supplemental Drinking Water Supply from Apex River

Conestoga-Rovers & Associates, 2014:
Pre-Existing Environmental Contamination Management Plan. Iqaluit International Airport Improvement Project, Iqaluit, Nunavut. May 2014

Department of Fisheries and Oceans Canada (DFO), 2019:
Government of Canada supports important coastal environmental research on Canada’s Arctic coast, August 2019

Dillon Consulting, 1999:
Environmental Baseline Study Reaudit, Iqaluit Airport, NT. July 1999

Dillon Consulting, 2005:
Environmental Site Assessment, Abandoned Hydrant and Distribution System, Apron I, February 2005

Dillon Consulting, 1996:
Iqaluit Airport, Environmental Baseline Study. March 26, 1996.

EBA Engineering Consultants Ltd., 1997:
Soil and Groundwater Investigation, Iqaluit Airport, Iqaluit, N.W.T. October 1997

Environment and Climate Change Canada, 2017:
Federal Environmental Quality Guidelines for Perfluorooctane Sulfonate (PFOS), Canadian Environmental Protection Act.

Environment Canada, 2019:
“Iqaluit". Canadian Climate Data. Environment Canada. Retrieved December 2019.

Environment Canada, 2019:
“Iqaluit". Canadian Climate Normals 1981–2010. Climate ID: 2202200. Retrieved December 2019.

EXP, 2014:
City of Iqaluit Supplementary Water Supply Study, August 2014

Golder, 2017:
FTA Summary Sheet

Health Canada, 2019:
PFOS, PFOA and Other PFAS: A Focus on Federal Guidelines, June 2019

Health Canada, 2016:
Health Canada’s Drinking Water Screening Values for Perfluoroalkylated Substances (PFAS). February 2016. Updated July 2018.

Health Canada, 2018:
Guidelines for Canadian Drinking Water Quality, Guideline Technical Document. Perfluorooctane Acid (PFOA). December 2018.

Health Canada, 2018:
Guidelines for Canadian Drinking Water Quality, Guideline Technical Document. Perfluorooctane Sulfonate (PFOS). December 2018.

Health Canada, 2019:
Summary Table: Health Canada Draft Guidelines, Screening Values and Toxicological Reference Values (TRVs) for Perfluoroalkyl Substances (PFAS). February 2019.

Health Canada, 2019:
Updates to Health Canada Soil Screening Values for Perfluoroalkylated Substances (PFAS). Health Canada. May 2019.

Health Canada, 2019:
Water Talk - Drinking Water and Perfluoroalkyl Substances (PFAS). April 2019.

LeBlanc, A.-M., G.A. Oldenborger, N. Short, W.E. Sladen, M. Allard and V. Mathon-Dufour, 2015:
Ground temperatures and spatial permafrost conditions in Iqaluit, Baffin Island, Nunavut; in Summary of Activities 2015, Canada-Nunavut Geoscience Office, p. 161–170

M.M. Dillon Ltd., 1995:
Iqaluit Environmental Baseline Study. March 8, 1995

Mathon-Dufour, V., M. Allard, and A.-M. LeBlanc, 2015:
Assessment of permafrost conditions in support of the rehabilitation and adaptation to climate change of the Iqaluit airport, Nunavut, Canada; in Proceedings of GEOQuébec 2015, Québec City, September 20–23, 2015, paper 146, 8 p

Natural Resources Canada (NRC), 2011:
Geomatics information for the watershed serving Iqaluit, Nunavut, using EO data and ground surveys

Shojae Ghias, M., R. Therrien and J. Molson, et al. :
Controls on permafrost thaw in a coupled groundwater-flow and heat-transport system: Iqaluit Airport, Nunavut, Canada, Hydrogeol J (2017) 25: 657.

Stantec, 2018:
Guidance for the Management and Disposal of PFAS-Impacted Waste Materials

Transport Canada, 2001:
Iqaluit Airport Fire Training Area Remediation, 2000 Summary Report. April 2001

7. Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations");
- represents AECOM's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

AECOM shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. AECOM accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

AECOM agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but AECOM makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

Without in any way limiting the generality of the foregoing, any estimates or opinions regarding probable construction costs or construction schedule provided by AECOM represent AECOM's professional judgement in light of its experience and the knowledge and information available to it at the time of preparation. Since AECOM has no control over market or economic conditions, prices for construction labour, equipment or materials or bidding procedures, AECOM, its directors, officers and employees are not able to, nor do they, make any representations, warranties or guarantees whatsoever, whether express or implied, with respect to such estimates or opinions, or their variance from actual construction costs or schedules, and accept no responsibility for any loss or damage arising therefrom or in any way related thereto. Persons relying on such estimates or opinions do so at their own risk.

Except (1) as agreed to in writing by AECOM and Client; (2) as required by-law; or (3) to the extent used by governmental reviewing agencies for the purpose of obtaining permits or approvals, the Report and the Information may be used and relied upon only by Client.

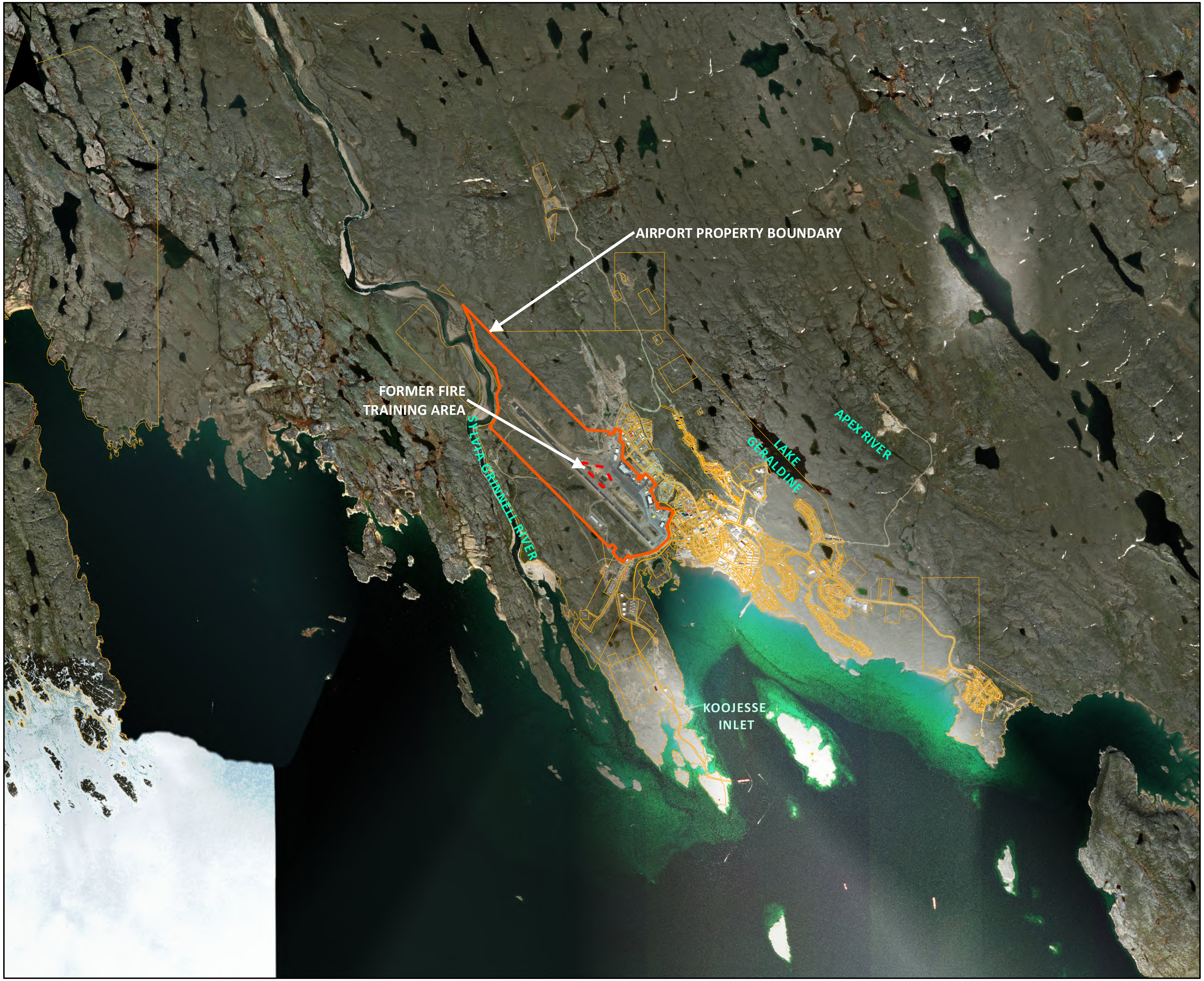
AECOM accepts no responsibility, and denies any liability whatsoever, to parties other than Client who may obtain access to the Report or the Information for any injury, loss or damage suffered by such parties arising from their use of, reliance upon, or decisions or actions based on the Report or any of the Information ("improper use of the Report"), except to the extent those parties have obtained the prior written consent of AECOM to use and rely upon the Report and the Information. Any injury, loss or damages arising from improper use of the Report shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

AECOM will perform all professional services in accordance with the standard of care customarily observed by professional consulting firms performing similar services at the same time and location. The standard of care will include adherence to all applicable published standards of the profession and laws, regulations, by-laws, building codes and governmental rules.

AECOM: 2015-04-13

Figures



Legend

- 🟧 Iqaluit Airport Boundary
- 🟨 Land Parcel Boundary
- ▭ Former Fire Training Area

0 0.5 1 2

Kilometers

SITE LOCATION MAP

Iqaluit Airport, Nunavut

Feb 2020	1:50,000	Datum: NAD 1983 UTM Zone 19N

AECOM

Figure 1

Map location: C:\Users\Stephanie.Cloutier\Desktop\Ongoing\60615382\Design\01_Reports\Monitoring Well Work Plan - Iqaluit Airport\60515382_Figure1_IqaluitAirport.mxd
Date Saved: 2/7/2020 12:16:44 PM

Legend

- ◘ Monitoring Well Location
- → Assumed Groundwater Flow Direction
- ▭ Iqaluit Airport Boundary
- ▭ Land Parcel Boundary
- ⬚ Former Fire Training Area

MW ID	X-Coordinate	Y-Coordinate
MW19-01	7069390.973	521883.3952
MW19-02	7068934.92	522323.8995
MW19-03	7068912.125	522775.9659

0 250 500 1,000
Meters

SITE PLAN AND MONITORING WELL LOCATIONS

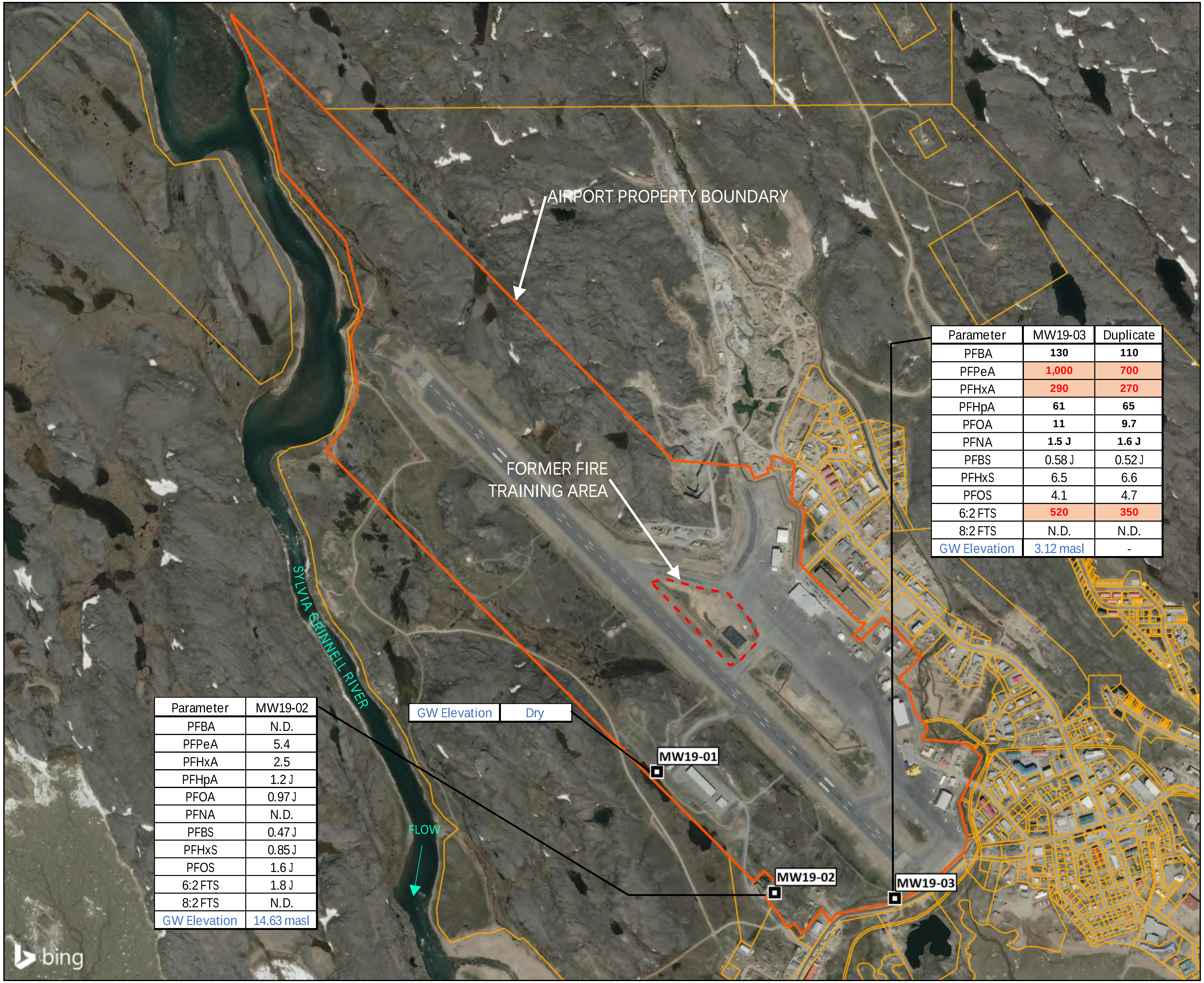
Iqaluit Airport, Nunavut

Feb 2020	1:14,000	Datum: NAD 1983 UTM Zone 19N

AECOM

Figure 2

Map location: C:\Users\Stephanie.Cloutier\Desktop\Ongoing\60615382\Design\01_Reports\Monitoring Well Work Plan - Iqaluit Airport\60615382_Figure2_IqaluitAirport.mxd
Date Saved: 2/7/2020 12:19:48 PM



Parameter	MW19-03	Duplicate
PFBA	**130**	**110**
PFPeA	**1,000**	**700**
PFHxA	**290**	**270**
PFHpA	**61**	**65**
PFOA	**11**	**9.7**
PFNA	**1.5 J**	**1.6 J**
PFBS	0.58 J	0.52 J
PFHxS	6.5	6.6
PFOS	4.1	4.7
6:2 FTS	**520**	**350**
8:2 FTS	N.D.	N.D.
GW Elevation	3.12 masl	-

GW Elevation	Dry

Parameter	MW19-02
PFBA	N.D.
PFPeA	5.4
PFHxA	2.5
PFHpA	1.2 J
PFOA	0.97 J
PFNA	N.D.
PFBS	0.47 J
PFHxS	0.85 J
PFOS	1.6 J
6:2 FTS	1.8 J
8:2 FTS	N.D.
GW Elevation	14.63 masl

Legend

- ▪ Monitoring Well Location
- ▭ Iqaluit Airport Boundary
- ▭ Land Parcel Boundary
- ⬚ Former Fire Training Area

PFAS compounds with inetrim Federal Guidline Values- All units are in ng/L

Parameter Name	Interim Federal Guideline Values	
	HC Guilidelines[1]	FWQG[2]
Perfluorobutanoic acid (PFBA)	30000	N/A
Perfluoropentanoic Acid (PFPeA)	200	N/A
Perfluorohexanoic Acid (PFHxA)	200	N/A
Perfluoroheptanoic Acid (PFHpA)	200	N/A
Perfluorooctanoic Acid (PFOA)*	200	N/A
Perfluorononanoic Acid (PFNA)	20	N/A
Perfluorobutane sulfonic acid (PFBS)	15000	N/A
Perfluorohexane sulfonic acid (PFHxS)	600	N/A
Perfluorooctane sulfonic acid (PFOS)*	600	6800
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	200	N/A
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	200	N/A

0 250 500 1,000
Meters

GROUNDWATER ELEVATION AND ANALYTICAL RESULTS

Iqaluit Airport, Nunavut

Feb 2020	1:14,000	Datum: NAD 1983 UTM Zone 19N

AECOM

Figure 3

Map location: C:\Users\Stephanie.Cloutier\Desktop\Ongoing\60615382\Design\01_Reports\Monitoring Well Work Plan - Iqaluit Airport\60515382_Figure3_IqaluitAirport.mxd
Date Saved: 2/7/2020 11:39:23 AM

Tables

Table 1

Groundwater Monitoring Results

Iqaluit Airport PFAS Investigation

Monitoring Well	X- coordinate (Easting)	Y-Coordinate (Northing)	Top of Pipe Elevation (m)	Ground Surface Elevation (m)	Well completion Method	Screen Interval (mbgs)	Borehole Depth (mbgs)	Date (mm/dd/YYYY)	Subsurface vapour Concentrations (ppm)	Free Product Thickness (mm)	Potentiometric Depth (mbtoc)	Potentiometric Depth (mbgs)	Potentiometric Elevation (masl)
MW19-01	7069390.973	521883.3952	19.29	18.7097	Stick-up	0.912-3.96	4.3	11/4/2019	N/A	N/A	Dry	Dry	Dry
MW19-02	7068934.92	522323.8995	17.3238	16.5177	Stick-up	2.02-3.54	3.75	11/4/2019	4	ND	2.69	1.8839	14.63
MW19-03	7068912.125	522775.9659	4.5354	3.6783	Stick-up	0.44-3.49	3.49	11/4/2019	0	ND	1.42	0.5629	3.12

Table 2
Water Quality Parameters during Groundwater Sampling

Fort Smith Airport PFAS Investigation

Monitoring Well	Temprature (°C)	EC (µS/cm)	DO (mg/L)	pH (-)	Redox Potential/ORP (mV)	Comment
MW19-01	N/A	N/A	N/A	N/A	N/A	Dry
MW19-02	-0.1	236	7.46	7.11	-24.5	YIS frozen, parameters not trabilized
MW19-03	-0.1	634..9	9.23	7.52	253.3	YIS frozen, parameters not trabilized

Notes:
EC: Electrical Conductivity
DO: Dissolived Oxygen
ORP: Oxidative- Reductive Potential
µS/cm: microsiemens per centimenter
mg/L : milligram per liter

Table 3
PFAS Analytical Results in Groundwater and Other Liquid Samples

Project Name					Iqaluit Airport PFAS Investigation									
Sample ID					**1465298-MW19-02 Groundwater**	**1465299-MW19-03 Groundwater**	**1465301-Dup-1 Groundwater**	**Calculated PRDs (%)**	**1465308-FRB-TB Water**	**1465305-EB-WLT Water**	**1465306-EB-DR Water**	**1465303-MW19-02MS Groundwater**	**1465304-MW19-02MSD Groundwater**	**1465307-IDW-GW Groundwater**
Sample Description					MW19-02	MW19-03	Dup 1-GW/MW19-03		Field Blank/Travel Blank	Equipment Blank/ Water Level Tape	Equipment Blank/ Drill Rod Rinsate	Matrix Spike	Matrix Spike Duplicate	IDW-GW
Sampling Date					11/5/2019	11/5/2019	11/5/2019		11/1/2019	11/4/2019	10/30/2019	11/5/2019	11/5/2019	10/31/2019
Screened Interval (mbgs)					2-3.5	0.2-3.2	0.2-3.2		Not Applicable	Not Applicable	Not Applicable	2-3.5	2-3.5	Not Applicable
Parameter Name	**Unit**	**Interim Federal Guideline Values**		**Detection Limit**	**Groundwater Samples**				**Field QA/QC samples**					**IDW-GW**
EPA Method 537- modified (Isotope Dilution)		**HC Guilidelines[1]**	**FGWQG[2]**											
Perfluorobutanoic acid (PFBA)	ng/L	**30000**	N/A	1.90	N.D.	**130**	**110**	16.7	N.D.	N.D.	N.D.	25	23	**54**
Perfluoropentanoic Acid (PFPeA)	ng/L	**200**	N/A	4.80	**5.4**	**1,000**	**700**	35.3	N.D.	N.D.	N.D.	29	28	**450**
Perfluorohexanoic Acid (PFHxA)	ng/L	**200**	N/A	0.48	**2.5**	**290**	**270**	7.1	N.D.	N.D.	N.D.	23	23	**120**
Perfluoroheptanoic Acid (PFHpA)	ng/L	**200**	N/A	0.48	**1.2 J**	**61**	**65**	-6.3	N.D.	N.D.	N.D.	22	22	**28**
Perfluorooctanoic Acid (PFOA)*	ng/L	**200**	N/A	0.48	**0.97 J**	**11**	**9.7**	12.6	N.D.	N.D.	N.D.	22	19	**4.2**
Perfluorononanoic Acid (PFNA)	ng/L	**20**	N/A	0.48	N.D.	**1.5 J**	**1.6 J**	-6.5	N.D.	N.D.	N.D.	22	22	**0.66 J**
Perfluorodecanoic Acid (PFDA)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	23	N.D.
Perfluoroundecanoic Acid (PFUnA)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	22	N.D.
Perfluorododecanoic Acid (PFDoA)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	20	22	N.D.
Perfluorotridecanoic Acid (PFTrDA)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	21	19	N.D.
Perfluorotetradecanoic Acid (PFTeDA)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	21	N.D.
Perfluorobutane sulfonic acid (PFBS)	ng/L	**15000**	N/A	0.48	**0.47 J**	**0.58 J**	**0.52 J**	10.3	N.D.	N.D.	N.D.	20	20	N.D.
Perfluoropentane sulfonic acid	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	24	25	N.D.
Perfluorohexane sulfonic acid (PFHxS)	ng/L	**600**	N/A	0.48	**0.85 J**	**6.5**	**6.6**	-1.5	N.D.	N.D.	**1.2 J**	20	19	**2.4**
Perfluoroheptane sulfonic acid (PFHpS)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	21	N.D.
Perfluorooctane sulfonic acid (PFOS)*	ng/L	**600**	**68000**	0.48	**1.6 J**	**4.1**	**4.7**	-13.6	N.D.	N.D.	N.D.	18	19	**2.5**
Perfluorononane sulfonic acid	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	22	N.D.
Perfluorodecane sulfonic acid (PFDS)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	21	22	N.D.
Perfluorooctane Sulfonamide (PFOSA)	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	21	N.D.
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/L	**200**	N/A	1.90	**1.8 J**	**520**	**350**	39.1	N.D.	N.D.	**3.1 J**	23	21	**190**
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	ng/L	**200**	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	21	22	N.D.
10:2 Fluorotelomersulfonic acid (10:2 FTS)	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	16	15	N.D.
4:2 Fluorotelomersulfonic acid (4:2 FTS)	ng/L	N/A	N/A	0.48	N.D.	**2.2**	**2.1**	4.7	N.D.	N.D.	N.D.	21	20	**1.1 J**
NEtFOSAA	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	21	20	N.D.
NEtPFOSA	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	22	21	N.D.
NEtPFOSAE	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	20	20	N.D.
NMeFOSAA	ng/L	N/A	N/A	0.58	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	24	22 Z	N.D.
NMePFOSA	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	18	21	N.D.
NMePFOSAE	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	19	20	N.D.
Perfluorododecanesulfonic acid	ng/L	N/A	N/A	0.48	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	21	22	N.D.
Perfluorohexadecanoic acid	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	23	23	N.D.
Perfluorooctadecanoic acid	ng/L	N/A	N/A	0.97	N.D.	N.D.	N.D.	NA	N.D.	N.D.	N.D.	25	19	N.D.
$[PFOS]/MAC_{PFOS} + [PFOA]/MAC_{PFOA} \leq 1$	-	-	-	-	Y	Y	Y	Y	Y	Y	Y	0.0016	0.0016	0.0016

Notes:

PFAS compound with corresponding guidline values

Exceeds Criteria

Bold: Detected

N/A: Not available

N.D.: Non-Detect

[1] - HC (2018, 2019), Health Canada Maximum Acceptable Concentration (MCA) and Driniking Water Screening Values (DWSV) for the protection of Human Health

[2]- ECCC (2017), Environmnet and Climate Change Canada Federal Groundwater Quality Guidelines for PFOS Considering Ecological Receptors.

* The recommended approach to summing PFOA and PFAS is: $PFOS/MAC_{PFOS} + PFOA/MAC_{PFOA} \leq 1$. Whenconcentration are non-detect (ND), ½ DL was

mbgs = metres below ground surface

ng/L= nanograms per liter

J: See Appendix F (lab certificate of analysis) and Appendix G (Data Quality Report) for details

QA/QC: Quality Assurance/ Quality Control

IDW-GW: Investigative-Derived Waste- Groundwater

NEtFOSAA is the acronym for N-ethyl perfluorooctanesulfonamidoacetic Acid
NEtPFOSA is the acronym for N-ethylperfluoro-1-octanesulfonamide
NEtPFOSAE is the acronym for 2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol
NMeFOSAA is the acronym for N-methyl perfluorooctanesulfonamidoacetic Acid
NMePFOSA is the acronym for N-methylperfluoro-1-octanesulfonamide
NMePFOSAE is the acronym for 2-(N-methylperfluoro-1-octanesulfonamido)-ethanol

Table 4

IDW- GW Additional Analysis for Hazardous Waste Characterization

Project Name	**Iqaluit Airport PFAS Investigation**
Sample ID	**1471422-IDW-GW**
Sample Description	IDW-GW
Sampling Date	10/31/2019

Additionak Analysis for Hazardous Waste Characeterizatiob	**Unit**	**Comparison Critera (ON Standards [a, b])**	**Detection Limit**	**Results**
Benzene	mg/L	0.0005	0.0005	<0.0005
Ethylbenzene	mg/L	0.0005	0.0005	<0.0005
Toluene	mg/L	0.0008	0.0005	<0.0005
Xylene (Total)	mg/L	0.072	0.0005	<0.0005
F1 (C6-C10)	mg/L	0.42	0.02	<0.02
F2 (C10-C16)	mg/L	0.15 (0.15)	0.02	**2.72**
F3 (C16-C34)	mg/L	0.5	0.05	<0.05
F4 (C34-C40)	mg/L	0.5	0.05	<0.05
Misc. Inorgani, Anions and Nutrients				
Alkalinity as CaCO3	mg/L	n/a	5	**153**
Conductivity	uS/cm	n/a	5	**445**
pH	-	n/a	1	**7.92**
Bicarbonate	mg/L	n/a	1	**153**
Carbonate	mg/L	n/a	1	n/a-pH
Hydroxide	mg/L	n/a	0.01	n/a-pH
Dissolved Chloride	mg/L	790	1	**42**
Dissolved Sulfate	mg/L	n/a	1	**23**
Dissolved Nitrite	mg/L	n/a	0.1	<0.1
Dissolved Nitrate	mg/L	n/a	0.1	<0.1
Elements				
Total Aluminium	mg/L	n/a	0.1	**69.7**
Antimony	mg/L	0.0015	0.01	<0.01
Arsenic	mg/L	0.013 (1.9)*	0.02	**0.02**
Barium	mg/L	0.61	0.01	0.54
Beryllium	mg/L	0.0005	0.01	<0.01
Boron	mg/L	1.7	0.1	**0.2**
Calcium	mg/L	n/a	1	**59**
Chromium	mg/L	0.011 (0.81)	0.05	**0.07**
Cobalt	mg/L	0.0038 (0.066)	0.01	**0.04**
Iron	mg/L	n/a	0.1	**143**
Lead	mg/L	0.0019 (0.025)	0.01	**0.04**
Lithium	mg/L	n/a	0.01	**0.07**
Magnesium	mg/L	n/a	1	**12**
Manganese	mg/L	n/a	0.01	**2.98**
Molybdenum	mg/L	0.023 (9.2)	0.01	**0.02**
Nickel	mg/L	0.014 (0.49)	0.01	**0.07**
Phosphorus	mg/L	n/a	0.002	**0.696**
Potassium	mg/L	n/a	1	**12**
Selenium	mg/L	0.005	0.02	<0.02
Silicon	mg/L	n/a	0.1	**21.6**
Silver	mg/L	0.0003	0.01	<0.01
Sodium	mg/L	490	2	**37**
Strontium	mg/L	n/a	0.05	0.22
Thallium	mg/L	0.0005	0.01	<0.01
Tin	mg/L	n/a	0.1	**<0.1**
Titanium	mg/L	n/a	0.1	**0.4**
Uranium	mg/L	0.0089	0.01	<0.01
Vanadium	mg/L	0.0039 (0.25)	0.05	**0.1**
Zinc	mg/L	0.16 (1.1)	0.04	**0.57**
Mercury	mg/L	0.0001	0.0001	<0.0001
Dissolved Calcium	mg/L	n/a	1	**48**
Dissolved Iron	mg/L	n/a	0.03	<0.03
Dissolved Magnesium	mg/L	n/a	1	**8**
Dissolved Manganese	mg/L	n/a	0.01	**1.13**
Dissolved Potassium	mg/L	n/a	1	**4**
Dissolved Sodium	mg/L	490	2	**44**
Calculated Parameters				
Hardness as CaCO3	mg/L	n/a	1	**197**
Iron Balance		n/a	0.01	**1.24**
Dissolved Nitrate	mg/L	n/a	0.1	<0.1
Nitrate+Nitrite	mg/L	n/a	0.1	<0.1
Dissolved Nitrite	mg/L	n/a	0.1	<0.1
Calculated Total Dissolved Solids (TDS)	mg/L	n/a	1	**289**

[a] Ontario Table 1: Full Depth Background Site Condition Standards (Table 1 SCS), April 2011

* For evaluation of potential disposal options, analytical date were first compared to Table 1 SCS which is the most stringent standard (if everything is below T1, it can go to a clean fill site). If a parameter is above Table 1, it was compared to Table 3 SCS for Industrial sites ((value in paranthesis).

Bold: Detected

Exceeds Table 1 SCS Criteria

Exceeds Table 3 SCS Criteria

Table 5a

IDW Soil Analytical Results- PFAS

Project Name	**Iqaluit Airport PFAS Investigation**
Sample ID	**1465311-IDW-Soil**
Sample Description	IDW-Soil
Sampling Date	10/31/2019

Parameter Name	Unit	Interim Federal Guideline Values		Detection Limit	Results
EPA Method 537- modified (Isotope Dilution)		**HC SSV-HH Guilidelines[1]**	**Draft FSQG[2]**		
Perfluorobutanoic acid (PFBA)	ng/g	**1630000**	N/A	0.82	N.D.
Perfluoropentanoic Acid (PFPeA)	ng/g	**11410**	N/A	0.20	N.D.
Perfluorohexanoic Acid (PFHxA)	ng/g	**11410**	N/A	0.20	N.D.
Perfluoroheptanoic Acid (PFHpA)	ng/g	**11410**	N/A	0.20	N.D.
Perfluorooctanoic Acid (PFOA)*	ng/g	**9940**	N/A	0.20	N.D.
Perfluorononanoic Acid (PFNA)	ng/g	**1200**	N/A	0.20	N.D.
Perfluorodecanoic Acid (PFDA)	ng/g	N/A	N/A	0.20	N.D.
Perfluoroundecanoic Acid (PFUnA)	ng/g	N/A	N/A	0.20	N.D.
Perfluorododecanoic Acid (PFDoA)	ng/g	N/A	N/A	0.20	N.D.
Perfluorotridecanoic Acid (PFTrDA)	ng/g	N/A	N/A	0.20	N.D.
Perfluorotetradecanoic Acid (PFTeDA)	ng/g	N/A	N/A	0.20	N.D.
Perfluorobutane sulfonic acid (PFBS)	ng/g	**872000**	N/A	0.41	N.D.
Perfluoropentane sulfonic acid	ng/g	N/A	N/A	0.20	N.D.
Perfluorohexane sulfonic acid (PFHxS)	ng/g	**33000**	N/A	0.20	N.D.
Perfluoroheptane sulfonic acid (PFHpS)	ng/g	N/A	N/A	0.20	N.D.
Perfluorooctane sulfonic acid (PFOS)*	ng/g	**30500**	**140[a]/210[b]**	0.20	N.D.
Perfluorononane sulfonic acid	ng/g	N/A	N/A	0.20	N.D.
Perfluorodecane sulfonic acid (PFDS)	ng/g	N/A	N/A	0.20	N.D.
Perfluorooctane Sulfonamide (PFOSA)	ng/g	N/A	N/A	0.20	N.D.
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/g	**11410**	N/A	0.61	N.D.
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	ng/g	**11410**	N/A	0.61	N.D.
10:2 Fluorotelomersulfonic acid (10:2 FTS)	ng/g	N/A	N/A	0.61	N.D.
4:2 Fluorotelomersulfonic acid (4:2 FTS)	ng/g	N/A	N/A	0.61	N.D.
NEtFOSAA	ng/g	N/A	N/A	0.20	N.D.
NEtPFOSA	ng/g	N/A	N/A	0.51	N.D.
NEtPFOSAE	ng/g	N/A	N/A	0.51	N.D.
NMeFOSAA	ng/g	N/A	N/A	0.20	N.D.
NMePFOSA	ng/g	N/A	N/A	0.51	N.D.
NMePFOSAE	ng/g	N/A	N/A	0.51	N.D.
Perfluorododecanesulfonic acid	ng/g	N/A	N/A	0.20	N.D.
Perfluorohexadecanoic acid	ng/g	N/A	N/A	0.20	N.D.
Perfluorooctadecanoic acid	ng/g	N/A	N/A	0.20	N.D.
$\frac{PFOS\ Concentration}{MAC_{PFOS}} + \frac{PFOA\ Concentration}{MAC_{PFOA}}$	ng/g	**1**	N/A	NA	0.00001

Notes:

PFAS compound with corresponding guidline values

Exceeds Criteria

bold: Detected

N/A: Not available

[1] - HC. 2019. Health Canada Soil Screening values for the protection of Human Health for Commercial/Industrial Land Use

[2]- The Federal environmental quality guideline (FSQG) for PFOS for commercial/industrial land use for Soil

* The recommended approach to summing PFOA and PFAS is: PFOS/SSVPFOS + PFOA/SSVPFOA ≤ 1. When concentrations are non-detect (ND), ½ DL was used for the calculations.

mBGS = metres below ground surface

ng/g = nanograms per gram

ng/L= nanograms per liter

mg/L= miligram per liter

µg/kg= microgram pr kilogram

PHC = Petroleum Hydrocarbon

TPH= Total petroleum hydrocarbon

J: See lab certificate of analysis for additional details

Table 5b

IDW Soil Analytical Results- Additional Analysis for Hazardous Waste Characterization

Project Name	**Iqaluit Airport PFAS Investigation**
Sample ID	**1465312-IDW-Soil**
Sample Description	IDW-Soil
Sampling Date	10/31/2019

Additionak Analysis for Hazardous Waste Characterizatiob	Unit	Comparison Critera (ON Standards [a, b])	Detection Limit	Results
BTEX and PHCs				
Benzene	µg/g	0.02	0.02	<0.02
Ethylbenzene	µg/g	0.05	0.05	<0.05
Toluene	µg/g	0.2	0.20	<0.2
Xylene (Total)	µg/g	0.05	0.05	<0.05
C6-C10 (F1)	µg/g	25	10	<10
C10-C16 (F2)	µg/g	10	10	<10
C16-C34 (F3)	µg/g	240	20	**180**
C34-C40 (F4)	µg/g	120	20	**110**
Fluoride	µg/g	n/a	0.50	2.0
Moisture	%	n/a	0.1	8.8
TCLP Non-volatile Extraction				
Antimony	mg/l	n/a	0.01	<0.01
Arsenic	mg/l	2.5	0.02	<0.02
Barium	mg/l	100	0.01	0.31
Beryllium	mg/l	n/a	0.01	<0.01
Boron	mg/l	500	0.10	<0.1
Cadmium	mg/l	0.5	0.01	<0.008
Chromium	mg/l	5	0.00	<0.05
Cobalt	mg/l	n/a	0.01	**0.01**
Copper	mg/l	n/a	0.01	**0.11**
Iron	mg/l	n/a	0.10	**0.50**
Lead	mg/l	5	0.01	<0.01
Mercury	mg/l	0.1	0.00	<0.001
Nickel	mg/l	n/a	0.01	**0.03**
Selenium	mg/l	1	0.02	<0.02
Silver	mg/l	5	0.01	<0.01
Thallium	mg/l	n/a	0.01	<0.01
Uranium	mg/l	10	0.01	<0.01
Vanadium	mg/l	n/a	0.05	<0.05
Zinc	mg/l	n/a	0.04	**0.53**
Zirconium	mg/l	n/a	0.02	<0.02
TCLP Volatile Extraction				
Benzene	µg/l	0.5	0.5	<0.5
Toluene	µg/l	n/a	0.5	<0.5
Ethylbenzene	µg/l	n/a	0.5	<0.5
o-Xylene	µg/l	n/a	0.4	<0.4
m & p-Xylene	µg/l	n/a	0.4	<0.4
Xylenes (Total)	µg/l	n/a	n/a	n/a
Carbon Tetrachloride	µg/l	0.5	0.2	<0.2
Chlorobenzene	µg/l	8	0.5	<0.5
Chloroform	µg/l	10	0.5	<0.5
1,2-Dichloroethane	µg/l	0.5	0.2	<0.2
1,1-dichloroethylene	µg/l	1.4	0.5	<0.5
Tetrachloroethylene	µg/l	3	0.3	<0.3
Trichloroethylene	µg/l	5	0.3	<0.3
Vinyl Chloride	µg/l	0.2	0.0	<0.2
SPLP PFAS Leachate Extraction				
Perfluorobutanoic acid (PFBA)	ng/L	n/a	2.5	N.D.
Perfluoropentanoic Acid (PFPeA)	ng/L	n/a	0.64	2.6 J
Perfluorohexanoic Acid (PFHxA)	ng/L	n/a	0.64	**1.6 J**
Perfluoroheptanoic Acid (PFHpA)	ng/L	n/a	0.64	**2.6 J**
Perfluorooctanoic Acid (PFOA)*	ng/L	n/a	0.64	**5.9**
Perfluorononanoic Acid (PFNA)	ng/L	n/a	0.64	N.D.
Perfluorodecanoic Acid (PFDA)	ng/L	n/a	0.64	N.D.
Perfluoroundecanoic Acid (PFUnA)	ng/L	n/a	0.64	N.D.
Perfluorododecanoic Acid (PFDoA)	ng/L	n/a	0.64	N.D.
Perfluorotridecanoic Acid (PFTrDA)	ng/L	n/a	0.64	N.D.
Perfluorotetradecanoic Acid (PFTeDA)	ng/L	n/a	0.64	N.D.
Perfluorobutane sulfonic acid (PFBS)	ng/L	n/a	0.64	N.D.
Perfluoropentane sulfonic acid	ng/L	n/a	0.64	N.D.
Perfluorohexane sulfonic acid (PFHxS)	ng/L	n/a	0.64	N.D.
Perfluoroheptane sulfonic acid (PFHpS)	ng/L	n/a	0.64	N.D.
Perfluorooctane sulfonic acid (PFOS)*	ng/L	n/a	0.64	**28**
Perfluorononane sulfonic acid	ng/L	n/a	0.64	N.D.
Perfluorodecane sulfonic acid (PFDS)	ng/L	n/a	0.64	N.D.
Perfluorooctane Sulfonamide (PFOSA)	ng/L	n/a	0.64	N.D.
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	ng/L	n/a	2.5	**33**
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	ng/L	n/a	1.3	N.D.
10:2 Fluorotelomersulfonic acid (10:2 FTS)	ng/L	n/a	1.3	N.D.
4:2 Fluorotelomersulfonic acid (4:2 FTS)	ng/L	n/a	0.64	N.D.
NEtFOSAA	ng/L	n/a	0.64	N.D.
NEtPFOSA	ng/L	n/a	1.3	N.D.
NEtPFOSAE	ng/L	n/a	1.3	N.D.
NMeFOSAA	ng/L	n/a	0.64	N.D.
NMePFOSA	ng/L	n/a	1.3	N.D.
NMePFOSAE	ng/L	n/a	1.3	N.D.
Perfluorododecanesulfonic acid	ng/L	n/a	0.64	N.D.
Perfluorohexadecanoic acid	ng/L	n/a	1.3	N.D.
Perfluorooctadecanoic acid	ng/L	n/a	1.3	N.D.

[a] Ontario Table 1: Full Depth Background Site Condition Standards (Table 1 SCS), April 2011

[b] Ontario Regulation 558/00 Toxicity Characteristic Leaching Procedure (TCLP) Schedule 4 TCLP criteria for waste characterization