Operations, Maintenance and Surveillance Report

BAF-5
Resolution Island, Nunavut

Public Services and Procurement Canada

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Executive Summary

AECOM Canada Ltd. (AECOM) was retained by Public Services and Procurement Canada (PSPC), on behalf of Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), to develop the Operations, Maintenance and Surveillance (OMS) Plan for BAF-5 at Resolution Island. BAF-5 (61 30'N, 65 00' W) is located on the northeast side of Resolution Island, approximately 310 kilometres (km) southeast of the City of Iqaluit, occupying an area of over three-square kilometres (km^2). The BAF-5 site was constructed as part of the Pole Vault system in 1954 by the United States Air Force (USAF), providing a link between the Distant Early Warning (DEW) Line and military bases in southern Canada and the United States. In 1987, at the time of conversion of the site to a Short-Range Radar (SRR) station, environmental investigations found PCB containing electrical equipment, unused transformer fluid, PCB stained soils, asbestos, and miscellaneous chemicals which prompted the site remediation that took place between 1997 and 2005. Post-construction monitoring has been completed at the site since 2005.

The OMS Plan outlines the remediation history of the Site and the remedial objectives. It also documents existing conditions at the Site, based on monitoring information collected to date, limited additional assessment completed in 2013, and following the 2019 minor remedial maintenance work. Residual risks of the remaining site features were evaluated using a Failure Modes and Effects Analysis (FMEA) method to document the expected failure pathways and their recommended monitoring requirements. The remaining site features that were determined to pose a risk greater than "low" as determined by the FMEA were recommended for monitoring. These include:

1. East and West Camp Landfill
2. Beach Landfill
3. Tier II Soil Landfill
4. Airstrip Landfill
5. Furniture Dump PCB Barrier
6. S1/S4 Beach Barrier
7. PCB Storage Facility (once in use)

Monitoring is proposed to be completed in two phases, following accurate documentation of site baseline post 2019 remedial work. Baseline monitoring program elements include collection of overall site conditions records to detect change on a site-wide basis in the future, as required, and to facilitate using remote monitoring methods as deemed appropriate. As well, climate statistical review is required to develop precipitation benchmark trigger values for use during Phase 2 monitoring and exit criteria.

Phase 1 monitoring will be conducted according to a set schedule, the frequency of which is based on the failure risk and conditions following monitoring since 2005. Specific exit criteria document when conditions can be considered sufficiently stabilized for all monitored elements to end Phase 1 monitoring and move into Phase 2. Phase 2 monitoring is recommended for completion in response to above-average precipitation events, the specific benchmark for which was developed during baseline. This approach requires the annual collection and review of precipitation data, which is assumed to be completed in-house by CIRNAC. An exceedance of the identified benchmark would trigger completion of monitoring during the following summer. Monitoring would continue until Phase 2 exit criteria are met. Phase 2 exit criteria define continued performance and acceptable physical and environmental conditions for each of the monitored features following high or extreme precipitation events, as defined during baseline monitoring. The proposed monitoring requirements and schedule are summarized in the table below.

Site Feature	Visual Inspection	Soil Sampling	Ground-water Sampling	Ground Temp Collection	Maintenance	Climate Data Collection	Phase 1 Monitoring Frequency	Phase 1 Exit Criteria	Performance Against Phase 1 Exit Criteria	Phase 2 Monitoring Frequency	Phase 2 Exit Criteria
Camp and Beach Landfills	x	-	-	-	-		15 years	• Geotechnically stable for 3 consecutive (consec.) monitoring events.	• Both landfills meet criteria	Following moderate precipitation event	• Geotechnically stable after 2 non-consec. high or 1 extreme precipitation event
Tier II Landfill	x	x	x	x	• Replace thermistor batteries		15 years (5 years for battery replace-ment)	• Geotechnically stable for 3 consec. monitoring events. • Landfill frozen for 3 consec monitoring events. • No contaminant migration for 3 monitoring events	• Meets criteria	Following moderate precipitation event	• Geotechnically stable after 2 non-consec. high or 1 extreme precipitation event
Airstrip Landfill	x	x	x	-			15 years	• Geotechnically stable for 3 consec. monitoring events • No contaminant levels exceeding HHERA for 3 monitoring events.	• Requires one more monitoring event for Geotech stability • Meets exit criteria for contaminants	Following moderate precipitation event	• Geotechnically stable after 2 non-consec. high or 1 extreme precipitation event
Furniture Dump PCB Barrier	x	x	-	-	• Remove soil • Replace filter media		5 years	• Soil from the barrier at Tier I or below for 3 monitoring events OR soil within barrier at or below 25% of holding capacity for 3 monitoring events.	• Has not met Tier 1 concentration criteria • Insufficient data related to capacity	Following moderate precipitation event	• Soil from the barrier at or below Tier I after 2 high non-consec or 1 extreme precipitation event.

Site Feature	Visual Inspection	Soil Sampling	Ground-water Sampling	Ground Temp Collection	Maintenance	Climate Data Collection	Phase 1 Monitoring Frequency	Phase 1 Exit Criteria	Performance Against Phase 1 Exit Criteria	Phase 2 Monitoring Frequency	Phase 2 Exit Criteria
S1/S4 Beach PCB Barrier	x	x	-	-	• Remove soil • Replace filter media		5 years	• Soil from the barrier at or below Tier I for 3 monitoring events. • Soil within barrier is at or below 50% of holding capacity for 3 monitoring events. • Upgradient soil impacts visibly stop moving for 3 monitoring events.	• Has met the Tier 1 concentration criteria • Insufficient data related to capacity and upgradient soil	Following moderate precipitation event	• Upgradient soil impacts have not moved and soil at barrier is at or below Tier I after 2 high non-consec or 1 extreme precipitation event, OR. • Upgradient impacts have moved down, been collected at the barrier, and soil within the barrier at or below Tier I.
Overall Site	x				• Inspect PCB storage area	x	5 years	• All features have met their respective Phase 1 Exit Criteria	n/a	Annually for Climate Data Collection	• All features have met their respective Phase 2 Exit Criteria

For both Phase 1 and Phase 2 monitoring, specific, measurable action levels have been derived to be considered a performance failure to the extent of posing a moderate or higher risk level, as per the FMEA evaluation. Each action level triggers corrective maintenance options to mitigate risk, with options listed in a step-wise manner according to level of complexity and cost. The steps vary from Step 1 which are measures that could be completed during site monitoring by site personnel, to Step 3 requiring mobilization of a contractor to site, set up of a camp, and obtaining of permits and licences. Where the action levels have not yet been exceeded but are approached, the recommended action plan is increased monitoring frequency, or in the case of Phase 2 monitoring, a return to regularly scheduled monitoring events may be necessary.

The developed phased approach is consistent with the typical monitoring programs implemented to date at CIRNAC sites, but has been modified for Resolution Island to account for the uncertainty in ongoing performance and timing of achieving stable conditions of the PCB barriers, coupled with the presently achieved stable conditions at the landfills. In contrast to the typical monitoring programs implemented to date, the proposed OMS plan also includes overall site exit criteria – Phase 2 Exit Criteria - which have not yet been developed for other abandoned military sites.

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1. Introduction

AECOM Canada Ltd. (AECOM) was retained by Public Services and Procurement Canada (PSPC), on behalf of Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), to develop the Operations, Maintenance and Surveillance (OMS) Plan for BAF-5 at Resolution Island.

As described in *Resolution Island Monitoring Program, Department of Indian Affairs and Northern Development 2013* (DIAND, now CIRNAC and referred to as such hereinafter), a long-term monitoring program was implemented at BAF-5 following the initial remediation that took place between 1997 and 2005. The most current remediation maintenance work was completed in September 2019. The OMS Plan will outline the remediation history of the Site, including updated conditions following the 2019 remediation program, and discuss the residual risks associated with remaining site features. It will also present a long-term monitoring plan that manages the risks associated with remaining site features, as well as defines the modes of failure for these features.

2. Site Background

2.1 Site Location

BAF-5 (61 30'N, 65 00' W) is located on the northeast side of Resolution Island, approximately 310 kilometres (km) southeast of the City of Iqaluit, occupying an area of over three-square kilometres (km^2), as shown in Figure 1 of Appendix A.

The BAF-5 site presently consists of four main areas: an upper site area (includes the station area), a lower beach area including a barge landing, the airstrip area, and freshwater lake area. The station area is situated on top of a cliff at the northeastern end of Resolution island, overlooking Brewer Bay. A 6 km service road connects the upper station area with the airstrip, freshwater lake, and lower beach areas. A smaller road, branching off the main road, leads to a remote antenna facility on a second hilltop to the west of the station area. Access to the site is provided by a 450 metre (m) long airstrip, located west of the main station, and by a barge landing area at Brewer Bay. An overview of the site is provided in Figure 1 and an overview of the station area and lower beach area are provided in Figures 2 and 3, respectively. All figures can be found in Appendix A.

2.2 BAF-5 Historical Use

The BAF-5 site was constructed as part of the Pole Vault system in 1954 by the United States Air Force (USAF), providing a link between the Distant Early Warning (DEW) Line and military bases in southern Canada and the United States. This was developed as a self-sustained industrial site including communication infrastructure, equipment warehouses, and on-site residences. Polychlorinated biphenyls (PCBs) were readily used in electrical equipment and transformer fluids. Petroleum hydrocarbons were present in fuels used for equipment, heating, and power generators. Infrastructure was constructed with hazardous building materials such as lead paint, asbestos, and PCBs used as fire retardants. The high cost of material transport to and from the site resulted in very little to no removal of materials from the site, and as such, waste materials and unused products were disposed of in onsite dumps. The site was abandoned as a Pole Vault station by the USAF in 1972.

In the 1970s, the site was used as a Long-Range Navigation (LORAN) station by the Canadian Coast Guard. The site was abandoned as a LORAN station in 1974.

In 1976, the assets at the site were sold to the Government of Nunavut (GN) (formerly the government of the Northwest Territories), through crown assets disposal and the land reverted to CIRNAC for administrative control. In 1985, a portion of the site was obtained by the Department of National Defence (DND) for use as a Short-Range Radar (SRR) station under the North Warning System Office (NWSO). This SRR station is presently in operation, controlled remotely by NWSO and their facility operation contractor. Figures 2 and 3 in Appendix A identify the owner-operators of the remaining site infrastructure items.

2.3 Site Remediation History

In 1987, at the time of conversion of the site to the SRR station, environmental investigations found PCB containing electrical equipment, unused transformer fluid, PCB stained soils, asbestos, and miscellaneous chemicals. Similar environmental investigations were done across the DEW Line and Pole Vault system sites, with consistent environmental issues and contaminants of concern (COCs) being identified at each of the sites. The results of the BAF-5 site assessment showed significant environmental concerns associated with PCB contaminated soils and containing equipment at concentrations in excess of the federal Canadian Environmental Protection Act (CEPA) criteria. In addition, impacts were identified to be entering the ocean, which was also a federal Fisheries Act violation. This prompted the immediate commencement of remedial activities at the site in 1997; remediation was completed in 2005. Specific remediation criteria for Resolution Island are discussed in Section 2.8.

Post-remediation monitoring has been completed at the site from 2005 onwards. In 2013, AECOM completed a Maintenance Assessment at BAF-5 in response to potential remedial deficiencies or maintenance requirements identified during the 2012 monitoring event (AECOM 2014). The intent of the Maintenance Assessment was to identify the remaining risk of the observed potential deficiencies and to obtain information to complete design and specifications for additional remedial maintenance work at the site. In 2019, AECOM oversaw the supplemental remediation activities.

2.4 Climate

The climate at Resolution Island is classified as sub-Arctic marine. There is considerable moisture in the form of rain, snow, and fog because of marine influence, as compared to typical sub-Arctic climate. Based on historical climate data obtained from Environment Canada, the mean overall annual temperature is -7.9 degrees Celsius (ºC) with an average summer temperature of 2.9 ºC (from July to September). Extremes in temperature range from -40 ºC during the winter months (from December to March) to 20 ºC during the summer. Historical annual precipitation normals for this area are 30 centimetres (cm) of rain and 130 cm of snow. The greatest amount of precipitation is received during the summer and fall, between June and October, with the peak amount received in August (climateatlas.ca).

2.5 Geology

Resolution Island is comprised of Archean undivided gneiss (Geological Survey of Canada 2006a), and surficial materials in the area consist of colluvial blocks: blocks and rubble with sand and silt; derived from crystalline bedrock, medium grade metamorphic substrate and cemented sandstone (Geological Survey of Canada, 2006b). The terrain is rolling to steep, with high cliffs with elevations in excess of 200 m dropping to sea level situated along the east, south, and southwest coasts of the summit. The summit consists of tilted bedrock with parallel rock ridges, knolls, and shallow gullies forming a series of ledges. The ground surface throughout much of the site is exposed bedrock, with isolated pockets of till in low-lying areas. Vegetation is limited to locations in gullies and other low-lying areas where enough soil is available for rooting (ESG 1994). Two freshwater lakes are present; Old Freshwater Lake, at the freshwater lake area, and New Freshwater Lake, at the lower beach area. Regional drainage is towards the ocean, where the island is at an intersecting point for Frobisher Bay and Hudson Strait (AECOM 2017).

Continuous permafrost is present throughout the region, and freeze / thaw cycles within the seasonally thawed active layer shape the soil and drainage channels. Depth of active layer varies based on presence or organic cover, proximity to water bodies, and soil type, but is typically in the order of 1.5 m (AECOM 2017). Surficial materials have significant frozen organic deposits, and continuous permafrost with low ice content.

2.6 Environmental Receptors

2.6.1 Ecological Environment

Resolution Island falls within the Meta Incognita Peninsula ecoregion. Characteristic wildlife of this ecoregion includes caribou, hare, arctic wolf, fox, polar bear, raptors, walrus, seal, whale, shorebirds, and waterfowl (Environment Canada 1999). As a remote, rugged, small island approximately 40 km off of Baffin Island and 100 km north of Labrador, Resolution Island itself has limited terrestrial fauna. It has been identified as a denning area for polar bears, and these animals are known to frequent the site. The island is also along the migration routes of whales. Other marine animals, including seals and walruses, are attracted to the area by the reported 49 species of fish occurring in nearby waters. The presence of birds is largely a seasonal phenomenon, with the higher concentrations of seabirds occurring from May to October, depending on ice breakup and prey distribution (AECOM 2017). Nesting colonies for seabirds, such as Thick-billed Murre (*Uria lomvia*) and Black-legged Kittiwake (*Rissa tridactyla*) are reported to occur on this and surrounding islands

Vegetation in the Meta Incognita Peninsula ecoregion is characterized by shrub tundra vegetation and includes: dwarf birch, willow, northern Labrador tea, *Dryas spp*., and *Vaccinium spp*. (Environment Canada 1999). Vegetation on Resolution Island is generally very sparse due to the prevalence of bare bedrock; where present, it includes but is not limited to arctic willow, mouse ear chickweed, and Bigelow's Sedge (AECOM 2017).

2.6.2 Human Land Use

The nearest communities to Resolution Island are Iqaluit (approximately 310 km to the north-northwest), Kimmirut (approximately 300 km to the northwest), and Pangnirtung (approximately 510 km to the north). Baffin Island Inuit peoples are known to hunt and fish in the area on occasion, but no permanent settlement exists on the island and it is not a common camping location.

2.7 Regulatory Compliance Objectives

The original project at Resolution Island was focused on bringing the site into legal compliance with respect to CEPA and the Federal Fisheries Act legislation. Under CEPA, materials (soils, fluids, paint, etc.) containing PCBs at concentrations in excess of 50 parts per million (ppm) are required to be treated in accordance with regulations for the storage of PCB material specified in the Act. Under the Fisheries Act, PCBs or other "deleterious substances" are not to enter any water body frequented by fish. BAF-5 was in violation of CEPA and the Fisheries Act due to the high concentrations of PCBs known to be on the site, and the site's proximity and local drainage into the ocean.

There is no specific legislation for classification of hazardous waste for landfilling purposes on federal lands; however, there is classification for the purposes of transport, and this classification has been typically used for disposal purposes as well. The hazardous waste classification criteria that have therefore been applied to demolition and debris waste for remedial and disposal purposes at BAF-5 are: the Transportation of Dangerous Goods Act and Regulations (TDG); and regulated substances under CEPA. Where applicable, territorial guidelines have also been implemented, such as for asbestos disposal. The regulated hazardous waste includes PCB-containing equipment or soil, PHC liquids, solvents, batteries, mercury-containing equipment, radioactive materials, and waste capable of generating leachate that exceeds applicable leachate criteria (e.g. lead painted waste). Prior to demolition, hazardous materials found in buildings were to be removed and packaged in accordance with the TDG Act and Regulations for shipment off-site and disposal at a licensed hazardous waste facility. Asbestos containing waste and non-hazardous waste could be landfilled on-site in an engineered landfill.

2.8 Generic Risk-Based Approach

As noted above, in the late 1980s and early 1990s, 1950s era military radar sites constructed across the Canadian Arctic were being assessed for contaminant impacts and potential remedial requirements in advance of conversion from DEW Line and associated (i.e. Pole Vault) military radar sites to modernized North Warning System Sites. Similar environmental investigations were done across the DEW Line and Pole Vault system, with consistent environmental issues and contaminants of concern (COCs) being identified at each of the sites. In addition to soil contaminant impacts, the assessments also included information about contaminant uptake into vegetation. On this basis, the DEW Line Clean-Up Criteria (DCC) was developed using a contaminant source and pathway targeted approach based on the Canadian Council of the Ministers of the Environment's (CCME) Tier 3 risk-based approach (INAC 2008). COCs at various DEW Line sites were identified and remediation targets were developed based on a general risk-based approach that considered the Arctic setting of these sites in terms of human land use and ecology. This approach developed the criteria for all the abandoned military sites stretching across the Arctic, but did not consider site-specific variations in flora, fauna, and traditional land use. The generic criteria are discussed in more detail below.

In addition to contaminated soil criteria, an overall DEW Line Clean Up (DLCU) protocol was developed that standardized remedial design requirements related to old waste disposal sites (existing landfills and dumps), and for construction of new disposal facilities at the sites. The protocol was developed and approved in consultation with Inuvialuit, Inuit, and regulatory stakeholders at the time.

While the DLCU protocol and DCC were initially developed for implementation at DEW Line sites being remediated by DND, they were also implemented at the BAF-5 Resolution Island remediation by CIRNAC. More recently, since CIRNAC has undertaken the assessment and remediation of all of the abandoned military sites under their authority, a review of the DCC and DLCU protocol was undertaken to confirm their continued applicability. The outcome of that review has maintained the earlier developed criteria and protocols, with some minor revisions, and adopted as the CIRNAC Abandoned Military Site Remediation Protocol (AMSRP) in 2009.

2.8.1 Metal and PCB Contaminated Soil

The DCC includes provisions for identification of contaminants in the following two categories: Tier I and Tier II. The Tier I and Tier II criteria were developed specifically for the Canadian Arctic to address persistent contaminant which have the potential to impact the Arctic ecosystem. Tier II criteria are concentrations of metals and PCBs that are considered an environmental risk to potential receptors and at sufficiently high concentration that there is a potential for contaminant migration at surface or depth. Tier I criteria apply only to PCBs and lead; soil contaminated at this level is only considered an environmental risk if at surface, with concentrations sufficient enough to migrate from the source area aerially. The DCC are summarized in Table 1 below.

Table 1: DEW Line Clean-Up Criteria for Soil

Contaminant Designation	Description	Remedial Requirements
Tier I Contaminated Soil	Soils containing concentrations of any or all contaminants listed as follows: • Lead ……….. 200 to 499 ppm • PCBs………..1 to <5 ppm	Excavate and place in an engineered non-hazardous waste landfill or cap in place with a minimum of 0.3 m of fill.
Tier II Contaminated Soil	Soils exceeding concentrations of any or all contaminants listed as follows: • Arsenic ……..30 ppm • Cadmium……5 ppm • Chromium…..250 ppm • Cobalt………50 ppm • Copper……..100 ppm • Lead…………500 ppm • Mercury……..2 ppm • Nickel……….100 ppm • Zinc………….500 ppm • PCBs……….≥ 5 ppm; < 50 ppm	Excavate and remove from direct contact of impact with the Canadian Arctic ecosystem either by containerization and disposal at a southern landfill or landfilling on-site at a specifically designed facility.

2.8.2 Petroleum Hydrocarbons (PHC) Contaminated Soil

The initial DCC did not include PHCs, as their ability to naturally attenuate was deemed sufficient risk mitigation; however, with more detailed depth assessment information, it was recognized that fuel spills were prevalent from past operational practices with oftentimes widespread impacts persisting at depth. PHC were therefore added to the protocol. The CCME Canadian Wide Standards (CWS) for PHCs were adopted for use at Resolution Island remediation in 2002. The CCME CWS were set up with three tiers of criteria: Tier 1 were standard, generic criteria that could be applied across Canada; Tier 2 levels used modified exposure and risk scenarios based on site-specific information; and Tier 3 levels used quantitative Human Health and Ecological Risk Assessment to generate site-specific criteria. The BAF-5 remediation program adopted Tier 2 levels, which are shown in Table 2 below.

Table 2: CCME Petroleum Hydrocarbon Tier 2 Derived Remediation Criteria

CCME Fraction	Tier 2 Remediation Criteria (ppm)
F1 >55 m to water body	15,000
F2 >55 m to water body	8,000
F3 >55 m to water body	18,000
F4 >55m to water body	25,000

2.8.3 Existing Landfills and Dumps

Existing landfills and dumps at Resolution Island were considered to be chemical hazards due to contaminant sources within them, as well as physical hazards due to exposed debris. Each dump / landfill was evaluated on both hazard types to define remedial requirements. The remedial objective in all instances was to provide a barrier between the chemical and/or physical hazard and the environment. If a stable barrier could not be installed and maintained, based on observations related to existing erosion and potential for continued long-term erosion by surface water runoff, the hazard source was removed.

Table 3 provides the DLCU protocol for existing dumps and landfills at Resolution Island.

Table 3: DEW Line Clean Up Protocol for Existing Dumps and Landfills

Landfill Designation	Description	Remedial Requirements
Class A	Landfills located in unstable and eroding areas	Excavation of landfill contents, waste and soil contents classified and disposed of accordingly as non-hazardous waste, hazardous waste, or contaminated (CEPA, Tier II, or Tier I).
Class B	Landfills that show evidence of leachate or the potential for generating leachate	Retro-fitted with leachate containment / control measures or excavated.
Class C	Landfills that are suitably sited, show no evidence of leachate, and are not susceptible to erosion.	Covering of exposed debris.

2.8.4 Infrastructure and Site Waste

Hazardous materials found in buildings were considered to be chemical hazards, which were removed, packaged and shipped south for the disposal according to regulations, or in the case of asbestos waste, bagged and disposed of in an on-site engineered landfill. After removal of hazardous components, remaining infrastructure and site waste were considered only a physical hazard. Site debris was buried in on-site non-hazardous waste landfills. Infrastructure deemed to be a physical hazard at the time of remediation was demolished and also placed in on-site non-hazardous waste landfills.

2.9 Site-Specific Risk-Based Approach

2.9.1 Metals

In 2017, recognizing that the BAF-5 Resolution Island site was very remote and had less receptors than the average DEW Line site (which included those in the western Arctic with much more lush flora and fauna), AECOM completed a Human Health and Ecological Risk Assessment (HHERA) to evaluate the risks of DCC Tier II metal contaminated soil that had been identified as remaining at the site. The goals of this assessment were to protect individuals against adverse health outcomes as a result of exposure to contaminants of concern (COCs), limit contaminants from accumulating in the base of the Arctic food-web, and protect populations of Arctic wildlife expected to be found at the Resolution Island site. The risk assessment excluded all PCB contaminated soil at the site because the original site remediation plan had been primarily focused on the clean up of PCB impacts and their complete removal from site according to the remedial objectives identified at the time.

The risk assessment at Resolution Island used the same traditional land use scenario developed by Jacques Whitford's *Human Health and Ecological Risk Assessment for a Former Navigational Aid and Weather Station located at Radio Island, Nunavut* (2006). Radio Island is located off the southern tip of Resolution Island. This traditional land use scenario consisted of Inuit families residing on the land in tents for periods of up to three weeks. Non-carcinogenic and carcinogenic contaminants were evaluated for potential adverse health outcomes through two receptor scenarios:

1) Toddler aged 6 months to 4 years exposed to surface soils impacted with non-carcinogenic contaminants by inadvertent ingestion / dermal contact / inhalation of surface dust, ingestion / dermal contact with surface water and ingestion of wild game; and

2) A person visits the site yearly (3 weeks per visit) from birth to 75 years of age is exposed to carcinogenic contaminants by inadvertent ingestion / dermal contact / inhalation of surface soil / dust, ingestion / dermal contact with surface water and wild game.

COCs were identified as metals found in excess of their respective DCC Tier II within the soil and enriched within the vegetation in the post-remedial setting. Human health and ecological soil quality screening benchmarks were selected in a hierarchical preference from 1) CCME and 2) Ontario Provincial guidelines. Table 4 below presents the soil COCs and selected benchmarks.

Table 4: Soil Quality Screening Benchmarks

Element	Tier II DCC	Ecological Benchmark	Human Health Benchmark
Cadmium	5 mg/kg	10 mg/kg	14 mg/kg
Cobalt	50 mg/kg	180 mg/kg	22 mg/kg
Copper	100 mg/kg	280 mg/kg	600 mg/kg
Nickel	100 mg/kg	5000 mg/kg	330 mg/kg
Zinc	500 mg/kg	340 mg/kg	5600 mg/kg

The COCs enriched within the vegetation (cadmium, cobalt, copper, lead, nickel, and zinc), by definition, are not bioaccumulating substances. In addition, there are no known traditional plant species in areas where COCs were found. Therefore, higher trophic transfer to predator receptors or humans was not considered. The ingestion of surface water from the site was screened out due to surface water quality meeting drinking water objectives.

The above soil screening benchmarks were used as a basis to review the results of the 2013 Maintenance Assessment to flag potential areas of concern. Localized areas where soil concentrations were identified as exceeding the screening benchmarks were the Airstrip Landfill and the North Slope Dump. These locations were reviewed on a more detailed basis, as discussed under their specific remedial objectives in Section 3.1 below.

In some areas of the site – primarily the upper site area - post-remediation monitoring and maintenance assessment identified relatively consistent concentrations of copper, nickel and zinc close to or above Tier II criteria. Review of assessment data indicated similar trends. Affected areas include the Airstrip Landfill, the Maintenance Dump, the Camp Landfill, the Tier II Landfill, and the overall station area. Tier II exceedances of these metals were also, therefore, reviewed on a case by case basis, in conjunction with the HHERA benchmark values, to evaluate risk-based remedial requirements.

2.9.2 PCBs

As noted above, the AECOM 2017 HHERA excluded PCB contaminated soil at the site due to the original site remediation plan's commitment for complete removal of PCB impacts from the soil. However, the HHERA conducted at Radio Island (Jacques Whitford 2006) did assess PCB impacts, which were similarly found in concentrations in excess of 50 ppm (CEPA regulated) at the Radio Island site. The HHERA concluded that PCBs were not anticipated to produce any adverse effects to human or ecological receptors at Radio Island. Due to the similarities between Radio Island and Resolution Island in terms of geological location, land use, and ecological receptors, it can be concluded that the risks to human and ecological receptors associated with PCBs are applicable to Resolution Island, and thus, may be applicable for consideration for potential further PCB impacts detected at the site, as applicable, based on the location. Regardless of the HHERA findings, soil concentrations of 50 ppm or greater remain a federally regulated exceedance that must be addressed. Furthermore, any "deleterious substance", such as PCB impacted soil, entering a fish-bearing water body is a Fisheries Act violation and therefore must be prevented. These regulatory compliance objectives remain the primary driver for PCB-impacted soil mitigation at Resolution Island.

2.10 Design Objectives of New Remedial Features

2.10.1 Tier II Landfill

The Tier II Landfill was constructed between 2003 and 2006 to consolidate and contain excavated Tier II contaminated soil to mitigate the chemical hazard by providing a barrier to receptor exposure and preventing migration into the environment.

2.10.2 Non-Hazardous Waste Landfills

Two non-hazardous landfills were constructed as part of the Resolution Island remediation activities: the Camp Landfill and the Beach Landfill. Both landfills were constructed to consolidate and dispose of site debris and infrastructure demolition waste in a manner to minimize physical hazards and to meet disposal requirements for regulated waste such as asbestos.

2.10.3 PCB Barriers

Downgradient of locations where not all PCB contaminated soil impacts could be removed, three PCB barriers were installed: S1/S4 Beach PCB Barrier (Beach Barrier), S1/S4 Valley PCB Barrier (Valley Barrier), and the Furniture Dump Barrier. These barriers were intended to collect fine-grained soil and rock with adhered PCBs being transported via water flow through bedrock crevasses or from inaccessible areas that could not be remediated to restrict migration towards receptors, especially the ocean. In the case of the ocean as receptor, the key design objective was to maintain regulatory compliance. The barriers consist of a lined funnel formed by rock gabions and a gate containing various filters through which all drainage must flow. Coarse soil was to be trapped in the funnel while finer material was to be collected by the filters in the gate.

3. Remaining Site Features

The following sections are an overview of the remaining site features at BAF-5 that are still under CIRNAC control, following the 2019 supplemental remedial and maintenance work. These features include dumps and landfills, buildings and structures, PCB barriers, and a PCB storage area. A description of each feature is provided. The remaining risk of each feature in terms of likelihood and severity of the event has been evaluated using a Failure Mode and Effects Analysis (FMEA). The FMEA is provided in Appendix E and further discussed in Section 4.1; the key issues for each feature are described in the sections below.

3.1 Existing Dumps and Landfills

3.1.1 Maintenance Dump

General Description

The Maintenance Dump is located between the station and airstrip areas, downgradient of the former equipment maintenance area of the site (and the present location of the Tier II Landfill). It is comprised of two distinct lobes: the East Lobe and the West Lobe. Based on geophysics completed in 2013, the lobes are 50 square metres (m^2) and 250 m^2 in area, respectively. The grade is approximately 10%, draining to the west-northwest. Some localized ponding has been observed at the north and south extents of the east lobe. Comparatively lush vegetation is present in the vicinity of this dump. An overview of the Maintenance Dump is provided in Figure 4 of Appendix A.

Pre-remediation Conditions

Prior to remediation in 2005, the surface of the Maintenance Dump included exposed debris, with a small drainage course leading away from the dump. Soil along this drainage course was contaminated with cobalt at concentrations exceeding Tier II levels.

Remedial Objectives

As per the 2003 Remediation Plan (ASU 2003), remediation objectives of the Maintenance Dump included the removal of visible debris, removal of contaminated soil from the drainage course, and covering of the area with clean fill graded to promote positive drainage.

Remediation Activities

Remediation was completed in 2005. Activities included surface debris removal as well as excavation of contaminated soil. It does not appear that remaining buried debris was covered. Following remediation, two monitoring wells and two soil monitoring stations were established downgradient of the Tier II soil excavation area.

Physical and Chemical Performance

The Maintenance Dump was monitored annually from 2005 until 2010, and then with decreasing frequency: years 2012 and 2016. Monitoring completed to date has included groundwater and soil monitoring at the two monitoring wells, and visual inspections. Historically observed elevated levels of cobalt in the soil and groundwater downgradient of the dump suggests potential contaminant migration, but this could be a result of flushing from residual cobalt in and surrounding the Tier II soil excavation area, rather than from ongoing source area migration at the Maintenance Dump itself. Zinc, copper, and nickel have been observed in the soil in the area at elevated concentrations (occasionally at Tier II levels for copper and nickel), but the metals are considered naturally occurring because of their presence together and at concentrations that have roughly consistent ratios to one another. Data obtained from groundwater and soil monitoring at the Maintenance Dump from 2005 to 2016 is presented in Tables C1 through C6 of Appendix C.

Visual inspections have documented marginal settlement throughout the Maintenance Dump in the form of sinkholes around exposed debris. Additional exposed debris was observed present in both lobes, along with marginal erosion. Subsurface drainage through the buried debris and surface run-off was documented to pool to the west of the East Lobe of the dump.

3.1.2 Airstrip Landfill

General Description

The Airstrip Landfill is located north of the airstrip and has an approximate area of 3800 m^2. The landfill has been developed historically by disposing of debris and waste of the side of a plateau-like area such that the landfill surface is relatively flat, but the side slopes are fairly steep (approximately 33% grade), with waste and granular soil present at its natural angle of repose. Local drainage at the landfill is semi-radially towards the northwest, west, and southwest extents, with ponding observed at both the northwest and southwest toes of the landfill. Relatively lush vegetation has been observed at the toe. An overview of the landfill is provided in Figure 5 of Appendix A.

Pre-remediation Conditions

PCB contaminated soil (CEPA, Tier II and Tier I) was identified on the landfill surface and at depth within, and there was exposed and surficial debris.

Remedial Objectives

As per the 2003 Remediation Plan, the remediation objective included the removal of surface debris, excavation of CEPA level PCB contaminated soil, and the covering of the remaining Tier I and Tier II PCB contaminated soil and debris with 0.5 m of clean granular fill.

Additional soil sampling was completed during the 2013 Maintenance Assessment to assess identified potential gaps in remediation on the landfill surface as well as from potential migration from the landfill along the toe in the area of lush vegetation. The assessment identified Tier II PCB exceedances in one isolated location on the landfill surface, which was to be excavated. Tier II cadmium, cobalt, copper, nickel and zinc were also identified downgradient. The risk associated with the metal exceedances were evaluated according to the documented naturally occurring geochemical conditions and the HHERA screening benchmark values: as per the HHERA, maximum cobalt concentrations exceeded the human health soil screening benchmark (human via soil exposure) and maximum concentrations of copper and zinc exceeded the ecological soil screening benchmarks (wildlife exposed to soil and potentially enriched vegetation). A localized quantitative HHERA was completed for the Airstrip Landfill area, evaluating the specific risk for human exposure and of wildlife exposure. The human health risk was evaluated as a negligible risk from soil exposure at the localized impacted area at the landfill toe. Rock ptarmigan and Canada Goose were assessed as the key wildlife receptors at risk via soil exposure and vegetation ingestion; both were predicted to experience negligible risk from exposure to impacted soils and vegetation at the toe. The Tier II metal impacts were therefore left in place.

Remediation Activities

The 2003 remediation of the Airstrip Landfill involved the excavation of PCB contaminated soil in excess of the CEPA criteria and removal of surface debris. A minimal amount of granular fill was placed on the surface (less than 0.5 m thickness) with no fill being placed on the slopes which left exposed debris. Following remediation, four monitoring wells were installed downgradient of the toe, with four soil monitoring locations established adjacent to them.

In 2019, the small volume of Tier II PCB soil identified during the Maintenance Assessment was excavated.

Physical and Chemical Performance

The Airstrip Landfill was monitored annually from 2005 until 2010, and then with decreasing frequency: years 2012 and 2016. Monitoring to date has included collection of soil and groundwater samples downgradient and visual inspection for geotechnical stability. According to data obtained from the analysis of groundwater and soil, found in Tables C13 through C18 of Appendix C, no evidence of contaminant migration from the Airstrip landfill is suggested. The PCB concentrations exhibited in soil samples taken around the Airstrip landfill are consistently below Tier I levels and do not show consistent increases. These are interpreted to be residual PCBs from the excavation of CEPA level soils and are not due to migration of contaminants from the landfill. Tier II copper and nickel, and occasionally zinc, have been identified in soil samples during monitoring, but, as noted above, these are considered to be naturally occurring.

Visual inspections at the Airstrip landfill have shown slumping, settlement and erosion along the steep west slope and exposed debris throughout the landfill that present a slight physical hazard. The capping material that was placed over the landfilled material was not thick enough in places and poor material gradation has caused large pore spaces. However, the erosional and instability features that have been observed along the side slope have not been observed as significantly worsening since their documentation.

3.1.3 PCL Dump

General Description

The PCL Dump is located at the station area, and consists of two lobes or debris pushed off the side of the station area infrastructure pad near its southeast corner. The north lobe is approximately 200 m^2 in size, and the south lobe is approximately 500 m^2. Local drainage is generally to the southwest at an approximate grade of 25, increasing to a steep, cliff-like drop-off 200 m beyond the toe. There is very little to no vegetation on or around the dump due to barren bedrock presence. The location of the PCL Dump is provided in Figure 2 of Appendix A.

Pre-remediation Conditions

CEPA level PCB contaminated soils were present within the Dump with Tier I soil within a well-defined channel leading from the dump to the top of the cliff.

Remedial Objective

As per the 2003 Remediation Plan, the remedial objective for the PCL Dump included the excavation of the dump to bedrock and the capping or excavation of the Tier I soil, if safe to do so.

Remediation Activities

The 2005 remediation activities at the PCL Dump included the excavation of the Tier I soils in the drainage channel near the cliff and the CEPA level soils within the landfill. The excavation of Tier I soils was terminated 20 m from the cliff edge due to accessibility. Surface debris was removed, and buried debris was reportedly excavated. It is unclear if all debris was excavated and contaminated soils removed.

During the 2013 Maintenance Assessment, geophysical survey confirmed that a small amount of buried debris remained, and some was exposed due to insufficient cover. Soil samples were collected along the drainage pathway, to assess potential residual Tier I PCB exceedances that had not been remediated, but no Tier I PCB exceedances within the drainage channel were found.

Physical and Chemical Performance

There has been no ongoing monitoring of the PCL Dump. While 2013 Maintenance Assessment visual inspection noted channelized drainage in the area with some minor rills present on the dump cover material and some debris exposure, the soil assessment identified no contaminants indicative of migration.

3.1.4 North Slope Dump

General Description

The North Slope Dump is located at the station area north of the PCL Dump, and based on geophysics completed in 2013, it is approximately 380 m^2 in size. The dump is predominately surrounded by bedrock with no vegetation or soil, and a well-defined drainage path towards the east. Relief varies from relatively flat to steep. The location of the dump is provided in Figure 2 of Appendix A.

Pre-remediation Conditions

The North Slope Dump had a small well-defined area of Tier II copper soil as well as a thinly spread area of Tier I PCB Soil. Surface debris was present.

Remedial Objective

The 2003 Remedial Plan called for the removal of exposed debris and the excavation of Tier II copper contaminated soil. The Tier I PCB contamination was to be left in place along with the remaining buried debris.

Additional soil sampling was completed during the 2013 Maintenance Assessment to assess identified potential gaps in remediation at the dump. The assessment identified Tier II copper soil which also exceeded the HHERA ecological screening benchmark. A more detailed review of the complete dataset of copper concentrations as well as the local ecological setting identified that: the copper concentrations were, on average, well below the ecological benchmark; and, no vegetation could develop in the area due to barren bedrock, precluding wildlife browsing and bioaccumulation potential. No remediation was, therefore, deemed necessary for the Tier II and ecological screening benchmark copper exceedance.

Remediation Activities

The originally identified Tier II copper contaminated soil was excavated during the main phase of remediation (2003-2005), while the residual Tier II copper contaminated soil identified in 2013 was left in place. The Tier I PCB soil and buried debris were left in place. Following removal of exposed and surface debris, it does not appear that the remaining buried debris was capped or stabilized.

Physical and Chemical Performance

There has been no ongoing long-term monitoring of the North Slope Dump. The 2013 Maintenance Assessment noted that there was settlement, some debris exposure, and erosion present at the dump.

3.2 New Landfills

3.2.1 East and West Camp Non-Hazardous Landfill

General Description

The Camp Landfill is located at the station area, south of the existing SRR facility. The Landfill was constructed in 1998 to contain building and demolition debris, empty barrels, and other debris from around the site. There are two lobes: the West Camp Landfill is 3000 m^2 and the East Camp Landfill is 800 m^2, based on 2013 geophysical survey. Local drainage from the East Lobe is towards the east while drainage from the West Lobe is towards the west, with localized ephemeral ponding downgradient of both lobes, but especially the West Lobe. The grade is flat to gentle with bedrock outcropping to south and north. Very little to no vegetation is present. An overview of the East and West Camp Landfill is provided in Figure 6 of Appendix A.

Pre-remediation conditions

The Camp Landfill was constructed as part of the BAF-5 site remediation.

Remedial Objective

As per the 2003 Remediation Plan, the Camp Landfill was to be constructed as an “engineered” landfill. Consistent with the DLCU Protocol, the intent of the landfill was to mitigate the physical and chemical hazard by consolidating non-hazardous debris and demolition waste and containing Tier I soil to prevent aerial transport. Asbestos was to be placed in the landfill to remove the risk of aerial transport and inhalation pathways.

Remediation Activities

Based on photographs from during construction, the Camp Landfill was constructed with granular fill for perimeter berms being dumped into topographic lows between bedrock outcrops and not placed in compacted lifts. Construction and landfilling began in 1999 and ended in 2005. There are no as-built drawing records, and as such the full scope of remediation and the locations of asbestos placement is unknown. The Landfill appears to be constructed to tie into the existing bedrock outcrops for containment, but based on photographs during construction, it does not appear to be engineered.

Physical and Chemical Performance

The Camp Landfill has been monitored annually from 2005 until 2010, and then with decreasing frequency: years 2012 and 2016. Monitoring to date has included only visual inspections. Since 2012, areas of erosion, settlement, and exposed debris have been identified on both lobes of the Camp Landfill, although the observations have not indicated worsening conditions since their original identification in 2012.

No long-term groundwater and soil monitoring has occurred at the Camp Landfill. Soil sampling as part of the 2013 and 2014 Maintenance Assessment detected Tier II copper and nickel and Tier I PCBs. The Tier II copper and nickel were below the HHERA screening benchmarks and also likely attributed to natural geochemistry. The Tier I PCBs were excavated as part of the 2019 remedial maintenance work. Given the location of the Tier I PCBs surrounded by historic buildings and in an area of widespread historic use during operations as well as remediation, it is impossible to attribute the exceedance to migration from the landfill.

3.2.2 Beach Non-Hazardous Landfill

General Description

The Beach Landfill is located west of the barge landing area and is approximately 6700 m^2 in size. It is a non-hazardous landfill that was constructed in 1999 to accommodate non-hazardous demolition waste associated with remediation activities. The landfill was completed in 2005. An overview of the Beach Landfill is provided in Figure 7 of Appendix A.

Pre-remediation conditions

The landfill was constructed as part of the site remediation.

Remedial Objective

Similar to the Camp Landfill and according to the 2003 Remediation Plan, the Beach landfill was to be an “engineered” landfill, with the DLCU Protocol intent of consolidating and covering non-hazardous debris and demolition waste to mitigate the physical hazards and containing Tier I soil to prevent its aerial transport to mitigate the chemical hazard. Asbestos was to be placed in the landfill to remove the risk of aerial transport and inhalation pathways.

Remediation Activities

There are no as-built drawing records for the Beach Landfill. Based on present condition observations, the landfill was likely constructed with side berms, loosely placed, as with the Camp Landfill to provide physical containment on three sides, and an existing bedrock outcrop providing containment on the fourth side. Asbestos was reportedly placed at the northeast tip of the landfill, and creosote timbers were disposed of within a polyethylene lined cell at the southwest tip. Construction and landfilling began in 1999 and ended in 2005.

Physical and Chemical Performance

The Beach Landfill has been monitored annually from 2005 until 2010, and then with decreasing frequency: years 2012 and 2016. Monitoring to date for the Beach Landfill has only included visual monitoring. Soil sampling during the 2013 Maintenance Assessment detected no PCB or metal exceedances downgradient.

Monitoring visual inspections have identified some localized areas of settlement and erosion, minor debris exposure, and seepage, but no significant performance issues have been identified.

3.2.3 Tier II Landfill

General Description

The Tier II Landfill was constructed between 2003 and 2006 to consolidate and contain Tier II contaminated soil excavated from various site areas during remediation; the landfill has an approximate area of 11,000 m^2 An overview of the Tier II Landfill is provided in Figure 4 of Appendix A.

Pre-remediation Conditions

The landfill was constructed at a location that had been historically used for equipment maintenance and that had pre-existing contamination. The buildings in this area were removed prior to landfill construction.

Remedial Objective

As per the 2003 Remediation Plan and the DLCU Protocol, the Tier II Landfill was to be constructed as an engineered landfill with a liner and saturated low-permeability berms with sufficient cover to aggrade permafrost into berms and content. By covering the Tier II soil, the risk of contaminant aerial dispersion, migration, and uptake by vegetation was to be mitigated. Dissolved phase contaminant migration was to be mitigated by permafrost aggradation, with the liner system and compacted low-permeability granular berms providing backup. The design included groundwater monitoring wells to confirm containment of dissolved phase contaminants and thermistors to confirm permafrost aggradation. There was mention of placing Petroleum Hydrocarbon (PHC) soil in the landfill.

Remediation Activities

Construction of the landfill was completed as per the remedial design, commencing in 2003 and ending in 2005 with capping following completion of Tier II soil placement. Four groundwater monitoring wells were established in 2003, with five additional ones added in 2004, all on the landfill's perimeter. Soil monitoring stations were established adjacent to the monitoring wells. Four thermistor strings were also placed in the landfill during construction to monitor ground temperature and establishment of permafrost: two were placed within the landfill and two within the berms. It is unknown if PHC soil was, in fact, placed in the landfill as per the remedial plan, but PHCs are being monitored for, along with metals and PCBs.

Physical and Chemical Performance

The Tier II Landfill has been monitored annually from 2005 until 2010, and then again during 2012 and 2016. Monitoring to date has included visual, thermal, and chemical monitoring. Groundwater and adjacent soil sampling data have not indicated significant or consistent contaminant impacts in groundwater or soil and no contaminant migration is therefore suspected. Consistent with elsewhere on-site, elevated levels of copper, nickel and zinc have been detected in the soil but have been attributed to natural geochemistry. Observations of elevated levels of PHCs and PCBs in comparison to area specific baseline levels are considered relic contamination from the former maintenance area in which the Tier II Landfill was constructed because they do not show an increasing trend which would suggest migration from the Tier II Landfill. Data obtained from soil and groundwater monitoring, as well as data collected from the thermistors at the Tier II Landfill are presented in Tables C7 through C12 and C23 through C26, respectively, of Appendix C.

Ground temperature data from installed thermistors has indicated that that the landfill contents and containment berms have been consistently frozen since 2007. This provides further evidence that the above-noted elevated contaminant levels are not from landfill migration.

Finally, while visual inspections have identified localized areas of erosion, slumping, differential settlement, and cap material grain size sorting (potentially due to frost action), no observed features have been documented as worsening and the landfill is therefore evaluated as performing well.

3.3 Buildings and Structures

Resolution Island has several buildings and structures remaining that are CIRNAC assets. The following subsections will provide an overview of the conditions of the buildings as documented during the 2019 site activities in order to record existing conditions in terms of remaining project risk. Building locations at the upper site and lower beach area can be seen in Figures 2 and 3, respectively, of Appendix A. A photographic log of each of the buildings as documented during the 2019 site activities is provided in Appendix B.

3.3.1 Upper Site Buildings and Structures

3.3.1.1 Generator Building

The Generator Building is located at the summit, on the east side of the Station Area. The building is on uneven terrain, with timber beams placed below as a levelling platform. The roof, walls, and floor are made of steel sheeting, with paint that has significantly worn away. The building dimensions are approximately 16 m long, 3 m wide, and 3 m tall. The building has a generator and miscellaneous storage items such as empty gasoline and diesel containers, a water tote, and fuel catchment pads within it.

3.3.1.2 Monitoring Camp S20 and Shed

The Monitoring Camp is located at the summit on the east side of the Station Area, just west of the Generator Building. The camp consists of two sections; a larger main section (approximately 12 m long, 2.5 m wide, and 2.8 m high) and a smaller auxiliary section (approximately 8 m long, 2 m wide, and 2.5 m tall) connected to the west side of the main section. Both sections appeared to have walls made of plywood covered in metal cladding. The built-up layered rooves of both sections have torn and are missing portions of roof felt. The main section has a concrete foundation with minor vertical cracks within it. The auxiliary building is situated on a steel skid and appears to be held in place during high winds by steel tethers on the west and east side. There is a small heating fuel tank on the exterior; it is not clear whether the tank was ever emptied when the camp was last used. Given the small size of the tank, it poses a low risk in the event of leakage. See Appendix B - BAF-5 CIRNAC Monitoring Camp and Shed Photos 7 and 8.

The Shed is located on the north side of the main section of the monitoring camp. The dimensions of the shed are approximately 2.5 m long, 2.5 m wide, and 2.5 m tall. It has plywood walls covered in metal cladding, a built-up layered roof, and is balanced on wooden beams. Portions of metal cladding and roof felt have torn away.

The interior of the Monitoring Camp and Shed were not accessed during 2019 site activities.

3.3.1.3 Remote Antenna Building

The Remote Antenna Building is located on a second summit to the west of the Station Area. It is a wood framed building (approximately 9 m long, 4.5 m wide, and 3 m tall) with plywood walls covered in metal cladding. The roof appears to have previously been a built-up layered roof, but almost all roof felt has torn away. The foundation is concrete with minor settlement and cracking. The interior of the building is filled with miscellaneous building debris and empty barrels. There is a small fuel tank on the exterior of the building; given that the tank has not been used since site operations and would have been included in hazardous material removal remedial work, it is assumed to be empty. See Appendix B: BAF-5 CIRNAC Remote Antenna Building Photos 11 and 12. In the event that the tank contains residual content, spills from the tank pose a very low risk given its location and small maximum volume.

3.3.1.4 Building S18

Building S18 is located at the upper site. The approximate dimensions of the building are 17 m long, 14 m wide, and 9 m tall. The building consists of wood columns and beams with plywood walls covered in metal cladding. The roof is also wood and is covered in built-up roofing material. There are sections of missing cladding and plywood along the walls and the roofing material appears weathered. The building sits atop a concrete foundation which has minor cracking and settling. Portions of the foundation are not visible on the outside of the building. Parts of the concrete pad are not visible within the building due to scattered debris and a significant amount of ponded water. The interior walls of the building are painted in places, with significant amounts of flaking and peeling; however, paint testing has indicated the paint to be non-hazardous for lead and PCB content. Both the front and rear doors are no longer present, with portions of the roof near the rear entrance falling to the ground.

3.3.1.5 Billboard Antennas and Circular Dishes

The Billboard Antennas and Circular Dishes are located at the west end of the upper site. The four Circular Dishes consist of hollow metal piping supported by steel tethers and bolted to concrete foundations. The approximate dimensions of the dishes are 12 m tall and 8 m in diameter. During the 2019 site activities, only one of the Circular Dishes remained standing, with the remaining three having fallen. The concrete foundations and steel bolts for all dishes remained in place. The two Billboard Antennas consist of steel frames with galbestos covered metal sheeting. The billboards are approximately 25 m high and 12 m long. The side dimensions of the billboards are approximately 8 m wide at the base, tapering to about 3 m at the top. Small sections of missing metal sheets are observed on the west antenna. Like the Circular Dishes, the steel frames of the antennas are anchored to concrete foundations. Galbestos is a non-friable asbestos-containing material whereby asbestos fibres were pressed onto the surface of a metal sheet during galvanization followed by application, under head and pressure, of asphalt. As the asphalt sealant weathers and is degraded, the asbestos fibres will release.

3.3.2 Lower Site Buildings and Structures

3.3.2.1 Beach Warehouse

The Beach Warehouse is located at the lower site area, east of the beach landing. The warehouse consists of steel columns and beams covered in steel cladding sitting on a raised concrete floor slab. The approximate dimensions of the warehouse are 20 m long, 10 m wide, and 6 m tall. Significant portions of cladding are missing along the walls and roof. The concrete slab does not appear to have any significant cracking or settlement. The interior of the building is vacant with the exception of fallen metal cladding from the walls and roof.

3.4 PCB Barriers

General Description and Remedial Objectives

Not all PCB contaminated soils could be removed from BAF-5 in 1999. Tier I, Tier II, and CEPA level soils were inaccessible for removal due to being within fractured bedrock, or on steep terrain (ASU 2019), and were still migrating into the environment, and in some cases, at risk of migrating into the ocean. To limit migration and provide a means of passive PCB contaminated soil collection for subsequent removal, barriers were proposed for placement at key interceptor points as part of the 2003 Remediation Plan.

Remediation Activities

Three PCB Barriers were designed and installed between 2003 and 2006 by the Queen's University Analytical Services Unit (ASU) to control the migration of PCB contaminated soil. The barriers consisted of a lined channel formed by rock gabions or bedrock outcrop that directed flow through a gate consisting of various filters. The S1/S4 Valley barrier and Furniture Dump barrier were installed near the Station area, and the S1/S4 Beach barrier was installed adjacent to the shoreline, at the end of the S1/S4 Valley drainage channel. The locations of the barriers are shown on Figure 2 of Appendix A.

Additional remediation and maintenance work was completed at the barriers in 2019; the specific details for each are reported below.

Physical and Chemical Performance

The barriers have undergone chemical and visual monitoring as well as periodic maintenance in the form of accumulated soil removal and barrier filter material replacement. Historical surface water and soil analytical data for the barriers are presented in Tables C19 through C22 of Appendix C. The specific information regarding performance of each of the barriers is discussed separately below.

3.4.1 Furniture Dump PCB Barrier

The Furniture Dump PCB barrier (Furniture Dump barrier) is located at the upper site and intercepts drainage from the excavated Furniture Dump area. An overview of the Furniture Dump barrier is provided in Figure 9 of Appendix A. Trend analysis of soil sample monitoring data indicates that it is capturing soil that continues to have PCBs at concentrations exceeding CEPA level, albeit at low volumes. In addition to the funnel and gate barrier, there was also a pre-screening filter consisting of geotextile wrapped around a former antenna structure piece that was lain across the drainage pathway to collect coarser soil upgradient of the barrier itself. Table 5 presents the volume of soil, and the average concentration of PCBs captured by the Furniture Dump Barrier between 2006 and 2019 for the years in which it was monitored and/or maintained. No accumulated soil was removed from the barrier between 2011-2019; only soil sampling was completed. All soil was excavated from the Furniture Dump Barrier and its upgradient drainage pathway during the 2019 site activities. The barrier liner was replaced, and the filter box remains in place.

Table 5: Volume of Soil, Average Concentration of PCB, and Mass of PCB in the Furniture Dump Barrier

	2006	2007	2008	2009	2010	2011	2012	2013	2011-2019
Soil Volume (m^3)	0.3	0.25	0.6	nd	0.48	nd	nd	nd	2.0
PCB Concentration (ppm)	29	37	78	43	42	101	77	81	47

nd: not determined because accumulated soil was not removed.
Adapted from Resolution Island 2019 Operation, Maintenance and Surveillance of the PCB Barriers, Table II-4

While the volumes recorded in Table 5 as accumulating within the barrier are low, in 2019, there was, in fact a total of 19 cubic metres (m^3) removed from the barrier and its drainage pathway, only 2 m^3 of which is understood to have accumulated at the barrier itself (ASU 2019). The remainder was retained along the drainage pathway, at least in part, by the geotextile wrapped antenna piece, and the deteriorated geotextile was not replaced in 2019. It is, therefore, not clear whether the barrier will continue to only receive very low volumes within it, which, based on photos, are well within its retention capacity.

3.4.2 S1/S4 Valley PCB Barrier

The S1/S4 Valley PCB barrier (Valley barrier) is located near the top of a cliff at the upper site limit and has been monitored from 2006 to 2019. Monitoring soil sampling data trend analysis of soil trapped within the barrier over the monitoring timeframe indicates that the amount of soil captured by the valley barrier is relatively stable, and the soil concentrations of PCBs are predominantly at Tier I levels (ASU 2019). Table 6 presents the volume of soil, and the average concentration of PCBs for the years in which it was monitored and/or maintained. No accumulated soil was removed from the barrier between 2011-2019; only soil sampling was completed. All soil was excavated from the Valley barrier during the 2019 site activities.

Table 6: Volume of Soil, Average Concentration of PCB, and Mass of PCB in the S1/S4 Valley Barrier

	2006	2007	2008	2009	2010	2011	2012	2011-2019
Soil Volume (m^3)	2.2	1.0	2.6	nd	2.5	0.5	2.5	12
PCB Concentration (ppm)	5.5	5.0	3.6	1.6	2.9	3.7	1.9	2.5

nd: not determined because accumulated soil was not removed.
Adapted from Resolution Island 2019 Operation, Maintenance and Surveillance of the PCB Barriers, Table II-6

As of 2019, all liners and filters have been removed from within the valley barrier, leaving only gravel behind. **The S1/S4 Valley PCB Barrier structure is no longer in place.**

3.4.3 S1/S4 Beach PCB Barrier

The S1/S4 Beach PCB Barrier (Beach Barrier) is located adjacent to the ocean at the lower site area, at the receiving end of the valley barrier drainage channel. CEPA and Tier II level PCB soils are located along the cliff area beyond the Valley Barrier in an area that is inaccessible for soil excavation. The goal of the Beach Barrier is therefore to collect migrating residual contaminated soil to prevent if from entering the ocean and violating the Federal Fisheries Act. An overview of the Beach Barrier is provided in Figure 8 of Appendix A. The barrier has been monitored since 2006. Trend analysis of monitoring soil samples show concentrations at or below Tier I levels. Table 7 presents the volume of soil, and the average concentration of PCBs captured by the Beach Barrier between 2006 and 2019 for the years in which it was monitored and/or maintained. No accumulated soil was removed from the barrier between 2011-2019; only soil sampling was completed. All soil was excavated from the Beach Barrier during the 2019 site activities. The liner system and filter gate both remain in place.

Table 7: Volume of Soil, Average Concentration of PCB, and Mass of PCB in the S1/S4 Beach Barrier

	2006	2007	2008	2009	2010	2011-2013	2011-2019
Soil Volume (m^3)	2.0	1.2	5.3	nd	2.3	6.0*	13
PCB Concentration (ppm)	0.7	0.45	1.6	0.8	1.4	0.62	0.65

nd: not determined because accumulated soil was not removed.
**recorded but not excavated*
Adapted from Resolution Island 2019 Operation, Maintenance and Surveillance of the PCB Barriers, Table II-10

In 2019, when 13 m^3 of soil was removed, the amount of accumulated soil was observed to be compromising the proper functioning of the barrier (ASU 2019). The depth of soil, which was generally at the full depth of the barriers, was preventing flow of water through the filter section of the barrier. The barrier had not been excavated since 2010.

As part of the 2013 monitoring program, soil samples were collected upgradient of the barrier, in the remaining contaminated soil area that was inaccessible to heavy equipment during remediation. Concentrations in excess of CEPA and Tier II were detected covering an approximate area (in which samples could be collected) of 1900 m^2; assuming of depth of 0.3 m, which is the typical depth of surficial contaminated soil at these sites, yields an approximate volume of 570 m^3. Accounting for a considerable amount of bedrock outcrop within the overall identified area, the volume could be potentially reduced to approximately a third or quarter, based on imagery and photographs. However, this is still a considerable amount of soil that will potentially require collection at the Beach barrier. Sampling by ASU in 2013 in the previously excavated contaminated soil footprints downgradient of the inaccessible area indicated that some contaminant migration of PCB has occurred back into the remediated area, with new impacts at Tier II and Tier I levels detected.

3.5 PCB Storage Area

The Beach Warehouse located at the Beach Landing Area had previously been used as a PCB storage area. During the 2019 site activities, all the PCB material within this area was bagged and shipped offsite for appropriate disposal. The containment of PCB impacted material must be done in a manner consistent with the PCB regulations. Presently there is a shipping container within the Beach Landing area intended for the storage of future PCB material periodically excavated from the PCB Barriers on site. No PCB material is currently stored in this container.

4. Residual Risk

4.1 Failure Modes Effects Analysis

A Failure Modes and Effects Analysis (FMEA) has been completed for each of the remaining site features to evaluate their residual risk and the most likely means of failure. The primary design intention(s) for risk management of each of the remaining site features has been evaluated in terms of failure modes, how they may fail (their pathways), their likelihood of failure, and their effects of failure, in consideration of potential severity of risk to the environment, traditional land use, regulatory requirements, costs, public perception (via media and local community) and human health and safety. The FMEA is provided in Appendix E.

To evaluate failure modes requires knowledge of the remedial design intents. The Resolution Island Remedial Action Plan (RAP) does not clearly articulate the remedial design intents for much of the remediation implemented at the remaining site features; AECOM has therefore assumed design intents for each, based on our knowledge of the overall site history as its relates to the timing of development of the DND DLCU protocol, the DCC, and the AMSRP. These are described below, with their associated failure modes.

It should be noted that in many cases, the highest risk ranking category in the FMEA was the consequence costs category because of the very high costs of any necessary maintenance or corrective actions associated at this remote, very logistically challenging site. During FMEA review and update with CIRNAC and PSPC, it was agreed that the FMEA scoring methodology was not strictly applicable to post-remediation monitoring sites and especially where evaluated risk applied to cost for mitigation; as such, it was agreed that the FMEA scoring would proceed as typical with evaluation according to the established methodology, but that the selection of the top evaluated risk rating for each failure mode item would be adjusted to select the consequence rating ranked highest when ignoring the cost consequence. Essentially, the cost consequence was scored, but it was not used in the evaluation of risk for monitoring.

4.1.1 Existing Dumps and Landfills

One of the underlying assumptions for evaluating existing dumps at abandoned military sites in the Arctic is that all dumps have a high likelihood of containing contaminated soil in addition to debris. The risk management approach for remediation of existing dumps in terms of chemical hazards is to evaluate purely on the basis of whether there is exposed contamination that poses a risk to receptors in the dump vicinity and whether there is evidence of contaminant migration that may continue to accumulate to a level that would be a risk to downgradient receptors. In terms of physical hazards, all dumps are assumed to contain debris, but the consideration for whether the dump should remain in place is based on whether the dump is considered geotechnically stable and not likely to be subject to erosion or other processes that would continue to expose the dump contents over time. On that basis, the two primary design intents for existing dumps and landfills are to:

- Remove existing and prevent further exposure of surface soil contamination available to receptors or more readily available for migration (aerially or via surface water): For the purposes of the FMEA evaluation, the qualification of “surface soil contamination” has been evaluated on the basis of whether it poses a chemical hazard – a risk to ecological or human health – as per the HHERA completed for this site as well as adjacent Radio Island. For PCBs, there is also the regulatory driver of CEPA exceedance. Failure of this remedial design intent would therefore equate to the exposure or downgradient accumulation via migration of sufficient contaminated surface soil that poses an ecological or human health risk.
- Remove existing and prevent any further debris exposure that will pose a physical hazard to humans or wildlife. Failure of this remedial design intent would therefore equate to sufficient debris exposure that it would pose a risk to wildlife or humans.

4.1.2 Non-Hazardous Waste Landfills (Camp and Beach Landfills)

Site debris and demolition waste were consolidated and placed within the Camp and Beach Landfills to lessen the physical hazards associated with them, and for overall site aesthetics. Painted demolition and site debris that was placed within them was defined as non-hazardous on the basis of meeting regulatory criteria for PCB and lead content. In particular, at the time of Resolution Island remediation, classification of PCB amended painted material usually included factoring in the substrate mass with the paint mass to derive an overall painted waste PCB concentration, which was compared to the CEPA criterion of 50 milligrams per kilogram (mg/kg). This practice resulted in very high PCB paint concentrations to be disposed in non-hazardous waste landfills; the practice has since been disallowed by Environment Canada (EC). Where PCB concentrations in paint were not high, lead was typically used as a paint amendment and lead testing in paint was much less common at the time of the Resolution Island assessment. In summary, the classification of non-hazardous waste does not necessarily imply that the paint concentrations were all low in lead or PCBs content. Asbestos and Tier I soil (which by definition means only a risk for aerial transport) were both disposed of within the landfills to cut off the airborne migration and exposure pathway; while not confirmed, it is likely that the asbestos waste was bagged. Based on limited as-built information and landfill monitoring observations, the landfills were not constructed in a manner to minimize infiltration of precipitation or lateral groundwater migration; there is water movement through them, particularly in the case of the Camp Landfill. The remedial design intents for the Non-Hazardous Waste Landfills were therefore as follows:

- Remove physical hazard of site debris & demolition waste. Failure of this remedial design intent would therefore equate to sufficient debris becoming exposed that it posed a physical hazard to wildlife or humans.
- Dispose of asbestos consistent with regulatory requirements, which equate to removal of the airborne hazard. Failure of this remedial design component would equate to exposure of sufficient volume of asbestos waste, including bag rupturing, that the waste would become dry (in the case of friable asbestos waste) or weather to the extent of becoming friable (in the case of non-friable asbestos waste), and become airborne to the extent of posing a risk to humans nearby. As per regulatory exposure criteria, airborne concentrations would need to consistently exceed the occupational exposure limit, which is 0.1 fibres/cubic centimetre (cm^3) over an 8-hour time weighted average (TWA, to be considered a regulatory infraction and a risk to humans).
- Dispose of non-regulated PCB and lead amended painted waste. This design objective would fail if PCB or lead amended painted waste became sufficiently exposed for weathering such that paint chips began to migrate and accumulate to the point of posing a chemical hazard to the ecosystem or humans (or a regulatory infraction). Migration could occur via water (most likely as suspended solids, possibly as dissolved phase for lead) or aerially. Aerial exposure would pose a risk to humans with a concentration of 1.0 mg/m^3 for PCBs with 42% Cl or 0.5 mg/m^3 for PCBs with 54% Cl and 0.05 mg/m^3 of lead (TWA over an 8-hour shift). The CEPA concentration of 50 mg/kg would be the regulatory infraction for accumulation of PCB paint chips.
- Stop Tier I contaminated soil from potential aerial transport. Failure of this remedial design intent would therefore equate to sufficient Tier I soil becoming exposed (and the soil drying out) that it posed an airborne migration hazard.

4.1.3 Tier II Soil Landfill

Tier II soil, by its definition, is considered a risk for airborne and water borne migration, for uptake by receptors, and to pose an ecological or human health risk for direct exposure. While the HHERA provided different recommended soil screening benchmarks and more quantitative risk evaluation for some areas of the site, the design intents of the Tier II landfill – a landfill for containment of contaminated soil - remain the same:

- Prevent direct receptor uptake or exposure of the soil at concentrations deemed an ecological or human health risk. Failure would entail exposure of the soil within the landfill to a level that would pose a risk to receptors.
- Prevent contaminants in the soil within the landfill from migrating. Failure would entail loss of containment sufficient to allow precipitation or groundwater migrating from the adjacent bedrock outcrop to enter the landfill, dissolve contaminants from soil, and transport them outside of the landfill so that they accumulate to concentrations deemed an ecological or human health risk. Loss of containment would specifically include: loss of permafrost within containment berms at the elevation or below that of contaminated soil combined with failure of the liner system plus migration of sufficient water through the compacted cover or berms.

4.1.4 Remaining Site Buildings and Structures

It is understood that remediation for site buildings and other structures included: removal of hazardous waste; demolition and disposal of those that posed a serious physical hazard at the time of remediation; and demolition and disposal of those that prevented access to areas needing remediation. Some buildings were retained for use during past operations, maintenance and surveillance (OMS). The remedial design intentions are therefore assumed to be as follows:

- Meet regulatory requirements with respect to hazardous materials. Failure would equate to regulatory non-compliance, which, in the case of asbestos would equate to asbestos becoming airborne to the point of exceeding the TWA occupational exposure index noted above while humans are present for 8 hours or more.
- Secure access for remediation and OMS work. Failure would therefore equate to a remaining structure collapsing and impeding access or inspection ability of remaining site features needing surveillance or maintenance.
- Remove acute health and safety risk to humans during site presence. Failure would constitute a human visiting the site being injured by a falling or collapsing structure, or by a piece of the structure becoming windblown and striking them.

4.1.5 PCB Barriers

The design intent for the PCB barriers are as follows:

- Prevent the surface water migration of highly concentrated (exceeding Tier II) PCB impacted soil remaining in inaccessible locations. The failure mechanism would therefore be for the high (Tier II or CEPA) concentration PCB soil to continue to migrate towards a receptor in a manner that would pose a chemical hazard or be a regulatory infraction. The key receptor downgradient of the barriers is the ocean; continued migration of the impacted soil into the ocean would constitute a Fisheries Act violation. If that impacted soil had PCB concentrations in excess of 50 mg/kg, it would also be a CEPA violation.

4.1.6 PCB Storage Facility

There is a requirement to securely contain PCB impacted soil in excess of CEPA concentrations that accumulates and gets periodically removed from the PCB barriers. The containment must be done in a manner consistent with the PCB regulations. The intentions of the PCB regulations, and therefore the storage facility itself are as follows:

- Prevent access by humans who are not trained in the hazards and therefore authorized to enter to avoid exposure and harm to humans. Failure would constitute a human getting into the facility, not being aware of the hazard, opening the containers and being exposed to the point of harm (inadvertent ingestion, inhalation of contaminated particulates, or dermal exposure).
- Prevent release of PCBs into the environment. Failure would constitute the PCB impacted soil removed from barriers not being properly contained and the soil being released to the environment.
- Maintain accurate records of a regulated substance. Failure could constitute not maintaining the proper inventory records or updating Environment Canada with updates.

4.1.7 FMEA Scoring Summary

Table 8 below provides a summary of the highest risk ranking for each of the evaluated features and their failure mechanism under the FMEA. Refer to Appendix E for the complete FMEA evaluation.

Table 8: FMEA Scoring Summary for Remaining Site Features

Failure Mode Description	Effects	Pathways	Highest Non-Cost Risk Rating
East and West Camp Non-Hazardous Landfill			
Significant Loss of Cover/Containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	• Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff) and altered drainage channel(s) leading to piping. • Animal burrowing. • Human disturbance. • Significant settlement and sinkholes due to voids within waste and/or non-compacted waste breaking down.	Moderate
	Asbestos waste becomes exposed and an airborne hazard to humans	• Same pathways as above for debris with the addition of: ○ Asbestos bags ripped by debris or angular cobbles within cover or animal or human disturbance, asbestos particulate gets transported by water and accumulates at surface outside of the landfill or sufficiently exposed aerially to dry out and become airborne at a concentration exceeding the occupational exposure limit, and humans are present over a sustained period.	Low
	Lead or PCB painted waste becomes sufficiently exposed to weather and be transported aerially or via water	Same pathways as for asbestos, minus bag ripping.	Low
	Tier I soil is sufficiently exposed for aerial dispersion to pose an ecological risk.	Same pathways as for debris and painted waste.	Low
Beach Non-Hazardous Landfill			
Significant Loss of Cover/Containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	• Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff) and altered drainage channel(s) leading to piping. • Animal burrowing. • Ice jacking. • Human disturbance. • Significant settlement and sinkholes due to voids within waste and/or non-compacted waste breaking down. • Flooding due to climate change, sea level rise and/or increase in surface water accumulation (from permafrost thaw and increased precipitation) with lake to west dramatically increasing in size/depth.	Moderate
	Asbestos waste becomes exposed and an airborne hazard to humans	Same pathways as above for debris but also: • Asbestos bags ripped by debris or angular cobbles within cover or animal or human disturbance, asbestos particulate gets transported by water and accumulates at surface outside of the landfill or sufficiently exposed aerially to dry out and become airborne at a concentration exceeding the occupational exposure limit, and humans are present over a sustained period.	Low

Failure Mode Description	Effects	Pathways	Highest Non-Cost Risk Rating
	Lead or PCB painted waste becomes sufficiently exposed to weather and be transported aerially or via water	Same pathways as for asbestos, minus bag ripping.	Low
	Tier I soil is sufficiently exposed for aerial dispersion to pose an ecological risk.	Same pathways as for debris and painted waste	Low
Tier II Soil Landfill			
Complete loss of containment such that Tier II soil becomes exposed to the environment	Contaminant uptake or exposure by receptors to point of posing an ecological or human health risk.	• Erosion completely through cover material or side slopes and berms, plus breaching of liner: through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff) and altered drainage channel(s). • Animal burrowing all the way through the cover material and liner. • Human disturbance. • Slope failure/significant side slope slumping with simultaneous damage to liner: due to build up of pore water pressure, possibly from loss of permafrost and melting of any ice lenses that may have developed in the fine within fine-grained soil while frozen, or due to patterned ground development in cap leading to lateral granular material distribution with coarse-grained edges to the patterns being a point of focus for surface water infiltration). • Frost wedge development through cover and breaching of liner due to cracks developing in the cover and accumulating water during thaw, with the crack growing and deepening over time through freeze thaw processes.	Moderate
Sufficient loss of containment for contaminants to migrate from landfill and accumulate downgradient	Contaminants accumulate to point of posing risk to receptors via uptake or direct exposure.	• Loss of permafrost within landfill due to climate change coupled with cover erosion or settlement and liner breaching in the surface and side slopes allows precipitation to infiltrate, contaminants within soil to dissolve in groundwater and migrate out of the landfill footprint.	Moderate
PCL Dump			
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	• Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). • Animal burrowing. • Human disturbance.	Low
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	• Same pathways as for debris exposure with that addition of water migration through the dump.	Low

Failure Mode Description	Effects	Pathways	Highest Non-Cost Risk Rating
North Slope Dump			
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	• Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). • Animal burrowing. • Human disturbance. • Ice jacking.	Low
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	• Same pathways as for debris exposure with the addition of water migration through the dump.	Low
Maintenance Dump			
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	• Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). • Animal burrowing. • Human disturbance. • Ice jacking	Low
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	• Same pathways as for debris exposure with the addition of water migration through the dump.	Low
Airstrip Landfill			
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	• Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). • Animal burrowing. • Human disturbance. • Ice jacking	Moderate
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	• Same pathways as for debris exposure (except ice jacking) with the addition of water migration through the dump.	Moderate
	Hazardous level soil is exposed in landfill (CEPA PCBs)	• Same pathways as for debris exposure except ice jacking.	Moderate

Failure Mode Description	Effects	Pathways	Highest Non-Cost Risk Rating
Site Buildings and Structures			
Structure collapses into an area requiring access for maintenance or monitoring	Prevents ability to properly monitor or maintain residual risk areas	• Progressive weakening due to weathering of structural members, increased by loss of envelope by precipitation (rotting of wood) or wind.	Low
Building collapse (partial) while occupied	Harm to human or large wildlife	• Rotting of wood through precipitation weathering of envelope or windblown loss of envelope pieces, precipitation entry and structural members causing roof or walls or floors to collapse. o while occupied, or in the case of the floor, due to loading from a person standing on it.	Low
Galbestos on billboards weathers to point of releasing asbestos fibres to become airborne risk.	Human standing nearby inhales asbestos fibres at a concentration above the occupational exposure limit.	• Weather degradation of asphalt in which the asbestos is impregnated on the siding that causes the fibres to be released.	Low
Piece(s) of a structure fly off when site is occupied and hit someone	Harm to human or wildlife	• Person or wildlife walking close by during high wind, with wind loosening and prying away siding or envelope piece(s).	Low
PCB Barriers			
Furniture Dump Barrier overtops	CEPA PCB contaminated soil migrates beyond barrier	• Large precipitation event (especially. related to climate change) causes flushing and large amount of soil is entrained and deposited in barrier filling it up. • Repeated weather-related access delays to site prevents necessary maintenance from being completed. • Large precipitation event or very quick melt of heavy snowpack physically breaches the barrier, allowing unimpeded migration of contaminated soil.	Moderate
	CEPA PCB contaminated soil migrates down cliff into ocean	• Same pathway as above, but larger scale precipitation and failure.	Moderately High
S1/S4 Beach Barrier overtops	Tier I (possibly Tier II) soil is released to the ocean.	• Large precipitation event (especially. related to climate change) causes erosion and migration of contaminated soil upgradient, and large amount of soil is entrained and deposited in barrier, filling it up. • Climate change related increase in active layer depth and soil saturation levels results in slope failure/massive movement of soil. • Repeated weather-related access problems prevent necessary maintenance from being completed.	Moderately High

Failure Mode Description	Effects	Pathways	Highest Non-Cost Risk Rating
PCB Storage Area			
Does not prevent site visitors from accessing the site and opening the container.	Possible exposure by humans, regulatory non-conformance	• Signage loss, sea can left open or lock cut, containers are opened and there is exposure through dermal contact or inhalation of fine-grained particulates.	Low
	Possible spillage of soil and exposure by wildlife, regulatory non-conformance	• Visiting humans open containers as per above pathways, and spill soil which leaks out of the container (wood bottom leaks).	Low
Inventory is not properly maintained or filed with Environment Canada	Regulatory non-compliance	• Improper management when new containers added (lack of training). • PCB labels on individual containers fall off or not placed originally. • Insufficient time during site visit to update records. • Updated records do not get sent to EC	Moderate

5. Operations, Maintenance, and Surveillance

Only those remaining site features that pose a risk greater than low are recommended for specific monitoring activities. As per the FMEA and the above table, this includes:

1. East and West Camp Landfill
2. Beach Landfill
3. Tier II Soil Landfill
4. Airstrip Landfill
5. Furniture Dump PCB Barrier
6. S1/S4 Beach PCB Barrier
7. PCB Storage Facility (once in use)

In addition, surveillance and any associated maintenance are only recommended for the failure modes and their pathways that yield a moderate or higher risk level, with the frequency of monitoring increasing with risk level.

No specific monitoring is considered necessary at the PCL, North Slope and Maintenance Dumps due to their low risk status. The PCL Dump and North Slope Dump risk classifications are derived from the lack of vegetation and receptors due to the widespread presence of barren bedrock. Considerable mechanical and chemical weathering of the bedrock would need to occur to develop soil to sustain vegetation in the area; even with climate change considerations, this is highly unlikely. The Maintenance Dump's low risk status is due to its small size and lack of human and wildlife receptors. No monitoring is considered necessary for remaining site structures because they are not at risk of falling on key areas of the site needing continued access, and they pose a low potential physical hazard risk to any humans or wildlife that may access them. Note that the potential failure modes of the PCB storage area, once implemented, were also scored; however, the monitoring and maintenance of it has been discussed below only in the context of the PCB Barriers.

While no specific monitoring – and associated reporting – is recommended for the features other than those listed above, general observations related to overall site conditions are typically noted during the course of monitoring work. Site-wide increases in erosion, water ponding, slope movement, and other such visible features get recorded because they are observed at specific monitoring areas, but also along access roads, the airstrip and apron, and other site infrastructure. On the basis of these observations, the monitoring personnel may inspect other low-risk site features as deemed appropriate. For these reasons, documenting baseline site conditions as a whole at the start of the monitoring program is recommended, as it allows for future change detection of any area of the site, not just the specific features being monitored. It also allows for change to be detected by any monitoring personnel, and does not require monitoring be completed by the same personnel each time. The recommended baseline documentation method is described below.

There are no ongoing site operations. This section therefore will focus solely on surveillance and associated maintenance.

5.1 Surveillance/Monitoring Methods

The following describes the surveillance, or monitoring, methods that are recommended for implementation at Resolution Island moving forward, based on the identified failure modes and their pathways, and the present-day site conditions after post-remediation monitoring since 2005, with some remedial maintenance completed in 2019.

Monitoring is proposed to be completed in the following stages:

- Baseline, to accurately record present-day site conditions from which to detect change in the future and to support the derivation of the proposed exit criteria for Phase 1 for the PCB barriers and Phase 2 for all features. Baseline monitoring may be completed concurrently with a Phase 1 monitoring event;
- Phase 1, to complete regular monitoring of the above noted site features until exit criteria related to general stability are met ("Phase 1 exit criteria"); and

- Phase 2, to monitor the sites in response to the occurrence of above-average climatic events until acceptable continued performance has been observed in response to such events (“Phase 2 exit criteria”).

The below sections detail the monitoring phases, the recommended monitoring requirements for each feature, and the recommended exit criteria for each feature.

5.1.1 Baseline

For all sites having undergone remedial work, clearly documenting baseline conditions is key for effective change detection moving forward, as well a required component of deriving the Phase 1 Exit Criteria for the PCB barriers and Phase 2 Exit Criteria for all features Recognizing the challenges of accessing remote sites, and Resolution Island in particular, or in continuing to access specific areas of the site where roads may be washed out or require considerable time to get to, it is recommended that baseline documentation include measures to facilitate potential use of remote monitoring methods; these measures will also provide a record of conditions of the overall site and features not being specifically monitored from which to detect change, as discussed above. Remote monitoring methods may include high resolution satellite imagery or aerial photographs to visually inspect the entire site instead of via traditional site visit, and the methodology for using satellite imagery is described in Appendix E. In addition, a hybrid version of “remote monitoring” could also consist of collecting drone imagery on-site to visually inspect features at challenging access locations, such as the Beach PCB Barrier. The following lists the recommended baseline monitoring work, broken into field work and desktop components.

Field Work:

- Completion of detailed topographic survey to record baseline conditions at all locations being specifically monitored. Key information to survey includes the as-built information for the PCB barriers: height and width of the structures, barrier collection basin detailed topography for calculating holding capacity, and flow path detailed ground conditions (including documenting bedrock outcrops that provide flow funneling capabilities versus overburden areas). The survey should also include the length, width, and depth recording of key existing geotechnical instability features such as large sinkholes, erosion channels, or locations of slope movement (slumping).
- Establishment of imagery identifiable permanent markers at monitoring locations and at other broadly spaced locations throughout the site, and accurately surveying their position (lateral and elevation).
- Collection of site-wide digital elevation model (DEM) with a higher level of vertical accuracy than the present one for the site – either by drone photogrammetric methods or LiDAR.
- Completion of the required monitoring and maintenance elements for each of the specific features being monitored, including: soil sampling; soil excavation and containerization filter material cleaning or replacing; groundwater sampling; geotechnical inspection and accurate documentation of all erosional, settlement, ponding, slumping, animal burrowing or vegetation regrowth as compared to the previous monitoring visit observations; ground temperature downloading from thermistors, and thermistor battery replacement.

Desktop Work:

- Traditional Monitoring Reporting:
  - Develop the site DEM and use localized detailed topographic information to augment the key areas of the site to be surveyed to create one integrate dataset of topographic information.
  - Transpose geotechnical observations and surveyed positional information of geomorphological features (erosion channels, etc.) into CAD or GIS on a specific layer tied to the baseline year observations.
  - Review ground temperature data to assess for active layer depth changes.
  - Review soil and groundwater data to assess for trend analysis and potential contaminant migration.
  - Review volume of soil collected in barriers for trend analysis.
  - Evaluate overall performance of each monitored feature.
- Imagery Site Baseline Documentation:

   - In consultation with a geomatics specialist, obtain high-resolution multispectral satellite imagery (0.3 m pixel size, available on the WorldView-3 platform), set for collection at a specific time and angle that will provide optimal viewing of the PCB barriers.
   - Using the installed markers, detailed survey information, and improved site-wide DEM, orthorectify and pan-sharpen the satellite imagery.
   - Using a standardized geomorphological classification method to distinguish linear versus polygonal features and to allow size distinctions, digitize all observed geomorphological features throughout the site on an imagery overlay and record each feature in a database. Compare observed and digitized features to those observed and recorded during the on-site geotechnical inspection and use surveyed/recorded dimensions to calibrate the digitized features from the imagery review.
   - Confirm sufficient visibility of features to be monitored (especially barriers) and viability of future use of satellite imagery for monitoring remotely.
- Baseline Information to Support Exit Criteria Evaluation
   - Using information to be gathered as described above, calculate holding capacity for barriers based on detailed structural as-built and topographic information and review upstream hydrology.
   - Obtain detailed historical climate data as wells as modelled future climate data for Resolution Island and/or Iqaluit from publicly available sources (such as climatedata.ca).
   - Review historical precipitation data to evaluate worst-case precipitation event that has occurred at the site to date. Complete statistical analysis of past and future precipitation dataset to identify three levels of precipitation event that would be considered sufficiently above average or extreme: a “moderate” event (sufficiently above historical climate normal to warrant concern of failure); a “high” event that would be well above historical normal; and an “extreme” event that would be very likely to cause failure of one of the barriers or a landfill/dump.
   - In consultation with hydrologist and geotechnical engineer, develop the specific precipitation benchmark values to initiate Phase 2 monitoring (as discussed below) and for use as Phase 2 exit criteria for each of the monitored features.

5.1.2 Phase 1 Monitoring

The goals of Phase 1 monitoring is to continue to collect performance information, related to their identified failure modes and associated pathways, until such time that there is a reasonable level of certainty that they are performing in a consistent manner. To allow for direct comparison between subsequent years of monitoring, it is critical that monitoring be completed in a consistent manner, which includes thorough documentation. The key requirements for consistent monitoring data collection are outlined in the AMSRP and are summarized here. In particular, the geotechnical visual inspection includes the following: photographic documentation from consistent viewpoints; documentation of settlement, erosion, frost action, slumping or cracking, debris or other landfill contents exposure, re-establishment of vegetation, burrowing animal disturbance, staining/seepage, and/or water ponding; detailed notation of location, width and depth of observed features; and evaluation of whether observed features are increasing in severity or have stabilized over time. Soil and groundwater samples must be collected using standardized methods, analyzed using consistent methodology and for consistent parameters (including detection limit), and in the case of groundwater, with clear documentation regarding analysis for dissolved or total metals (and, for dissolved, filtered in the field or in the lab).

Recommended Phase 1 Exit Criteria are listed below for each of the site features being monitored. Note that monitoring data collected between 2005 and 2019 may also be used for evaluating meeting Phase 1 Exit Criteria.

To evaluate the monitored features on the basis of their identified failure modes, specific conditions have been identified that would be considered triggers for the need for corrective action. The triggers and their recommended corrective actions are discussed in Section 5.3 below.

5.1.2.1 Non-Hazardous Waste Landfills (East- and West-Camp and Beach)

Failure Mode: Debris Exposure Posing Potential Physical Hazard

Recommended Monitoring

- Complete the full geotechnical visual inspection of the landfill, as per the AMSRP, and evaluate geotechnical stability.
- Document any debris exposure, including type, angularity and other physical hazard risk-related issue.
- On the basis of the visual inspection, evaluate whether corrective actions are required and, if so, commence suitable corrective actions.
- Respond according to suggested Maintenance and Corrective Actions documented below as required.

Monitoring to Date:

- As discussed in Section 3.2 above, the Camp and Beach Landfills have been monitored visually during the years 2005 to 2010 inclusive, and the years 2012 and 2016.
- In the case of the Camp Landfill, areas of erosion, settlement, and exposed debris have been identified on both lobes of the Camp Landfill, although the observations have not indicated worsening conditions since their original identification in 2012. The extent of debris exposure was not evaluated to pose a physical hazard.
- In the case of the Beach Landfill, visual inspections have identified some localized areas of settlement and erosion, minor debris exposure, and seepage, which were considered insignificant in terms of performance. No worsening of the noted features has been observed.

Phase 1 Frequency:

- The recommended frequency is 15 years, on the basis of present-day generally stable conditions.

Phase I Exit Criteria:

- Landfills are observed to be geotechnically stable with no overall deterioration of observed features over 3 consecutive monitoring events.

Performance Against Phase 1 Exit Criteria to Date:

- Based on performance up until 2016, the Camp Landfill will be considered to have met Phase 1 Exit Criteria following one more monitoring event with no further deterioration of conditions.
- Based on performance up until 2016, the Beach Landfill is considered to have met Phase 1 Exit Criteria.

5.1.2.2 Tier II Soil Landfill

Failure Mode: Soil Exposure or Contaminant Migration Posing Potential Chemical Hazard

Recommended Monitoring:

- Complete the full geotechnical visual inspection of the landfill, as per the AMSRP, evaluate geotechnical stability.
- To evaluate risk related to potential loss of containment, for any significant observed erosional feature, record dimensions, particularly depth, and note whether the geomembrane is visible and/or is breached.
- Collect ground temperature data to record whether the Tier II soil and/or containment berms are still frozen. Replace thermistor batteries.
- On the basis of the visual inspection, evaluate potential corrective measures. If landfill containment has been breached based on the visual assessment, respond according to suggested corrective actions documented below.
- Collect soil and groundwater samples at the previous monitoring locations.
- If Tier II soil is suspected to be exposed within the landfill, collect soil sample at suspected exposure location(s) and document lateral extent.

- Evaluate soil according to HHERA benchmark values to determine if exposure poses a risk.
- As required based on results of soil sampling, consider need for corrective actions.

Monitoring to Date:

- As discussed in Section 3.2 above, the Tier II Soil Landfill has been monitored visually, thermally, and chemically during the years 2005 to 2010 inclusive, and the years 2012 and 2016.
- Visual inspections have identified localized areas of erosion, slumping, differential settlement, and cap material grain size sorting (potentially due to frost action), but no observed features have been documented as worsening.
- Ground temperature data from installed thermistors has indicated that that the landfill contents and containment berms have been consistently frozen (below 0 degrees Celsius) since 2007.
- Groundwater and adjacent soil sampling data have not indicated significant or consistent contaminant impacts in groundwater or soil; no soil sample concentrations have been detected above the HHERA benchmark values and no contaminant migration is suspected from the landfill.

Phase 1 Frequency:

- The recommended frequency is 15 years, on the basis of present-day generally stable conditions. However, it is recommended that ground temperature be downloaded from the thermistors and batteries be replaced every 5 years following the same monitoring frequency, with associated site visits, as for the PCB barriers (see below).

Phase I Exit Criteria:

- The landfill is observed to be geotechnically stable, with no overall deterioration of observed features over 3 consecutive monitoring events.
- The landfill contents and containment berms are observed to be consistently frozen as per design active layer depth for 3 consecutive monitoring events.
- No evidence of contaminant migration that may be definitively attributed to the landfill is observed over 3 consecutive monitoring events.

Performance Against Phase 1 Exit Criteria to Date:

- Based on performance up until 2016, the Tier II Soil Landfill has met all three Phase 1 Exit Criteria.

5.1.2.3 Airstrip Landfill

Failure Modes: Soil Exposure Posing Potential Chemical Hazard or Debris Exposure Posing Potential Physical Hazard

Recommended Monitoring:

- Complete the geotechnical visual inspection of the landfill, as per the AMSRP, evaluate geotechnical stability.
- Document significant geotechnical performance issues that may result in sufficient loss of containment to pose a chemical hazard (as defined under action level triggers below).
- Document significant debris exposure, including type, angularity and other physical hazard risk-related issue and evaluate from the perspective of posing a physical hazard.
- On the basis of the visual inspection, evaluate potential corrective measures, and respond according to the actions below.
- Collect soil and groundwater samples at the previous monitoring locations.
- Collect soil samples at the exposed location.
- Evaluate soil concentrations according to HHERA benchmark values to determine if exposure poses risk.
- As required based on results of soil sampling, consider need for corrective actions.

Monitoring to Date:

- As discussed in Section 3.1 above, the Airstrip Landfill has been monitored visually, and chemically during the years 2005 to 2010 inclusive, and the years 2012 and 2016.
- Visual inspections have recorded slumping, settlement and erosion along the steep west slope and exposed debris throughout the landfill. The exposed debris has not been evaluated to be a significant physical hazard, and the observed erosional features have not been observed to be worsening since their documentation in 2012.
- Soil and groundwater data collected downgradient of the landfill have not indicated contaminant migration from the landfill. No soil metal concentrations have been documented above the HHERA quantitative risk values for the Airstrip Landfill site area.
- PCB soil detected on the landfill surface in 2013 and removed in 2019 has been assumed to be residual impacts remaining from remediation, as the impacts were not associated with observed erosion penetrating into the landfill contents.

Phase 1 Frequency:

- The recommended frequency is 15 years, on the basis of present-day generally stable conditions.

Phase I Exit Criteria:

- The landfill is observed to be geotechnically stable, with no overall deterioration of observed features over 3 consecutive monitoring events.
- No evidence of contaminant levels in soils is detected at the landfill or immediately downgradient at concentrations that exceed the HHERA evaluation over 3 consecutive monitoring events.

Performance Against Phase 1 Exit Criteria to Date:

- Based on performance up until 2016, the Airstrip Landfill has met the contaminant level Phase I Exit Criteria and will have met Phase 1 Exit Criteria following one more monitoring event without further geotechnical performance degradation.

5.1.2.4 Furniture Dump PCB Barrier

Failure Mode: Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction)

Recommended Monitoring and Maintenance:

- Document volume of soil present and visually inspect barriers for integrity.
- Collect soil samples to assess PCB levels of soil and filter material for containerization requirements.
- Manually dig up soil accumulating within the funnel and gate section and place in containers.
- As required, within the gate section, replace all 1200 R filters, and cartridge gravel and granular activated carbon.
- Remove containerized soil and place within the PCB storage area. Label and add newly placed containers to inventory.

Monitoring and Maintenance to Date:

- As noted in Section 3.4, the Furniture Dump was monitored with soil sample collection and analysis in 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, and 2019.
- Soil volume within the barrier was recorded annually from 2006 to 2010 inclusive, with associated accumulated soil excavated. Incremental soil volume accumulation and soil removal was not completed from 2011 until 2019.
- The gate section was fully rebuilt with new materials in 2019.

- Soil sample results to date have been consistently above Tier II soil concentrations, and, in most cases, either above or approaching CEPA concentrations.

Phase 1 Frequency:

- The recommended monitoring frequency is 5 years on the basis that ongoing maintenance is required to remove the accumulating soil to maintain barrier function.

Phase I Exit Criteria:

- Soil collected from the barriers is consistently at Tier I level or below (including maximum concentration measured) for three consecutive monitoring events OR soil accumulating within the barrier collection area is consistently at or below 25% of the barrier holding capacity for three consecutive monitoring events.

Performance Against Phase 1 Exit Criteria to Date:

- Based on soil concentrations up until 2019, the Furniture Dump has not had one event to date that meets the soil concentration Phase I Exit Criteria, and insufficient data exists to document whether performance to date has met the barrier holding capacity Phase I Exit Criteria.

5.1.2.5 S1/S4 Beach PCB Barrier

Failure Mode: Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction)

Recommended Monitoring and Maintenance:

- Document volume of soil present and visually inspect barriers for integrity.
- Collect soil samples to assess PCB levels of soil and filter material for containerization requirements.
- Visually inspect for movement of remaining contaminated soil upgradient.
- Complete maintenance as per below.
- Manually dig up soil accumulating within the funnel and gate section and place in containers.
- As required, within the gate section, replace all 1200 R filters, and cartridge gravel and granular activated carbon.
- Remove containerized soil via helicopter slinging (as available, depending on site mobilization method) and place within the PCB storage area.

Monitoring and Maintenance to Date:

- As noted in Section 3.4, the S1/S4 Beach Barrier was monitored with soil sample collection and analysis in 2006, 2007, 2008, 2009, 2010, 2013, and 2019.
- Soil volume within the barrier was recorded annually from 2006 to 2010 inclusive, with associated accumulated soil excavated. Incremental soil volume accumulation was documented but without removal between 2011 and 2013, and between 2011 and 2019 when it was also removed.
- The gate section was fully rebuilt with new materials in 2019.
- Soil sample results to date have been consistently below Tier II soil concentrations, and, in all cases but two, also below Tier I soil concentrations.
- In 2019, prior to removing soil for rebuilding the barrier, the accumulated soil was noted to have exceeded the holding capacity and was compromising its function.

Phase 1 Frequency:

- The recommended monitoring frequency is 5 years on the basis that ongoing maintenance is required to remove the accumulating soil to maintain barrier function.

Phase I Exit Criteria:

- Soil collected from the barriers is consistently at Tier I level or below (including maximum concentration measured) for three consecutive monitoring events.
- Soil accumulating within the barrier collection area is consistently at or below 50% of the barrier holding capacity for three consecutive monitoring events. The holding capacity Phase 1 Exit Criteria is higher for the Beach Barrier due to the lower hazard ranking associated with its overtopping; there is a lower likelihood that overtopping soil will pose a regulatory infraction or chemical hazard. It is also at a location that will consistently receive migrating soil from overall upgradient erosion (including clean soil from remediated soil areas).
- The remaining upgradient soil impacts visibly stop moving (due to reaching a slightly flatter slope section, or possibly, due to self-armouring or some surficial vegetation establishment) for 3 consecutive monitoring events.

Performance Against Phase 1 Exit Criteria to Date:

- Based on monitoring to date, the Beach Barrier has met the first Phase I Exit Criteria related to soil concentrations. There is insufficient data to document whether the holding capacity and upgradient soil movement Exit Criteria have been met.

5.1.2.6 PCB Storage Area

Failure Mode: Inventory is not properly maintained or filed with Environment Canada (regulatory non-compliance)

Monitoring and Maintenance Requirements

- Establish PCB storage area consistent with regulatory requirements. Register (if not already completed), establish, and inspect the PCB storage area.
- Label all containers placed in the storage area, as per regulations.
- Develop and maintain inventory of containers within the facility. File with regulators as needed.
- Maintain the storage area as per regulations (kept locked, external signage in place, etc.).

Phase 1 Frequency:

- Monitor at each site visit.

Phase 1 Exit Criteria:

- No criteria - see below for overall site Phase I exit procedures.

5.1.2.7 Overall site

Data collection to support moving into Phase 2 monitoring:

- Document general site observations related to increases in erosion, water ponding, evidence of active layer changes (widespread slope movement), or increase in vegetation.
- Collect actual precipitation data for the monitoring period (previous five years) and compare actual precipitation data to benchmark values calculated during baseline and make observations related to observed performances, such as volume of soil accumulate in barrier in response to the precipitation experienced.

Overall Site Phase I Exit Criteria:

- When all site features have met their specific exit criteria and the identified specific exit criteria are still considered viable (i.e. there is a reasonable level of confidence that the features are performing and stable).

<u>Overall Site Phase I Exit Procedures</u>:

- If general site observations at close of Phase I exit criteria show there has been significant erosion on a site-wide, regional basis, collect additional imagery for documentation of end of Phase 1 conditions.
- Review performance of monitored features vis-à-vis weather during that monitoring time: Tier II landfill re temperatures, and all features re precipitation. As appropriate based on performance vs actual weather conditions, update weather benchmark values developed during baseline.
- As required, remove containerized PCB soil from PCB Storage Facility and consider overall closure of facility.

5.1.3 Phase 2 Monitoring

As a Site, Phase 2 monitoring would begin when all site features have met their respective conditions to exit Phase 1 monitoring. Because the Phase 1 Exit Criteria define generally stable conditions that have been observed over 15 years (and longer when considering the site monitoring completed since 2005), the recommended approach for Phase 2 monitoring is to implement an atypical weather-event based approach. The primary failure pathway for all of the monitored features is via water flow, either causing erosion or mobilizing contaminants, and at a much greater flow rate or volume than experienced at the site under climatic conditions to date. It is, therefore, recommended that monitoring be completed in response to precipitation events. In particular, monitoring would be initiated after the **moderate precipitation event**, as defined during the baseline monitoring program, and updated as deemed necessary at the close of Phase 1 monitoring. The recommendation for using a moderate precipitation event as the trigger to complete monitoring is due to the uncertainty with respect to performance to date against precipitation events; because no precipitation data and associated hydrologic impacts were incorporated into the design of earthworks and PCB barriers, it is recommended that a moderate precipitation event be, at least initially, used as the trigger to initiate Phase 2 monitoring. Depending on observed performance following a moderate event, the trigger level may warrant increasing to a high precipitation event.

5.1.3.1 Phase 2 Monitoring Implementation:

- On an annual basis, precipitation data is collected and reviewed in the fall (after freeze-up). It is assumed that the data collection and review would be completed in-house by CIRNAC. The data is reviewed and compared to the precipitation benchmark values. If the data indicates a moderate precipitation event (or worse) has occurred, then monitoring would be planned for the next summer.
- Monitoring would be completed to visually inspect the site features and compare them to the last monitoring visit during Phase 1. Depending on the length of time passed since the site was last visited, monitoring could be completed using one of two methods: remote visual inspection (as described in Appendix E), especially if the last visit was within five years; or site visual inspection. The completion of remote monitoring is dependent on whether the baseline work demonstrates that the barriers can be clearly seen.
- In the case of monitoring completed by site visual inspection, the recommended monitoring scope would also include the collection of soil and groundwater samples, downloading of ground temperature data and replacement of thermistor batteries, and barrier maintenance (digging out and containerizing accumulated soil and replacing filter materials).
- All data would be compared to Phase 1 information for trend analysis and to confirm that Phase 1 Exit Criteria are still being met. As noted above, depending on observed performance following a moderate precipitation event, consideration may be given to changing the Phase 2 monitoring trigger to a high precipitation event.
- Phase 2 monitoring would proceed until the individual features have met their respective Phase 2 Exit Criteria, as listed below. As with Phase 1, Phase 2 Exit Criteria are tied to the failure pathways for each site feature.
- Phase 2 overall site exit would include demobilization of containerized PCB soil and decommissioning of the PCB Storage Facility.
- The PCB barriers may be left in place once they cease to be needed. They do not pose a physical or chemical hazard by remaining in place.

5.1.3.2 Non-Hazardous Waste Landfills (East- and West-Camp and Beach)

Failure Mode:

- Debris Exposure Posing Potential Physical Hazard.

Phase 2 Exit Criteria:

- The landfill continues to be geotechnically stable after experiencing either two non-consecutive high precipitation events or one extreme precipitation event.

5.1.3.3 Tier II Soil Landfill

Failure Mode:

- Soil Exposure or Contaminant Migration Posing Potential Chemical Hazard.

Phase 2 Exit Criteria:

- The landfill continues to be geotechnically stable after experiencing either two non-consecutive high precipitation events or one extreme precipitation event.

5.1.3.4 Airstrip Landfill

Failure Modes:

- Soil Exposure Posing Potential Chemical Hazard.
- Debris Exposure Posing Potential Physical Hazard.

Phase 2 Exit Criteria:

- The landfill continues to be geotechnically stable after experiencing either two non-consecutive high precipitation events or one extreme precipitation event.

5.1.3.5 Furniture Dump PCB Barrier

Failure Mode:

- Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction).

Phase 2 Exit Criteria:

- Soil collected at the barrier remains at Tier I level or below (including maximum concentration measured) following two non-consecutive high or one extreme precipitation event.

5.1.3.6 S1/S4 Beach PCB Barrier

Failure Mode:

- Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction).

Phase 2 Exit Criteria:

- Remaining inaccessible soil impacts have not visibly moved and the soil collected at the barrier remains at Tier I level or below following two non-consecutive high or one extreme precipitation event, OR
- Remaining impacts have visibly moved down via a mass slope movement mechanism (such as large scale erosion, slumping, solifluction), been collected at the barrier, and concentrations within the barrier remain at or below Tier I level (i.e. concentrations sufficiently dispersed through movement).

5.1.3.7 PCB Storage Area

Failure Mode:

- Inventory is not properly maintained or filed with Environment Canada (regulatory non-compliance).

Phase 2 Exit Criteria:

- No criteria - see below for overall site Phase 2 exit procedures.

5.1.3.8 Overall site

Overall Site Phase 2 Exit Criteria:

- When all site features have met their specific Phase 2 Exit Criteria.

Overall Site Phase 2 Exit Procedures:

- As required, remove containerized PCB soil from PCB Storage Facility and ship south for disposal at a licensed facility.
- Officially close PCB storage facility with Environment Canada.

5.2 Surveillance/Monitoring Summary

Table 9 below summarizes the above-described Phase 1 and Phase 2 monitoring requirements.

Table 9: Summary of Phase 1 and Phase 2 Monitoring Requirements

Site Feature	Visual Inspection	Soil Sampling	Ground-water Sampling	Ground Temperature Collection	Maintenance	Climate Data Collection	Phase 1 Monitoring Frequency	Phase 1 Exit Criteria	Phase 2 Monitoring Frequency	Phase 2 Exit Criteria
Overall Site	x				• Inspect PCB storage area	x	5 years	• All individual features have met their respective Phase 1 Exit Criteria	Annually for Climate Data Collection	• All individual features have met their respective Phase 2 Exit Criteria
Camp and Beach Non-Hazardous Waste Landfills	x	-	-	-	-		15 years	• Geotechnically stable with no deterioration over 3 consecutive monitoring events.	Following moderate precipitation event	• Geotechnically stable after experiencing either two high, non-consecutive precipitation events or one extreme precipitation event.
Tier II Landfill	x	x	x	x	• Replace thermistor batteries		15 years (5 years for battery replacement, coincident with PCB barrier monitoring)	• Geotechnically stable with no deterioration over 3 consecutive monitoring events. • Contents and containment berms consistently frozen as per design for 3 consecutive monitoring events. • No evidence of contaminant migration over 3 consecutive monitoring events	Following moderate precipitation event	• Geotechnically stable after experiencing either two high, non-consecutive precipitation events or one extreme precipitation event.
Airstrip Landfill	x	x	x	-			15 years	• Geotechnically stable with no deterioration over 3 consecutive monitoring events • No evidence of contaminant levels in downgradient soils exceeding HHERA evaluation over 3 consecutive monitoring events.	Following moderate precipitation event	• Geotechnically stable after experiencing either two high, non-consecutive precipitation events or one extreme precipitation event.

Site Feature	Visual Inspection	Soil Sampling	Ground-water Sampling	Ground Temperature Collection	Maintenance	Climate Data Collection	Phase 1 Monitoring Frequency	Phase 1 Exit Criteria	Phase 2 Monitoring Frequency	Phase 2 Exit Criteria
Furniture Dump PCB Barrier	x	x	-	-	• Dig up and containerize soil. • Replace filter media		5 years	• Soil collected from the barrier consistently at Tier I or below for three consecutive monitoring events OR soil accumulating behind barrier consistently at or below 25% of the barrier holding capacity for three consecutive monitoring events.	Following moderate precipitation event	• Soil collected at the barrier remains at Tier I level or below (including maximum concentration measured) following two high non-consecutive or one extreme precipitation event.
S1/S4 Beach PCB Barrier	x	x	-	-	• Dig up and containerize soil. • Replace filter media		5 years	• Soil collected from the barrier is consistently at Tier I or below for three consecutive monitoring events. • Soil accumulating within the barrier collection area is consistently at or below 50% of the barrier holding capacity for three consecutive monitoring events. • Remaining upgradient soil impacts visibly stop moving for 3 consecutive monitoring events.	Following moderate precipitation event	• Remaining inaccessible soil impacts have not moved and the soil collected at the barrier remains at Tier I level or below following two high non-consecutive or one extreme precipitation event, OR. • Remaining impacts have moved down, been collected at the barrier, and concentrations within the barrier remain at or below Tier I level (i.e. concentrations sufficiently dispersed through movement).

5.3 Monitoring Performance Action Level Triggers

The recommended performance action level triggers discussed below are those for the identified failure modes in the FMEA. They have been developed to provide a specific, measurable means to identify when failure has occurred, and corrective action should be considered. For site features with more than one failure mode, the mode with a higher likelihood of occurrence is the one discussed below, as it will likely trigger a response in advance of the other failure mode(s).

5.3.1 Non-Hazardous Waste Landfills (East- and West-Camp and Beach)

Debris Exposure Posing Potential Physical Hazard: An excavation or hole in the ground is considered a significant safety hazard needing mitigation against entry or inadvertent falling into when it is greater than four feet or 1.2 m. To account for inability to accurately measure depth with the imagery, an angle of repose of 45 degrees could be assumed for the moist, loose sandy gravel cover material. This equates to a lateral surface opening radius of approximately 1.2 m or a rough opening size of 4.5 m^2. For the two non-hazardous waste landfills, the most likely failure mode is sinkhole development from differential settlement or piping leading to a roughly circular opening versus a linear one (which would be more of an erosional features). Thus, an approximate surface opening size of 4-5 m^2 could be used as a trigger to consider that an opening with likely debris exposure was sufficient to constitute a physical hazard in need of Level 2 monitoring. A second trigger could also be visual observation via remote sensing of protruding or exposed debris.

5.3.2 Tier II Soil Landfill

Soil Exposure or Contaminant Migration Posing Potential Chemical Hazard: The Tier II soil lies at 2.7 m depth below the landfill surface. The geomembrane is at 1.7 m below surface. The second failure mode in which there is a partial loss of containment sufficient to allow precipitation infiltration and facilitate contaminant migration out of the landfill is considered the more likely scenario for a Level 1 monitoring trigger. This type of failure would simultaneously also start to weaken the facility overall leading to a higher potential for the first failure mode of Tier II soil exposure within the landfill. Therefore, using the same considerations as above with respect to angle of repose of the cover material, but in consideration that failure at this landfill is more likely to be erosional (or slumping along the slope), a suggested trigger for Level 2 monitoring is an opening of approximately 1.2 m width visible via remote sensing.

5.3.3 Airstrip Landfill

Soil Exposure Posing Potential Chemical Hazard: AECOM has tracked the percentages of waste and soil types derived from landfill excavations for all of the DND DEW Line Sites as well as many of the CIRNAC northern military sites. Average values from this data are typically used for design estimates for landfill excavations. These same values may be used as an estimate of the areal extent of severely eroded or slumped landfill that might yield exposure of Tier II level soil. Using the Tier II contaminant level estimates are considered conservative in the case of remote monitoring, recognizing that the HHERA has demonstrated that the Tier II concentrations of most DCC metals do not pose an environmental or human health risk. The average Tier II soil percentage derived from the excavation of existing dumps/landfills is 20%. The implication for likelihood of contaminated soil presence due to significant loss of containment within the landfill is that approximately 20%of the landfill surface would need to be disturbed, or an area of roughly 780 m^2.

Debris Exposure Posing Potential Physical Hazard: The typical percentage of debris that is derived from existing dump/landfill excavations is also 20%, thus, a physical hazard risk at the existing Airstrip Landfill may also be considered as a risk if an area approximately 20% of the overall landfill surface area becomes exposed.

5.3.4 PCB Barriers

Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction): Any evidence of soil having visibly overtopped or been transported around the barriers is the clear trigger. In addition, a barrier having visibly breached or been damaged is also a trigger. In the case of monitoring potentially being done remotely, the trigger would be one of the barriers visibly at its capacity (i.e. soil accumulated to the top of the barrier).

5.3.5 Monitoring or Corrective Maintenance Response

If monitoring – either during Phase 1 or Phase 2 - indicate conditions approaching but not yet at an action level trigger or failure in need of correction action, then the recommended course of action would be to increase monitoring frequency. It should be noted that if an action level is approached during Phase 2 monitoring, a return to regularly scheduled monitoring events may be necessary.

If an action level trigger is exceeded, then corrective maintenance or actions is the appropriate response. Corrective maintenance can range from work that can be addressed by site inspection personnel during the on-site monitoring work, possibly with support from local contractors, up to higher level maintenance that would require dedicated mobilization of contractor personnel and equipment.

Table 10 below lists corrective maintenance options that may be implemented in response to action level exceedances of the key failure modes for each monitored feature. For each failure type, maintenance options are listed step-wise according to increasing cost and effort. Step 1 measures are those that are considered achievable during the monitoring site visit. Step 2 are items that may require a dedicated, short term, fly-in site visit once additional supplies are obtained. Step 3 are measures that would require a dedicated mobilization of contractor crew, with potential camp, heavy equipment, and the advance securing of necessary Water Licence and Land Use Permit/Quarry Permit.

In all cases of corrective maintenance, completed work must be clearly recorded, visually, and in writing. This is particularly necessary in cases requiring filing a Spill Report.

Table 10: Corrective Maintenance Options

Item	Step 1	Step 2	Step 3
Camp and Beach Non-Hazardous Waste Landfills: Sufficient Loss of Containment for Debris Exposure Posing Physical Hazard	Provide visual cue of hazard with any available site materials. • Cut off or flag protruding debris. • Manually fill/flatten abrupt settlement openings. • Place overtop of physical hazard and weigh down with rocks or manually placed soil any plywood or siding sheets that can be pulled from unused buildings and sufficiently secured from being blown away. Spray paint or flag rocks.	Place a dedicated barrier or marker of hazard presence. • Erect signage and snow fencing or some easily erected barrier around hazard. • Manually, or with equipment easily flown to site, pack down surrounding cover edges to provide gentle relief around opening.	Replace lost cover material. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum). • As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established). • Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.
Tier II Soil Landfill: Partial Loss of Containment Leading to Migration and Downgradient Chemical Hazard	Prevent further deterioration of geomembrane and loss of permafrost. • Manually remove angular cobbles and replace (from the sides of the eroded cover wall) some fine-grained material (or any available geotextile) over the geomembrane to protect it from further damage. • Following cushioning of geomembrane, manually shovel fill over the exposure to prevent further loss of frozen conditions due to albedo effect with black geomembrane and geotextile.	Fix geomembrane and overlying cushion material. • Weld patch onto damaged geomembrane or place layer of bentonite overtop of exposure. • Replacement geotextile overtop. • Place sand overtop of geotextile (fly in bags of monitoring well filter sand and bentonite). Note that the practicality of this would depend on the size of opening.	Replace lost cover material. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum). • As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established). • Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.

<table>
<tr><th>Item</th><th>Step 1</th><th>Step 2</th><th>Step 3</th></tr>
<tr><td>Tier II Soil Landfill:

Full Loss of Containment Leading to Soil Exposure Within Landfill</td><td colspan="2">There is unlikely to be any easy repairs to such a significant failure in these steps.</td><td>Repair:
• Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence).
• Mobilize, erect, and operate temporary camp.
• Mobilize equipment and contractor staff, including specialized geomembrane contractor.
• Repair geomembrane (weld patch, with remove of surrounding to sufficiently expose full breach).
• Develop borrow area(s) capable of providing bedding sand, well-graded sand and gravel cover (and possibly well-graded silt-sand and gravel if berms are also in need of repair). Extract borrow for repairs.
• Replace geotextile and bedding sand.
• As needed, replace and saturate as needed low-permeability berm material.
• Replace overlying cover.</td></tr>
<tr><td>Airstrip Landfill:

Sufficient Loss of Containment for Debris Exposure Posing Physical Hazard</td><td>Provide visual cue of hazard with any available site materials.
• Cut off or flag protruding debris.
• Manually flatten abrupt settlement openings.</td><td>Place a dedicated barrier or marker of hazard presence.
• Erect signage and snow fencing or some easily erected barrier around hazard.
• Manually, or with equipment easily flown to site, pack down surrounding cover edges to provide gentle relief around opening.</td><td>Replace lost cover material.
• Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum).
• As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established).
• Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.</td></tr>
<tr><td>Airstrip Landfill:

Sufficient Containment Loss for Exposed Soil or Migrated Soil Posing Chemical Hazard.</td><td>There is unlikely to be any actions that can be taken during a Level 2 monitoring site visit.</td><td>Place a temporary overlying cover.
• Place geomembrane, secured in place by rocks, overtop of exposed contaminated soil.</td><td>Replace lost cover material.
• Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum).
• As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established).
• Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.</td></tr>
<tr><td>Furniture Dump PCB Barrier:

CEPA Level Soil Migrates Beyond Barrier</td><td>• Manually dig up soil beyond the barrier to the extent possible and place in containers.
• Complete standard monitoring maintenance on the barriers.
• Make all possible barrier repairs if migration was due to a breach.</td><td>• Complete additional manual (or via equipment that can be flown in) excavation of soil beyond barrier with containerization, as possible.
• Complete all necessary barrier repairs.
• Move filled soil containers (sling via helicopter) from the barrier areas and place at the PCB storage facility.</td><td>Install new upgraded barriers with additional capacity and potentially additional engineering remedial design for potential source containment or cutting off migration potential towards barriers. This would require an intermediate step of significant subsurface investigation for source identification and assessment of potential for capture or isolation.
• Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence).
• Mobilize, erect, and operate temporary camp.
• Mobilize equipment and contractor staff,
• Remove or upgrade existing barriers, as appropriate, and install new remedial solutions.
• Demobilize from site, removing soil containers as wells.</td></tr>
</table>

Item	Step 1	Step 2	Step 3
Furniture Dump PCB Barrier: CEPA Level Soil Migrates Beyond Barrier into Ocean	This would be an emergency response situation with Step 2 proceeding during the same season. • Manually dig up soil beyond to the extent possible and place in containers. • Complete standard monitoring barrier maintenance. • Make all possible barrier repairs if migration was due to a breach. • Place spill collection materials (silt fence or curtain) along or near shoreline. • File Spill Report.	• Mobilize a contractor with equipment to site ASAP to complete additional repairs and soil removal. • Mobilize an engineering team to assess revised remedial options and prepare a remedial design for implementation ASAP. • Assess alternate, more permanent and secure remedial options, as per Step 3.	Install new upgraded barriers with additional capacity +/- additional engineering remedial design for potential source containment or cutting off migration potential towards barriers. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence). • Mobilize, erect, and operate temporary camp. • Mobilize equipment and contractor staff, • Remove or upgrade existing barriers, as appropriate, and install new remedial solutions. • Demobilize from site, removing soil containers as wells.
S1/S4 Beach Barrier: Tier I and Possibly Tier II soil is Released to Ocean	This would be an emergency response situation with Step 2 proceeding during the same season. • Manually dig up soil beyond to the extent possible and place in containers. • Complete standard monitoring barrier maintenance. • Make all possible barrier repairs if migration was due to a breach. • Place spill collection materials (silt fence or curtain) along or near shoreline. • File Spill Report.	• Mobilize a contractor with equipment to site ASAP to complete additional repairs and soil removal. • Mobilize an engineering team to assess remedial options and prepare a remedial design for implementation ASAP. • Assess potential need for alternate, more permanent and secure remedial options, as per Step 3 above.	Install new upgraded barriers with additional capacity +/- additional engineering remedial design for potential source containment or cutting off migration potential towards barriers. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence). • Mobilize, erect, and operate temporary camp. • Mobilize equipment and contractor staff, • Remove or upgrade existing barriers, as appropriate, and install remedial solutions. • Demobilize from site, removing soil containers as well.

6. Summary and Conclusions

Remediation at Resolution Island was completed in 2005, and monitoring has been conducted since that time. Additional maintenance assessment was completed at the site in 2013, with a follow-up HHERA, to assess some noted deficiencies identified during monitoring. Notably, the identified deficiencies related to the extent of remediation originally completed, and not necessarily the performance of the remediated features. The HHERA identified that, from a chemical contaminant perspective, the DCC criteria to which the site had been originally remediated were generally very conservative due to the remote nature of the site and its lack of receptors; the site is rarely visited by humans, especially for traditional land use activities, and there are little to no receptors in the form of vegetation or higher trophic level populations. In the absence of receptors, the evaluated risk level using an FMEA evaluation method is moderate at the highest level for landfills and moderately high for PCB barriers, the latter of which is primarily tied to regulatory compliance.

Monitoring data since 2005 has shown the landfills to be generally stable, geotechnically. The Tier II Soil Landfill is considered very stable, with contents that have been frozen since shortly after its construction. The geotechnical observations related to containment deficiencies at the Camp Landfill and the Airstrip Landfill appear stable. No concerning trends with respect to increasing soil or groundwater contaminant levels have been observed or measured. The Tier II Soil Landfill and the Beach Landfill have, as of the last monitoring event in 2016, met their respective Phase 1 Exit Criteria. The Camp Landfill and Airstrip Landfill will have met their Phase 1 Exit Criteria if they remain geotechnically stable after one more monitoring event.

The only site features that are still subject to consistent change in conditions are the PCB barriers. While it is encouraging that the S1/S4 Valley Barrier could be removed and monitoring discontinued as of 2019, the continued presence of CEPA level soil in the Furniture Dump Barrier, with no identified source, is a major risk to the project which makes the timing of monitoring completion and site exit completely uncertain. Based on the estimated volume of remaining CEPA and Tier II soil upgradient, the S1/S4 Beach Barrier does not have sufficient capacity to collect all of the soil in the event of slope mass wasting, a geotechnical occurrence that is considered a higher likelihood under climate change. This is particularly the case when the barrier presently gets regularly filled up by movement of soil from upgradient in the previously remediated area, due, presumably to that area not being sufficiently stabilized post excavation. On that basis, the length of time for continued monitoring and maintenance also cannot be ascertained at the Beach Barrier.

The typical post-remediation schedule under the DLCU protocol and the AMSRP specify two phases of monitoring: typical AMSRP Phase 1 occurs for the first five years post-remediation and is completed on an annual basis for Tier II landfills which have the most stringent monitoring frequency requirements. Following year 5, AMSRP Phase 2 monitoring commences with an increasing frequency of years 7, 10, 15, and 25. The two phases with different monitoring frequencies are defined to account for achieving generally stable conditions. Earthworks, and especially the Tier II landfills designed for permafrost containment, are fairly predictably stable after five years following construction/remediation; this is the rationale for the Phase 1 specific timeframe identified under the protocols. Significant changes after five years are typically due to irregular weather events or regional changes in climate. Resolution Island has been monitored to date, since 2005, using the standard AMSRP schedule approach. As expected, the landfills are generally stable.

The two phases of monitoring proposed herein for the Resolution Island OMS Plan are consistent with the existing AMSRP procedure of implementing regular monitoring at the site until conditions have generally stabilized. However, the Phase definitions – especially Phase 1 - have required significant modification for use at Resolution Island to account for the inherent uncertainty associated with the PCB barriers achieving stable conditions, which they have not yet done after 14 years of monitoring. The proposed method, using Phase I exit criteria, is intended to address that uncertainty. The proposed frequency of landfill monitoring during the Resolution Island extended Phase 1 program has been increased to be somewhat consistent with the frequency under which they would be monitored under the typical AMSRP program. From administrative and logistical perspectives, the proposed end of Resolution Island Phase 1 monitoring will be when all monitored site features have been documented to be stable, as per their Phase 1 Exit Criteria.

The monitoring program under the DLCU protocol and the AMSRP do not presently include exit criteria, although this is a recommended practice under the Federal Contaminated Sites Action Plan (FSCAP) program. The selection of Phase 2 Exit Criteria tied to precipitation events is consistent with the primary failure pathway for all site features; however, there are considerable challenges in selecting appropriate precipitation events to use for remedial measures that were not designed to meet specific precipitation events. Because of the challenges in developing such definitions, it is recommended that their appropriateness be periodically checked, particularly as they relate to climate change predictions.

The primary monitoring requirements for all of the remaining site features are visual assessment. Assuming that baseline imagery demonstrates that there is sufficient resolution to clearly see the PCB barriers, on-site monitoring could be substituted for remote monitoring via satellite imagery for some, if not all of the program. This is particularly the case for Phase 2 monitoring. A cost comparison of the traditional versus remote methods has been provided in Appendix F (using present-day costs). Regardless of the use of traditional site versus remote monitoring, the exit criteria for both Phases require at least one site visit each to confirm the criteria have been met.

7. References

AECOM Canada Ltd. (AECOM). 2014. BAF-5, Resolution Island Maintenance Assessment Report.

AECOM Canada Ltd. (AECOM). 2016. Resolution Island, BAF-5 2016 Monitoring Report.

AECOM Canada Ltd. (AECOM). 2017. BAF-5, Resolution Island, Nunavut: Problem Formulation with Human Health and Ecological Risk Assessment.

AECOM Canada Ltd. (AECOM). 2020. BAF-5, Resolution Island Site Remediation 2019 Construction Summary Report.

Analytical Services Unit (ASU). 2003. Resolution Island Project Description and New Remediation Plan, Revision 1. Analytical Services Unit, Queen's University, Kingston, ON.

Analytical Services Unit (ASU). 2019. Resolution Island 2019 Operation, Maintenance, and Surveillance of the PCB Barriers. Analytical Services Unit, Queen's University, Kingston, ON.

Environment Canada. 1999. The Ecological Framework of Canada: Norther Arctic Ecozone. http://ecozones.ca/english/region/28.html. Accessed April 2020.

ESG (Environmental Sciences Group). 1994. Environmental Study of a Military Installation at Resolution Island BAF-5. Environmental Sciences Group, Royal Roads Military College, Victoria, BC.

ESG (Environmental Sciences Group) and Franz Environmental Inc., 2013. FSCAP Long Term Monitoring Planning Guidance.

FCSAP (Federal Contaminated Sites Action Plan), 2012. Guidance for Site Closure Tools for Federal Contaminated Sites.

Geological Survey of Canada and Canada-Nunavut Geoscience Office. 2006a. Geology of Nunavut (map). https://m.cngo.ca/wp-content/uploads/geology_of_nunavut.pdf. Accessed April 2020.

Geological Survey of Canada and Canada-Nunavut Geoscience Office. 2006b. Surficial Materials of Nunavut (map). https://m.cngo.ca/wp-content/uploads/surficial_materials_of_nunavut.pdf. Access April 2020.

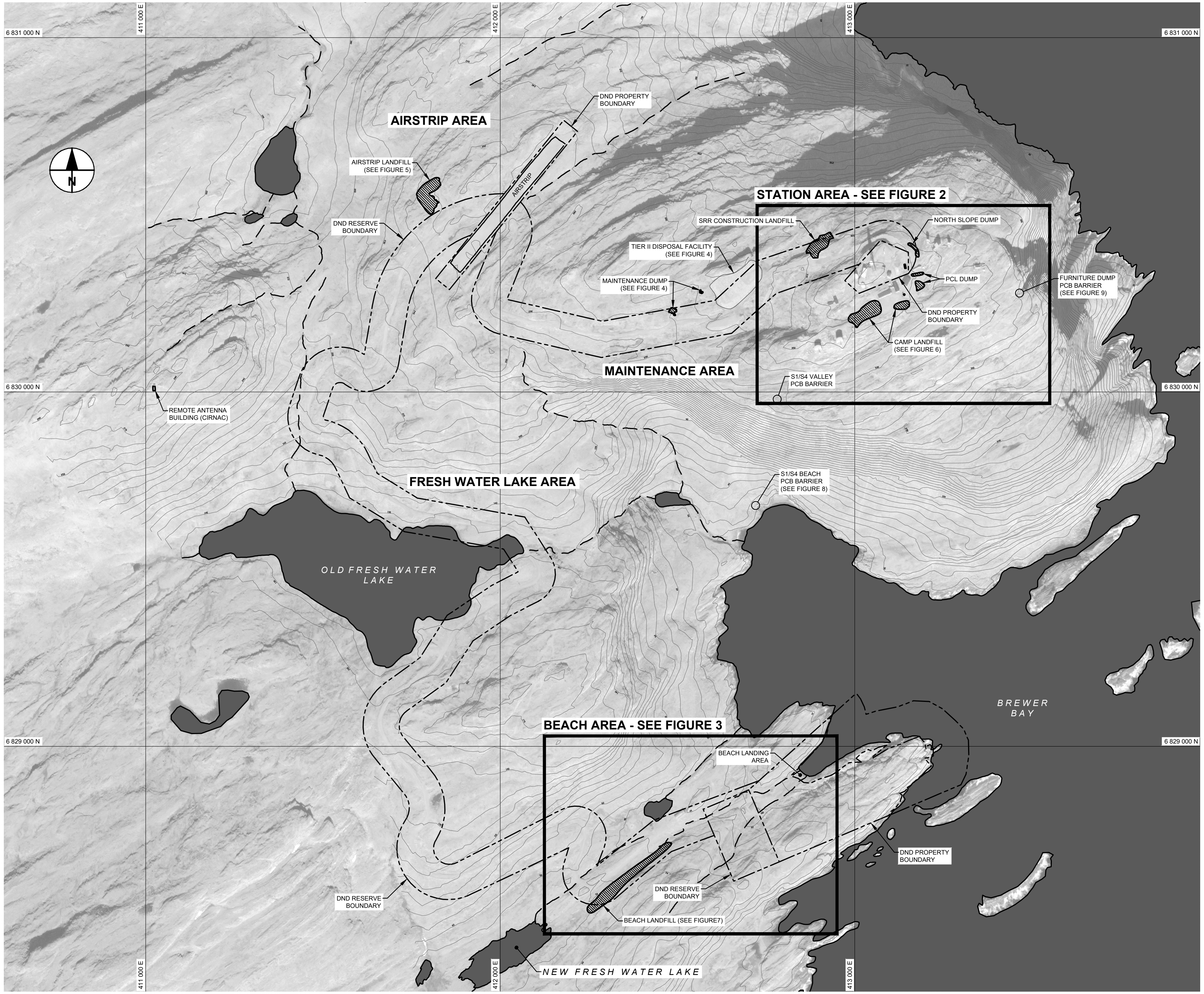
Indian and Northern Affairs Canada (INAC). 2008. Abandoned Military Site Remediation Protocol: Volume I – Main Report and Volume 2 – Technical Supporting Documentation.

Jacques Whitford Limited. 2006. Human Health and Ecological Risk Assessment for a Former Navigational Aid and Weather Station Located at Radio Island, Nunavut. Prepared for Public Services and Government Services Canada.

LePage, D., D.N. Nettleship, and A. Reed. 1998. Birds of Bylot Island and Adjacent Baffin Island, Northwest Territories, Canada, 1979 to 1997. Arctic 52: 125-141.

Appendix A

Figures



KEY PLAN

SCALE: NTS

GENERAL NOTES:

1. ALL COORDINATES ARE REFERENCED TO NAD83 (CSRS), UTM ZONE 20N. ALL ELEVATIONS REFER TO GEODETIC DATUM.
2. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
3. CONTOUR INTERVAL IS 10 m.

LEGEND:

—·—·—	APPROXIMATE LOCATION OF PROPERTY BOUNDARIES
(hatched shape)	EXISTING LANDFILL / DUMP
— — — —	DRAINAGE

0 312.5 625 m

1:12500

Issue Status: FINAL

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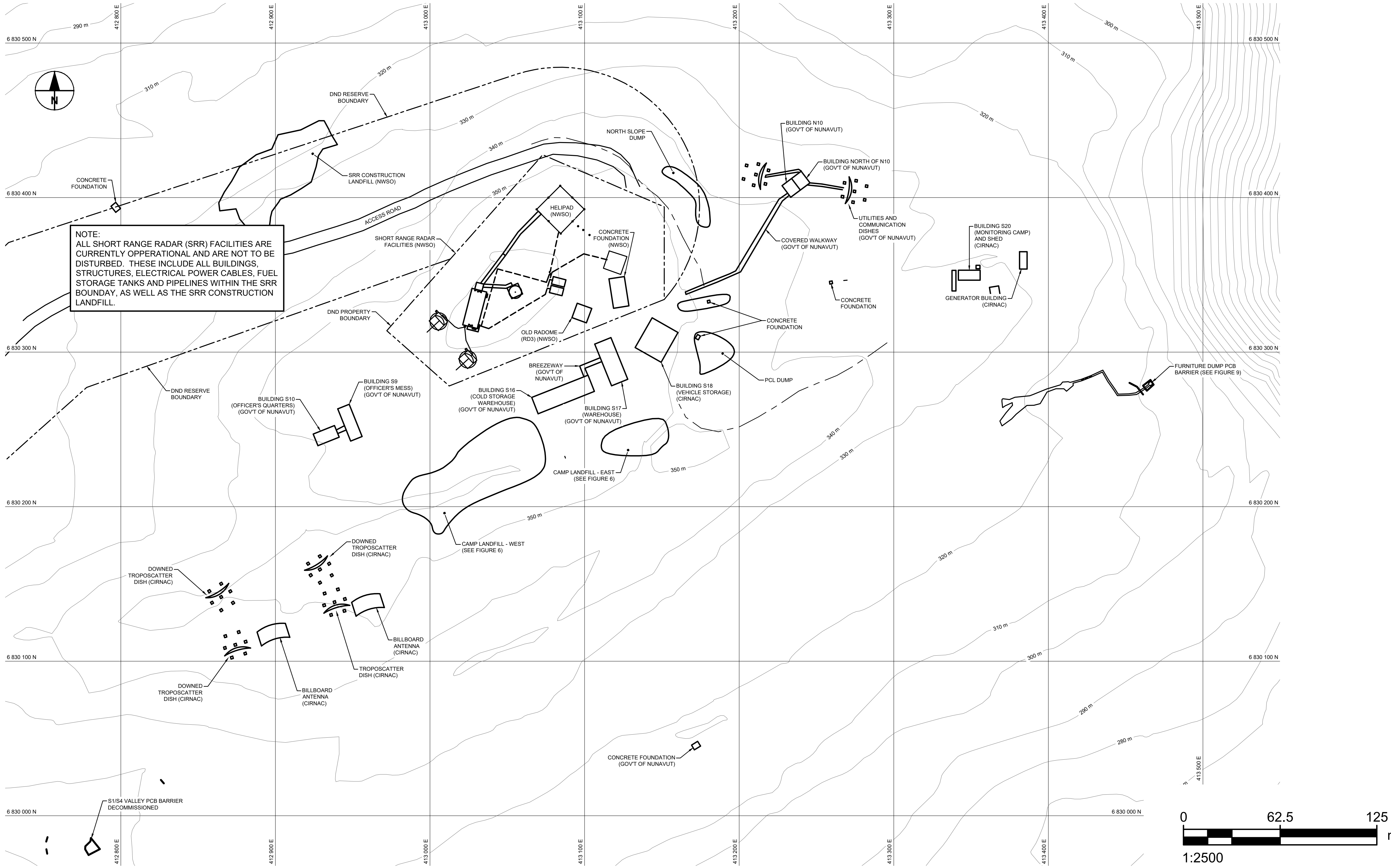
Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

SITE OVERVIEW

AECOM

Figure 1



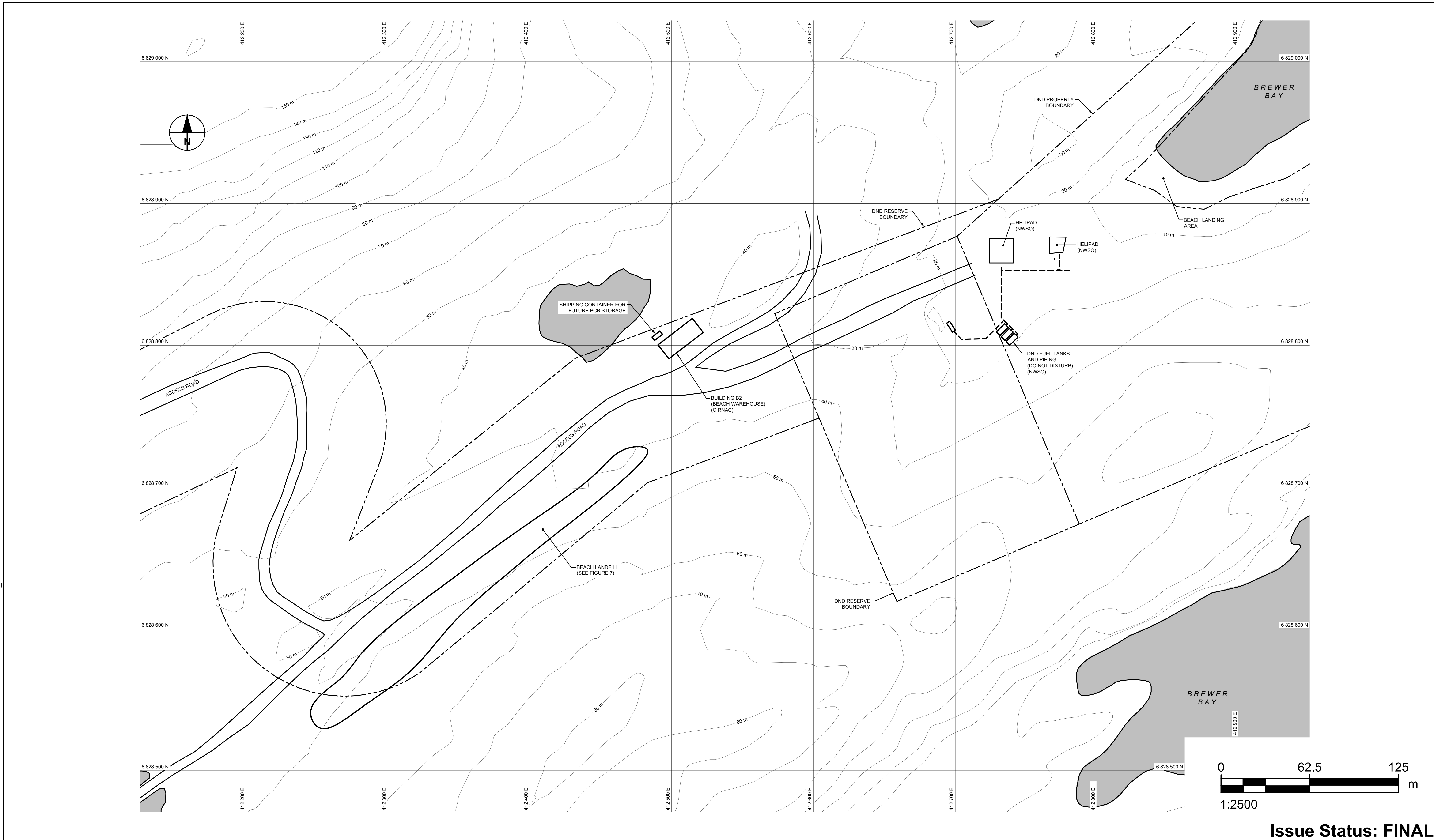
Issue Status: FINAL

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

UPPER SITE
STATION AREA OVERVIEW

AECOM

Figure 2



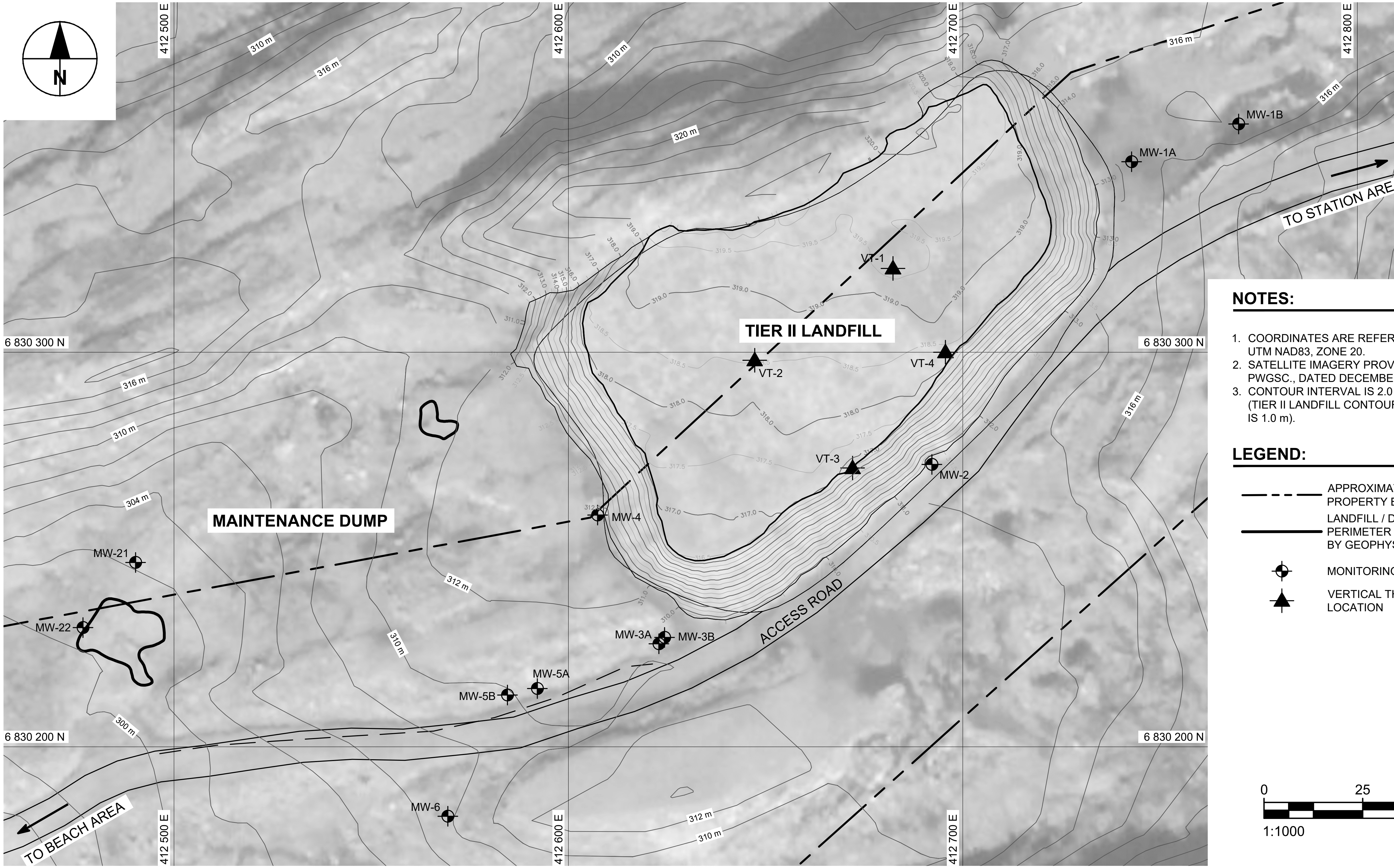
Issue Status: FINAL

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

LOWER BEACH AREA OVERVIEW

AECOM

Figure 3



NOTES:

1. COORDINATES ARE REFERENCED TO UTM NAD83, ZONE 20.
2. SATELLITE IMAGERY PROVIDED BY PWGSC., DATED DECEMBER 05, 2013.
3. CONTOUR INTERVAL IS 2.0 m. (TIER II LANDFILL CONTOUR INTERVAL IS 1.0 m).

LEGEND:

- APPROXIMATE LOCATION OF PROPERTY BOUNDARIES
- LANDFILL / DUMP PERIMETER AS DETERMINED BY GEOPHYSICS
- MONITORING WELL LOCATION
- VERTICAL THERMISTOR LOCATION

0 25 50 m

1:1000

Issue Status: FINAL

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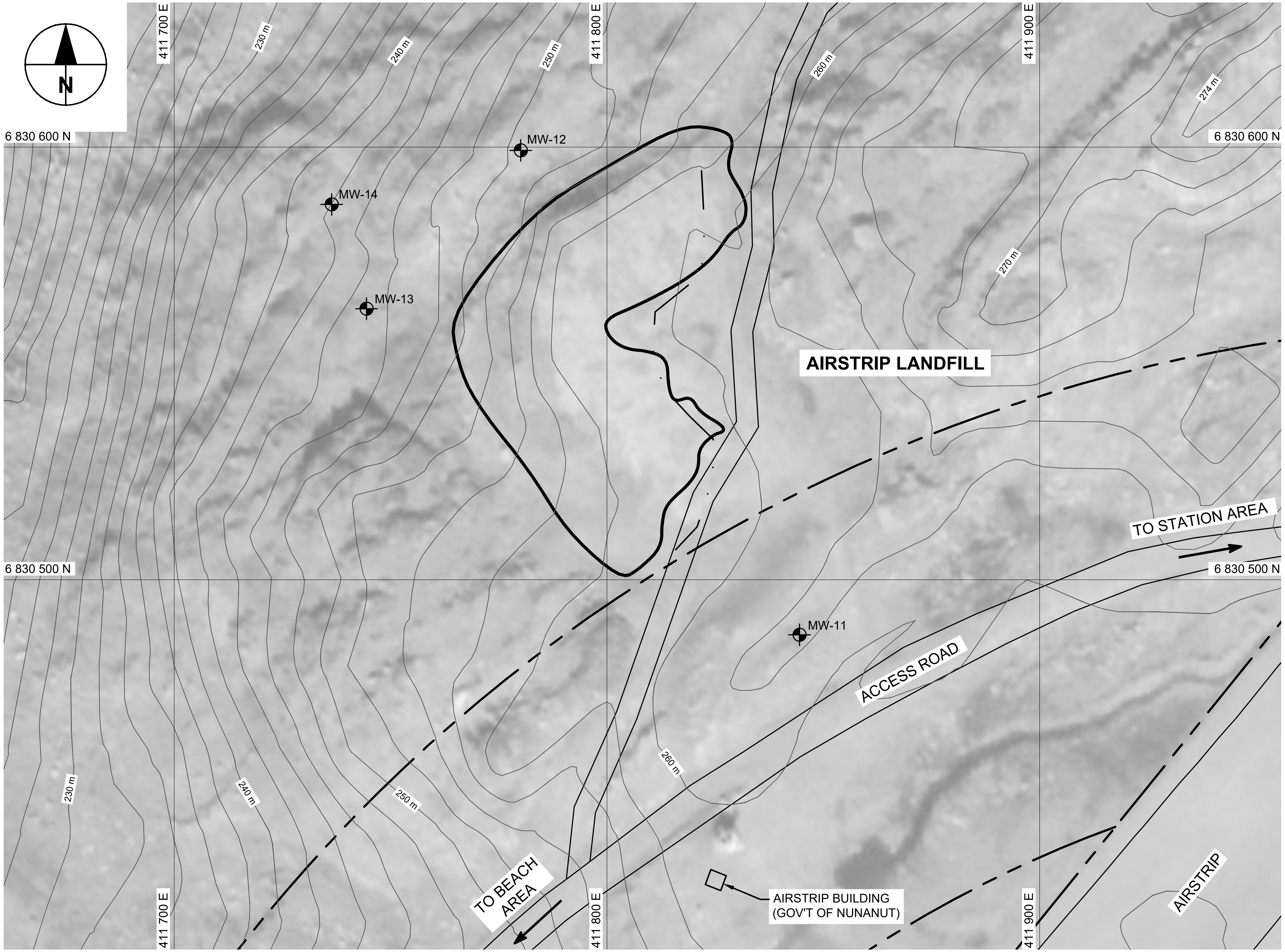
BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

MAINTENANCE DUMP AND TIER II LANDFILL

AECOM

Figure 4



NOTES:

1. COORDINATES ARE REFERENCED TO UTM NAD83, ZONE 20.
2. SATELLITE IMAGERY PROVIDED BY PWGSC., DATED DECEMBER 05, 2013.
3. CONTOUR INTERVAL IS 2.0 m.

LEGEND:

APPROXIMATE LOCATION OF PROPERTY BOUNDARIES

LANDFILL / DUMP PERIMETER AS DETERMINED BY GEOPHYSICS

MONITORING WELL LOCATION

0 25 50 m

1:1000

Issue Status: FINAL

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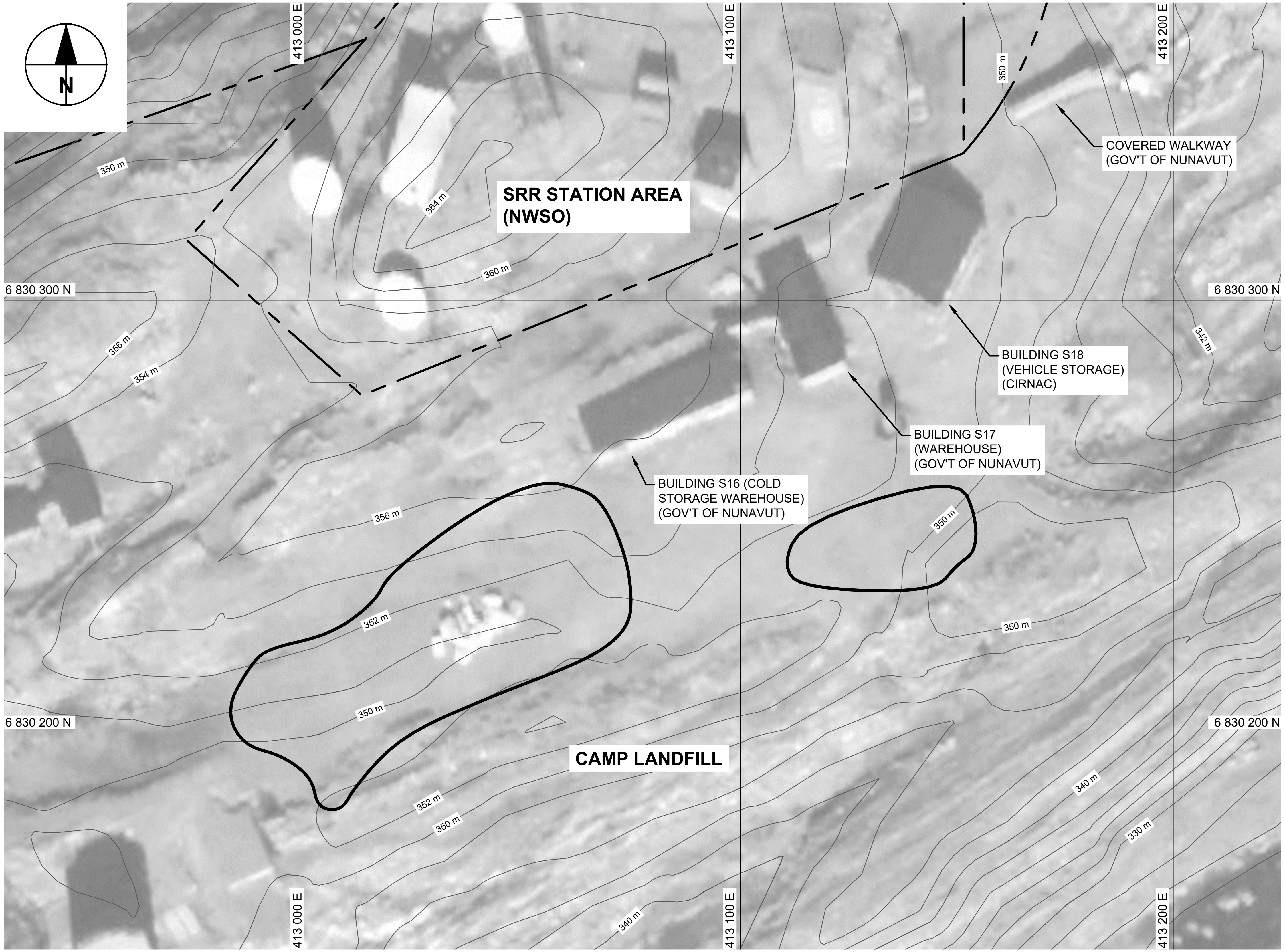
BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

AIRSTRIP LANDFILL

AECOM

Figure 5



NOTES:

1. COORDINATES ARE REFERENCED TO UTM NAD83, ZONE 20.
2. SATELLITE IMAGERY PROVIDED BY PWGSC., DATED DECEMBER 05, 2013.
3. CONTOUR INTERVAL IS 2.0 m.

LEGEND:

APPROXIMATE LOCATION OF PROPERTY BOUNDARIES

LANDFILL / DUMP PERIMETER AS DETERMINED BY GEOPHYSICS

0 25 50 m

1:1000

Issue Status: FINAL

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

CAMP LANDFILL

AECOM

Figure 6

ANSI B 279.4mm x 431.8mm
Approved:
Checked:
Designer:
Project Management Initials:
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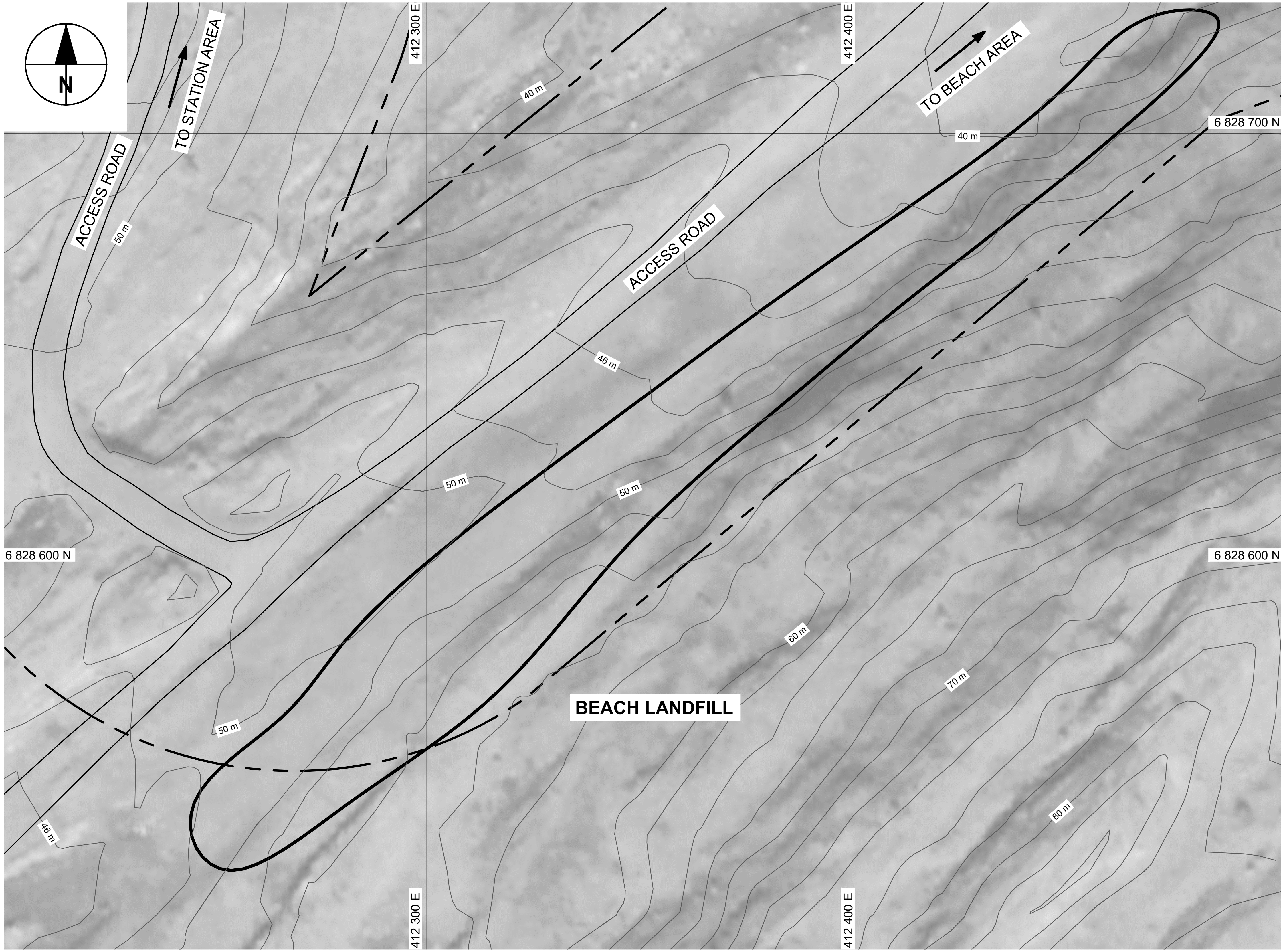

NOTES:

1. COORDINATES ARE REFERENCED TO UTM NAD83, ZONE 20.
2. SATELLITE IMAGERY PROVIDED BY PWGSC., DATED DECEMBER 05, 2013.
3. CONTOUR INTERVAL IS 2.0 m.

LEGEND:

APPROXIMATE LOCATION OF PROPERTY BOUNDARIES

LANDFILL / DUMP PERIMETER AS DETERMINED BY GEOPHYSICS

Issue Status: FINAL

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Project Management Initials: Designer: Checked: Approved: ANSI B 279.4mm x 431.8mm

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

BEACH LANDFILL

AECOM

Figure 7

NOTES:

1. COORDINATES ARE REFERENCED TO UTM NAD83, ZONE 20.
2. SATELLITE IMAGERY PROVIDED BY PWGSC, DATED DECEMBER 05, 2012.
3. CONTOUR INTERVAL IS 2.0 m.

LEGEND:

GABION BASKET

0 25 50 m
1:1000

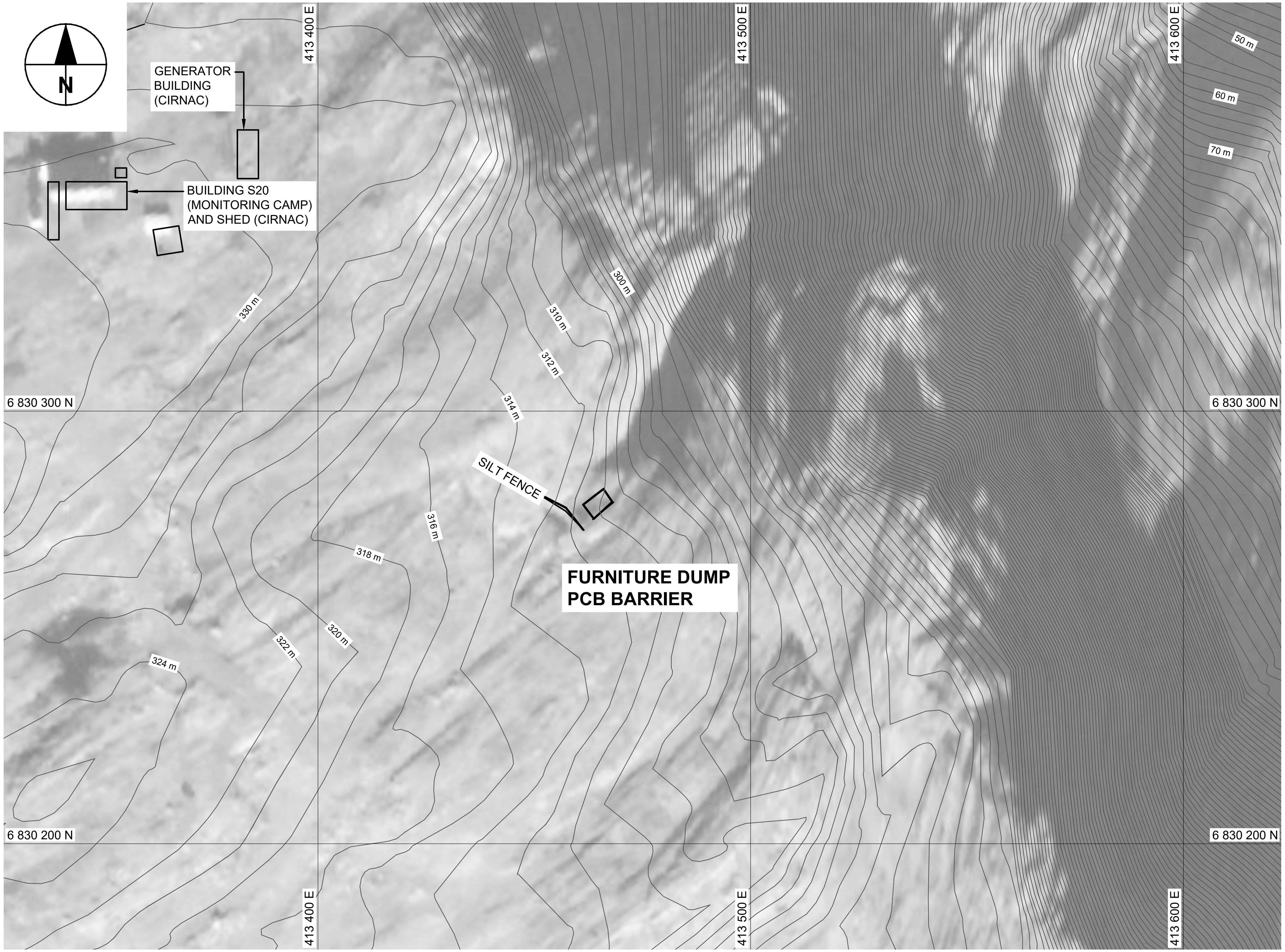
Issue Status: FINAL

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

S1/S4 BEACH PCB BARRIER

AECOM

Figure 8



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Issue Status: FINAL

BAF-5 - Resolution Island, NU
Operation, Maintenance and Surveillance Plan
Public Services and Procurement Canada
Project No.: 60579718 Date: 2021-02-19

FURNITURE DUMP PCB BARRIER

AECOM

Figure 9

ANSI B 279.4mm x 431.8mm
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Appendix B

Remaining Site Structure Photograph Log

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Generator Building	Resolution Island, NU	60579718

Photo No.	Date:	
1	02/09/2019	
Photo File Name: IMG_1484		
Description: Front View of the Generator Building (facing northeast)		

Photo No.	Date:	
2	02/09/2019	
Photo File Name: IMG_1488		
Description: Back View of the Generator Building (facing northwest)		

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Generator Building	Resolution Island, NU	60579718

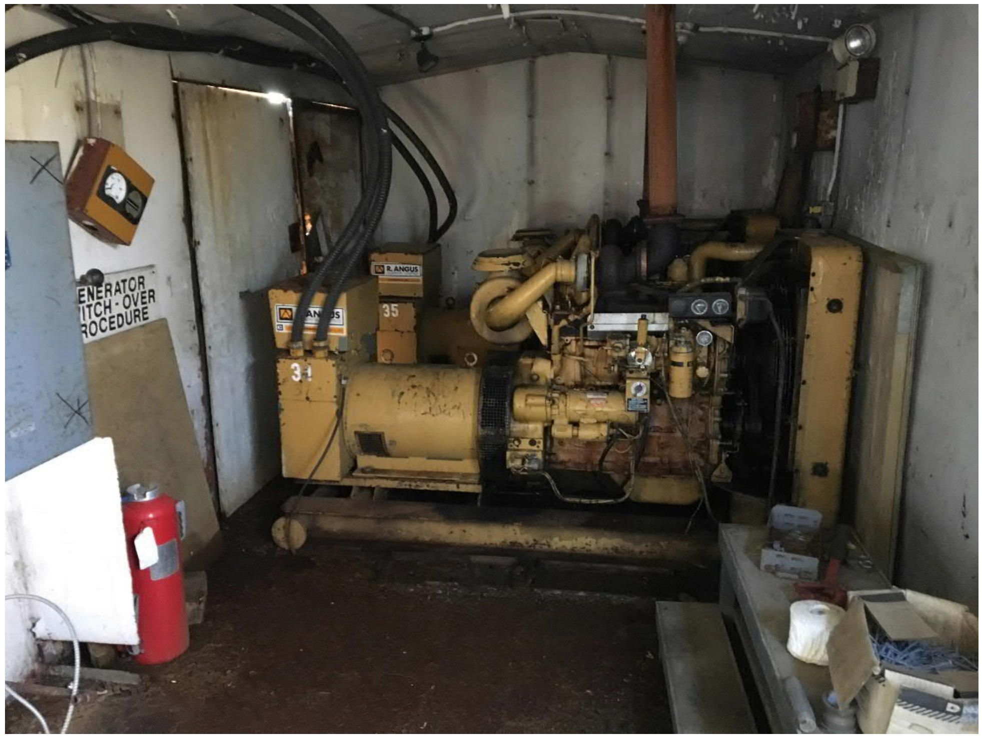
Photo No.	Date:	
3	02/09/2019	
Photo File Name: IMG_1491		
Description: Interior View of the Generator Building		

Photo No.	Date:	
4	02/09/2019	
Photo File Name: IMG_1492		
Description: Interior View of the Generator Building		

PHOTOGRAPHIC RECORD

AECOM Imagine it. Delivered.

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Monitoring Camp and Shed	Resolution Island, NU	60579718

Photo No.	Date:
5	02/09/2019

Photo File Name:

IMG_1468

Description:

Overview of Monitoring Camp

Photo No.	Date:
6	02/09/2019

Photo File Name:

IMG_1470

Description:

Exterior View of Monitoring Camp (facing north)

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Monitoring Camp and Shed	Resolution Island, NU	60579718

Photo No.	Date:
7	02/09/2019

Photo File Name:

IMG_1473

Description:

Exterior View of Monitoring Camp (facing northwest)

Photo No.	Date:
8	02/09/2019

Photo File Name:

IMG_1474

Description:

Monitoring Camp Shed (facing west)

PHOTOGRAPHIC RECORD

Site Name: BAF-5 CIRNAC Monitoring Camp and Shed	Site Location: Resolution Island, NU	Project No. 60579718

Photo No. 9 **Date:** 02/09/2019 **Photo File Name:** IMG_1476 **Description:** Exterior View of Monitoring Camp (facing south)	
Photo No. 10 **Date:** 02/09/2019 **Photo File Name:** IMG_1482 **Description:** Exterior View of Monitoring Camp (facing south)	

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Remote Antenna Building	Resolution Island, NU	60579718

Photo No.	Date:
11	02/09/2019

Photo File Name:

IMG_1550

Description:

Exterior View of Remote Antenna Building (facing northeast)

Photo No.	Date:
12	02/09/2019

Photo File Name:

IMG_1552

Description:

Exterior View of Remote Antenna Building (facing north)

PHOTOGRAPHIC RECORD

Site Name: BAF-5 CIRNAC Remote Antenna Building	Site Location: Resolution Island, NU	Project No. 60579718

Photo No.	Date:
13	02/09/2019

Photo File Name:

IMG_1553

Description:

Exterior View of Remote Antenna Building (facing south)

Photo No.	Date:
14	02/09/2019

Photo File Name:

IMG_1558

Description:

Interior View of Remote Antenna Building

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Remote Antenna Building	Resolution Island, NU	60579718

Photo No.	Date:
15	02/09/2019

Photo File Name:

IMG_1560

Description:

Interior View of Remote Antenna Building

Photo No.	Date:
16	02/09/2019

Photo File Name:

IMG_1556

Description:

Interior View of Remote Antenna Building

PHOTOGRAPHIC RECORD

AECOM Imagine it. Delivered.

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Remote Antenna Building	Resolution Island, NU	60579718

Photo No.	Date:
17	02/09/2019

Photo File Name:

IMG_1555

Description:

Interior View of Remote Antenna Building

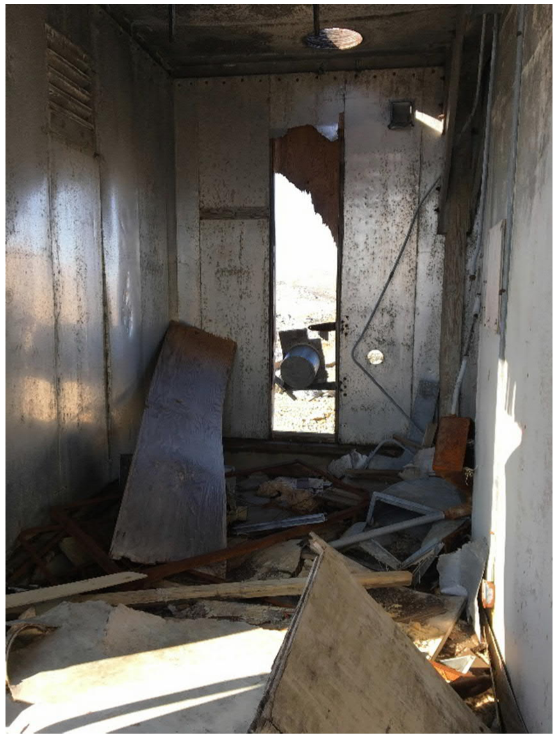


Photo No.	Date:
18	02/09/2019

Photo File Name:

IMG_1557

Description:

Interior View of Remote Antenna Building

PHOTOGRAPHIC RECORD

Site Name: BAF-5 CIRNAC Building S18	Site Location: Resolution Island, NU	Project No. 60579718

Photo No.	Date:
19	02/09/2019

Photo File Name:

IMG_1538

Description:

Exterior View of Building S18 (Vehicle Storage)

Photo No.	Date:
20	02/09/2019

Photo File Name:

IMG_1539

Description:

Exterior View of Building S18 (Vehicle Storage)

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Building S18	Resolution Island, NU	60579718

Photo No. 21 **Date:** 02/09/2019

Photo File Name:

IMG_1540

Description:

Exterior View of Building S18 (Vehicle Storage)

Photo No. 22 **Date:** 02/09/2019

Photo File Name:

IMG_1541

Description:

Interior View of Building S18 (Vehicle Storage)

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Building S18	Resolution Island, NU	60579718

Photo No.	Date:
23	02/09/2019

Photo File Name:

IMG_1542

Description:

Interior View of Building S18 (Vehicle Storage)

Photo No.	Date:
24	02/09/2019

Photo File Name:

IMG_1543

Description:

Interior View of Building S18 (Vehicle Storage)

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Building S18	Resolution Island, NU	60579718

Photo No.	Date:	
25	02/09/2019	
Photo File Name: IMG_1544		
Description: Interior View of Building S18 (Vehicle Storage)		

Photo No.	Date:	
26	02/09/2019	
Photo File Name: IMG_1545		
Description: Interior View of Building S18 (Vehicle Storage)		

PHOTOGRAPHIC RECORD

AECOM Imagine it. Delivered.

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Building S18	Resolution Island, NU	60579718

Photo No. 27 **Date:** 02/09/2019

Photo File Name:

IMG_1546

Description:

Interior View of Building S18 (Vehicle Storage)

Photo No. 28 **Date:** 02/09/2019

Photo File Name:

IMG_1548

Description:

Interior View of Building S18 (Vehicle Storage)

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Building S18	Resolution Island, NU	60579718

Photo No.	Date:
29	02/09/2019

Photo File Name:

IMG_1549

Description:

Interior View of Building S18 (Vehicle Storage)

Photo No.	Date:

Photo File Name:

Description:

PHOTOGRAPHIC RECORD		AECOM Imagine it. Delivered.
Site Name: BAF-5 CIRNAC Billboards, Projectors, and Circular Dishes	**Site Location:** Resolution Island, NU	**Project No.** 60579718

Photo No. 30	**Date:** 02/09/2019

Photo File Name:

IMG_1511

Description:

Facing North from Valley PRB Area

Photo No. 31	**Date:** 02/09/2019

Photo File Name:

IMG_1512

Description:

Troposcatter Dish Debris near Valley PRB Area

PHOTOGRAPHIC RECORD

Site Name: BAF-5 CIRNAC Billboards, Projectors, and Circular Dishes	Site Location: Resolution Island, NU	Project No. 60579718

Photo No.	Date:
33	02/09/2019

Photo File Name:

IMG_1516

Description:

Facing Southwest from Station Area

Photo No.	Date:
34	02/09/2019

Photo File Name:

IMG_1523

Description:

Downed Troposcatter Dish Debris (facing northeast)

PHOTOGRAPHIC RECORD

Site Name: BAF-5 CIRNAC Billboards, Projectors, and Circular Dishes	Site Location: Resolution Island, NU	Project No. 60579718

Photo No.	Date:
35	02/09/2019

Photo File Name:

IMG_1525

Description:

Downed Troposcatter Dish Debris (facing west)

Photo No.	Date:
36	02/09/2019

Photo File Name:

IMG_1536

Description:

Downed Troposcatter Dish Debris (facing southwest)

PHOTOGRAPHIC RECORD

Site Name:	Site Location:	Project No.
BAF-5 CIRNAC Beach Warehouse	Resolution Island, NU	60579718

Photo No.	Date:
37	02/09/2019

Photo File Name:

IMG_1577

Description:

Front View of the Beach Warehouse (facing northeast)

Photo No.	Date:
38	02/09/2019

Photo File Name:

IMG_1579

Description:

Back View of the Beach Warehouse (facing southwest)

PHOTOGRAPHIC RECORD

Site Name:		
BAF-5 CIRNAC Beach Warehouse		

Photo No.	Date:
39	02/09/2019

Photo File Name:

IMG_1581

Description:

Interior View of the Beach Warehouse (facing northeast)

Photo No.	Date:
40	02/09/2019

Photo File Name:

IMG_1587

Description:

Interior View of the Beach Warehouse (facing southwest)

Appendix C

Analytical Results Tables

Table C1: Maintenance Dump Historical Groundwater Analytical Results

Parameters	Units	Maintenance Dump															
		MW21								MW22							
		2005	2006	2007	2008	2009	2010	2012	2016	2005	2006	2007	2008	2009	2010	2012	2016
Metals																	
Dissolved Arsenic (As)	mg/L	<0.003	<0.003	<0.003	-	-	-	<0.0010	-	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.0010	0.00024
Dissolved Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	-	-	-	<0.00010	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00010	<0.000010
Dissolved Chromium (Cr)	mg/L	<0.005	0.13	<0.005	-	-	-	<0.0050	-	-	<0.005	0.00060	<0.005	<0.005	<0.005	<0.0050	0.0059
Dissolved Cobalt (Co)	mg/L	<0.003	<0.003	0.0040	-	-		0.011	-	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.0005	<0.00050
Dissolved Copper (Cu)	mg/L	<0.005	0.0063	<0.005	-	-	-	<0.0010	-	-	0.0060	<0.005	<0.005	<0.005	<0.005	<0.0010	0.00045
Dissolved Lead (Pb)	mg/L	<0.010	<0.010	<0.010	-	-	-	<0.00050	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.00050	<0.00020
Dissolved Nickel (Ni)	mg/L	<0.005	0.036	0.008	-	-	-	0.014	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	0.0016	<0.0010
Dissolved Zinc (Zn)	mg/L	<0.010	<0.010	<0.020	-	-	-	<0.0050	-	-	<0.010	<0.020	<0.010	<0.010	<0.010	<0.0050	<0.0050
Petroleum Hydrocarbons																	
BTEX & F1 Hydrocarbons																	
Benzene	mg/L	-	-	-	-	-	-	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
Toluene	mg/L	-	-	-	-	-	-	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
Ethylbenzene	mg/L	-	-	-	-	-	-	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
o-Xylene	mg/L	-	-	-	-	-	-	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
p+m-Xylene	mg/L	-	-	-	-	-	-	<0.00040	-	-	-	-	-	-	-	<0.00040	<0.00040
Total Xylenes	mg/L	-	-	-	-	-	-	<0.00040	-	-	-	-	-	-	-	<0.00040	<0.00040
F1 (C6-C10)	mg/L	-	-	-	-	-	-	<0.025	-	-	-	-	-	-	-	<0.025	<0.025
F1 (C6-C10) - BTEX	mg/L	-	-	-	-	-	-	<0.025	-	-	-	-	-	-	-	<0.025	<0.025
F2-F4 Hydrocarbons																	
F2 (C10-C16 Hydrocarbons)	mg/L	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	<0.1	<0.1
F3 (C16-C34 Hydrocarbons)	mg/L	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	<0.1	<0.2
F4 (C34-C50 Hydrocarbons)	mg/L	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	<0.1	<0.2
TPH (lube) - F2-F4	mg/L	-	<1.0	<1.0	-	-	-	<0.1	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<0.1	0.25
TPH (fuel) - F1	mg/L	-	<1.0	<1.0	-	-	-	<0.025	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<0.025	<0.025
TPH (total)		<1.0	1	1.00	-	-	-	<0.1	-	-	1.00	1.00	1.00	1.00	1.00	<0.1	0.3
Polychlorinated Biphenyls																	
Aroclor 1016	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1221	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1232	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1242	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1248	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1254	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1260	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1262	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1268	ug/L	-	-	-	-	-	-	<0.01	-	-	-	-	-	-	-	<0.01	0.02
Total PCB	ug/L	<0.020	<0.020	0.042	-	-	-	<0.01	-	-	<0.020	<0.020	0.024	0.079	<0.020	<0.01	0.02

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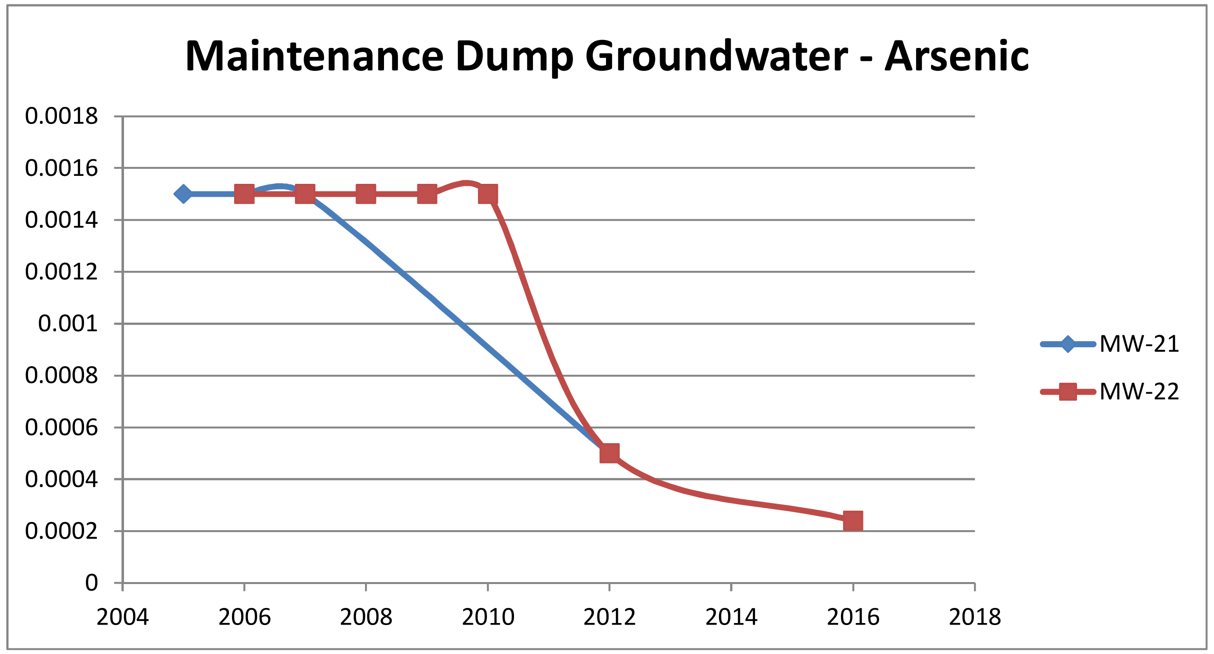
Table C2: Maintenance Dump Historical Soil Analytical Results

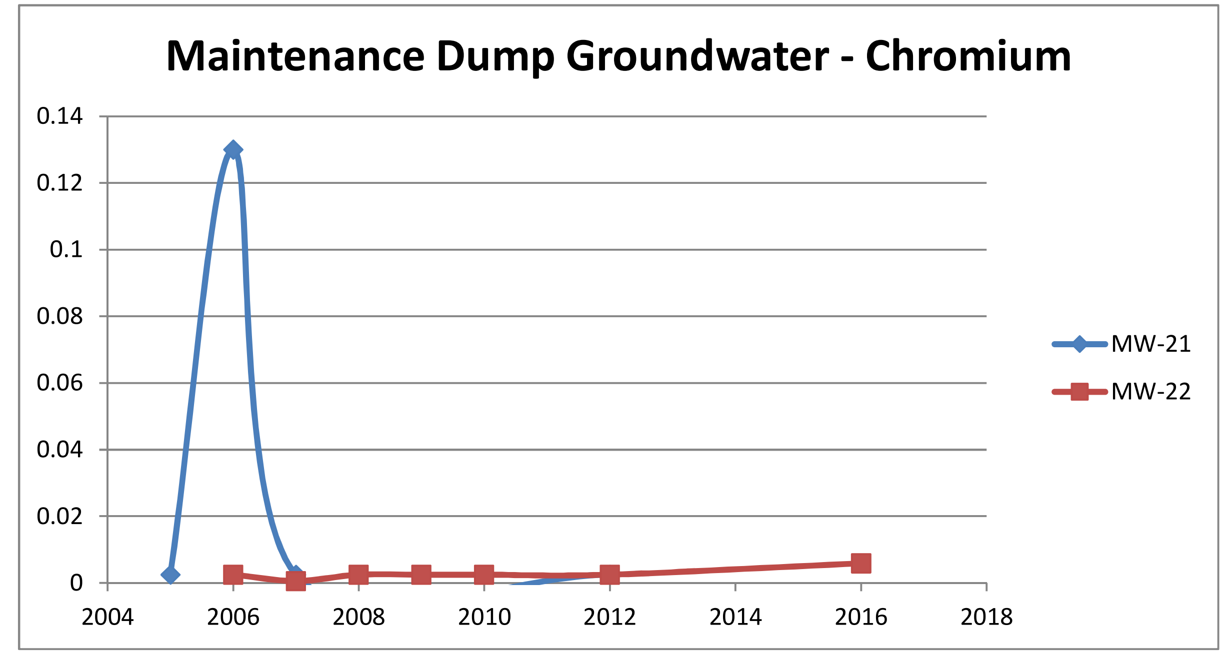
Parameters	Units	Maintenance Dump															
		MW21								MW22							
		2005	2006	2007	2008	2009	2010	2012	2016	2005	2006	2007	2008	2009	2010	2012	2016
Metals																	
Arsenic (As)	mg/kg	1.1	1.8	<1.0	1.2	<1.0	1	<1.0	1	<1.0	2	1	<1.0	<1.0	1.5	<1.0	1
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.105	0.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.28	0.4
Chromium (Cr)	mg/kg	47	38.5	38	46	39	39	38	48	41	43	51	45	54	43	33	46
Cobalt (Co)	mg/kg	15	14	13.3	17.5	14.2	16	17	21	23	27.5	15.6	415	37	26.7	24.5	46
Copper (Cu)	mg/kg	60	15.5	50	71	55	54.3	78	99	75	88.5	82	74	101	72.1	82.5	120
Lead (Pb)	mg/kg	<10	<10	<10	<10	<10	<10	4.6	5	13	12	<10	11	14	<10	12	15
Nickel (Ni)	mg/kg	72	66	60	84	69	67	92	120	79	82.5	78	86	100	73.15	83	120
Zinc (Zn)	mg/kg	105	84	74	91	93	116	96	110	211	200.5	120	223	216	180	190	240
Petroleum Hydrocarbons																	
BTEX & F1 Hydrocarbons																	
Benzene	mg/kg	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	<0.020	<0.0050
Toluene	mg/kg	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	<0.020	<0.020
Ethylbenzene	mg/kg	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	<0.020	<0.010
o-Xylene	mg/kg	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	<0.020	<0.020
p+m-Xylene	mg/kg	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	<0.040	<0.040
Total Xylenes	mg/kg	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	<0.040	<0.040
F1 (C6-C10)	mg/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<10	<10
F1 (C6-C10) - BTEX	mg/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<10	<10
F2-F4 Hydrocarbons																	
F2 (C10-C16 Hydrocarbons)	mg/kg	-	-	-	-	-	-	13.00	<10	-	-	-	-	-	-	<10	<10
F3 (C16-C34 Hydrocarbons)	mg/kg	-	-	-	-	-	-	25.50	<50	-	-	-	-	-	-	118.50	<50
F4 (C34-C50 Hydrocarbons)	mg/kg	-	-	-	-	-	-	16.00	<50	-	-	-	-	-	-	37.50	<50
TPH (lube) - F2-F4	mg/kg	-	<40	<40	<40	<40	163.00	54.50	55	-	<40	<40	<40	<40	<40	161.00	55
TPH (fuel) - F1	mg/kg	<40	<40	<40	<40	<40	<40	<10	<10	<40	<40	<40	<40	<40	<40	<10	<10
TPH (total)	mg/kg	<40	20	40	40	40	183.00	59.50	60	<40	20	20	20	20	20	166.00	60
Polychlorinated Biphenyls																	
Aroclor 1016	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Aroclor 1221	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Aroclor 1232	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Aroclor 1242	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Aroclor 1248	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Aroclor 1254	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<25
Aroclor 1260	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	49.50	20
Aroclor 1262	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Aroclor 1268	ug/kg	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	<20	<10
Total PCB	ug/kg	9	13.50	86.00	4.00	9.00	11.30	<10	<10	39	52.00	70.00	56.00	6.00	55.30	49.50	<25

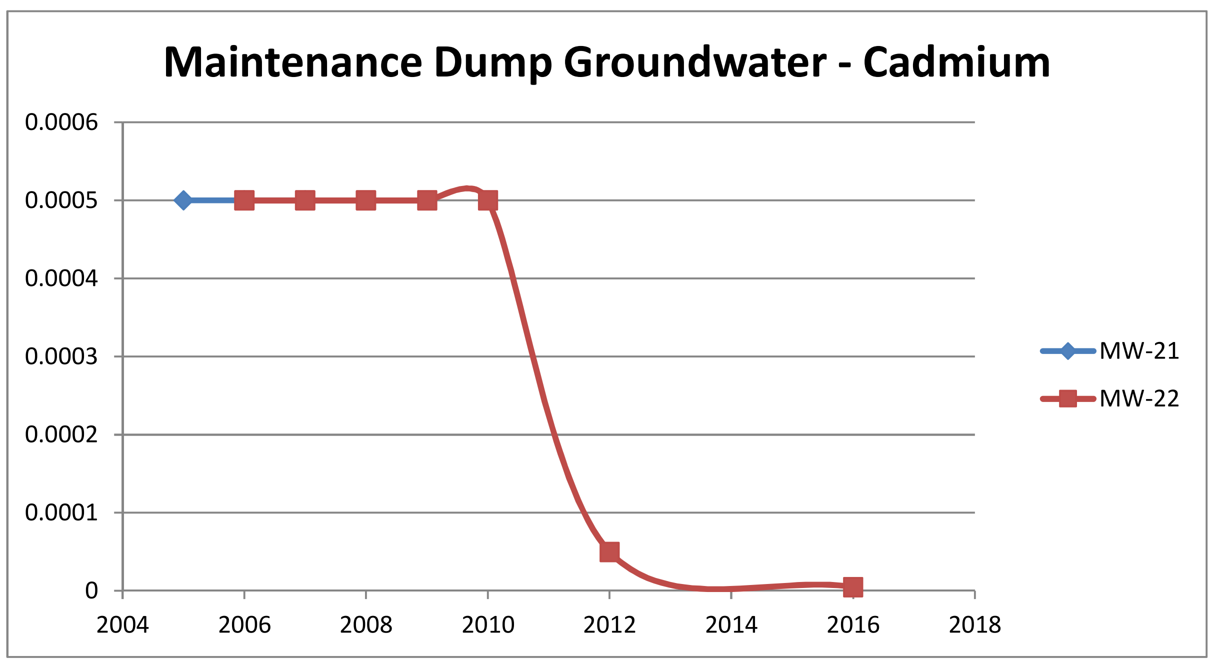
Table C3: Maintenance Dump Historical Groundwater Analytical Trends

Parameters	Units	Maintenance Dump															
		MW21								MW22							
		2005	2006	2007	2008	2009	2010	2012	2016	2005	2006	2007	2008	2009	2010	2012	2016
Metals																	
Dissolved Arsenic (As)	mg/L	0.0015	0.0015	0.0015	-	-	-	0.0005	-	-	0.0015	0.00150	0.00150	0.00150	0.00150	0.0005	0.00024
Dissolved Cadmium (Cd)	mg/L	0.0005	0.0005	0.0005	-	-	-	0.00005	-	-	0.00	0.00050	0.00050	0.00050	0.00050	0.00	0.000005
Dissolved Chromium (Cr)	mg/L	0.0025	0.13	0.00	-	-	-	0.0025	-	-	0.0025	0.00060	0.00250	0.00250	0.00250	0.00	0.0059
Dissolved Cobalt (Co)	mg/L	0.0015	0.0015	0.00	-	-	-	0.011	-	-	0.0015	0.00150	0.00150	0.00150	0.00150	0.00	0.0003
Dissolved Copper (Cu)	mg/L	0.0025	0.0063	0.00	-	-	-	0.0005	-	-	0.006	0.00250	0.00250	0.00250	0.00250	0.00	0.0005
Dissolved Lead (Pb)	mg/L	0.005	0.005	0.01	-	-	-	0.00025	-	-	0.005	0.00500	0.00500	0.00500	0.00500	0.00	0.0001
Dissolved Nickel (Ni)	mg/L	0.0025	0.036	0.01	-	-	-	0.014	-	-	0.0043	0.00250	0.00250	0.00250	0.00250	0.00	0.0005
Dissolved Zinc (Zn)	mg/L	0.005	0.005	0.01	-	-	-	0.0025	-	-	0.005	0.01000	0.00500	0.00500	0.00500	0.00	0.0025
Petroleum Hydrocarbons																	
BTEX & F1 Hydrocarbons																	
TPH (lube)	mg/L	-	<1.0	<1.0	-	-	-	0.15	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	0.15	0.25
TPH (fuel)	mg/L	-	<1.0	<1.0	-	-	-	<0.025	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	0.01	0.0015
TPH (total)	mg/L	0.5	1.00	1.00	-	-	-	0.16	-	-	1.00	1.00	1.00	1.00	1.00	0.16	0.3
Polychlorinated Biphenyls																	
Total PCB	ug/L	0.01	0.01	0.042	-	-	-	0.005	-	-	0.018	0.010	0.024	0.079	0.010	0.01	0.020

Table C4: Maintenance Dump Historical Groundwater Analytical Trend Graphs







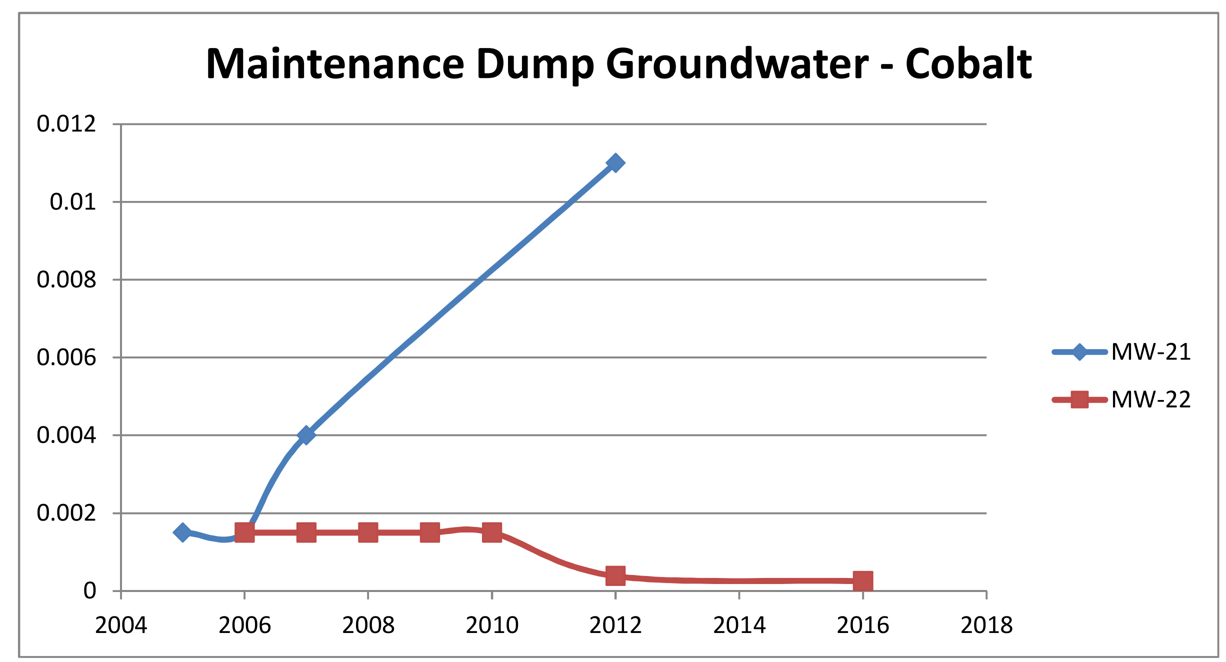
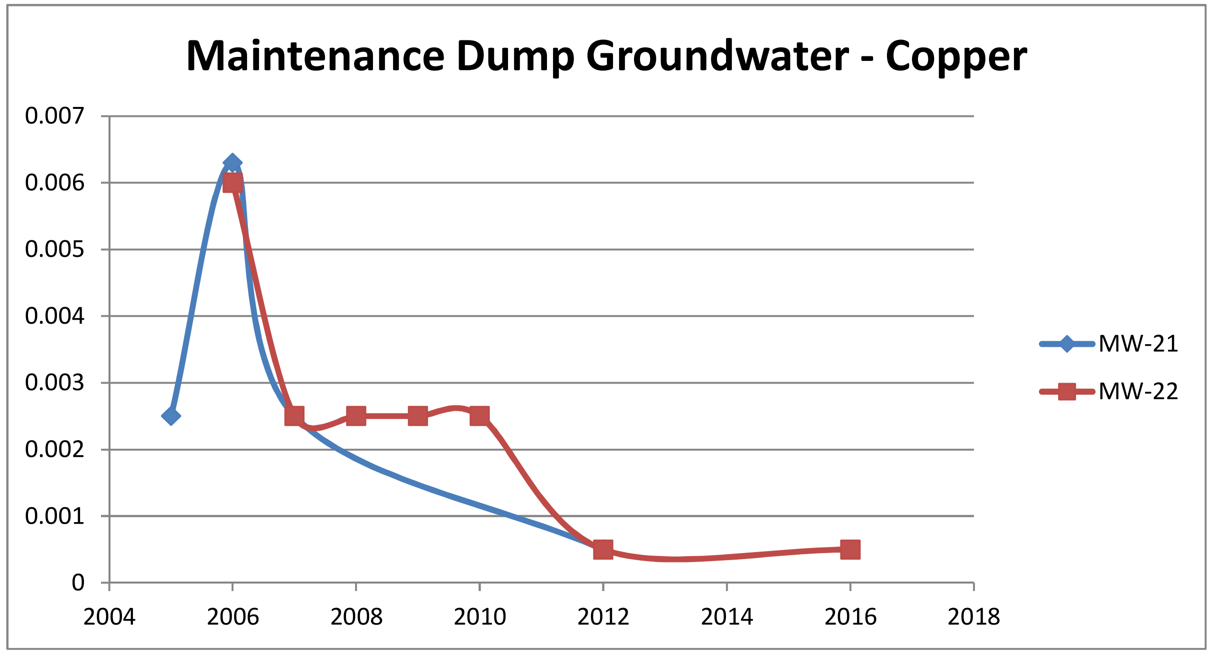
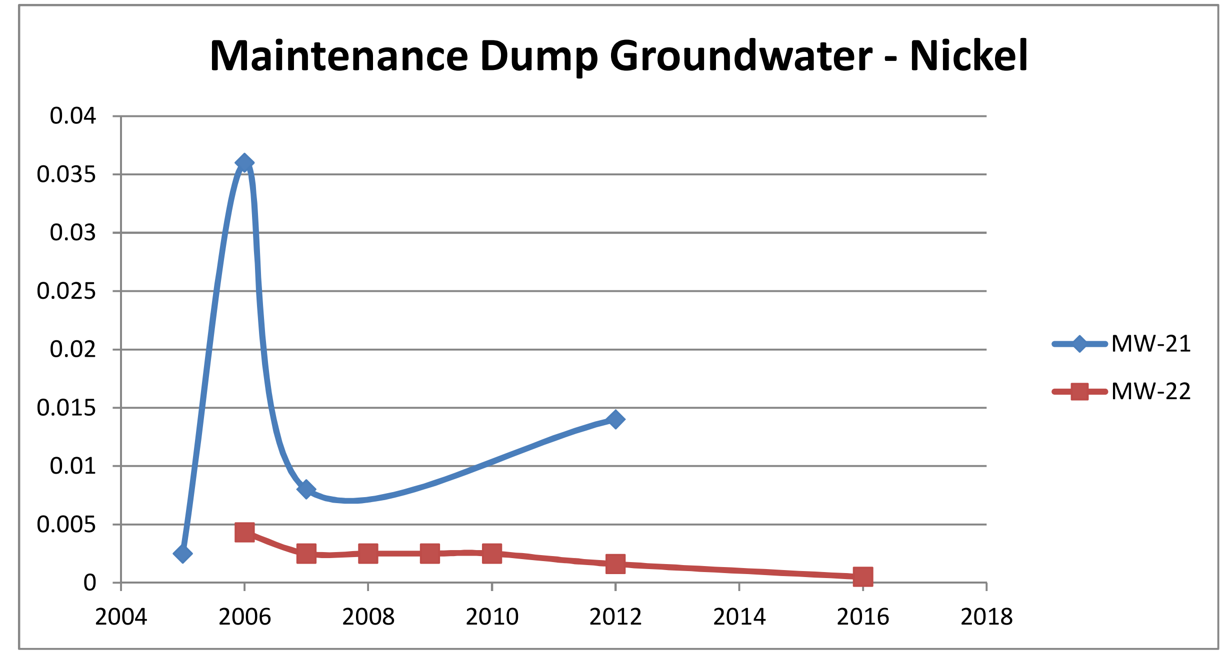
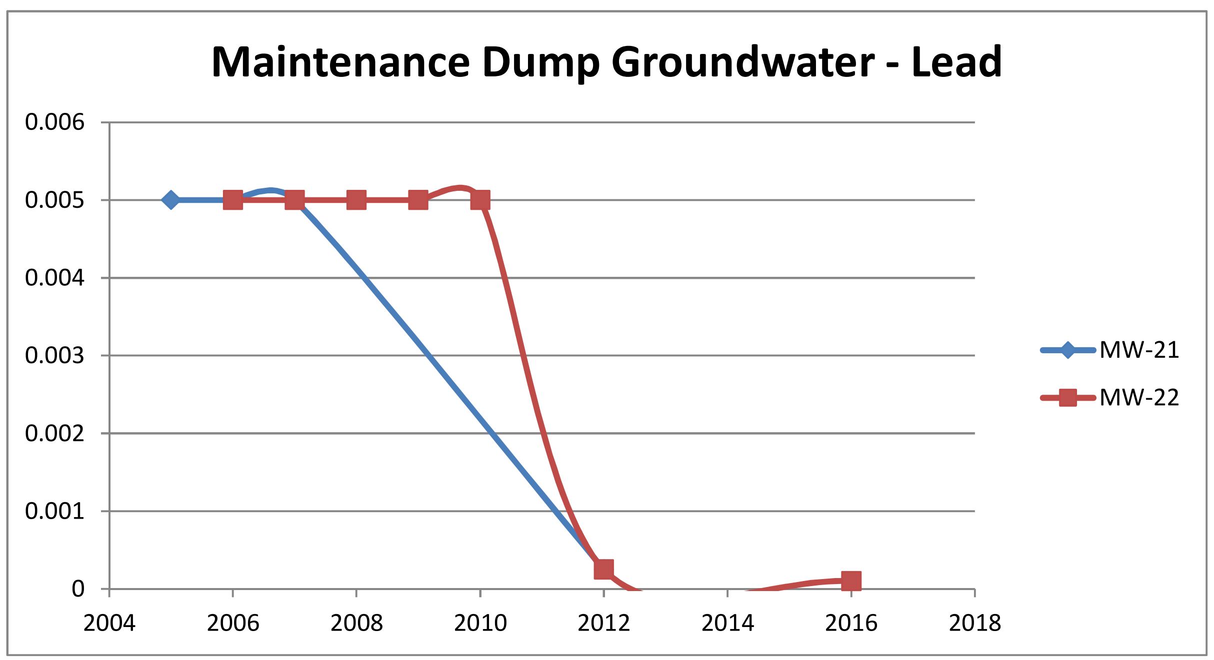


Table C4: Maintenance Dump Historical Groundwater Analytical Trend Graphs







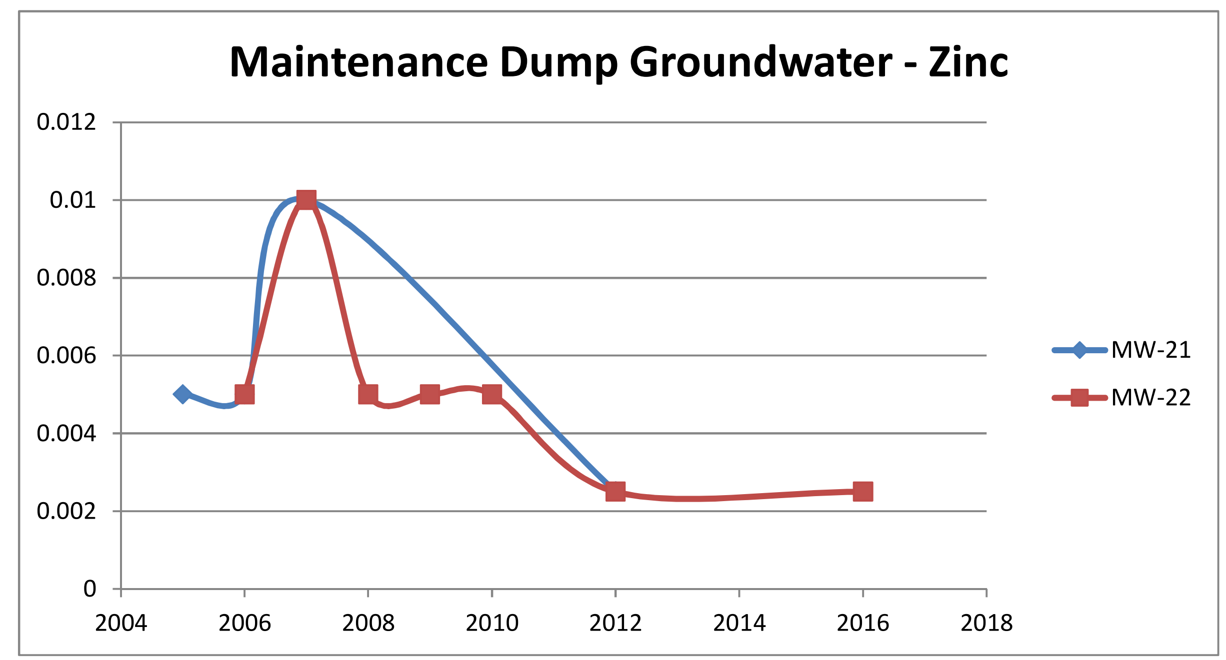
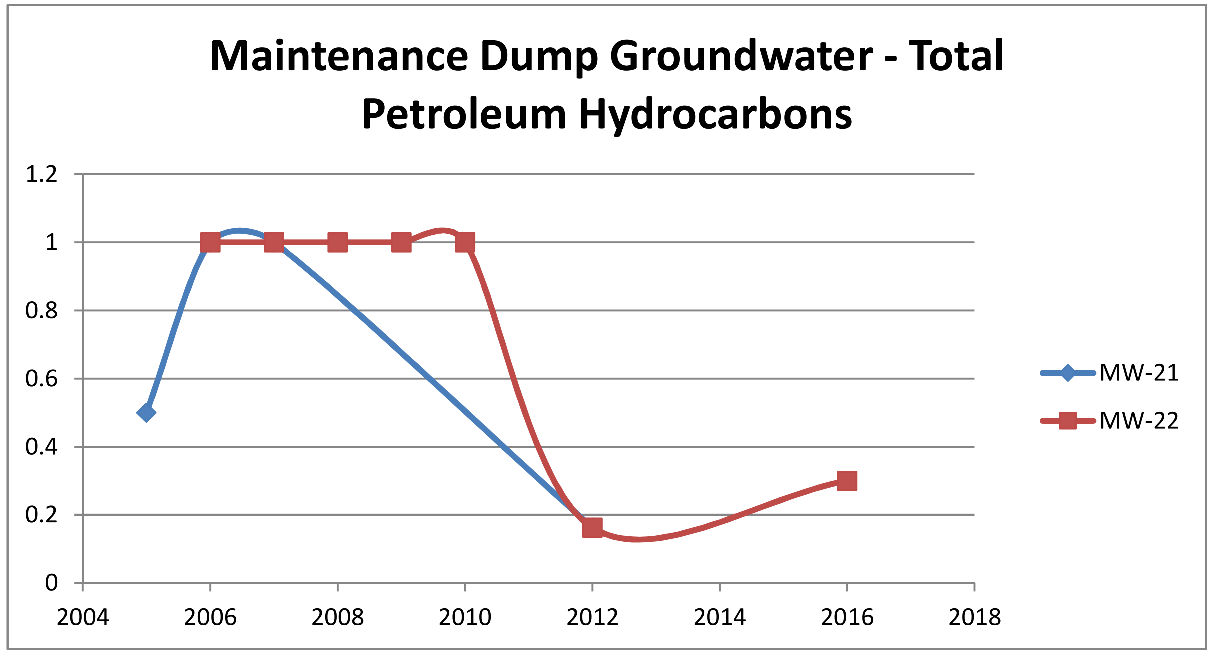


Table C4: Maintenance Dump Historical Groundwater Analytical Trend Graphs



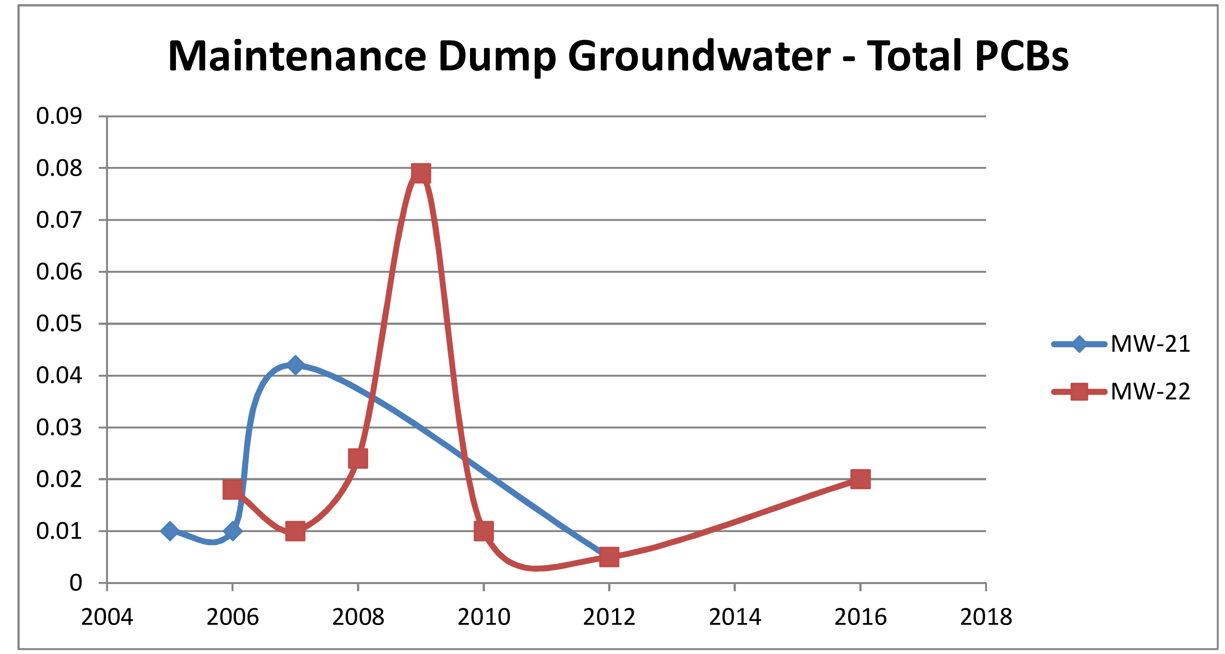


Table C5: Maintenance Dump Historical Soil Analytical Trends

Parameters	Units	Maintenance Dump															
		MW21								MW22							
		2005	2006	2007	2008	2009	2010	2012	2016	2005	2006	2007	2008	2009	2010	2012	2016
Metals																	
Arsenic (As)	mg/kg	1.1	1.8	0.5	1.2	0.5	1	0.5	1	0.5	2	1	0.5	0.5	1.5	0.5	1
Cadmium (Cd)	mg/kg	0.5	0.50	0.5	0.5	0.5	0.5	0.105	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.28	0.4
Chromium (Cr)	mg/kg	47	38.5	38	46	39	39	38	48	41	43	51	45	54	43	33	46
Cobalt (Co)	mg/kg	15	14	13.3	17.5	14.2	16	17	21	23	27.5	15.6	415	37	26.7	24.5	46
Copper (Cu)	mg/kg	60	15.5	50	71	55	54.3	78	99	75	88.5	82	74	101	72.1	82.5	120
Lead (Pb)	mg/kg	5	5	5	5	5	5	4.6	5	13	12	5	11	14	5	12	15
Nickel (Ni)	mg/kg	72	66	60.00	84.00	69.00	67.30	92.00	120	79.00	82.5	78.00	86.00	100.00	73.15	83.00	120
Zinc (Zn)	mg/kg	105	84	74.00	91.00	93.00	116.00	96.00	110	211.00	200.5	120.00	223.00	216.00	180.00	190.00	240
Petroleum Hydrocarbons																	
BTEX & F1 Hydrocarbons																	
TPH (lube)	mg/kg	20	20	20	20	20	163.00	54.50	55	20.00	20	20	20	20	20	161.00	55
TPH (fuel)	mg/kg	20	20	20	20	20	20.00	5.00	5	20.00	20	20	20	20	20	5.00	5
TPH (total)	mg/kg	40	40	40	40	40	183.00	59.50	60	40.00	40.00	40.00	40.00	40.00	40.00	166.00	60
Polychlorinated Biphenyls																	
Total PCB	ug/kg	9	13.50	86.00	4.00	9.00	11.30	5.00	5.00	39.00	52.00	70.00	56.00	6.00	55.30	49.50	12.5

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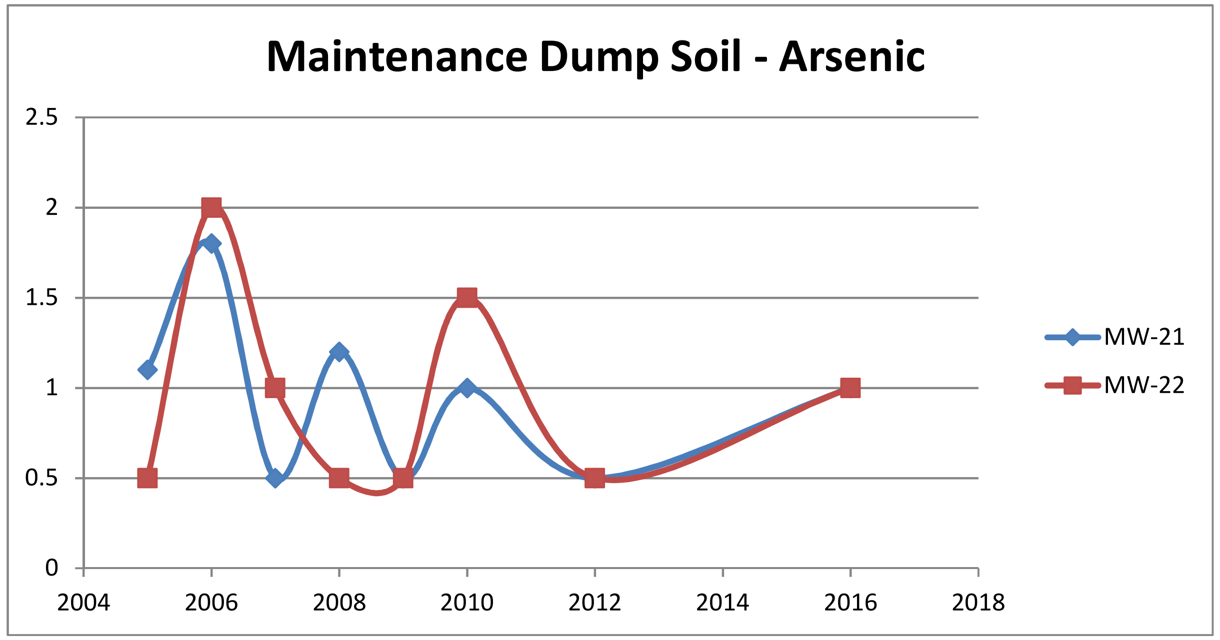
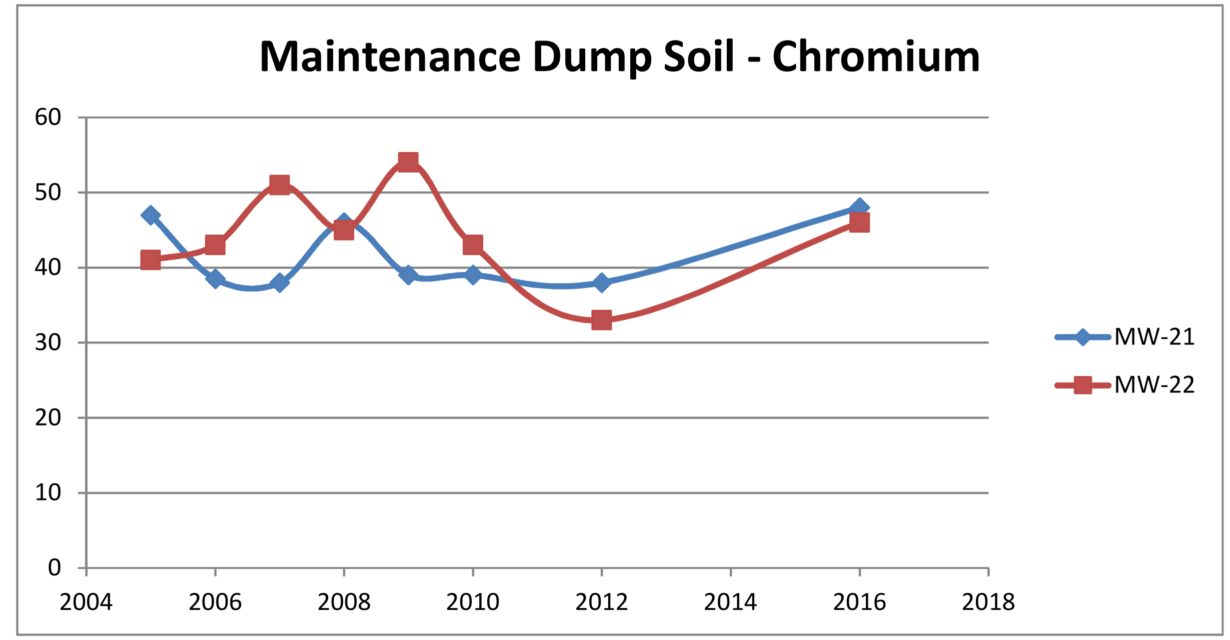
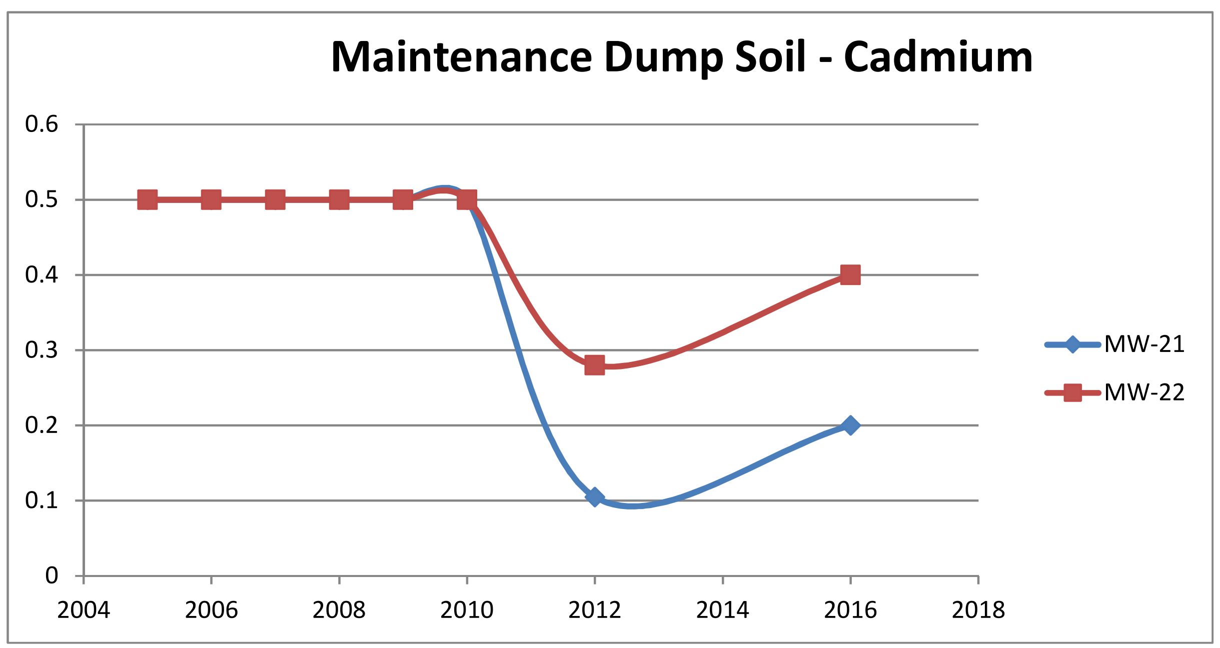
Table C6: Maintenance Dump Historical Soil Analytical Trend Graphs







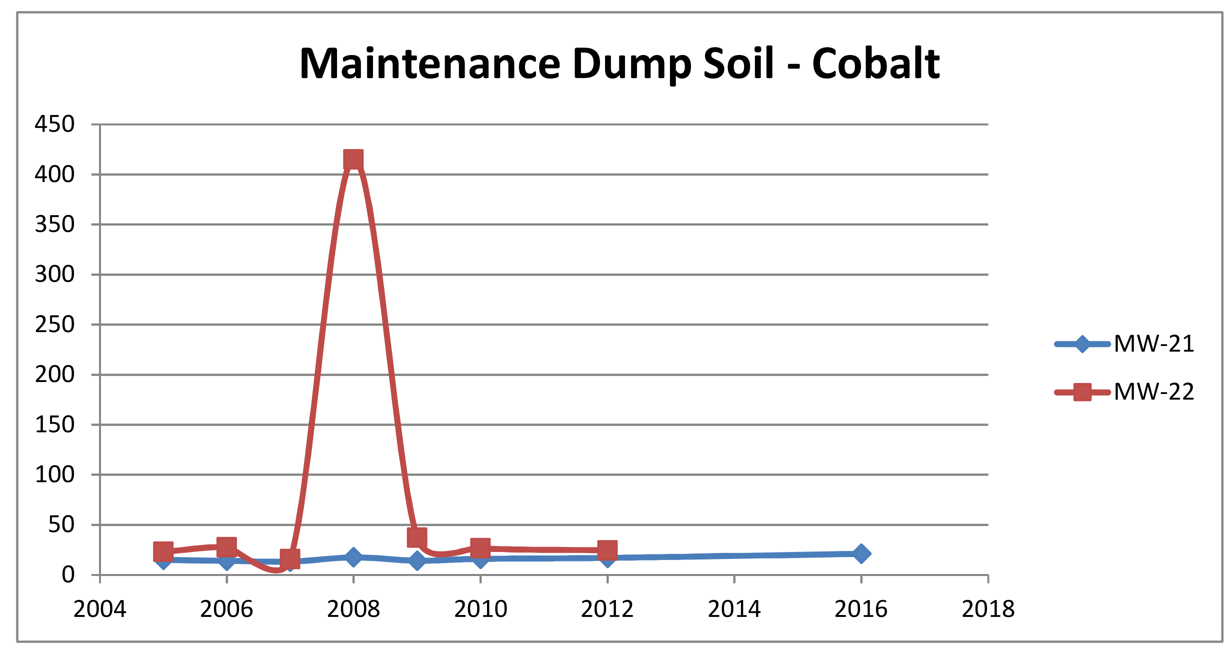
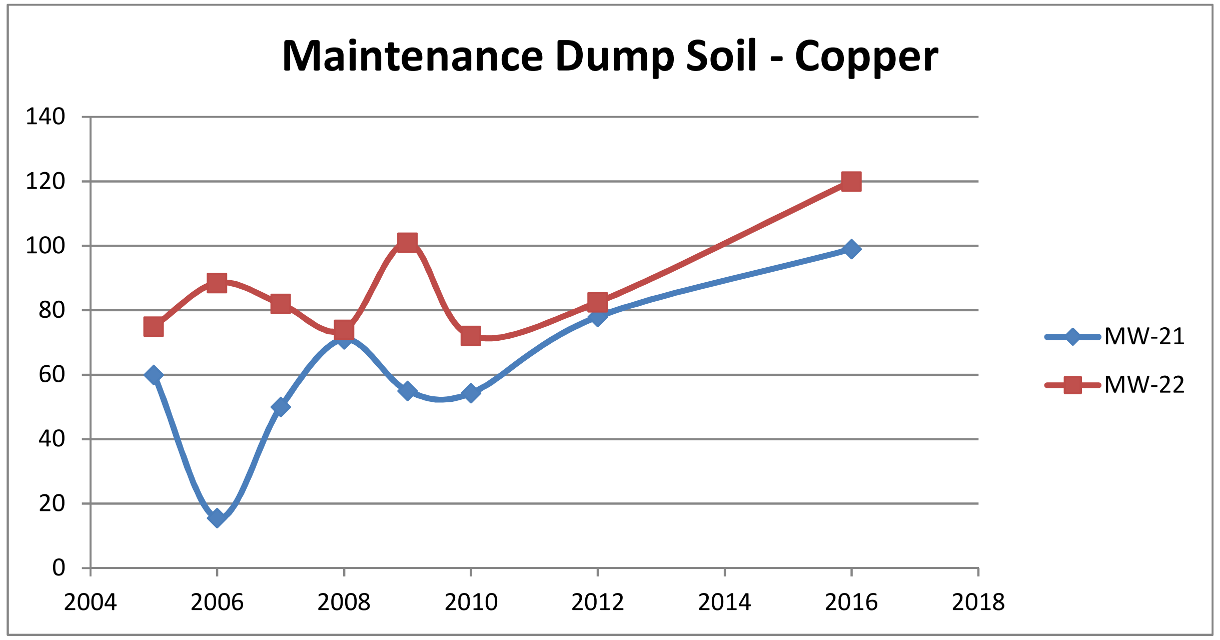
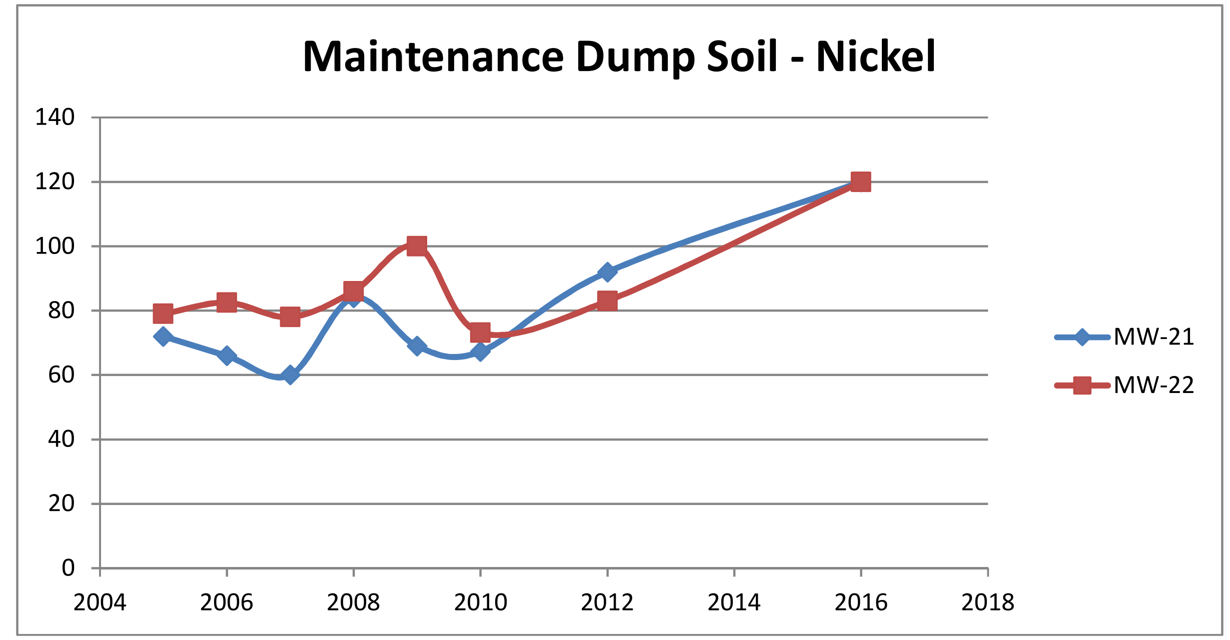
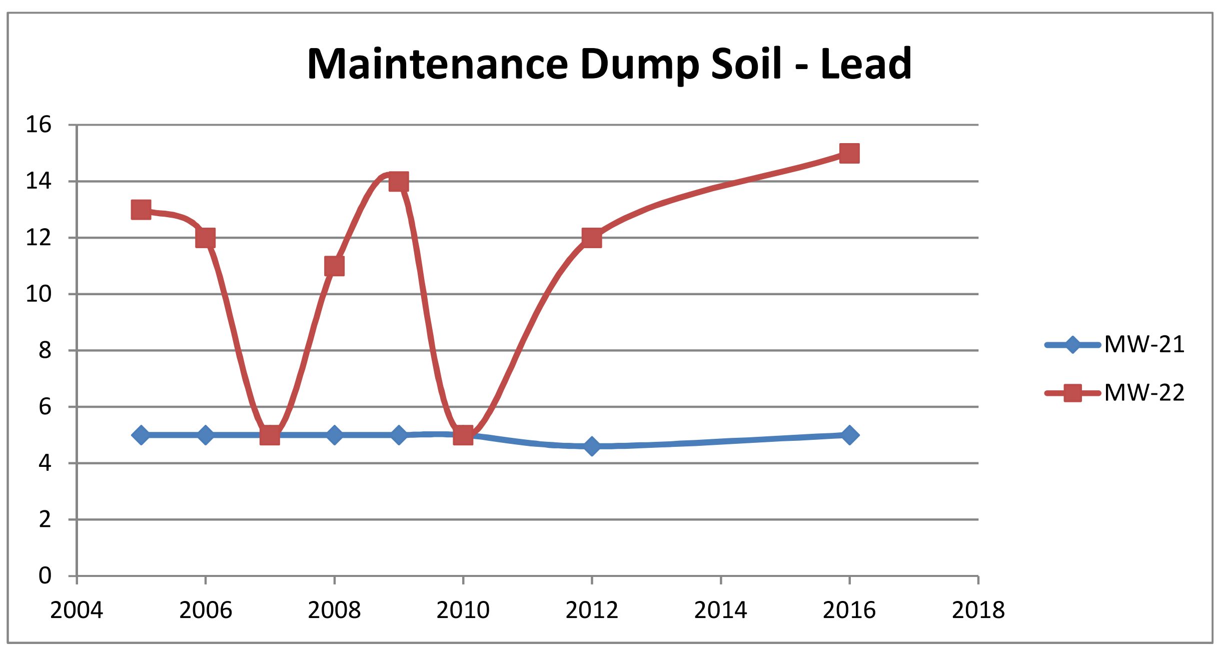


Table C6: Maintenance Dump Historical Soil Analytical Trend Graphs







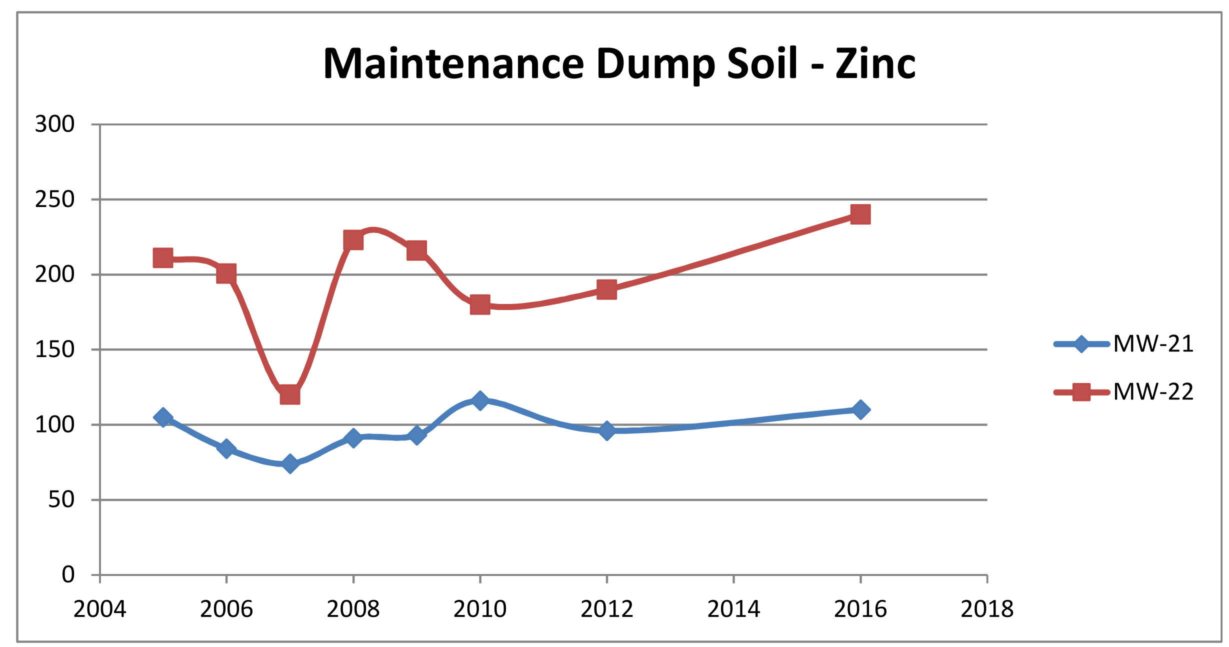
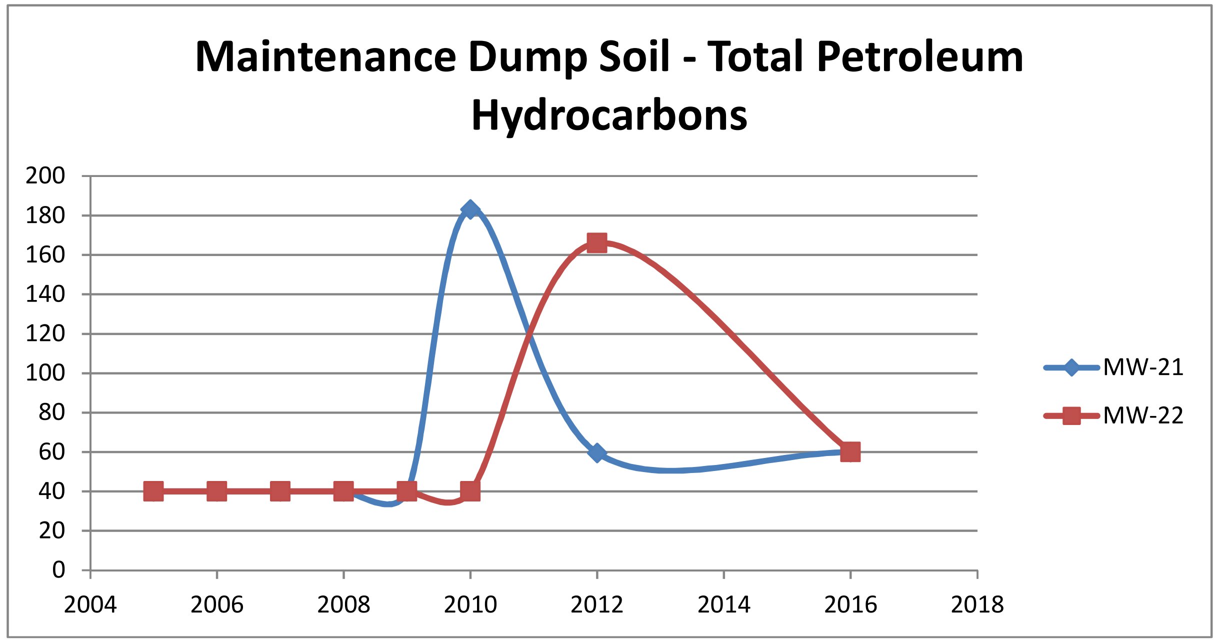


Table C6: Maintenance Dump Historical Soil Analytical Trend Graphs



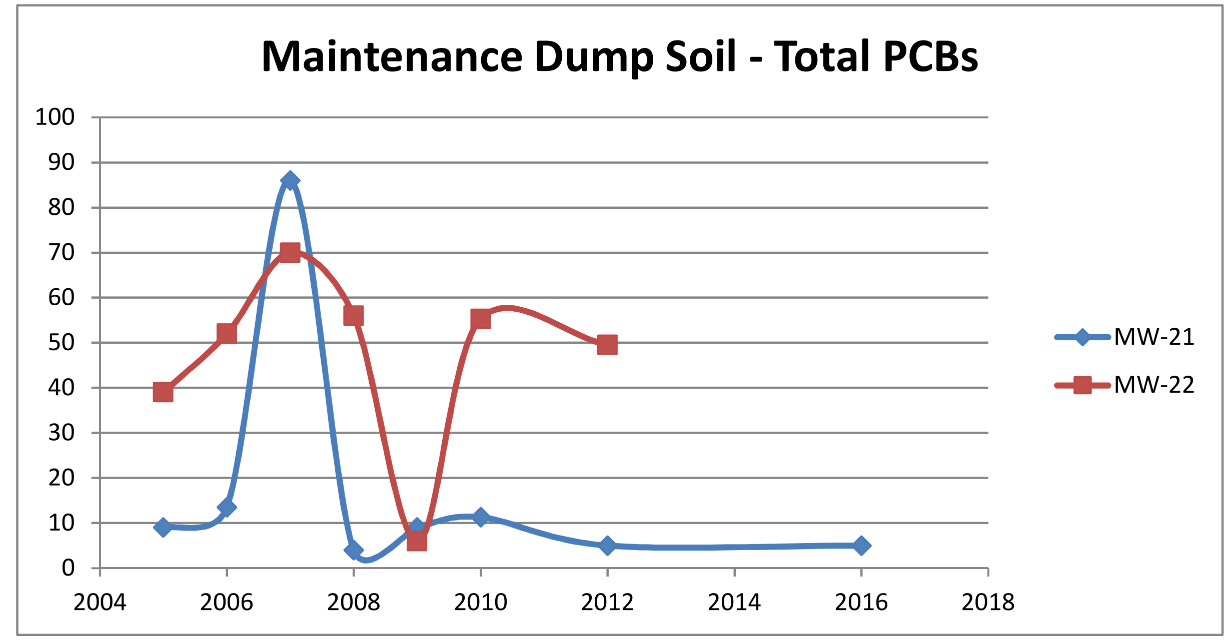


Table C7: Tier II Landfill Historical Groundwater Analystical Results

Parameters	Units	Tier II Landfill																						
		MW-1A									MW-1B				MW-2									
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																								
Dissolved Arsenic (As)	mg/L	<0.003	<0.003	<0.003	<0.003	-	<0.003	<0.003	<0.0010	<0.00010	-	-	-	-	<0.003	<0.003	<0.003	<0.003	<0.003	-	<0.003	<0.003	<0.001	<0.00010
Dissolved Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	0.0003	0.00	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	0.00	0.00
Dissolved Chromium (Cr)	mg/L	<0.005	0.0632	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.0010	-	-	-	-	<0.005	<0.005	<0.005	0.00675	<0.005	-	<0.005	<0.005	<0.005	<0.0010
Dissolved Cobalt (Co)	mg/L	<0.003	0.0040	<0.015	0.0280	-	0.0100	0.01	0.029	0.02	-	-	-	-	<0.003	0.01	0.0315	0.06250	0.02	-	0.04	0.06800	0.0610	0.01
Dissolved Copper (Cu)	mg/L	0.021	<0.005	0.022	0.018	-	<0.005	<0.005	0.00210	0.00	-	-	-	-	<0.005	0.00500	<0.005	0.01550	<0.005	-	<0.005	0.00800	0.01200	0.00
Dissolved Lead (Pb)	mg/L	<0.010	<0.010	<0.010	<0.010	-	<0.010	<0.010	<0.00050	<0.00020	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	-	<0.010	<0.010	<0.00050	<0.00020
Dissolved Nickel (Ni)	mg/L	0.0090	0.0396	0.0260	0.0340	-	0.0210	0.0200	0.0360	0.04	-	-	-	-	<0.005	0.0430	0.1460	0.2635	0.0170	-	0.1680	0.2770	0.3000	0.08
Dissolved Zinc (Zn)	mg/L	<0.010	<0.010	0.0155	0.0210	-	0.0200	0.0190	0.0260	0.08	-	-	-	-	<0.010	0.0100	0.0747	0.1520	<0.020	-	0.0850	0.1700	0.1400	0.03
Petroleum Hydrocarbons																								
BTEX & F1 Hydrocarbons																								
Benzene	mg/L	-	-	-	-	-	-	-	<0.0002	<0.00020	-	-	-	-	<0.002	-	-	-	-	-	-	-	<0.0002	<0.00020
Toluene	mg/L	-	-	-	-	-	-	-	<0.0002	<0.00020	-	-	-	-	<0.002	-	-	-	-	-	-	-	<0.0002	<0.00020
Ethylbenzene	mg/L	-	-	-	-	-	-	-	<0.0002	<0.00020	-	-	-	-	<0.002	-	-	-	-	-	-	-	<0.00020	<0.00020
o-Xylene	mg/L	-	-	-	-	-	-	-	<0.0002	<0.00020	-	-	-	-	-	-	-	-	-	-	-	-	<0.00020	<0.00020
p+m-Xylene	mg/L	-	-	-	-	-	-	-	<0.0004	<0.00040	-	-	-	-	-	-	-	-	-	-	-	-	<0.0004	<0.00040
Total Xylenes	mg/L	-	-	-	-	-	-	-	<0.0004	<0.00040	-	-	-	-	<0.0051	-	-	-	-	-	-	-	<0.0004	<0.00040
F1 (C6-C10)	mg/L	-	-	-	-	-	-	-	<0.025	<0.025	-	-	-	-	-	-	-	-	-	-	-	-	<0.025	<0.025
F1 (C6-C10) - BTEX	mg/L	-	-	-	-	-	-	-	<0.025	<0.025	-	-	-	-	-	-	-	-	-	-	-	-	<0.025	<0.025
F2-F4 Hydrocarbons																								
F2 (C10-C16 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	-	<0.1	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	<0.1
F3 (C16-C34 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	<0.2
F4 (C34-C50 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	<0.2
TPH (lube) - F2-F4	mg/L	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	-	0.25	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	1.50	0.25
TPH (fuel) - F1	mg/L	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	-	<0.025	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	<1.0	<0.025	<0.025
TPH (total)	mg/L	1.0	1.0	1.0	1.0	-	1.0	1.0	-	0.2625	-	-	-	-	<1.0	1.0	1.0	1.0	1.0	-	1.0	1.0	1.51	0.26
Polychlorinated Biphenyls																								
Aroclor 1016	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1221	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1232	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1242	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1248	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1254	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1260	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1262	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1268	ug/L	-	-	-	-	-	-	-	0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Total PCB	ug/L	<0.02	0.1060	0.0215	<0.020	-	<0.020	0.0320	0.0100	<0.01	-	-	-	-	<0.02	0.0200	0.0774	0.0740	<0.020		0.0820	<0.020	<0.01	<0.01

Table C7: Tier II Landfill Historical Groundwater Analystical Results

Parameters	Tier II Landfill																							
	MW-3A										MW3B				MW-4									
	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																								
Dissolved Arsenic (As)	<0.003	0.0020	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.001	<0.00010	-	-	-	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.0010	<0.00010
Dissolved Cadmium (Cd)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0002	0.0003	-	-	-	-	<0.001	<0.001	<0.001	<0.0041	<0.001	<0.001	<0.001	<0.001	<0.00010	<0.000010
Dissolved Chromium (Cr)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0010	-	-	-	-	<0.005	<0.005	<0.005	0.0143	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0010
Dissolved Cobalt (Co)	0.0060	0.0120	0.0239	0.0208	0.0080	<0.003	0.0100	0.0245	0.0500	0.0363	-	-	-	-	0.0280	0.0180	0.0521	0.0455	0.0110	<0.003	0.0170	0.0390	0.0430	0.0337
Dissolved Copper (Cu)	<0.005	0.00500	<0.005	0.01250	<0.005	<0.005	0.01900	<0.005	0.01800	0.0010	-	-	-	-	0.00750	0.00500	0.00600	0.01750	<0.005	<0.005	<0.005	<0.005	<0.0010	<0.00020
Dissolved Lead (Pb)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.00050	<0.00020	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0017	<0.00020
Dissolved Nickel (Ni)	0.0093	0.0140	0.0213	0.0295	0.0170	<0.005	0.0420	0.0705	0.1100	0.1540	-	-	-	-	0.0660	0.0450	0.0734	0.0620	0.0170	<0.005	0.0320	0.0510	0.0870	0.0535
Dissolved Zinc (Zn)	<0.010	0.0070	0.0151	<0.01	<0.020	<0.010	0.0140	0.0410	0.0700	0.1130	-	-	-	-	0.0255	0.0180	0.0263	0.0105	<0.020	<0.010	0.0180	<0.010	0.0091	<0.0050
Petroleum Hydrocarbons																								
BTEX & F1 Hydrocarbons																								
Benzene	<0.0025	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	<2.0	-	-	-	-	-	-	-	<0.00020	<0.00020
Toluene	0.04	-	-	-	-	-	-	-	0.00	<0.00020	-	-	-	-	<2.0	-	-	-	-	-	-	-	<0.00020	<0.00020
Ethylbenzene	0.14	-	-	-	-	-	-	-	0.00	<0.00020	-	-	-	-	<2.0	-	-	-	-	-	-	-	<0.00020	0.000
o-Xylene	0.03	-	-	-	-	-	-	-	0.00	<0.00020	-	-	-	-	<2.0	-	-	-	-	-	-	-	0.001	0.001
p+m-Xylene	-	-	-	-	-	-	-	-	0.00	<0.00040	-	-	-	-	-	-	-	-	-	-	-	-	<0.00040	0.003
Total Xylenes	0.18	-	-	-	-	-	-	-	0.00	<0.00040	-	-	-	-	<5.0	-	-	-	-	-	-	-	0.001	0.004
F1 (C6-C10)	-	-	-	-	-	-	-	-	0.06	<0.025	-	-	-	-	-	-	-	-	-	-	-	-	0.067	0.040
F1 (C6-C10) - BTEX	-	-	-	-	-	-	-	-	0.06	<0.025	-	-	-	-	-	-	-	-	-	-	-	-	0.066	0.036
F2-F4 Hydrocarbons																								
F2 (C10-C16 Hydrocarbons)	-	-	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	-	-	-	-	-	-	0.560
F3 (C16-C34 Hydrocarbons)	-	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.2
F4 (C34-C50 Hydrocarbons)	-	-	-	-	-	-	-	-	-	<0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.2
TPH (lube) - F2-F4	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	0.33	-	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	0.760
TPH (fuel) - F1	2.20	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<0.025	-	-	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	0.036
TPH (total)	2.20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	0.34	-	-	-	-	<1.0	1.0	1.0	1.0	1.0	1.0	-	1.0	-	0.796
Polychlorinated Biphenyls																								
Aroclor 1016	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1221	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1232	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1242	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1248	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1254	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1260	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1262	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1268	-	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.01	<0.01
Total PCB	<0.02	<0.02	0.0377	<0.020	0.0340	0.0350	0.0410	<0.020	<0.01	<0.01	-	-	-	-	0.0500	<0.02	0.0269	0.0955	<0.020	0.0470	0.0240	<0.020	<0.01	<0.01

Table C7: Tier II Landfill Historical Groundwater Analytical Results

Parameters	Tier II Landfill																										
	MW-5A									MW-5B									MW-6								
	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																											
Dissolved Arsenic (As)	<0.003	<0.003	<0.003	-	-	-	<0.003	<0.0010	<0.00010	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.0010	<0.00010	<0.003	<0.003	<0.003	-	<0.003	<0.003	<0.003	<0.0010	<0.00010
Dissolved Cadmium (Cd)	<0.001	<0.001	<0.001	-	-	-	<0.001	0.0001	0.000047	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0001	0.000113	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	0.0001	0.00009
Dissolved Chromium (Cr)	<0.005	<0.005	<0.005	-	-	-	<0.005	<0.0050	<0.0010	<0.005	<0.005	0.0123	<0.005	<0.005	<0.005	<0.005	<0.0050	<0.0010	<0.005	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.0050	<0.0010
Dissolved Cobalt (Co)	0.0170	0.0367	0.0415	-	-	-	0.0240	0.0420	0.0106	0.0050	0.0209	0.0255	0.0060	0.0230	0.0140	0.0155	0.0125	0.00778	<0.003	0.0067	<0.003	-	0.0470	0.0540	0.0290	0.0180	0.0221
Dissolved Copper (Cu)	0.00730	0.07330	0.02600	-	-	-	0.02300	0.00680	0.00985	<0.005	<0.005	0.01600	<0.005	<0.005	0.01900	0.00550	0.00340	0.0117	<0.005	<0.005	<0.005	-	<0.005	0.01100	<0.005	0.00260	0.0292
Dissolved Lead (Pb)	<0.010	<0.010	<0.010	-	-	-	<0.010	0.0010	0.00115	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.0028	0.00263	<0.010	<0.010	<0.010	-	<0.010	<0.010	<0.010	0.0062	0.00515
Dissolved Nickel (Ni)	0.0170	0.0407	0.0405	-	-	-	0.0470	0.0480	0.0194	0.0180	0.0500	0.0520	0.0200	0.0640	0.0400	0.0935	0.0365	0.0289	0.0073	0.0372	<0.005	-	0.1640	0.2120	0.0980	0.0680	0.098
Dissolved Zinc (Zn)	0.0390	0.1250	0.0575	-	-	-	0.0510	0.0340	0.0454	<0.010	0.0361	0.0520	<0.020	0.1290	0.1540	0.1495	0.0940	0.158	<0.010	<0.010	<0.010	-	0.0800	0.1960	0.1260	0.0380	0.0736
Petroleum Hydrocarbons																											
BTEX & F1 Hydrocarbons																											
Benzene	-	-	-	-	-	-	-	0.001	<0.00020	-	-	-	-	-	-	-	<0.0020	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
Toluene	-	-	-	-	-	-	-	0.006	0.0014	-	-	-	-	-	-	-	0.001	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
Ethylbenzene	-	-	-	-	-	-	-	0.006	0.00051	-	-	-	-	-	-	-	0.001	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
o-Xylene	-	-	-	-	-	-	-	0.011	0.0021	-	-	-	-	-	-	-	0.001	<0.00020	-	-	-	-	-	-	-	0.000	<0.00020
p+m-Xylene	-	-	-	-	-	-	-	0.031	0.0049	-	-	-	-	-	-	-	0.004	<0.00040	-	-	-	-	-	-	-	0.000	<0.00040
Total Xylenes	-	-	-	-	-	-	-	0.042	0.007	-	-	-	-	-	-	-	0.005	<0.00040	-	-	-	-	-	-	-	0.001	<0.00040
F1 (C6-C10)	-	-	-	-	-	-	-	0.400	0.048	-	-	-	-	-	-	-	0.140	0.027	-	-	-	-	-	-	-	<0.025	<0.025
F1 (C6-C10) - BTEX	-	-	-	-	-	-	-	0.350	0.039	-	-	-	-	-	-	-	0.135	0.027	-	-	-	-	-	-	-	<0.025	<0.025
F2-F4 Hydrocarbons																											
F2 (C10-C16 Hydrocarbons)	-	-	-	-	-	-	-	0.850	0.14	-	-	-	-	-	-	-	3.800	5.5	-	-	-	-	-	-	-	<0.1	<0.1
F3 (C16-C34 Hydrocarbons)	-	-	-	-	-	-	-	0.360	<0.2	-	-	-	-	-	-	-	2.800	4	-	-	-	-	-	-	-	<0.1	<0.2
F4 (C34-C50 Hydrocarbons)	-	-	-	-	-	-	-	<0.1	<0.2	-	-	-	-	-	-	-	<0.1	<0.2	-	-	-	-	-	-	-	<0.1	<0.2
TPH (lube) - F2-F4	<1.0	-	<1.0	-	-	-	<1.0	1.710	0.34	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.250	7.100	9.6	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	1.500	0.25
TPH (fuel) - F1	<1.0	-	<1.0	-	-	-	<1.0	0.400	0.039	<1.0	1.040	<1.0	1.300	1.600	33.000	<1.0	0.140	0.027	<1.0	<1.0	<1.0	-	<1.0	<1.0	<1.0	<0.025	<0.025
TPH (total)	1.0	-	1.0	-	-	-	1.0	2.110	0.379	1.0	1.540	1.000	1.800	2.100	33.500	1.750	7.240	9.627	1.000	1.000	1.000	-	1.000	1.000	1.000	1.513	0.2625
Polychlorinated Biphenyls																											
Aroclor 1016	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1221	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1232	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1242	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1248	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1254	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1260	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1262	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1268	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.1	<0.01	-	-	-	-	-	-	-	<0.01	0.11
Total PCB	0.1300	0.0570	0.3280	-	-	-	<0.020	<0.01	<0.01	0.0350	0.0916	0.0215	<0.020	0.0970	0.2000	<0.020	<0.1	<0.01	0.1200	0.0930	0.0415	-	<0.048	0.0220	<0.020	<0.01	0.11

Table C8: Tier II Landfill Historical Soil Analytical Results

Parameters	Units	Tier II Landfill																												
		MW-1									MW-2										MW-3									
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																														
Arsenic (As)	mg/kg	1.15	<1.0	1.55	1.00	<1.0	<1.0	1.20	<1.0	<1	<1.0	1.50	1.15	1.95	1.10	<1.0	1.60	1.90	<1.0	1	<1.0	1.40	<1.0	1.80	1.10	<1.0	<1.0	2.00	<1.0	<1
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.10	<0.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.10	0.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.18	0.3
Chromium (Cr)	mg/kg	40	36.00	37.00	33.00	40.00	37.00	33.00	15.00	35	35	44.00	36.50	56.00	42.00	46.00	47.00	47.50	35.00	52	30.00	32.50	35.00	41.50	35.00	45.00	43.00	40.00	24.00	38
Cobalt (Co)	mg/kg	9.375	8.25	9.35	7.80	11.40	7.90	8.20	7.20	8.1	7.6	10.10	9.75	19.25	12.20	13.30	13.70	9.45	11.00	19	8.65	7.70	10.80	14.45	10.40	13.90	13.30	13.50	15.00	14
Copper (Cu)	mg/kg	54.75	53.00	69.50	45.00	72.00	54.00	44.70	36.00	72	55.5	59.50	66.50	106.00	79.00	82.00	81.00	57.65	98.00	120	48.00	41.50	50.50	66.00	44.00	76.00	67.00	48.40	51.00	76
Lead (Pb)	mg/kg	19.5	<10	<10	<10	10.70	<10	<10	1.50	16	<10	19.50	<10	<10	11.00	<10	11.00	<10	12.00	14	20.00	19.00	31.00	37.00	36.00	16.70	32.00	30.00	4.50	52
Nickel (Ni)	mg/kg	47	51.50	53.00	43.00	60.00	37.00	47.80	37.00	51	33.5	39.00	48.50	84.00	57.00	60.00	60.00	33.40	65.00	100	34.00	32.00	44.50	62.50	44.00	61.00	60.00	51.40	69.00	72
Zinc (Zn)	mg/kg	58.5	44.50	57.00	50.00	73.00	43.00	44.00	29.00	49	38.5	47.50	47.00	75.50	56.00	63.00	58.00	44.50	54.00	82	77.50	68.00	75.50	82.50	71.00	79.00	75.00	77.00	71.00	90
Petroleum Hydrocarbons																														
BTEX & F1 Hydrocarbons																														
Benzene	mg/kg	-	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	-	-	<0.020	<0.0050
Toluene	mg/kg	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	-	<0.020	0.024	-	-	-	-	-	-	-	-	<0.020	<0.020
Ethylbenzene	mg/kg	-	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	-	-	<0.020	<0.010
o-Xylene	mg/kg	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	-	<0.020	<0.020
p+m-Xylene	mg/kg	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	-	<0.040	<0.040
Total Xylenes	mg/kg	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	-	<0.040	<0.040
F1 (C6-C10)	mg/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
F1 (C6-C10) - BTEX	mg/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
F2-F4 Hydrocarbons																														
F2 (C10-C16 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	45
F3 (C16-C34 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	36.00	170	-	-	-	-	-	-	-	-	43.00	<50	-	-	-	-	-	-	-	-	28.00	680
F4 (C34-C50 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	16.00	<50	-	-	-	-	-	-	-	-	16.00	<50	-	-	-	-	-	-	-	-	13.00	110
TPH (lube) - F2-F4	mg/kg	220	<40	325	1760.00	<40	<40	<40	57.00	200.00	<20	<40	<40	<40	<40	<40	<40	<40	64.00	55.00	<20	<40	470.00	680.00	740.00	<40	<40	682.00	46.00	835.00
TPH (fuel) - F1	mg/kg	55	<40	<40	<40	<40	<40	<40	<10	<10	34.5	<40	<40	<40	<40	<40	<40	<40	<10	<10	<20	50.00	525.00	87.00	1330.00	190.00	<40	422.00	<10	<10
TPH (total)	mg/kg	275.00	40.00	345.00	1780.00	40.00	40.00	40.00	62.00	205.00	39.5	40.00	40.00	40.00	40.00	40.00	40.00	40.00	69.00	60.00	<40	70.00	995.00	767.00	2070.00	210.00	40.00	1104.00	51.00	840.00
Polychlorinated Biphenyls																														
Aroclor 1016	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1221	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1232	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1242	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1248	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1254	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1260	ug/kg	-	-	-	-	-	-	-	19.00	34.00	-	-	-	-	-	-	-	-	65.00	30.00	-	-	-	-	-	-	-	-	51.00	250.00
Aroclor 1262	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1268	ug/kg	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Total PCB	ug/kg	37.75	8.5	49.5	29.00	44.00	35.00	6.00	19.00	34.00	67	13.50	14.25	21.50	43.00	47.00	29.00	33.50	65.00	30.00	190.000	245.000	139.000	255.000	140.000	86.000	147.000	231.000	51.000	250.00

Table C8: Tier II Landfill Historical Soil Analytical Results

Parameters	Units	MW-4										MW-5									MW-6								
		2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																													
Arsenic (As)	mg/kg	<1.0	1.60	<1.0	1.50	1.00	<1.0	<1.0	-	1.00	1	1.55	1.40	2.20	1.20	1.20	<1.0	2.00	1.10	2	1.30	1.15	1.70	1.20	1.50	<1.0	1.40	<1.0	<1
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	0.63	0.6	0.50	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.27	0.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.10	<0.1
Chromium (Cr)	mg/kg	38.00	38.50	40.00	46.00	52.00	49.00	47.00	-	50.00	58	42.50	60.00	66.50	40.00	62.00	47.00	62.00	52.00	82	33.00	40.00	42.00	38.00	48.00	39.00	34.00	26.00	36
Cobalt (Co)	mg/kg	27.30	17.05	13.90	18.80	21.00	22.00	19.50	-	26.00	32	12.93	21.90	29.00	11.70	24.00	19.30	29.50	28.00	43	5.65	6.50	7.30	6.70	9.30	6.50	6.70	4.30	6.5
Copper (Cu)	mg/kg	71.00	54.50	54.00	72.50	77.00	77.00	66.00	-	110.00	100	77.25	105.50	131.00	57.00	101.00	88.00	115.10	120.00	180	49.50	67.50	77.50	58.00	96.00	66.00	49.70	64.00	80
Lead (Pb)	mg/kg	50.50	<10	<10	<10	12.00	14.10	10.00	-	35.00	74	8.00	27.50	31.00	17.00	25.00	16.00	21.00	22.00	35	<10	<10	<10	<10	<10	<10	<10	8.00	15
Nickel (Ni)	mg/kg	57.00	58.00	59.50	80.50	89.00	91.00	79.00	-	120.00	120	52.25	93.00	121.00	51.00	104.00	80.00	118.40	120.00	190	25.00	30.50	31.00	29.00	43.00	31.00	25.70	30.00	39
Zinc (Zn)	mg/kg	80.50	49.00	57.00	128.50	81.00	83.00	65.00	-	110.00	120	62.50	93.00	128.50	58.00	98.00	81.00	109.00	110.00	170	36.50	39.00	41.50	39.00	49.00	36.00	35.00	32.00	40
Petroleum Hydrocarbons																													
BTEX & F1 Hydrocarbons																													
Benzene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	-	<0.020	<0.0050
Toluene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	<0.020	<0.020
Ethylbenzene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	-	<0.020	<0.010
o-Xylene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	<0.020	<0.020
p+m-Xylene	mg/kg	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	<0.040	<0.040
Total Xylenes	mg/kg	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	<0.040	<0.040
F1 (C6-C10)	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
F1 (C6-C10) - BTEX	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
F2 (C10-C16 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	170.00	310	-	-	-	-	-	-	-	16.00	<10	-	-	-	-	-	-	-	12.00	<10
F3 (C16-C34 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	1500.00	530	-	-	-	-	-	-	-	430.00	280	-	-	-	-	-	-	-	20.00	<50
F4 (C34-C50 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	250.00	<50	-	-	-	-	-	-	-	100.00	<50	-	-	-	-	-	-	-	18.00	<50
TPH (lube) - F2-F4	mg/kg	3430.00	130.00	<40	<40	<40	<40	<40	-	1920.00	865.00	20.00	177.50	<40	<40	<40	<40	<40	546.00	310.00	<40	<40	<40	<40	<40	<40	<40	50.00	55.00
TPH (fuel) - F1	mg/kg	1985.00	<40	865.00	145.00	<40	180.00	<40	-	<10	<10	41.25	90.00	<40	<40	<40	<40	<40	<10	<10	<40	60.00	<40	<40	<40	<40	<40	<10	5.00
TPH (total)	mg/kg	5400.00	150.00	885.00	165.00	40.00	200.00	40.00	-	1925.00	870.00	61.25	267.50	40.00	40.00	40.00	40.00	40.00	551.00	315.00	40.00	80.00	40.00	40.00	40.00	40.00	40.00	55.00	60.00
Polychlorinated Biphenyls																													
Aroclor 1016	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1221	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1232	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1242	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1248	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1254	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1260	ug/kg	-	-	-	-	-	-	-	-	170.00	29.00	-	-	-	-	-	-	-	120.00	150.00	-	-	-	-	-	-	-	11.00	25.00
Aroclor 1262	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1268	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Total PCB	ug/kg	325.000	35.000	13.500	70.500	11.000	7.000	29.000	-	170.000	29.00	14.250	97.500	101.000	230.000	79.000	220.000	144.000	120.000	150.00	37.000	14.250	14.500	14.000	14.000	16.000	8.200	11.000	25.00

Table C9: Tier II Landfill Historical Groundwater Analytical Trends

		Tier II Landfill																						
		MW-1A									MW-1B				MW-2									
Parameters	Units	2004	2005	2006	2007	2008	2009	2010	2012	2016	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																								
Dissolved Arsenic (As)	mg/L	0.0015	0.0015	0.0015	0.0015	-	0.0015	0.0015	0.0005	0.0001	-	-	-	-	0.0015	0.0015	0.0015	0.0015	0.0015	-	0.0015	0.0015	0.0005	0.0001
Dissolved Cadmium (Cd)	mg/L	0.0005	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0003	0.0002	-	-	-	-	0.0005	0.0005	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0006	0.0002
Dissolved Chromium (Cr)	mg/L	0.0025	0.0632	0.0025	0.0025	-	0.0025	0.0025	0.0025	0.0005	-	-	-	-	0.0025	0.0025	0.0025	0.0068	0.0025	-	0.0025	0.0025	0.0025	0.0005
Dissolved Cobalt (Co)	mg/L	0.0015	0.0040	0.0075	0.0280	-	0.0100	0.0100	0.0290	0.0213	-	-	-	-	0.0015	0.0060	0.0315	0.0625	0.0240	-	0.0370	0.0680	0.0610	0.0108
Dissolved Copper (Cu)	mg/L	0.0210	0.0040	0.0220	0.0180	-	0.0025	0.0025	0.0021	0.0006	-	-	-	-	0.0038	0.0050	0.0025	0.0155	0.0025	-	0.0025	0.0080	0.0120	0.0008
Dissolved Lead (Pb)	mg/L	0.0050	0.0050	0.0050	0.0050	-	0.0050	0.0050	0.0003	0.0001	-	-	-	-	0.0050	0.0050	0.0070	0.0050	0.0050	-	0.0050	0.0050	0.0003	0.0001
Dissolved Nickel (Ni)	mg/L	0.0090	0.0396	0.0260	0.0340	-	0.0210	0.0200	0.0360	0.0351	-	-	-	-	0.0025	0.0430	0.1460	0.2635	0.0170	-	0.1680	0.2770	0.3000	0.0831
Dissolved Zinc (Zn)	mg/L	0.0050	0.0070	0.0155	0.0210	-	0.0200	0.0190	0.0260	0.0823	-	-	-	-	0.0050	0.0100	0.0747	0.1520	0.0100	-	0.0850	0.1700	0.1400	0.0312
Petroleum Hydrocarbons																								
TPH (lube) - F2-F4	mg/L	0.5000	0.5000	0.5000	0.5000	-	0.5000	0.5000	-	0.2500	-	-	-	-	-	0.5000	0.5000	0.5000	0.5000	-	0.5000	0.5000	1.5000	0.2500
TPH (fuel) - F1	mg/L	0.5000	0.5000	0.5000	0.5000	-	0.5000	0.5000	-	0.0125	-	-	-	-	0.5000	0.5000	0.5000	0.5000	0.5000	-	0.5000	0.5000	0.0125	0.0125
TPH (total)	mg/L	1.0000	1.0000	1.0000	1.0000	-	1.0000	1.0000	-	0.2625	-	-	-	-	0.5000	1.0000	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.5125	0.2625
Polychlorinated Biphenyls																								
Total PCB	ug/L	0.0100	0.1060	0.0215	0.0100	-	0.0100	0.0320	0.0100	0.0050	-	-	-	-	0.0100	0.0200	0.0774	0.0740	<0.020		0.0820	0.0100	0.0050	0.0050

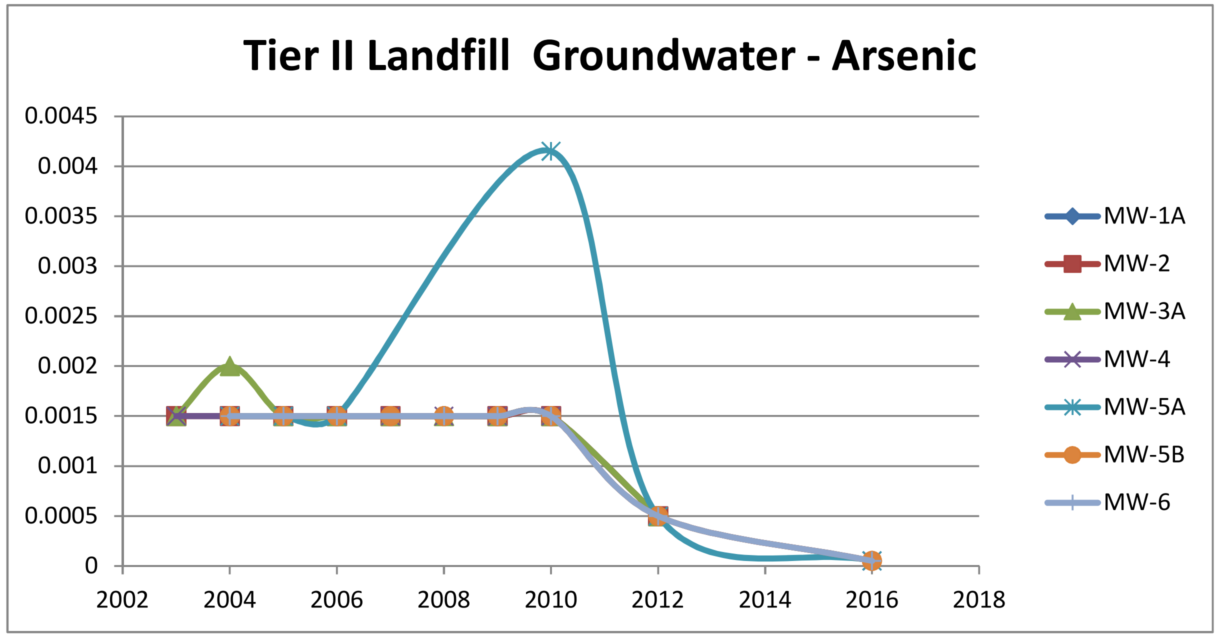
Table C9: Tier II Landfill Historical Groundwater Analytical Trends

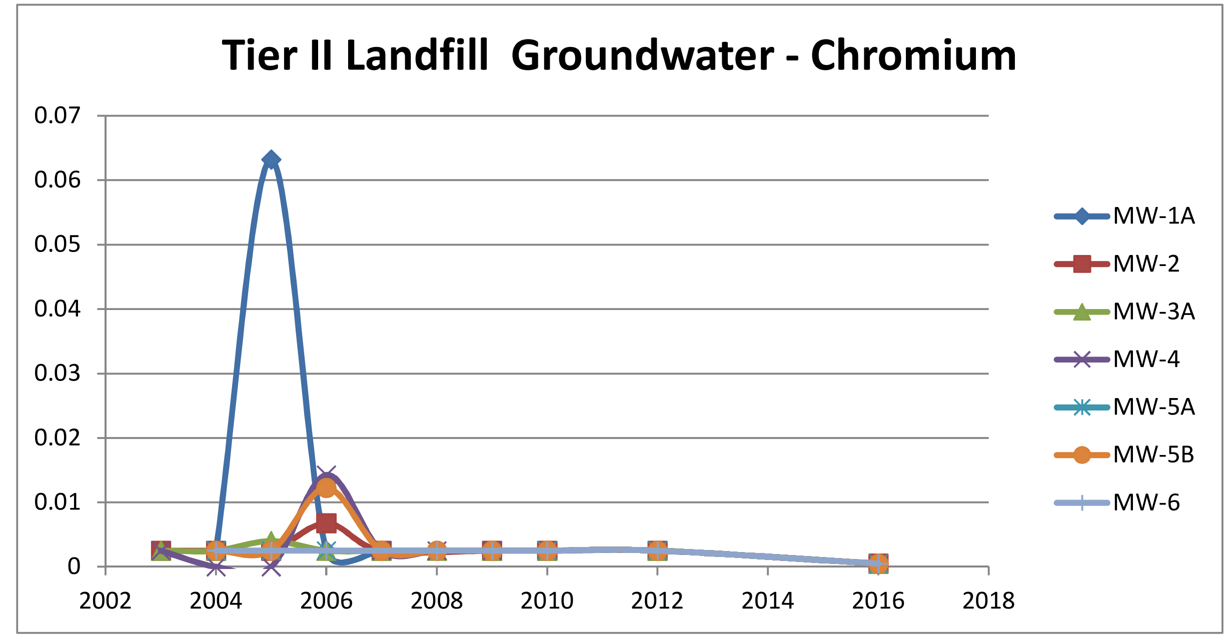
		Tier II Landfill																							
		MW-3A										MW3B				MW-4									
Parameters	Units	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																									
Dissolved Arsenic (As)	mg/L	0.0015	0.0020	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0005	0.0001	-	-	-	-	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0005	0.0001
Dissolved Cadmium (Cd)	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0002	0.0003	-	-	-	-	0.0005	0.0005	0.0005	0.0021	0.0005	0.0005	0.0005	0.0005	0.0001	0.0000
Dissolved Chromium (Cr)	mg/L	0.0025	0.0025	0.0040	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0005	-	-	-	-	0.0025	<0.005	<0.005	0.0143	0.0025	0.0025	0.0025	0.0025	0.0025	0.0005
Dissolved Cobalt (Co)	mg/L	0.0060	0.0120	0.0239	0.0208	0.0080	0.0015	0.0100	0.0245	0.0500	0.0363	-	-	-	-	0.0280	0.0180	0.0521	0.0455	0.0110	0.0015	0.0170	0.0390	0.0430	0.0337
Dissolved Copper (Cu)	mg/L	0.0038	0.0050	0.0030	0.0125	0.0025	0.0025	0.0190	0.0025	0.0180	0.0010	-	-	-	-	0.0075	0.0050	0.0060	0.0175	0.0025	0.0025	0.0025	0.0025	0.0005	0.0001
Dissolved Lead (Pb)	mg/L	0.0050	0.0050	0.0060	0.0050	0.0050	0.0050	0.0050	0.0050	0.0003	0.0001	-	-	-	-	0.0050	0.0070	0.0089	0.0050	0.0050	0.0050	0.0050	0.0050	0.0017	0.0001
Dissolved Nickel (Ni)	mg/L	0.0093	0.0140	0.0213	0.0295	0.0170	0.0025	0.0420	0.0705	0.1100	0.1540	-	-	-	-	0.0660	0.0450	0.0734	0.0620	0.0170	0.0025	0.0320	0.0510	0.0870	0.0535
Dissolved Zinc (Zn)	mg/L	0.0050	0.0070	0.0151	0.0095	0.0100	0.0050	0.0140	0.0410	0.0700	0.1130	-	-	-	-	0.0255	0.0180	0.0263	0.0105	0.0100	0.0050	0.0180	0.0050	0.0091	0.0025
Petroleum Hydrocarbons																									
TPH (lube) - F2-F4	mg/L	-	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	-	0.3300	-	-	-	-	-	0.5000	0.5000	0.5000	0.5000	0.5000	-	0.5000	-	0.7600
TPH (fuel) - F1	mg/L	2.2000	0.9500	0.8860	0.5000	0.5000	0.5000	0.5000	0.5000	-	0.0125	-	-	-	-	0.9000	0.5000	0.7830	0.5000	0.5000	0.5000	-	0.5000	-	0.0360
TPH (total)	mg/L	2.2000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	-	0.3425	-	-	-	-	0.9000	1.0000	1.0000	1.0000	1.0000	1.0000	-	1.0000	-	0.7960
Polychlorinated Biphenyls																									
Total PCB	ug/L	0.0100	0.0130	0.0377	0.0100	0.0340	0.0350	0.0410	0.0100	0.0050	0.0050	-	-	-	-	0.0500	0.0850	0.0269	0.0955	0.0100	0.0470	0.0240	0.0100	0.0050	0.0050

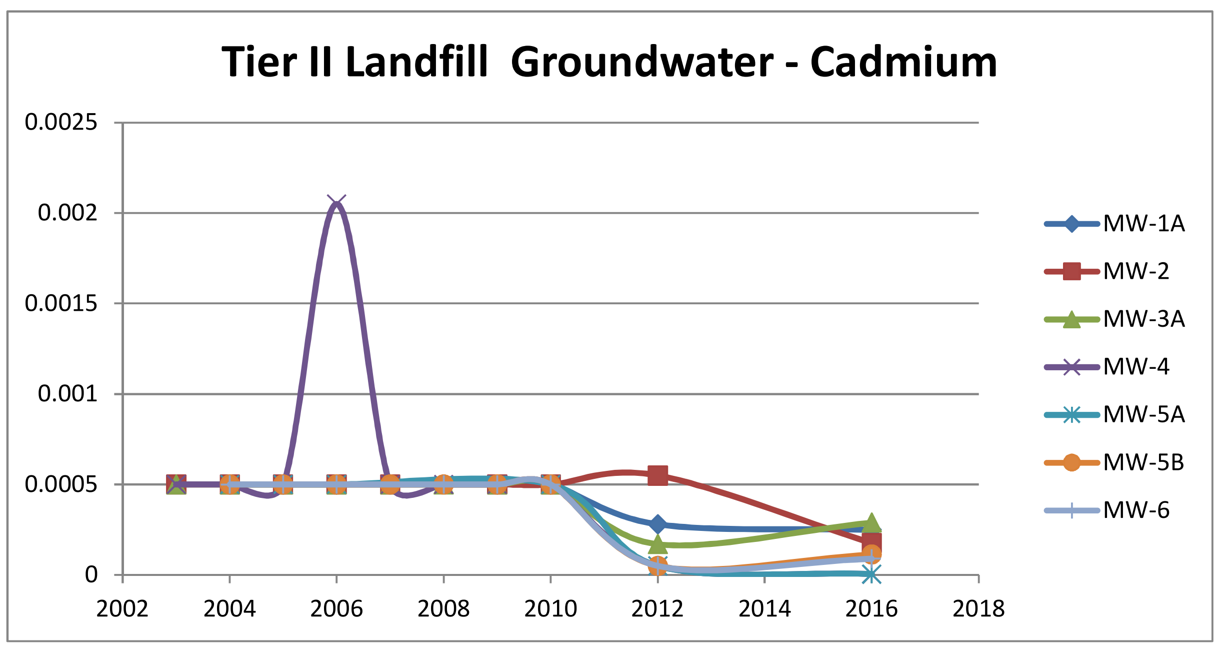
Table C9: Tier II Landfill Historical Groundwater Analytical Trends

Parameters	Units	Tier II Landfill																									
		MW-5A									MW-5B									MW-6								
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																												
Dissolved Arsenic (As)	mg/L	0.0015	0.0015	0.0015	-	-	-	0.0042	0.0005	0.0001	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0005	0.0001	0.0015	0.0015	0.0015	-	0.0015	0.0015	0.0015	0.0005	0.0001
Dissolved Cadmium (Cd)	mg/L	0.0005	0.0005	0.0005	-	-	-	0.0005	0.0001	0.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0001	0.0005	0.0005	0.0005	-	0.0005	0.0005	0.0005	0.0001	0.0001
Dissolved Chromium (Cr)	mg/L	0.0025	0.0025	0.0025	-	-	-	0.0025	0.0025	0.0005	0.0025	0.0025	0.0123	0.0025	0.0025	0.0025	0.0025	0.0025	0.0005	0.0025	0.0025	0.0025	-	0.0025	0.0025	0.0025	0.0025	0.0005
Dissolved Cobalt (Co)	mg/L	0.0170	0.0367	0.0415	-	-	-	0.0240	0.0420	0.0337	0.0050	0.0209	0.0255	0.0060	0.0230	0.0140	0.0155	0.0125	0.0078	0.0015	0.0067	0.0015	-	0.0470	0.0540	0.0290	0.0180	0.0221
Dissolved Copper (Cu)	mg/L	0.0073	0.0733	0.0260	-	-	-	0.0230	0.0068	0.0001	0.0025	0.0030	0.0160	0.0025	0.0025	0.0190	0.0055	0.0034	0.0117	0.0038	0.0025	0.0043	-	0.0025	0.0110	0.0025	0.0026	0.0292
Dissolved Lead (Pb)	mg/L	0.0050	0.0050	0.0050	-	-	-	0.0050	0.0005	0.0001	0.0050	0.0070	0.0050	0.0050	0.0050	0.0050	0.0050	0.0028	0.0026	0.0050	0.0050	0.0050	-	0.0050	0.0050	0.0050	0.0062	0.0052
Dissolved Nickel (Ni)	mg/L	0.0170	0.0407	0.0405	-	-	-	0.0470	0.0480	0.0535	0.0180	0.0500	0.0520	0.0200	0.0640	0.0400	0.0935	0.0365	0.0289	0.0073	0.0372	0.0025	-	0.1640	0.2120	0.0980	0.0680	0.0980
Dissolved Zinc (Zn)	mg/L	0.0390	0.1250	0.0575	-	-	-	0.0510	0.0340	0.0025	0.0050	0.0361	0.0520	0.0100	0.1290	0.1540	0.1495	0.0940	0.1580	0.0050	0.0050	0.0050	-	0.0800	0.1960	0.1260	0.0380	0.0736
Petroleum Hydrocarbons																												
TPH (lube) - F2-F4	mg/L	0.5000	-	0.5000	-	-	-	0.5000	1.7100	0.7600	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	1.2500	7.1000	9.6000	0.5000	0.5000	0.5000	-	0.5000	0.5000	0.5000	1.5000	0.2500
TPH (fuel) - F1	mg/L	0.5000	-	0.5000	-	-	-	0.5000	0.4000	0.0360	0.9000	1.0400	0.5000	1.3000	1.6000	33.0000	0.5000	0.1400	0.0270	0.5000	0.5000	0.5000	-	0.5000	0.5000	0.5000	0.0125	0.0125
TPH (total)	mg/L	1.0000	-	1.0000	-	-	-	1.0000	2.1100	0.7960	1.0000	1.5400	1.0000	1.8000	2.1000	33.5000	1.7500	7.2400	9.6270	1.0000	1.0000	1.0000	-	1.0000	1.0000	1.0000	1.5125	0.2625
Polychlorinated Biphenyls																												
Total PCB	ug/L	0.1300	0.0570	0.3280	-	-	-	0.0100	0.0050	0.0050	0.0350	0.0916	0.0215	0.0100	0.0970	0.2000	0.0100	0.0500	0.0050	0.1200	0.0930	0.0415	-	0.0240	0.0220	0.0100	0.0050	0.11

Table C10: Tier II Landfill Historical Groundwater Analytical Trend Graphs







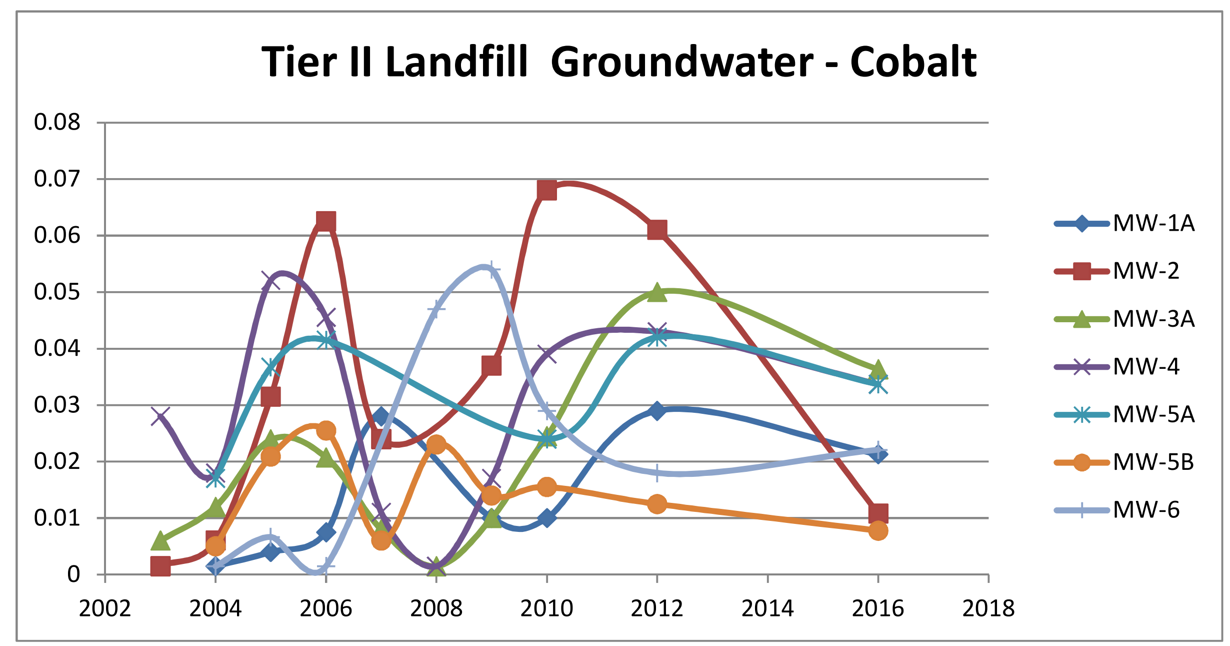
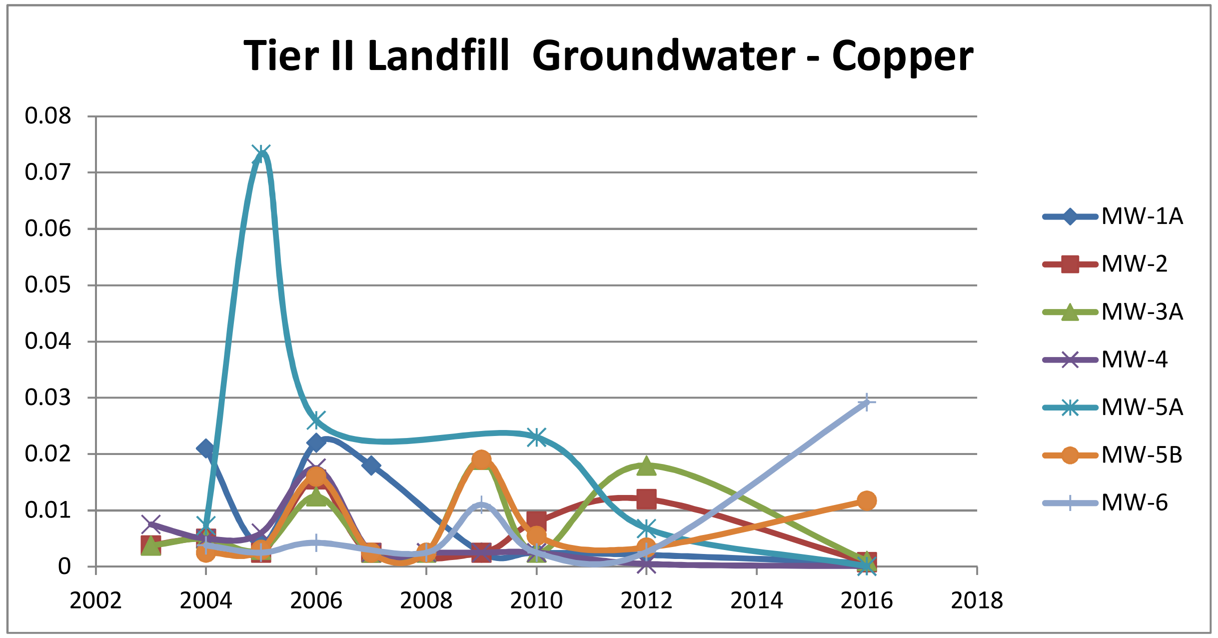
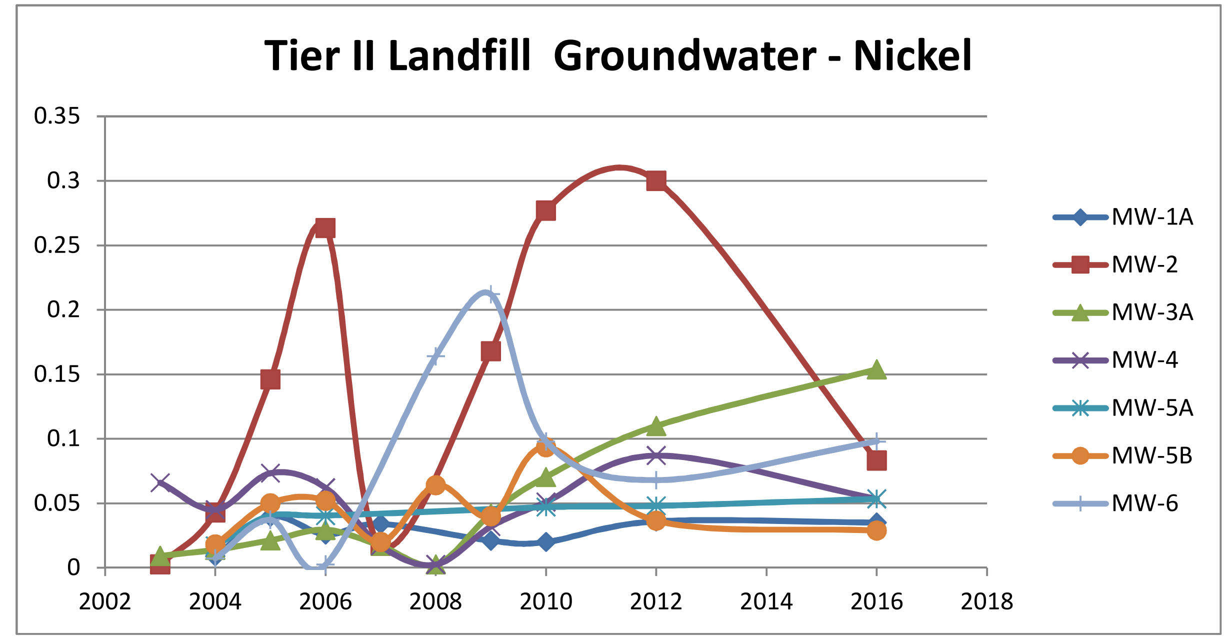
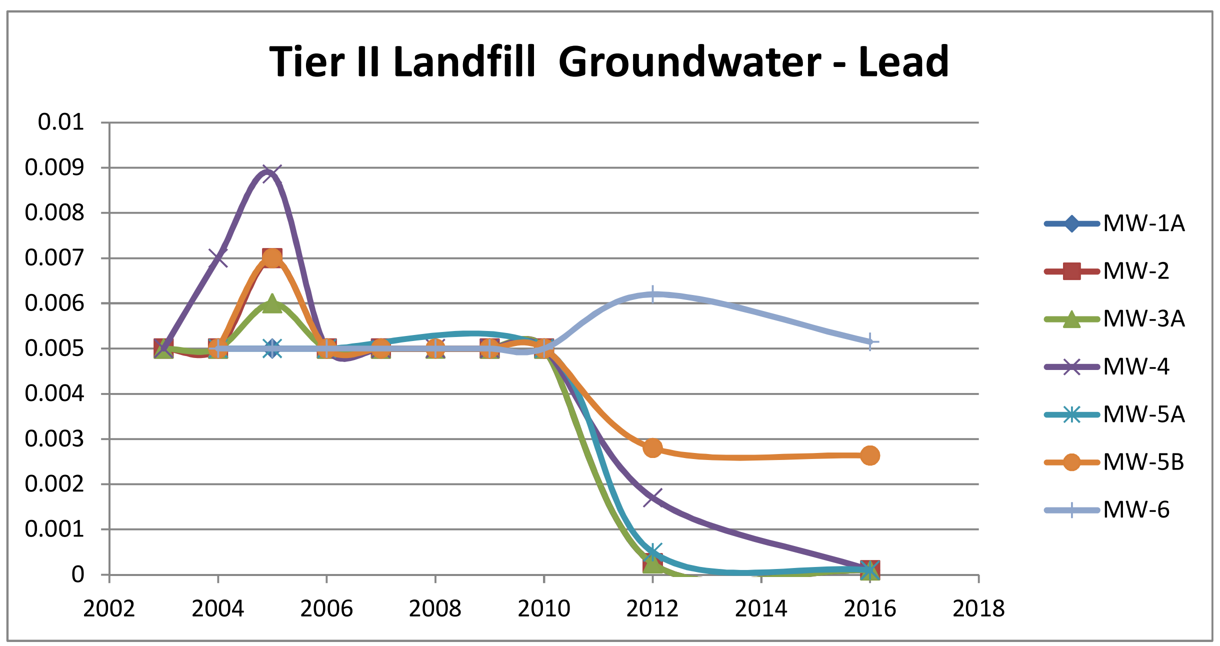


Table C10: Tier II Landfill Historical Groundwater Analytical Trend Graphs







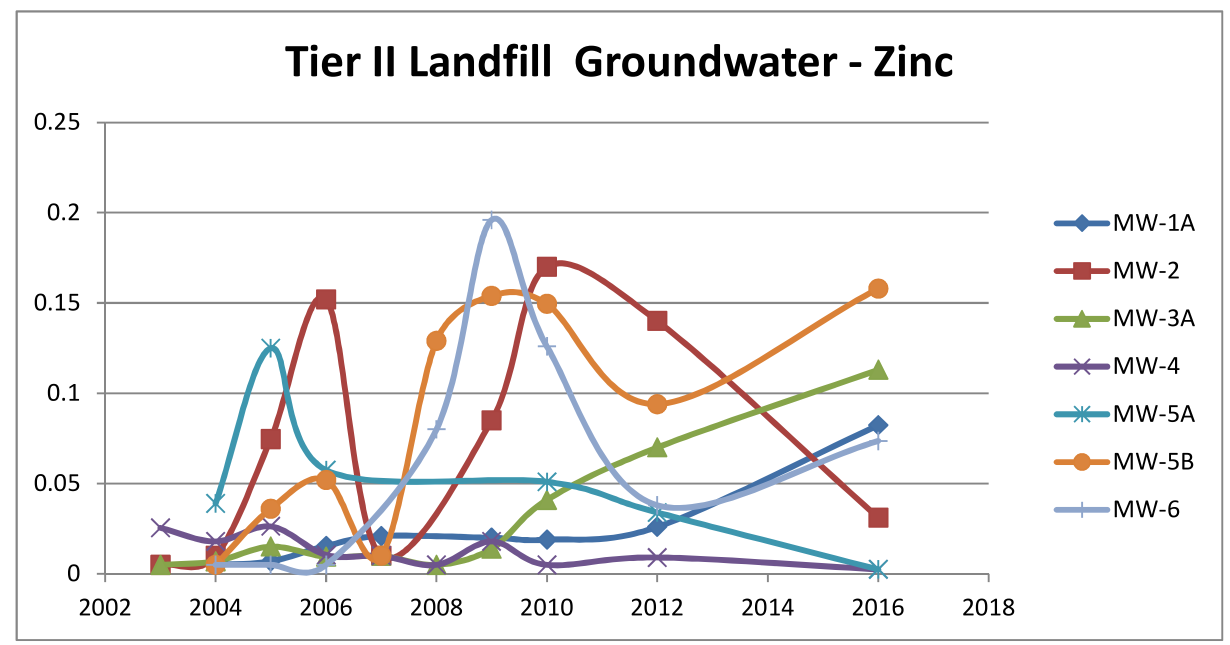
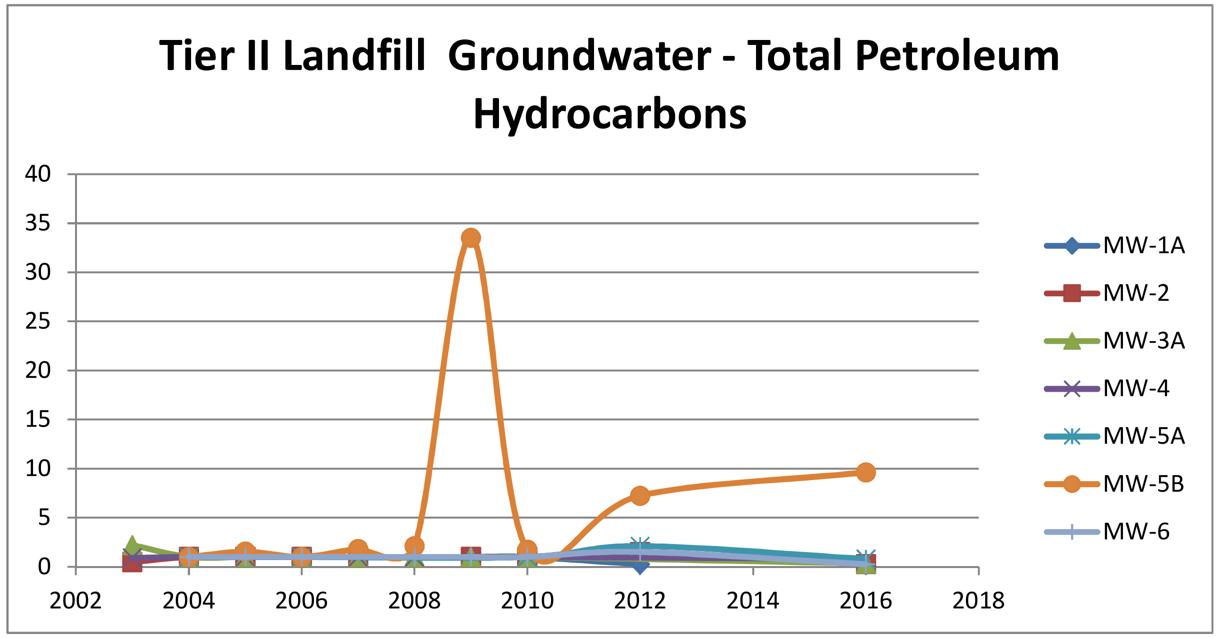


Table C10: Tier II Landfill Historical Groundwater Analytical Trend Graphs



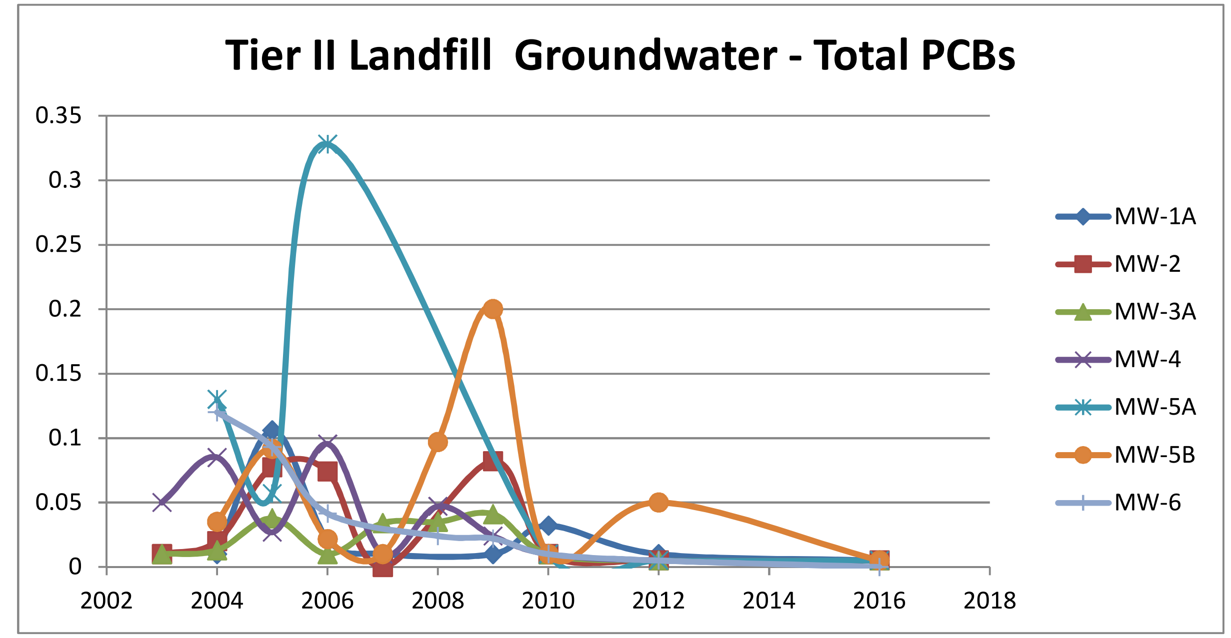


Table C11: Tier II Historical Soil Analytical Trend Graphs

Parameters	Units	Tier II Landfill																												
		MW-1									MW-2										MW-3									
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																														
Arsenic (As)	mg/kg	1.15	0.50	1.55	1.00	0.50	0.50	1.20	0.50	0.50	0.5	1.50	1.15	1.95	1.10	0.50	1.60	1.90	0.50	1	0.50	1.40	0.50	1.80	1.10	0.50	0.50	2.00	0.50	0.50
Cadmium (Cd)	mg/kg	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.05	0.05	0.5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.05	0.1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.18	0.3
Chromium (Cr)	mg/kg	40	36.00	37.00	33.00	40.00	37.00	33.00	15.00	35.00	35	44.00	36.50	56.00	42.00	46.00	47.00	47.50	35.00	52	30.00	32.50	35.00	41.50	35.00	45.00	43.00	40.00	24.00	38
Cobalt (Co)	mg/kg	9.375	8.25	9.35	7.80	11.40	7.90	8.20	7.20	8.10	7.6	10.10	9.75	19.25	12.20	13.30	13.70	9.45	11.00	19	8.65	7.70	10.80	14.45	10.40	13.90	13.30	13.50	15.00	14
Copper (Cu)	mg/kg	54.75	53.00	69.50	45.00	72.00	54.00	44.70	36.00	72.00	55.5	59.50	66.50	106.00	79.00	82.00	81.00	57.65	98.00	120	48.00	41.50	50.50	66.00	44.00	76.00	67.00	48.40	51.00	76
Lead (Pb)	mg/kg	19.5	5.00	7.50	5.00	10.70	5.00	5.00	1.50	16.00	7.5	19.50	5.00	5.00	11.00	5.00	11.00	7.50	12.00	14	20.00	19.00	31.00	37.00	36.00	16.70	32.00	30.00	4.50	52
Nickel (Ni)	mg/kg	47	51.50	53.00	43.00	60.00	37.00	47.80	37.00	51.00	33.5	39.00	48.50	84.00	57.00	60.00	60.00	33.40	65.00	100	34.00	32.00	44.50	62.50	44.00	61.00	60.00	51.40	69.00	72
Zinc (Zn)	mg/kg	58.5	44.50	57.00	50.00	73.00	43.00	44.00	29.00	49.00	38.5	47.50	47.00	75.50	56.00	63.00	58.00	44.50	54.00	82	77.50	68.00	75.50	82.50	71.00	79.00	75.00	77.00	71.00	90
Petroleum Hydrocarbons																														
TPH (lube) - F2-F4	mg/kg	220	20	325	1760.00	20	20	20	57.00	200.00	10	20.00	20.00	20.00	20.00	20.00	20.00	20.00	64.00	55.00	10.00	20.00	470.00	680.00	740.00	20.00	20.00	682.00	46.00	835.00
TPH (fuel) - F1	mg/kg	55	20	20	20	20	20	20	5.00	5.00	34.5	20.00	20.00	20.00	20.00	20.00	20.00	20.00	5.00	5.00	15.50	50.00	525.00	87.00	1330.00	190.00	20.00	422.00	5.00	5.00
TPH (total)	mg/kg	275.00	40.00	345.00	1780.00	40.00	40.00	40.00	62.00	205.00	39.5	40.00	40.00	40.00	40.00	40.00	40.00	40.00	69.00	60.00	20.00	70.00	995.00	767.00	2070.00	210.00	40.00	1104.00	51.00	840.00
Polychlorinated Biphenyls																														
Total PCB	ug/kg	37.75	8.5	49.5	29.00	44.00	35.00	6.00	19.00	34.00	67	13.50	14.25	21.50	43.00	47.00	29.00	33.50	65.00	30.00	190.000	245.000	139.000	255.000	140.000	86.000	147.000	231.000	51.000	250.000

Note: All entries that were lower than the method detection limit were changed to half of the detection limit in order to plot. In the cases where the average was caluclated, this was entered in order to plot

Table C11: Tier II Historical Soil Analytical Trend Graphs

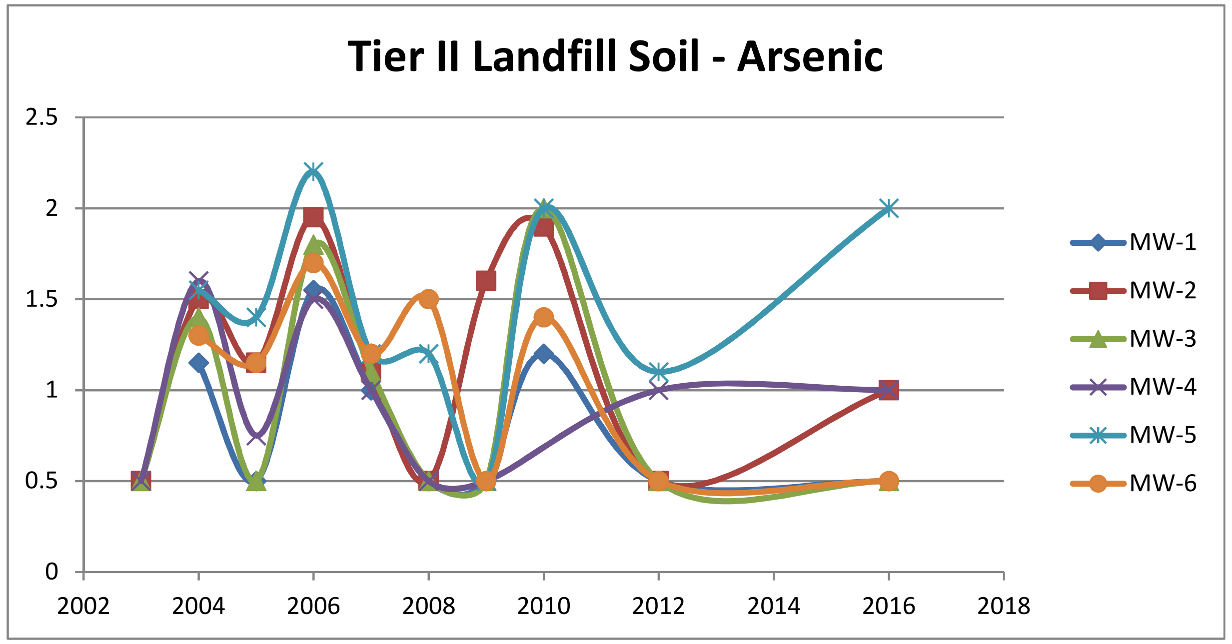
Parameters	Units	MW-4 2003	MW-4 2004	MW-4 2005	MW-4 2006	MW-4 2007	MW-4 2008	MW-4 2009	MW-4 2010	MW-4 2012	MW-4 2016
Metals											
Arsenic (As)	mg/kg	0.50	1.60	0.75	1.50	1.00	0.50	0.50	-	1.00	1
Cadmium (Cd)	mg/kg	0.50	0.50	0.50	0.50	0.50	0.50	0.50	-	0.63	0.6
Chromium (Cr)	mg/kg	38.00	38.50	40.00	46.00	52.00	49.00	47.00	-	50.00	58
Cobalt (Co)	mg/kg	27.30	17.05	13.90	18.80	21.00	22.00	19.50	-	26.00	32
Copper (Cu)	mg/kg	71.00	54.50	54.00	72.50	77.00	77.00	66.00	-	110.00	100
Lead (Pb)	mg/kg	50.50	9.00	7.50	9.50	12.00	14.10	10.00	-	35.00	74
Nickel (Ni)	mg/kg	57.00	58.00	59.50	80.50	89.00	91.00	79.00	-	120.00	120
Zinc (Zn)	mg/kg	80.50	49.00	57.00	128.50	81.00	83.00	65.00	-	110.00	120
Petroleum Hydrocarbons											
TPH (lube) - F2-F4	mg/kg	3430.00	130.00	20.00	20.00	20.00	20.00	20.00	-	1920.00	865.00
TPH (fuel) - F1	mg/kg	1985.00	20.00	865.00	145.00	20.00	180.00	20.00	-	5.00	5.00
TPH (total)	mg/kg	5400.00	150.00	885.00	165.00	40.00	200.00	40.00	-	1925.00	870.00
Polychlorinated Biphenyls											
Total PCB	ug/kg	325.000	35.000	13.500	70.500	11.000	7.000	29.000	-	170.000	29.000

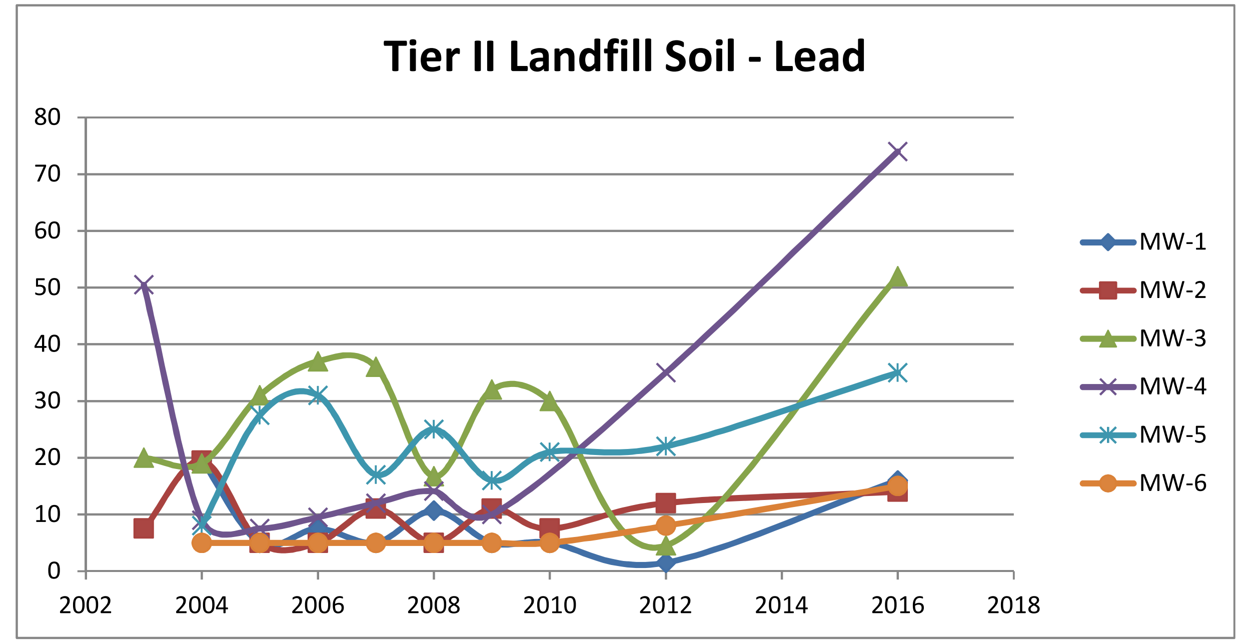
Parameters	MW-5 2004	MW-5 2005	MW-5 2006	MW-5 2007	MW-5 2008	MW-5 2009	MW-5 2010	MW-5 2012	MW-5 2016
Metals									
Arsenic (As)	1.55	1.40	2.20	1.20	1.20	0.50	2.00	1.10	2
Cadmium (Cd)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.27	0.5
Chromium (Cr)	42.50	60.00	66.50	40.00	62.00	47.00	62.00	52.00	82
Cobalt (Co)	12.93	21.90	29.00	11.70	24.00	19.30	29.50	28.00	43
Copper (Cu)	77.25	105.50	131.00	57.00	101.00	88.00	115.10	120.00	180
Lead (Pb)	8.00	27.50	31.00	17.00	25.00	16.00	21.00	22.00	35
Nickel (Ni)	52.25	93.00	121.00	51.00	104.00	80.00	118.40	120.00	190
Zinc (Zn)	62.50	93.00	128.50	58.00	98.00	81.00	109.00	110.00	170
Petroleum Hydrocarbons									
TPH (lube) - F2-F4	20.00	177.50	20.00	20.00	20.00	20.00	20.00	546.00	310.00
TPH (fuel) - F1	41.25	90.00	20.00	20.00	20.00	20.00	20.00	5.00	5.00
TPH (total)	61.25	267.50	40.00	40.00	40.00	40.00	40.00	551.00	315.00
Polychlorinated Biphenyls									
Total PCB	14.250	97.500	101.000	230.000	79.000	220.000	144.000	120.000	150.000

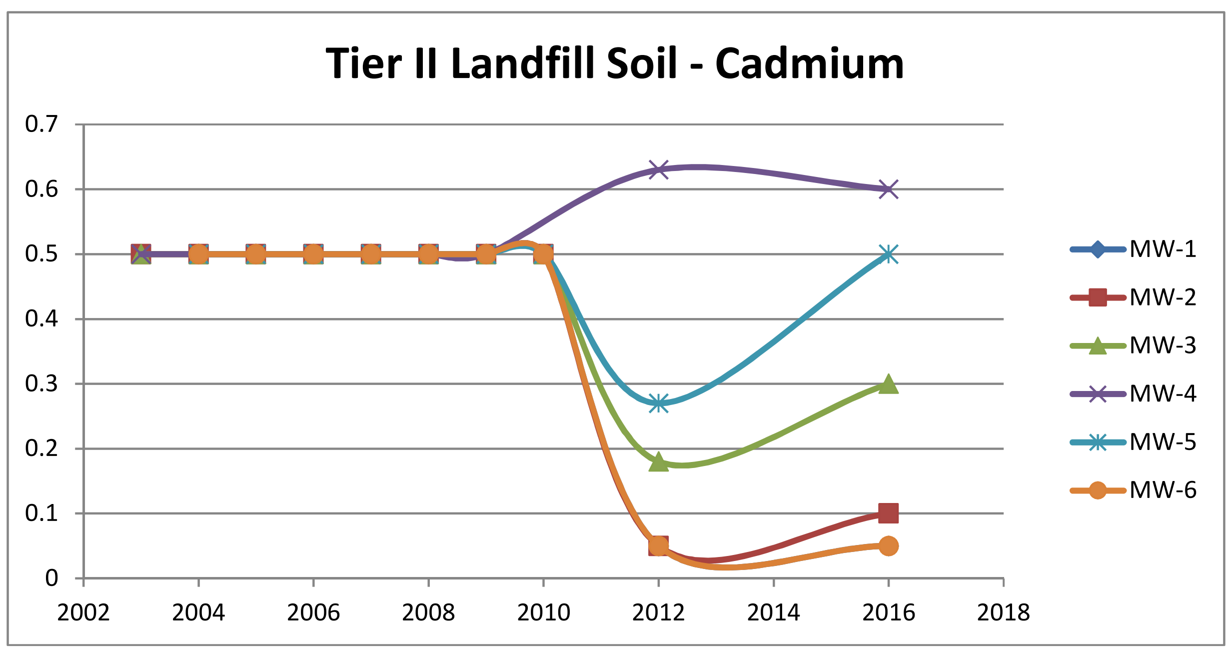
Parameters	MW-6 2004	MW-6 2005	MW-6 2006	MW-6 2007	MW-6 2008	MW-6 2009	MW-6 2010	MW-6 2012	MW-6 2016
Metals									
Arsenic (As)	1.30	1.15	1.70	1.20	1.50	0.50	1.40	0.50	0.50
Cadmium (Cd)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.05	0.05
Chromium (Cr)	33.00	40.00	42.00	38.00	48.00	39.00	34.00	26.00	36
Cobalt (Co)	5.65	6.50	7.30	6.70	9.30	6.50	6.70	4.30	6.5
Copper (Cu)	49.50	67.50	77.50	58.00	96.00	66.00	49.70	64.00	80
Lead (Pb)	5.00	5.00	5.00	5.00	5.00	5.00	5.00	8.00	15
Nickel (Ni)	25.00	30.50	31.00	29.00	43.00	31.00	25.70	30.00	39
Zinc (Zn)	36.50	39.00	41.50	39.00	49.00	36.00	35.00	32.00	40
Petroleum Hydrocarbons									
TPH (lube) - F2-F4	20.00	20.00	20.00	20.00	20.00	20.00	20.00	50.00	55.00
TPH (fuel) - F1	20.00	60.00	20.00	20.00	20.00	20.00	20.00	5.00	5.00
TPH (total)	40.00	80.00	40.00	40.00	40.00	40.00	40.00	55.00	60.00
Polychlorinated Biphenyls									
Total PCB	37.000	14.250	14.500	14.000	14.000	16.000	8.200	11.000	25.000

Note: All entries that were lower than the method detection limit were changed to half of the detection limit in order to plot. In the cases where the average was caluclated, this was entered in order to plot

Table C12: Teir II Landfill Historical Soil Analytical Trend Graphs







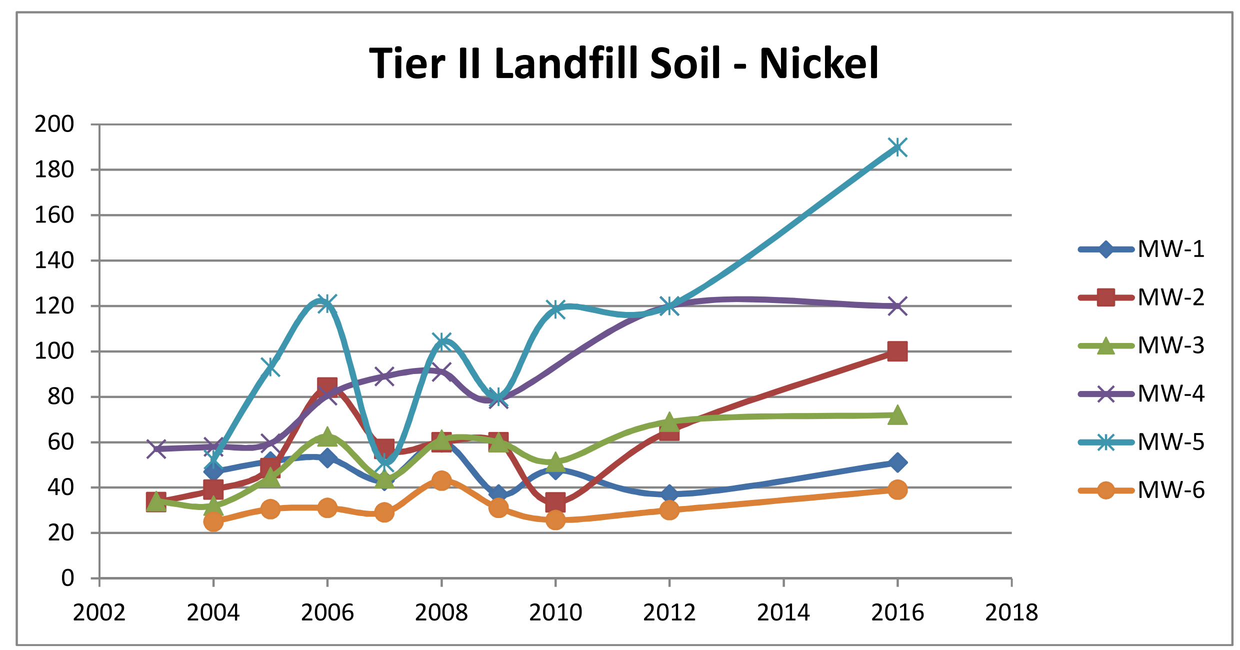
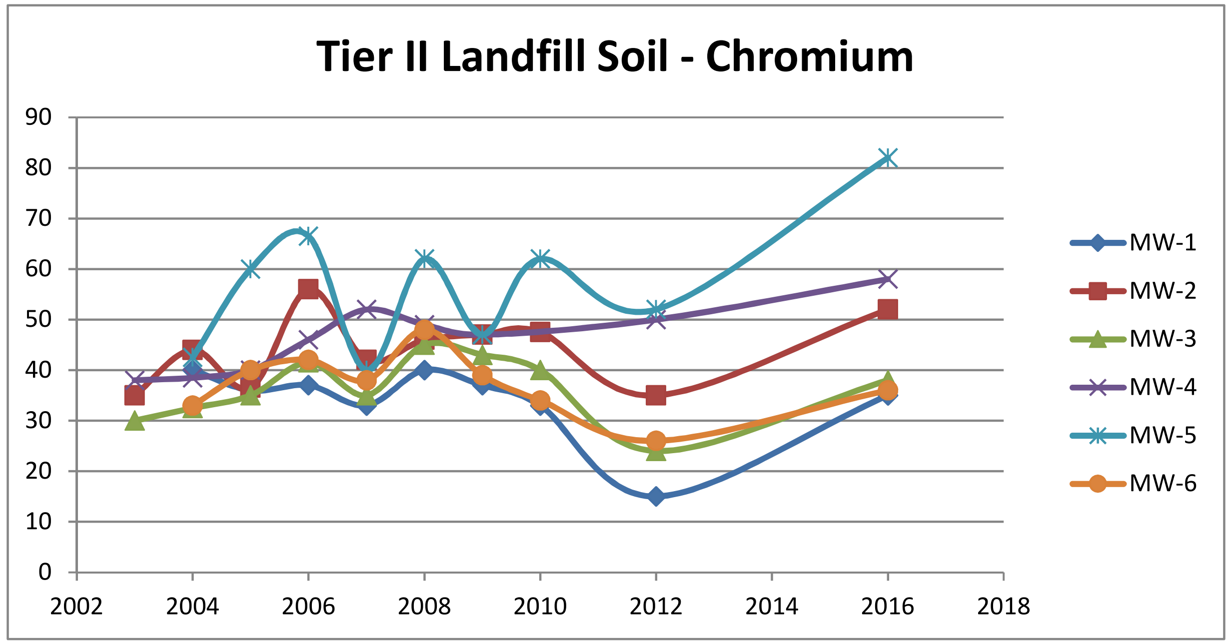
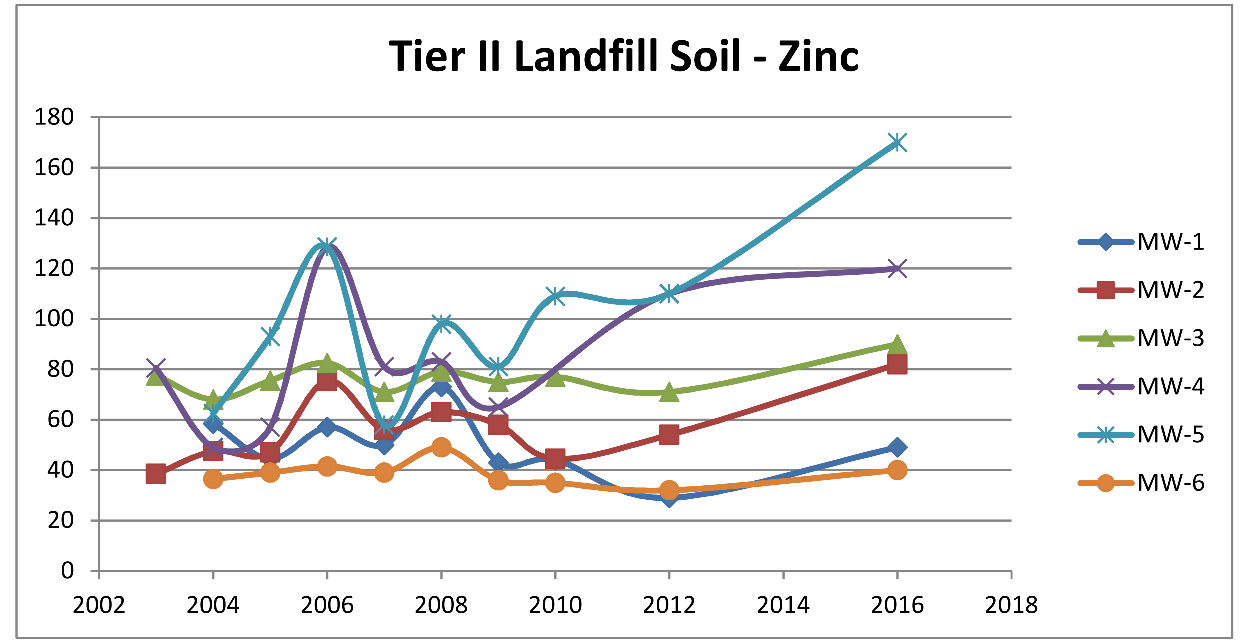
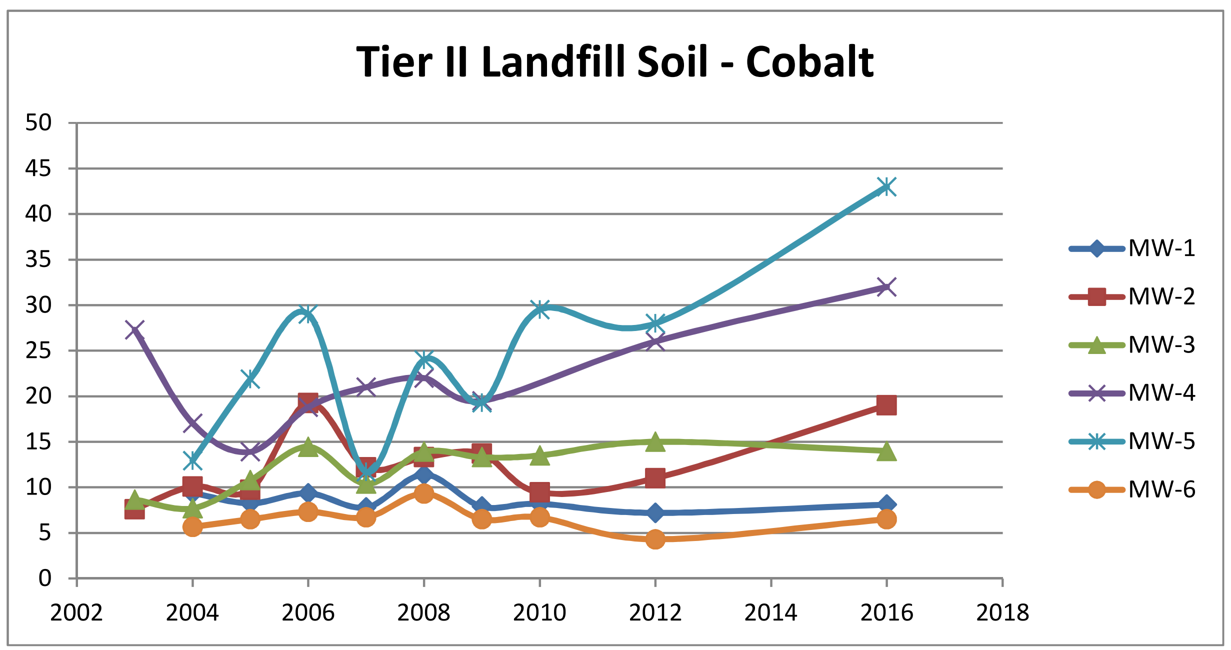


Table C12: Teir II Landfill Historical Soil Analytical Trend Graphs







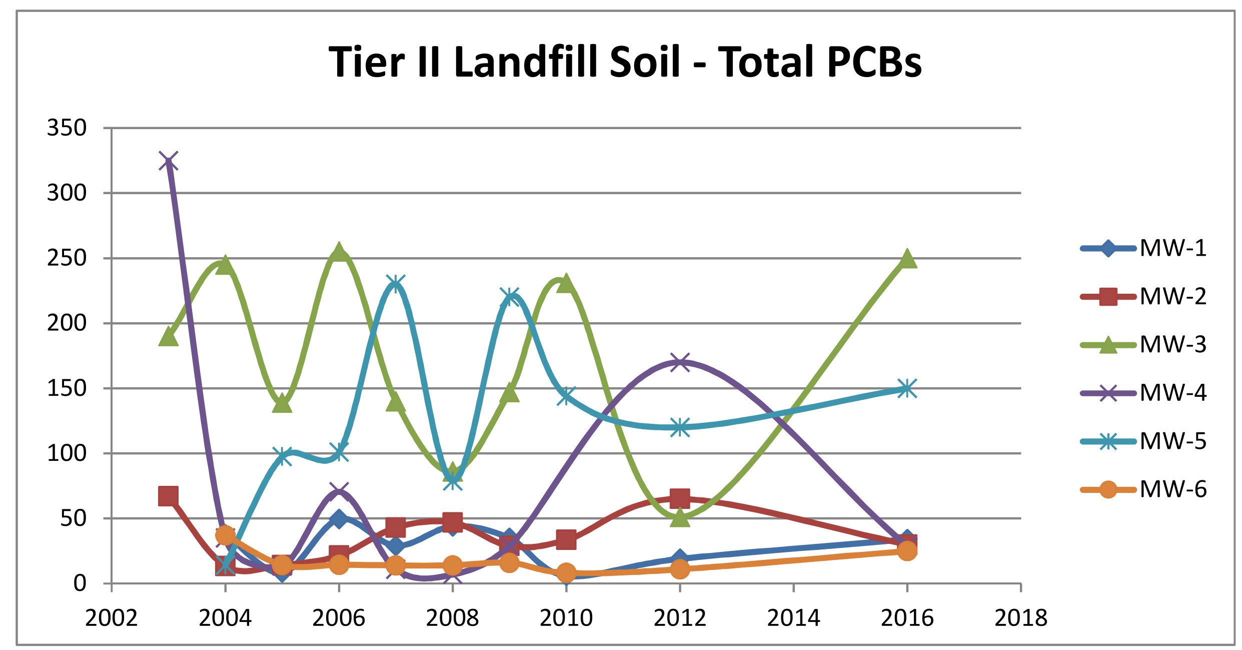
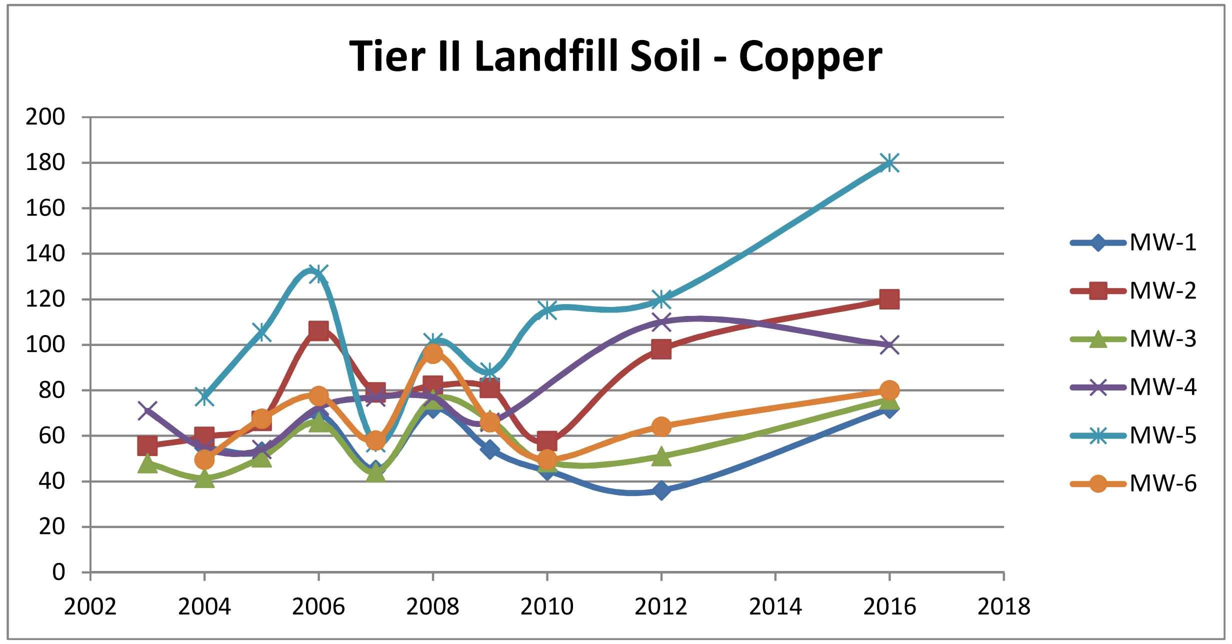


Table C12: Teir II Landfill Historical Soil Analytical Trend Graphs



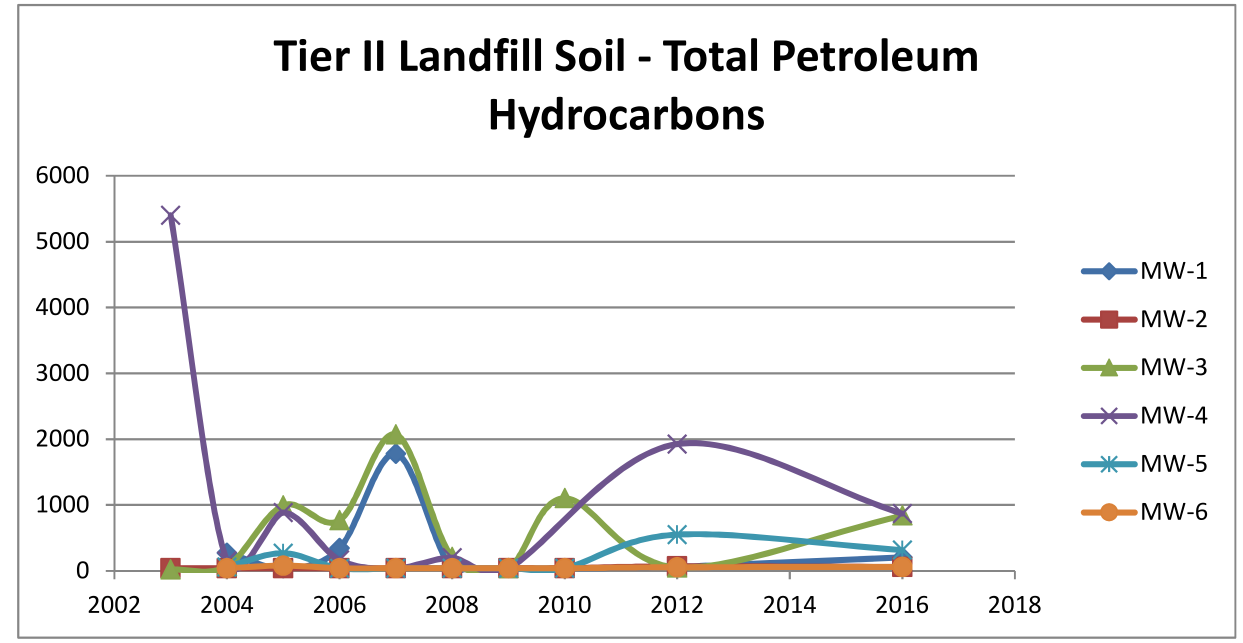


Table C13: Airstrip Landfill Historical Groundwater Analytical Results

Parameters	Units	Airstrip Landfill																	
		MW-11									MW12								
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																			
Dissolved Arsenic (As)	mg/L	<0.003	-	-	-	-	-	<0.003	<0.0010	<0.00010	<0.003	<0.003	<0.003	<0.003	<0.003	-	<0.003	<0.0010	0.0002
Dissolved Cadmium (Cd)	mg/L	<0.001	-	-	-	-	-	<0.001	<0.001	0.00003	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.00010	<0.000010
Dissolved Chromium (Cr)	mg/L	<0.005	-	-	-	-	-	<0.005	<0.0050	<0.0010	<0.005	<0.005	<0.005	0.0080	0.0100	-	<0.005	0.0061	<0.0010
Dissolved Cobalt (Co)	mg/L	<0.003	-	-	-	-	-	<0.003	<0.00050	<0.00050	<0.003	<0.003	<0.003	<0.003	0.0040	-	<0.003	<0.00050	<0.00050
Dissolved Copper (Cu)	mg/L	0.005	-	-	-	-	-	<0.005	0.0017	0.00079	<0.005	<0.005	<0.005	<0.005	0.0160	-	<0.005	0.0012	<0.00020
Dissolved Lead (Pb)	mg/L	<0.010	-	-	-	-	-	<0.010	<0.00050	0.00030	<0.010	<0.010	<0.010	<0.010	0.0130	-	<0.010	<0.00050	<0.00020
Dissolved Nickel (Ni)	mg/L	0.012	-	-	-	-	-	0.010	0.011	0.03630	<0.005	<0.005	<0.005	<0.005	0.0210	-	0.0050	<0.0010	<0.0010
Dissolved Zinc (Zn)	mg/L	0.012	-	-	-	-	-	0.0100	0.0093	0.01590	<0.010	<0.010	<0.010	<0.020	0.0500	-	<0.010	0.0094	<0.0050
Petroleum Hydrocarbons																			
BTEX & F1 Hydrocarbons																			
Benzene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
Toluene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
Ethylbenzene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
o-Xylene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	<0.00020	<0.00020
p+m-Xylene	mg/L	-	-	-	-	-	-	-	<0.00040	<0.00040	-	-	-	-	-	-	-	<0.00040	<0.00040
Total Xylenes	mg/L	-	-	-	-	-	-	-	<0.00040	<0.00040	-	-	-	-	-	-	-	<0.00040	<0.00040
F1 (C6-C10)	mg/L	-	-	-	-	-	-	-	<0.025	<0.025	-	-	-	-	-	-	-	<0.025	<0.025
F1 (C6-C10) - BTEX	mg/L	-	-	-	-	-	-	-	<0.025	<0.025	-	-	-	-	-	-	-	<0.025	<0.025
F2-F4 Hydrocarbons																			
F2 (C10-C16 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	<0.100	<0.1	-	-	-	-	-	-	-	<0.100	<0.1
F3 (C16-C34 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	<0.100	<0.2	-	-	-	-	-	-	-	<0.100	<0.2
F4 (C34-C50 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	<0.100	<0.2	-	-	-	-	-	-	-	<0.100	<0.2
TPH (lube) - F2-F4	mg/L	-	-	-	-	-	-	<1.0	0.15	0.35	-	-	-	<1.0	<1.0	-	<1.0	0.15	0.25
TPH (fuel) - F1	mg/L	-	-	-	-	-	-	<1.0	<0.025	<0.025	-	-	-	<1.0	<1.0	-	<1.0	<0.025	<0.025
TPH (total)	mg/L	<1.0	-	-	-	-	-	1.00	0.16	0.36	<1.0	<1.0	<1.0	1.00	1.00	-	1.00	0.16	0.26
Polychlorinated Biphenyls																			
Aroclor 1016	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1221	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1232	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1242	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1248	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1254	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1260	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1262	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Aroclor 1268	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	<0.01	<0.01
Total PCB	ug/L	-	-	-	-	-	-	0.0620	<0.01	<0.01	<0.02	<0.020	<0.020	0.0270	0.0490	-	0.0540	<0.01	<0.01

Table C13: Airstrip Landfill Historical Groundwater Analytical Results

Parameters	Units	Airstrip Landfill																	
		MW13									MW14								
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																			
Dissolved Arsenic (As)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.0010	<0.00010	<0.003	<0.003	<0.003	<0.003	-	<0.003	<0.003	-	<0.00010
Dissolved Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.00010	<0.000010	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.000010
Dissolved Chromium (Cr)	mg/L	<0.005	<0.005	0.0623	<0.005	<0.005	<0.005	<0.005	<0.005	<0.0010	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.0010
Dissolved Cobalt (Co)	mg/L	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.00050	<0.00050	<0.003	<0.003	0.0043	<0.003	-	<0.003	<0.003	-	<0.00050
Dissolved Copper (Cu)	mg/L	0.0050	<0.005	0.0120	<0.005	0.0060	0.0060	<0.005	0.0020	0.0013	<0.005	<0.005	0.0195	0.0050	-	0.0070	<0.005	-	0.0011
Dissolved Lead (Pb)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.00050	<0.00020	<0.010	<0.010	<0.010	<0.010	-	<0.010	<0.010	-	<0.00020
Dissolved Nickel (Ni)	mg/L	0.0140	0.0270	0.0425	0.0520	0.0070	0.0160	0.0120	0.0140	0.0059	<0.005	0.0100	0.0140	0.0060	-	<0.005	0.0070	-	0.0016
Dissolved Zinc (Zn)	mg/L	<0.010	0.0260	0.0125	<0.020	<0.010	0.0150	<0.010	0.0190	<0.0050	<0.010	0.0110	<0.010	<0.020	-	<0.010	<0.010	-	<0.0050
Petroleum Hydrocarbons																			
BTEX & F1 Hydrocarbons																			
Benzene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	-	<0.00020
Toluene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	-	<0.00020
Ethylbenzene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	-	<0.00020
o-Xylene	mg/L	-	-	-	-	-	-	-	<0.00020	<0.00020	-	-	-	-	-	-	-	-	<0.00020
p+m-Xylene	mg/L	-	-	-	-	-	-	-	<0.00040	<0.00040	-	-	-	-	-	-	-	-	<0.00040
Total Xylenes	mg/L	-	-	-	-	-	-	-	<0.00040	<0.00040	-	-	-	-	-	-	-	-	<0.00040
F1 (C6-C10)	mg/L	-	-	-	-	-	-	-	<0.025	<0.025	-	-	-	-	-	-	-	-	<0.025
F1 (C6-C10) - BTEX	mg/L	-	-	-	-	-	-	-	<0.025	<0.025	-	-	-	-	-	-	-	-	<0.025
F2-F4 Hydrocarbons																			
F2 (C10-C16 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	<0.100	<0.1	-	-	-	-	-	-	-	-	<0.1
F3 (C16-C34 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	<0.100	<0.2	-	-	-	-	-	-	-	-	<0.2
F4 (C34-C50 Hydrocarbons)	mg/L	-	-	-	-	-	-	-	<0.100	<0.2	-	-	-	-	-	-	-	-	<0.2
TPH (lube) - F2-F4	mg/L	-	-	-	<1.0	<1.0	<1.0	<1.0	0.15	0.25	-	-	-	<1.0	-	<1.0	<1.0	-	0.25
TPH (fuel) - F1	mg/L	-	-	-	<1.0	<1.0	<1.0	<1.0	<0.025	<0.025	-	-	-	<1.0	-	<1.0	<1.0	-	<0.025
TPH (total)	mg/L	<1.0	<1.0	<1.0	1.00	1.00	1.00	1.00	0.16	0.26	<1.0	<1.0	<1.0	1.00	-	1.00	1.00	-	0.26
Polychlorinated Biphenyls																			
Aroclor 1016	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1221	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1232	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1242	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1248	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1254	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1260	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1262	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Aroclor 1268	ug/L	-	-	-	-	-	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	<0.01
Total PCB	ug/L	<0.02	<0.020	0.0260	0.0210	0.1080	0.0200	<0.020	<0.01	<0.01	<0.02	<0.020	0.0235	0.0730	-	<0.020	0.0200	-	<0.01

Table C14: Airstrip Landfill Historical Soil Analytical Trends

Parameters	Units	Airstrip Landfill																			
		MW-11										MW12									
		2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																					
Arsenic (As)	mg/kg	<1.0	<1.0	<1.0	1.60	1.10	<1.0	-	1.20	<1.0	<1	<1.0	<1.0	1.25	2.10	1.00	1.20	<1.0	1.10	<1.0	<1
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	0.43	0.3	<1.0	<1.0	<1.0	<1.0	<1.0	1.50	<1.0	<1.0	0.24	0.3
Chromium (Cr)	mg/kg	46	53	43.50	50.00	51.00	35.00	-	45.00	35.00	50	43.00	51.00	45.50	46.50	42.00	66.00	35.00	37.00	33.00	49
Cobalt (Co)	mg/kg	17	23	15.80	16.20	18.30	12.90	-	15.10	16.00	23	9.70	21.00	22.00	19.70	16.50	49.00	11.90	15.50	16.00	24
Copper (Cu)	mg/kg	75	92	72.00	71.00	75.00	80.00	-	65.40	79.00	98	67.00	82.00	70.00	73.50	69.00	155.00	54.00	60.10	72.00	100
Lead (Pb)	mg/kg	14	114	10.50	<10	15.00	33.00	-	31.00	43.00	12	<10	<10	18.00	18.50	16.00	67.00	16.00	14.00	16.00	23
Nickel (Ni)	mg/kg	74	93	16.50	69.00	75.00	57.00	-	58.90	77.00	100	57.00	109.00	84.50	85.50	76.00	154.00	58.00	77.30	79.00	120
Zinc (Zn)	mg/kg	73	108	72.00	66.00	76.00	91.00	-	93.00	81.00	91	91.00	109.00	112.00	118.00	118.00	268.00	89.00	97.00	110.00	160
Petroleum Hydrocarbons																					
BTEX & F1 Hydrocarbons																					
Benzene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	-	-	<0.020	<0.0050
Toluene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	-	<0.020	<0.020
Ethylbenzene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	-	-	<0.020	<0.010
o-Xylene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	-	<0.020	<0.020
p+m-Xylene	mg/kg	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	-	<0.040	<0.040
Total Xylenes	mg/kg	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	-	<0.040	<0.040
F1 (C6-C10)	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
F1 (C6-C10) - BTEX	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
F2-F4 Hydrocarbons																					
F2 (C10-C16 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
F3 (C16-C34 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	14.00	<50	-	-	-	-	-	-	-	-	97.00	220
F4 (C34-C50 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	16.00	<50	-	-	-	-	-	-	-	-	29.00	<50
TPH (lube)	mg/kg	<20	<40	<40	<40	<40	<40	-	<40	35.00	55.00	<20	<40	5765.00	2080.00	3240.00	4390.00	370.00	1970.00	131.00	250.00
TPH (fuel)	mg/kg	100	<40	<40	<40	<40	<40	-	<40	<10	<10	98	<40	<40	<40	<40	<40	<40	<40	<10	<10
TPH (total)	mg/kg	100	40	40	40	40	40	-	40.00	40.00	60.00	98	40	5785.00	2100.00	3260.00	4410.00	390.00	1990.00	136.00	255.00
Polychlorinated Biphenyls																					
Aroclor 1016	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1221	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1232	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1242	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1248	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1254	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1260	ug/kg	-	-	-	-	-	-	-	-	29.00	<10	-	-	-	-	-	-	-	-	22.00	19.00
Aroclor 1262	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Aroclor 1268	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	-	<10	<10
Total PCB	ug/kg	170	<3	13.00	18.00	17.0000	112.0000	-	108.0000	29.00	<10	53	4	3.25	<100	<100	<3	44.00	60.80	22.000	19.00

Table C14: Airstrip Landfill Historical Soil Analytical Trends

Parameters	Units	Airstrip Landfill																		
		MW13										MW14								
		2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																				
Arsenic (As)	mg/kg	<1.0	<1.0	2.55	3.70	1.60	1.50	2.40	1.10	2.00	2	<1.0	1.10	2.00	1.30	<1.0	<1.0	1.70	<1.0	<1
Cadmium (Cd)	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.35	0.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.39	0.4
Chromium (Cr)	mg/kg	43.50	56.00	46.50	54.50	43.00	51.00	48.00	42.00	49.00	50	46.00	44.00	52.50	48.00	45.00	60.00	45.00	46.00	46
Cobalt (Co)	mg/kg	35.10	24.00	12.40	14.65	12.10	14.40	14.80	13.50	17.00	15	22.00	16.30	18.75	46.60	17.20	19.60	15.70	20.00	19
Copper (Cu)	mg/kg	81.00	91.00	78.00	89.50	82.00	82.00	87.00	77.90	110.00	97	82.00	74.00	93.50	74.00	74.00	93.00	66.00	100.00	92
Lead (Pb)	mg/kg	10.50	<10	20.00	11.50	20.00	18.00	20.00	35.00	17.00	14	<10	<10	<10	<10	10.00	<10	10.00	16.00	11
Nickel (Ni)	mg/kg	93.00	132.00	63.50	81.50	68.00	80.00	78.00	63.30	110.00	99	100.00	85.50	97.00	83.00	86.00	99.00	75.10	120.00	110
Zinc (Zn)	mg/kg	108.00	156.00	176.50	155.50	201.00	196.00	215.00	233.00	230.00	200	75.00	140.50	159.50	118.00	149.00	141.00	135.00	200.00	160
Petroleum Hydrocarbons																				
BTEX & F1 Hydrocarbons																				
Benzene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.0050	-	-	-	-	-	-	-	<0.020	<0.0050
Toluene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	<0.020	<0.020
Ethylbenzene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.010	-	-	-	-	-	-	-	<0.020	<0.010
o-Xylene	mg/kg	-	-	-	-	-	-	-	-	<0.020	<0.020	-	-	-	-	-	-	-	<0.020	<0.020
p+m-Xylene	mg/kg	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	<0.040	<0.040
Total Xylenes	mg/kg	-	-	-	-	-	-	-	-	<0.040	<0.040	-	-	-	-	-	-	-	<0.040	<0.040
F1 (C6-C10)	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
F1 (C6-C10) - BTEX	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
F2-F4 Hydrocarbons																				
F2 (C10-C16 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
F3 (C16-C34 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	63.00	53	-	-	-	-	-	-	-	24.00	<50
F4 (C34-C50 Hydrocarbons)	mg/kg	-	-	-	-	-	-	-	-	44.00	<50	-	-	-	-	-	-	-	14.00	<50
TPH (lube)	mg/kg	1775.00	<40	<40	<40	<40	<40	<40	100.00	112.00	83.00	<40	<40	<40	<40	<40	<40	<40	43.00	55.00
TPH (fuel)	mg/kg	45.00	<40	<40	<40	<40	<40	<40	<40	<10	<10	<40	<40	<40	<40	<40	<40	<40	<10	<10
TPH (total)	mg/kg	1810.00	40.00	40.00	40.00	40.00	40.00	40.00	120.00	117.00	88.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	60.00
Polychlorinated Biphenyls																				
Aroclor 1016	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1221	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1232	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1242	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1248	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1254	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	25.00	<10
Aroclor 1260	ug/kg	-	-	-	-	-	-	-	-	20.00	11.00	-	-	-	-	-	-	-	11.00	<10
Aroclor 1262	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Aroclor 1268	ug/kg	-	-	-	-	-	-	-	-	<10	<10	-	-	-	-	-	-	-	<10	<10
Total PCB	ug/kg	17.400	5.000	34.500	47.000	48.000	38.000	12.000	0.106	20.000	11.00	<3	39.000	26.500	20.000	103.000	16.000	10.500	36.000	10.00

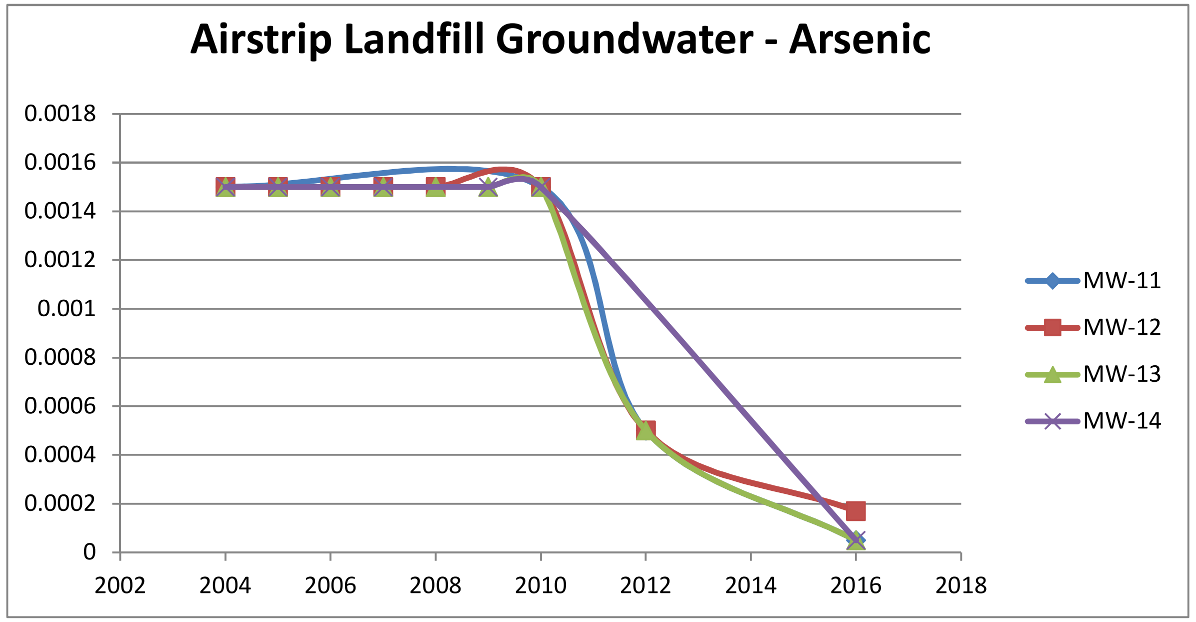
Table C15: Airstrip Landfill Historical Groundwater Analytical Trends

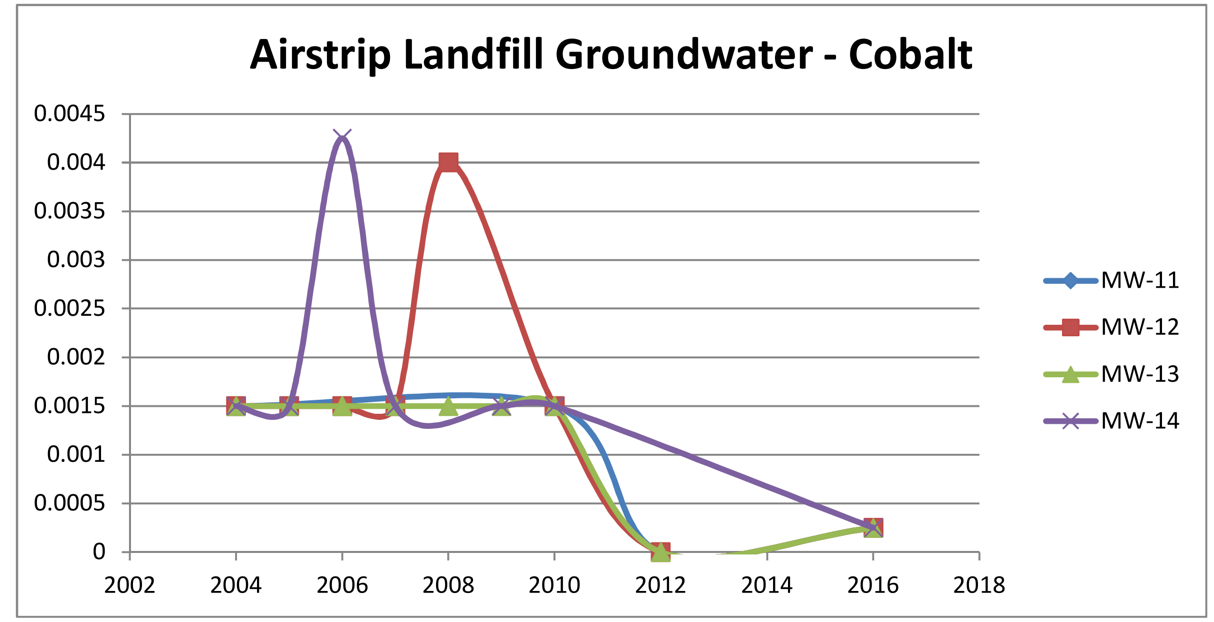
Parameters	Units	Airstrip Landfill																	
		MW-11									MW12								
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																			
Dissolved Arsenic (As)	mg/L	0.0015	-	-	-	-	-	0.0015	0.0005	0.00	0.0015	0.00	0.0015	0.0015	0.0015	-	0.0015	0.0005	0.0002
Dissolved Cadmium (Cd)	mg/L	0.00	-	-	-	-	-	0.0005	0.00050	0.000030	0.00	0.00	0.0005	0.0005	0.0005	-	0.0005	0.00005	0.0000
Dissolved Chromium (Cr)	mg/L	0.0025	-	-	-	-	-	0.0025	0.00250	0.000500	0.0025	0.00	0.0025	0.0080	0.0100	-	0.0025	0.0061	0.0005
Dissolved Cobalt (Co)	mg/L	0.0015	-	-	-	-	-	0.0015	0.00025	0.000250	0.0015	0.00	0.0015	0.0015	0.0040	-	0.0015	0.00025	0.0003
Dissolved Copper (Cu)	mg/L	0.005	-	-	-	-	-	0.0025	0.00	0.000790	0.0025	0.00	0.0025	0.0025	0.0160	-	0.0025	0.0012	0.0001
Dissolved Lead (Pb)	mg/L	0.005	-	-	-	-	-	0.0050	0.00025	0.000300	0.005	0.01	0.0050	0.0050	0.0130	-	0.0050	0.00025	0.0001
Dissolved Nickel (Ni)	mg/L	0.012	-	-	-	-	-	0.0100	0.01	0.036300	0.0025	0.00	0.0025	0.0025	0.0210	-	0.0050	0.00050	0.0005
Dissolved Zinc (Zn)	mg/L	0.012	-	-	-	-	-	0.0100	0.01	0.015900	0.005	0.01	0.0050	0.0100	0.0500	-	0.0050	0.0094	0.0025
Petroleum Hydrocarbons																			
TPH (lube) - F2-F4	mg/L	-	-	-	-	-	-	0.50	0.15	0.35	-	-	-	0.50	0.50	-	0.50	0.15	0.25
TPH (fuel) - F1	mg/L	-	-	-	-	-	-	0.50	0.0125	0.01	-	-	-	0.50	0.50	-	0.50	0.0125	0.01
TPH (total)	mg/L	0.5	-	-	-	-	-	1.00	0.16	0.36	0.5	0.50	0.50	1.00	1.00	-	1.00	0.16	0.26
Polychlorinated Biphenyls																			
Total PCB	ug/L	-	-	-	-	-	-	0.0620	0.0050	0.0050	0.0100	0.0100	0.0100	0.0270	0.0490	-	0.0540	0.005	0.0050

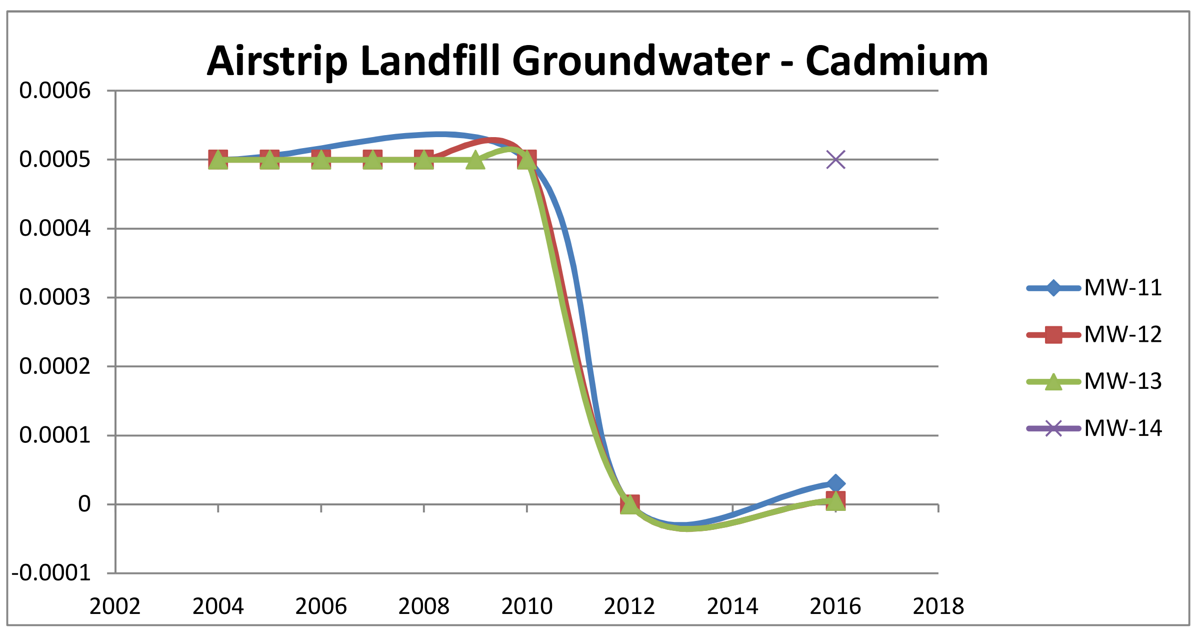
Table C15: Airstrip Landfill Historical Groundwater Analytical Trends

Parameters	Units	Airstrip Landfill																	
		MW13									MW14								
		2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																			
Dissolved Arsenic (As)	mg/L	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0005	0.0001	0.0015	0.0015	0.0015	0.0015	-	0.0015	0.0015	-	0.0001
Dissolved Cadmium (Cd)	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.00005	0.0000	0.0005	0.0005	0.0005	0.0005	-	0.0005	0.0005	-	0.0000
Dissolved Chromium (Cr)	mg/L	0.0025	0.0025	0.0623	0.0025	0.0025	0.0025	0.0025	0.0025	0.0005	0.0025	0.0025	0.0025	0.0025	-	0.0025	0.0025	-	0.0005
Dissolved Cobalt (Co)	mg/L	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.00025	0.0003	0.0015	0.0015	0.0043	0.0015	-	0.0015	0.0015	-	0.0003
Dissolved Copper (Cu)	mg/L	0.0050	0.0025	0.0120	0.0025	0.0060	0.0060	0.0025	0.0020	0.0013	0.0025	0.0025	0.0195	0.0050	-	0.0070	0.0025	-	0.0011
Dissolved Lead (Pb)	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.00025	0.0001	0.0050	0.0050	0.0050	0.0050	-	0.0050	0.0050	-	0.0001
Dissolved Nickel (Ni)	mg/L	0.0140	0.0270	0.0425	0.0520	0.0070	0.0160	0.0120	0.0140	0.0059	0.0025	0.0100	0.0140	0.0060	-	0.0025	0.0070	-	0.0016
Dissolved Zinc (Zn)	mg/L	0.0050	0.0260	0.0125	0.0100	0.0050	0.0150	0.0050	0.0190	0.0025	0.0050	0.0110	0.0050	0.0100	-	0.0050	0.0050	-	0.0025
Petroleum Hydrocarbons																			
TPH (lube) - F2-F4	mg/L	-	-	-	0.50	0.50	0.50	0.50	0.15	0.25	-	-	-	0.50	-	0.50	0.50	-	0.25
TPH (fuel) - F1	mg/L	-	-	-	0.50	0.50	0.50	0.50	0.0125	0.01	-	-	-	0.50	-	0.50	0.50	-	0.01
TPH (total)	mg/L	0.50	0.50	0.50	1.00	1.00	1.00	1.00	0.16	0.26	0.50	0.50	0.50	1.00	-	1.00	1.00	-	0.26
Polychlorinated Biphenyls																			
Total PCB	ug/L	0.0100	0.0100	0.0260	0.0210	0.1080	0.0200	0.0100	0.005	0.0050	0.0100	0.0100	0.0235	0.0730	-	0.0100	0.0200	-	0.01

Table C16: Airstrip Landfill Historical Groundwater Analytical Trend Graphs







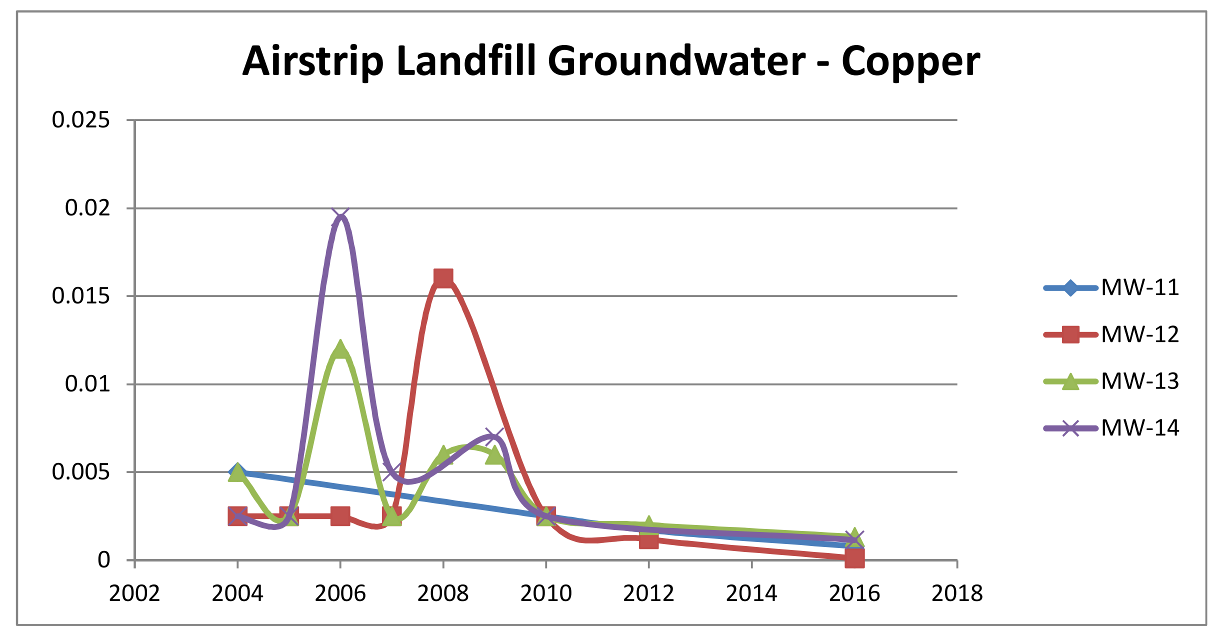
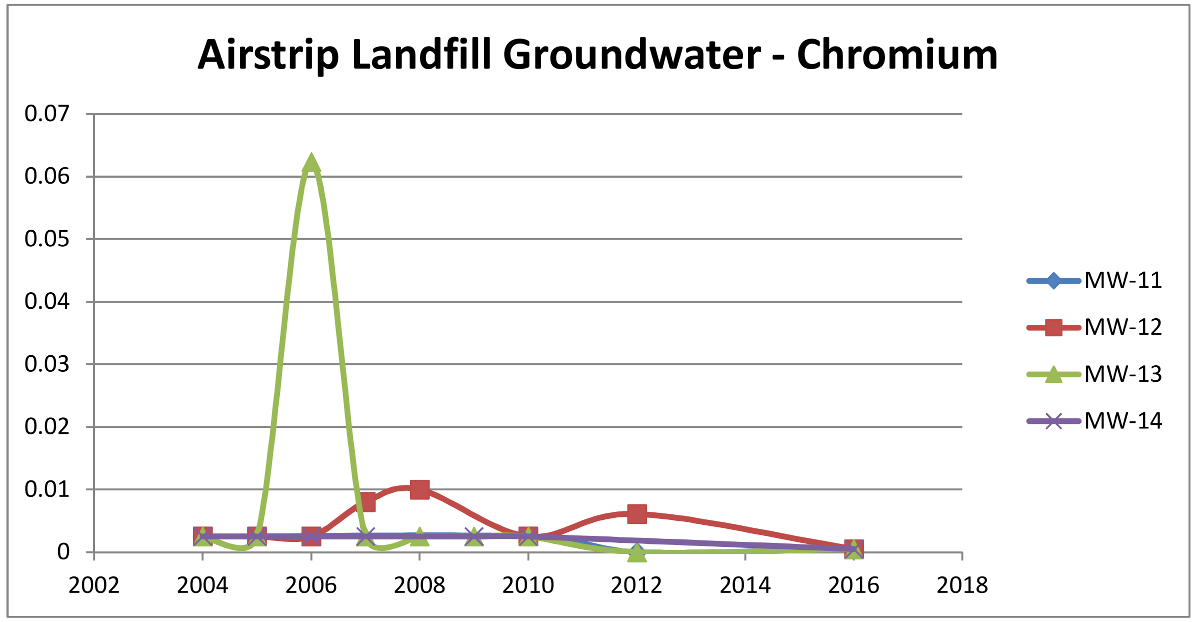
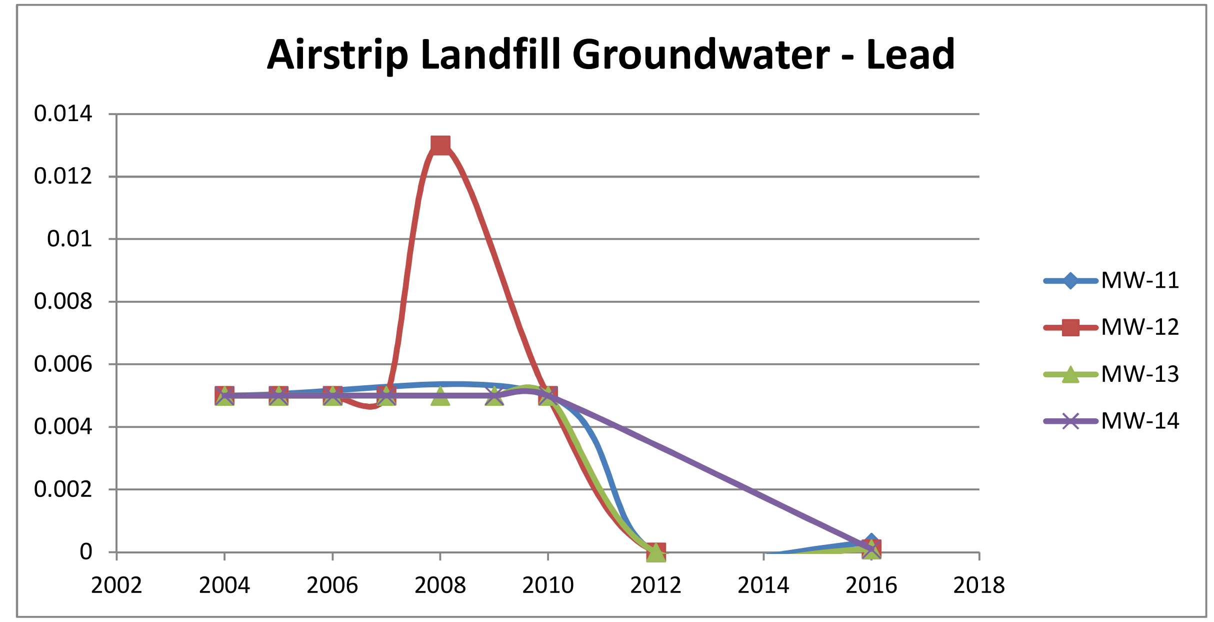
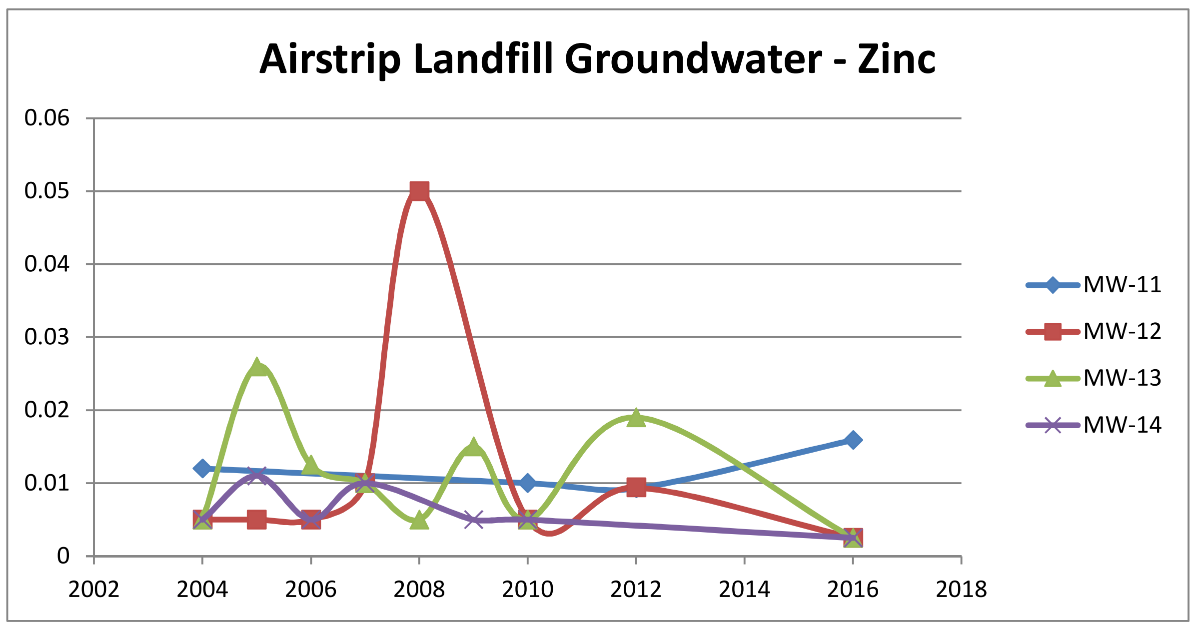


Table C16: Airstrip Landfill Historical Groundwater Analytical Trend Graphs







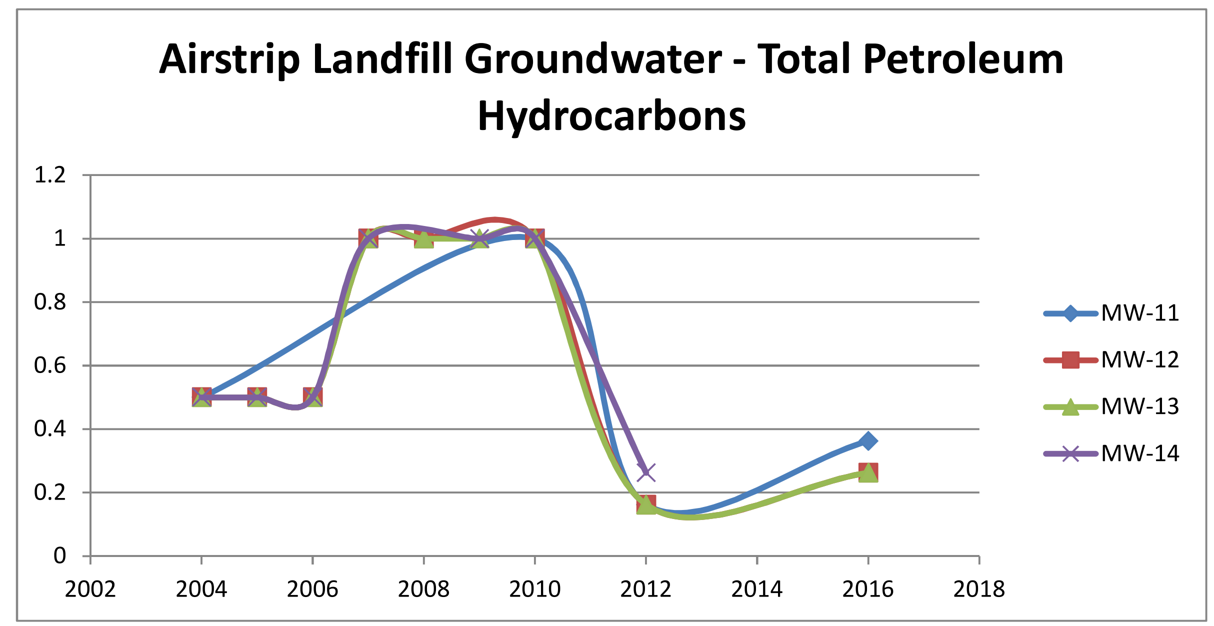
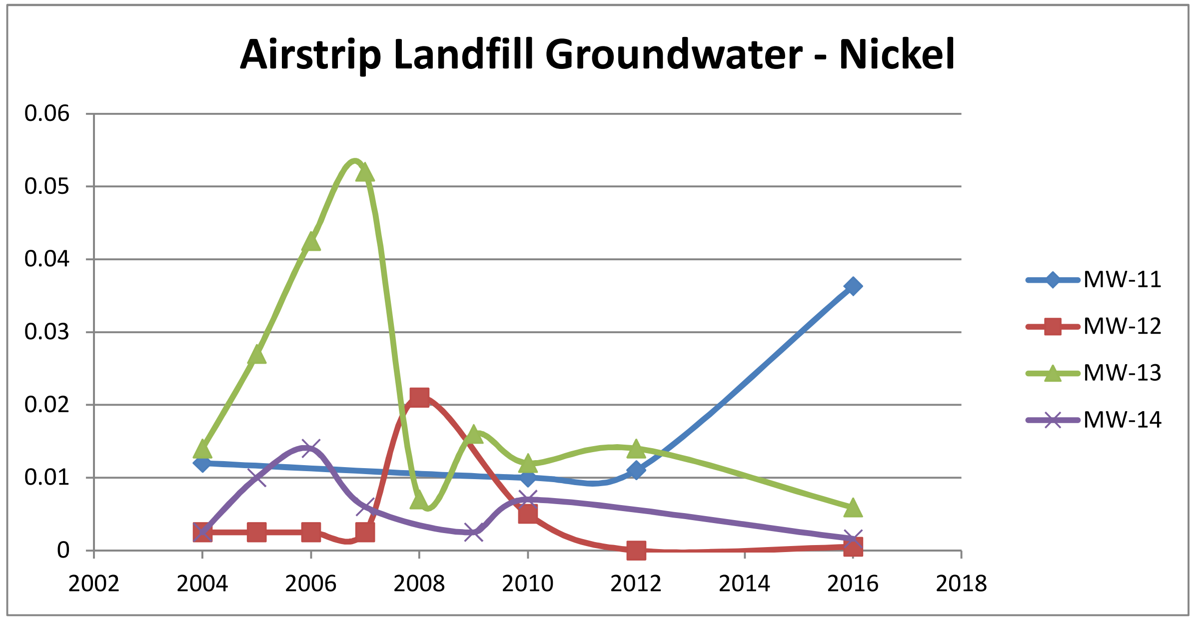


Table C16: Airstrip Landfill Historical Groundwater Analytical Trend Graphs



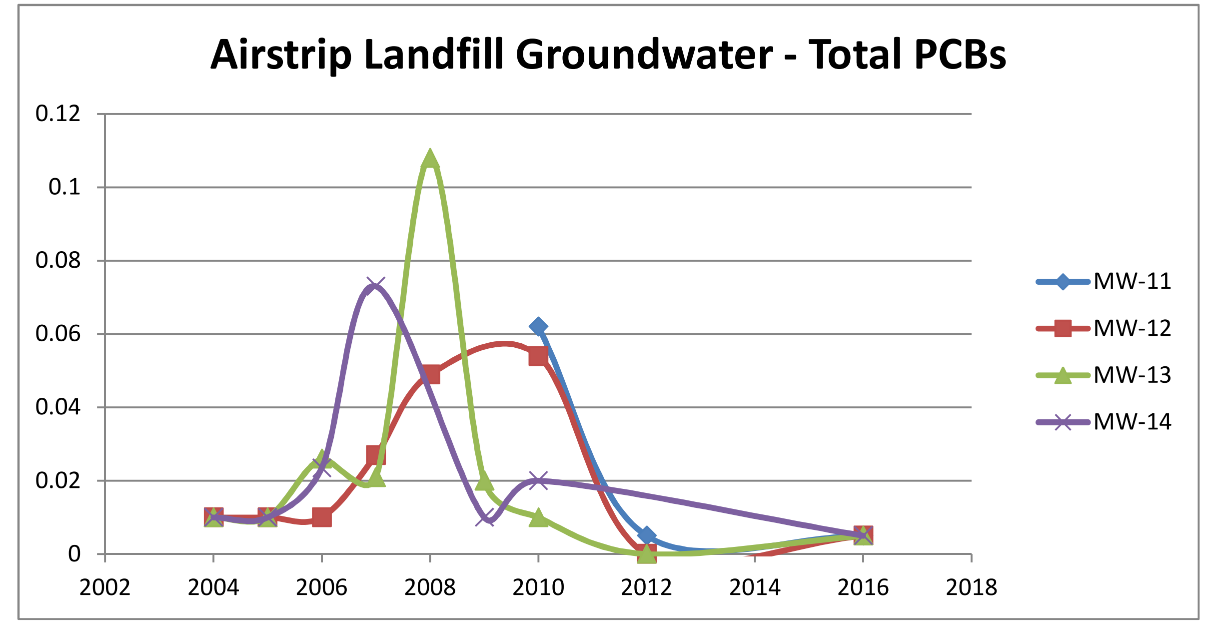


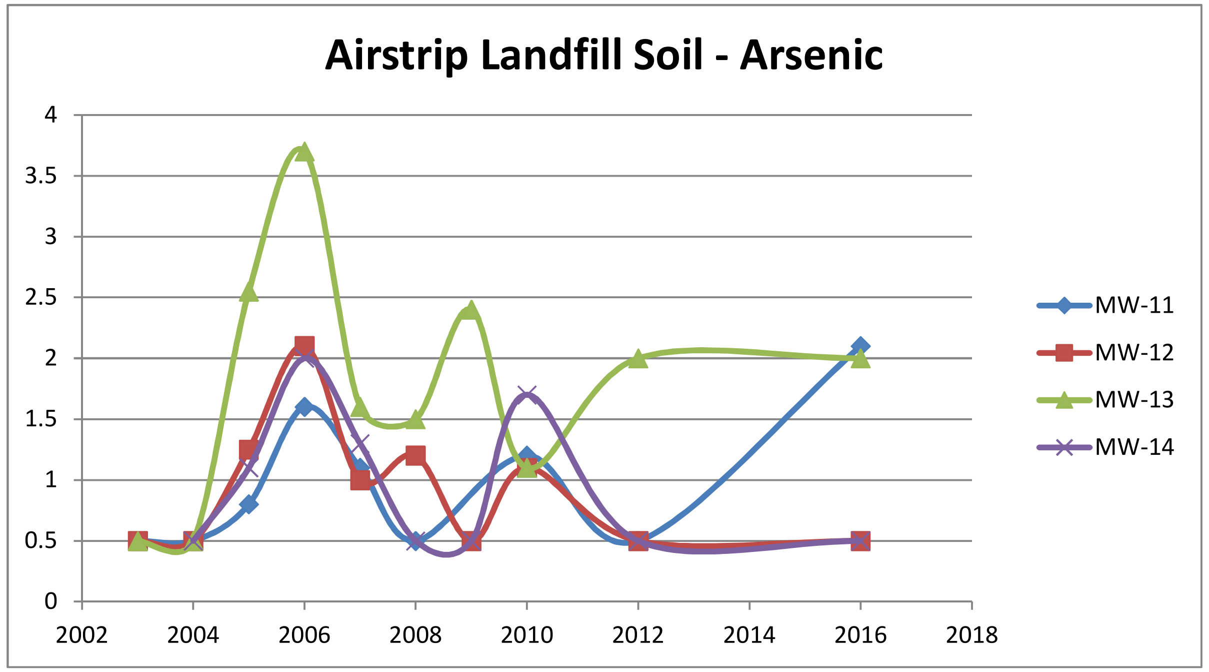
Table C17: Airstrip Landfill Historical Soil Analytical Trends

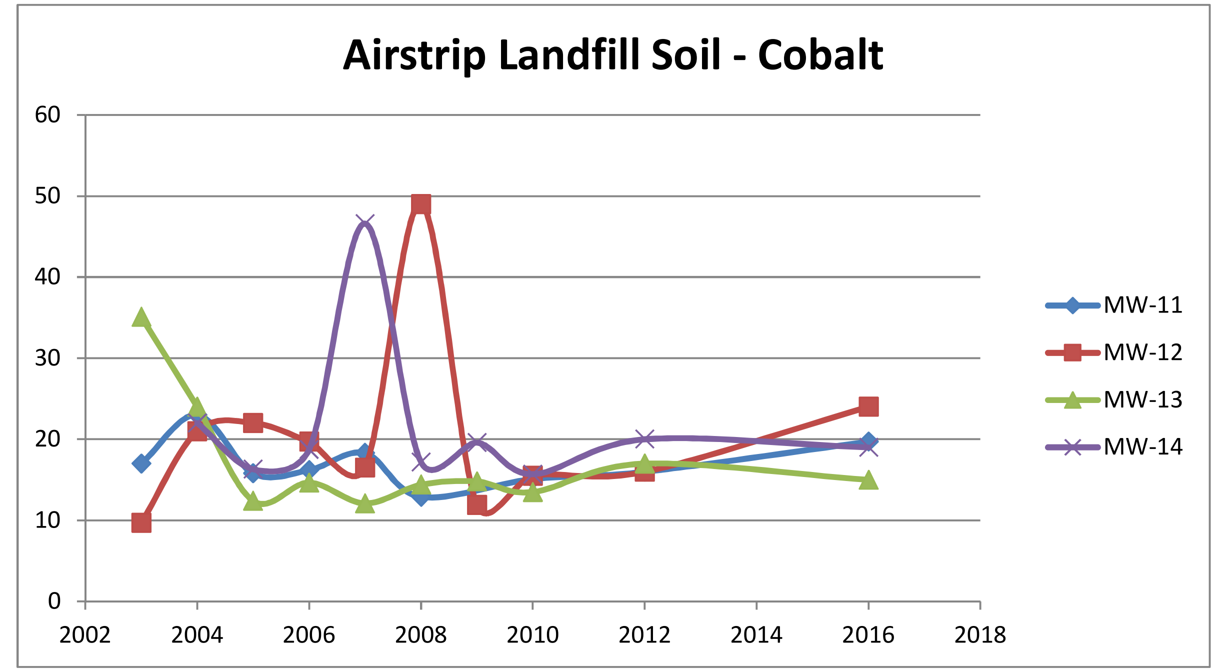
		Airstrip Landfill																			
		MW-11										MW12									
Parameters	Units	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																					
Arsenic (As)	mg/kg	0.5	0.5	0.80	1.60	1.10	0.50	-	1.20	0.50	2.10	0.50	0.50	1.25	2.10	1.00	1.20	0.50	1.10	0.50	0.50
Cadmium (Cd)	mg/kg	0.5	0.50	0.50	0.50	0.50	0.50	-	0.50	0.43	0.50	0.50	0.50	0.50	0.50	0.50	1.50	0.50	0.50	0.24	0.3
Chromium (Cr)	mg/kg	46	53	43.50	50.00	51.00	35.00	-	45.00	35.00	46.50	43.00	51.00	45.50	46.50	42.00	66.00	35.00	37.00	33.00	49
Cobalt (Co)	mg/kg	17	23	15.80	16.20	18.30	12.90	-	15.10	16.00	19.70	9.70	21.00	22.00	19.70	16.50	49.00	11.90	15.50	16.00	24
Copper (Cu)	mg/kg	75	92	72.00	71.00	75.00	80.00	-	65.40	79.00	73.50	67.00	82.00	70.00	73.50	69.00	155.00	54.00	60.10	72.00	100
Lead (Pb)	mg/kg	14	114	10.50	<10	15.00	33.00	-	31.00	43.00	18.50	5.00	5.00	18.00	18.50	16.00	67.00	16.00	14.00	16.00	23
Nickel (Ni)	mg/kg	74	93	16.50	69.00	75.00	57.00	-	58.90	77.00	85.50	57.00	109.00	84.50	85.50	76.00	154.00	58.00	77.30	79.00	120
Zinc (Zn)	mg/kg	73	108	72.00	66.00	76.00	91.00	-	93.00	81.00	118.00	91.00	109.00	112.00	118.00	118.00	268.00	89.00	97.00	110.00	160
Petroleum Hydrocarbons																					
TPH (lube)	mg/kg	10	20	20	20	20	20	-	20.00	35.00	55.00	10	20	5765.00	2080.00	3240.00	4390.00	370.00	1970.00	131.00	250.00
TPH (fuel)	mg/kg	100	20	20	20	20	20	-	20.00	5.00	5.00	98	20	20.00	20.00	20.00	20.00	20.00	20.00	5.00	5.00
TPH (total)	mg/kg	100	40	40	40	40	40	-	40.00	40.00	60.00	98	40	5785.00	2100.00	3260.00	4410.00	390.00	1990.00	136.00	255.00
Polychlorinated Biphenyls																					
Total PCB	ug/kg	170	1.5	13.00	18.00	17.0000	112.0000	-	108.0000	29.00	5.00	53	4	3.25	50.00	50.00	1.50	44.00	60.80	22.000	19.000

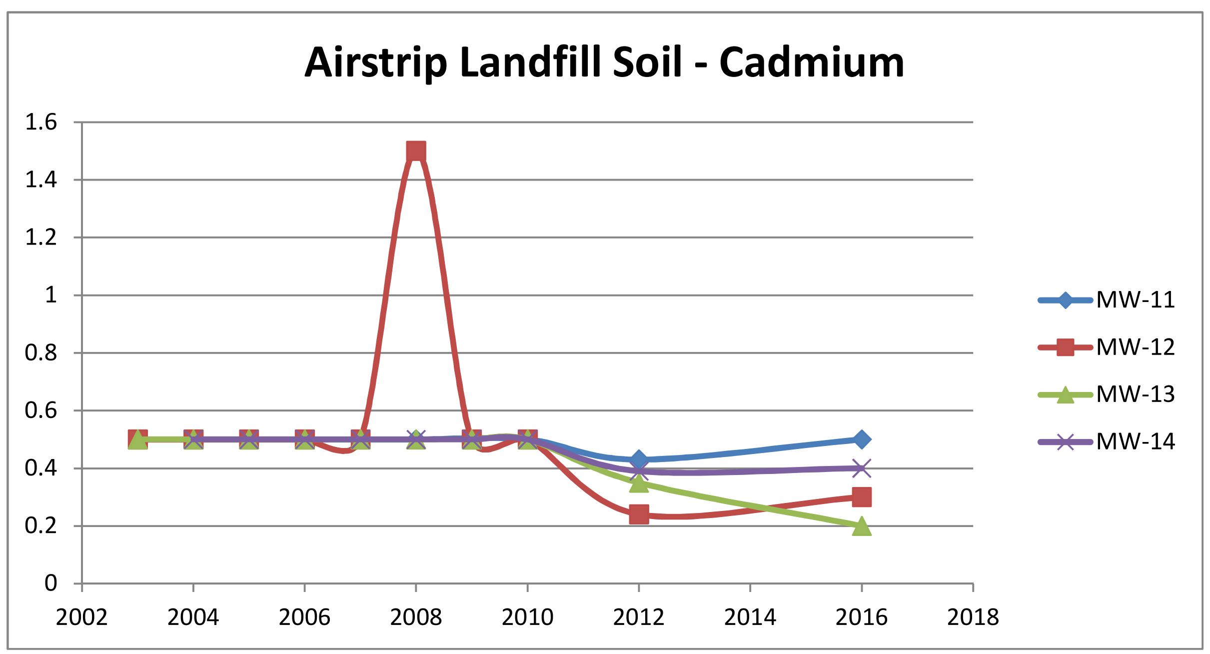
Table C17: Airstrip Landfill Historical Soil Analytical Trends

		Airstrip Landfill																		
		MW13										MW14								
Parameters	Units	2003	2004	2005	2006	2007	2008	2009	2010	2012	2016	2004	2005	2006	2007	2008	2009	2010	2012	2016
Metals																				
Arsenic (As)	mg/kg	0.50	0.50	2.55	3.70	1.60	1.50	2.40	1.10	2.00	2	0.50	1.10	2.00	1.30	0.50	0.50	1.70	0.50	0.50
Cadmium (Cd)	mg/kg	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.35	0.2	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.39	0.4
Chromium (Cr)	mg/kg	43.50	56.00	46.50	54.50	43.00	51.00	48.00	42.00	49.00	50	46.00	44.00	52.50	48.00	45.00	60.00	45.00	46.00	46
Cobalt (Co)	mg/kg	35.10	24.00	12.40	14.65	12.10	14.40	14.80	13.50	17.00	15	22.00	16.30	18.75	46.60	17.20	19.60	15.70	20.00	19
Copper (Cu)	mg/kg	81.00	91.00	78.00	89.50	82.00	82.00	87.00	77.90	110.00	97	82.00	74.00	93.50	74.00	74.00	93.00	66.00	100.00	92
Lead (Pb)	mg/kg	10.50	5.00	20.00	11.50	20.00	18.00	20.00	35.00	17.00	14	5.00	9.50	9.50	5.00	10.00	5.00	10.00	16.00	11
Nickel (Ni)	mg/kg	93.00	132.00	63.50	81.50	68.00	80.00	78.00	63.30	110.00	99	100.00	85.50	97.00	83.00	86.00	99.00	75.10	120.00	110
Zinc (Zn)	mg/kg	108.00	156.00	176.50	155.50	201.00	196.00	215.00	233.00	230.00	200	75.00	140.50	159.50	118.00	149.00	141.00	135.00	200.00	160
Petroleum Hydrocarbons																				
TPH (lube)	mg/kg	1775.00	20.00	20.00	20.00	20.00	20.00	20.00	100.00	112.00	83.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	43.00	55.00
TPH (fuel)	mg/kg	45.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	5.00	5.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	<10	5.00
TPH (total)	mg/kg	1810.00	40.00	40.00	40.00	40.00	40.00	40.00	120.00	117.00	88.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	60.00
Total PCB	ug/kg	17.400	5.000	34.500	47.000	48.000	38.000	12.000	0.106	20.000	11.000	1.500	39.000	26.500	20.000	103.000	16.000	10.500	36.000	10.000

Table C18: Airstrip Landfill Historical Soil Analytical Trend Graphs







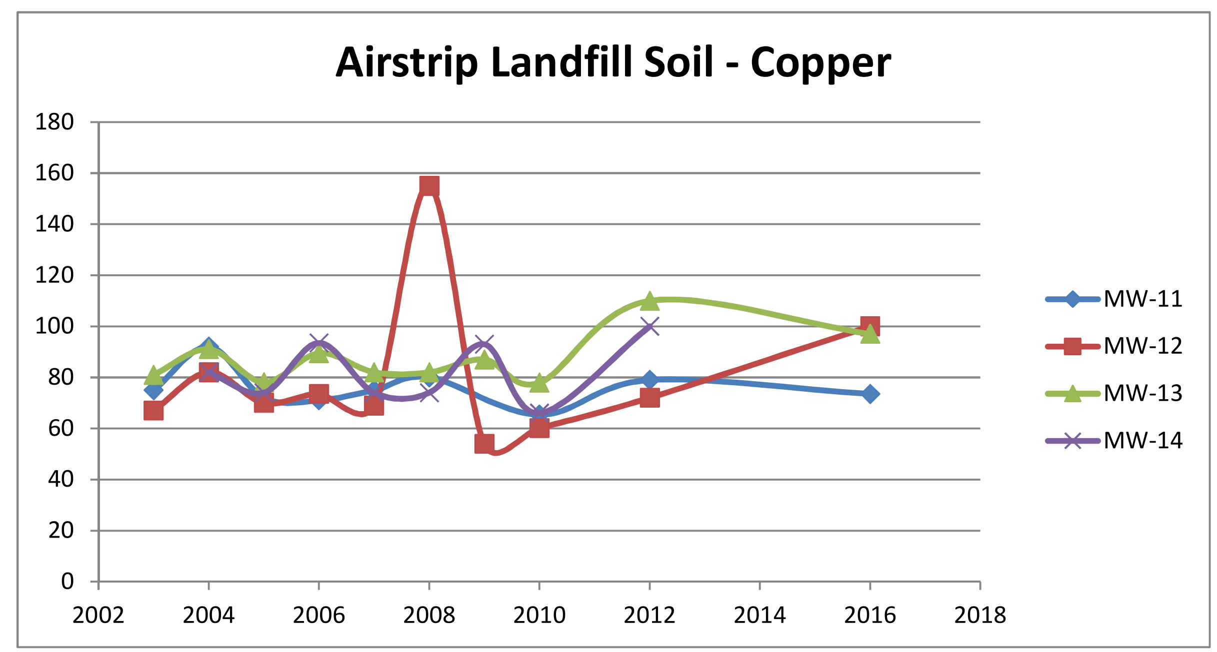
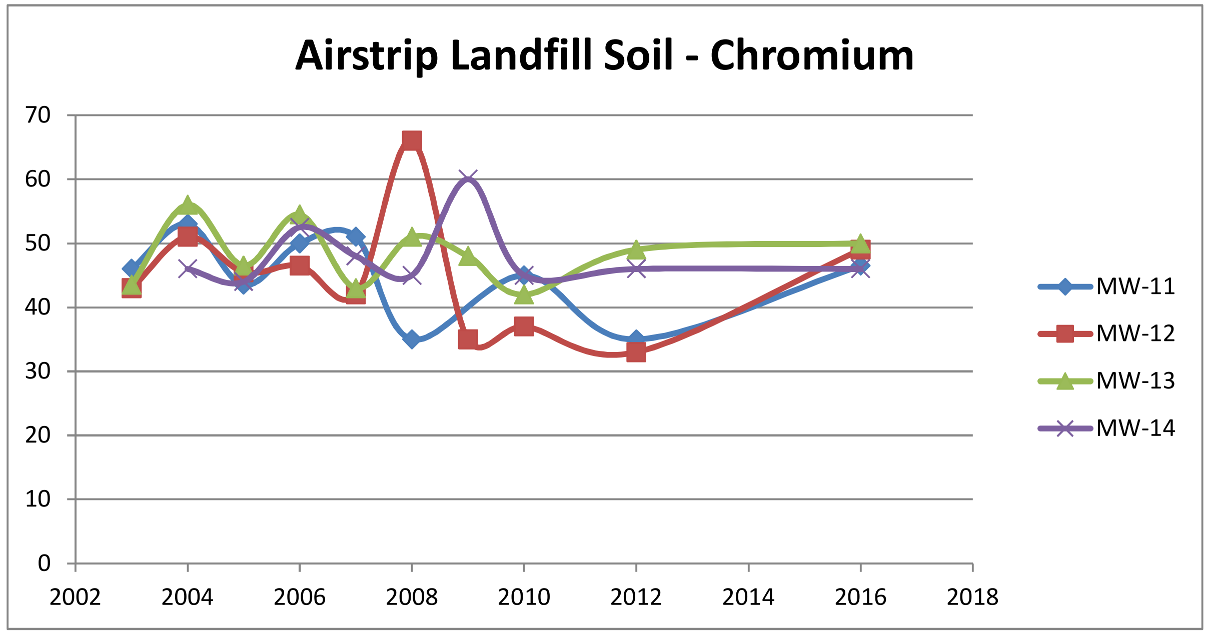
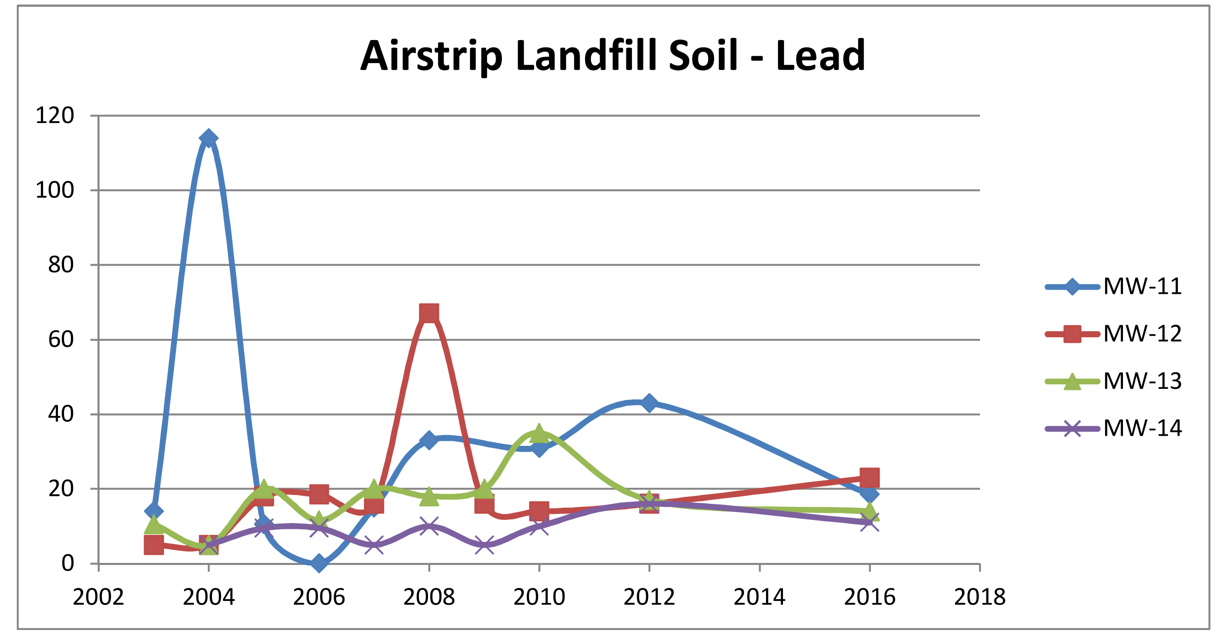
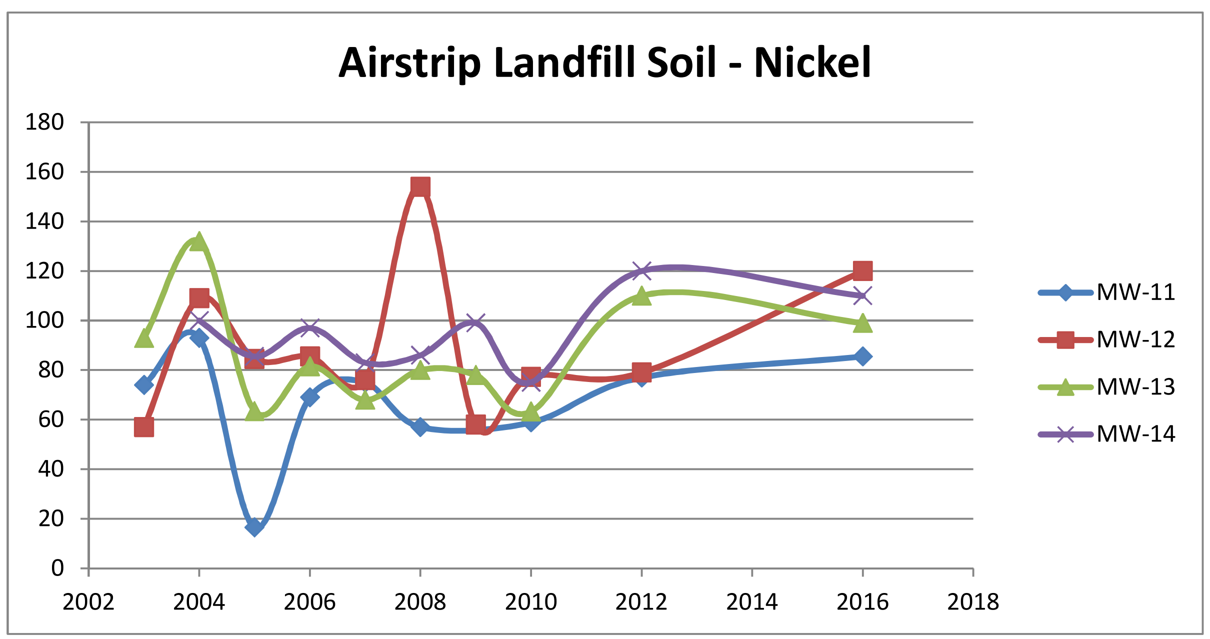


Table C18: Airstrip Landfill Historical Soil Analytical Trend Graphs







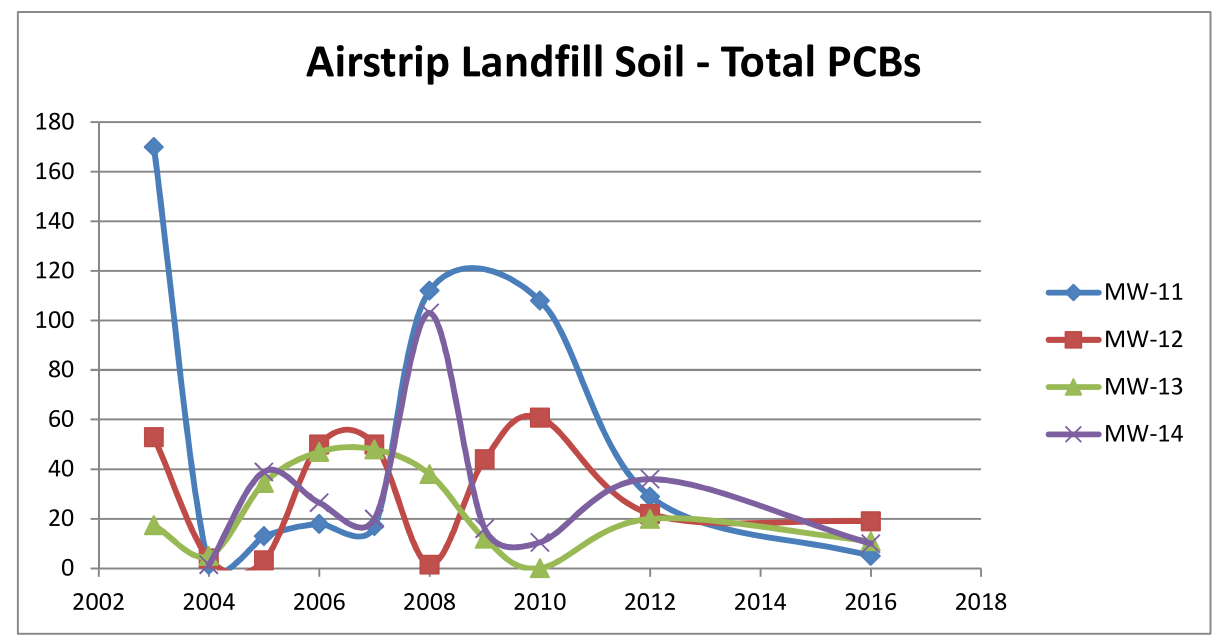
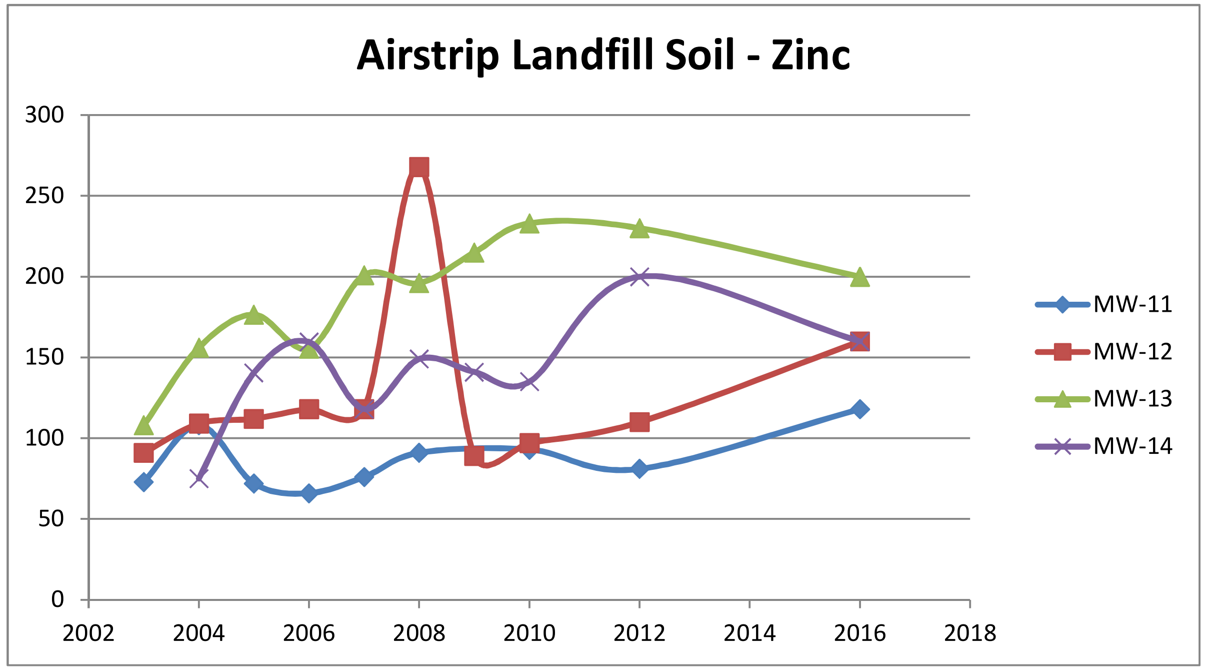


Table C18: Airstrip Landfill Historical Soil Analytical Trend Graphs



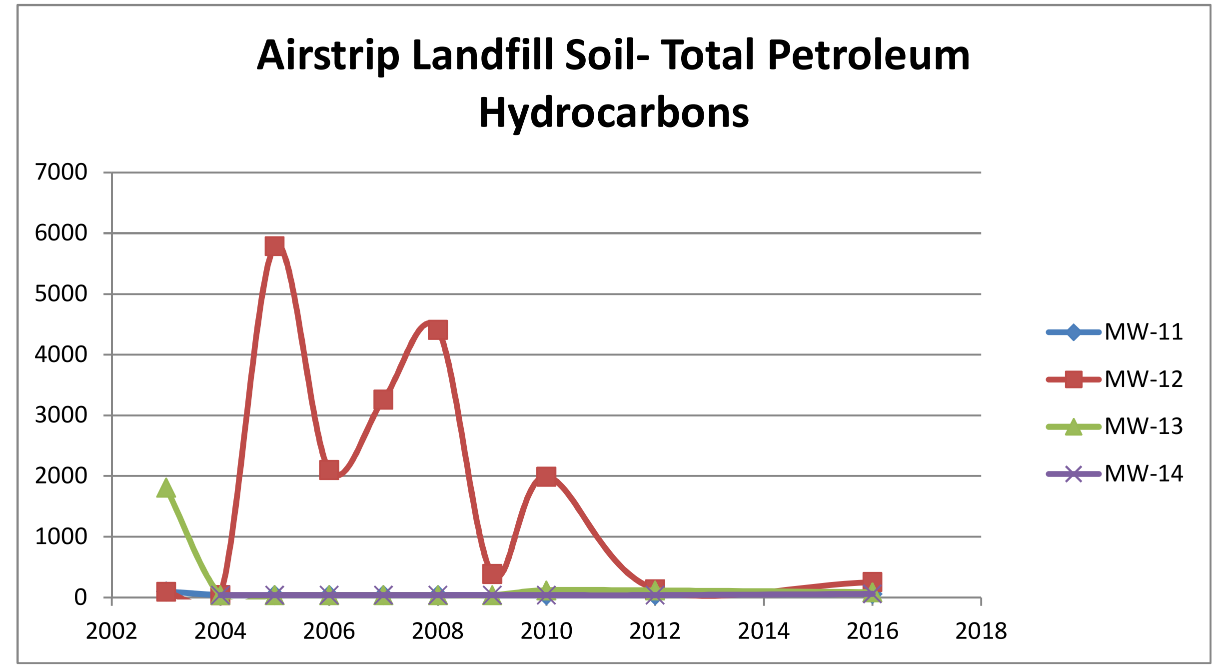


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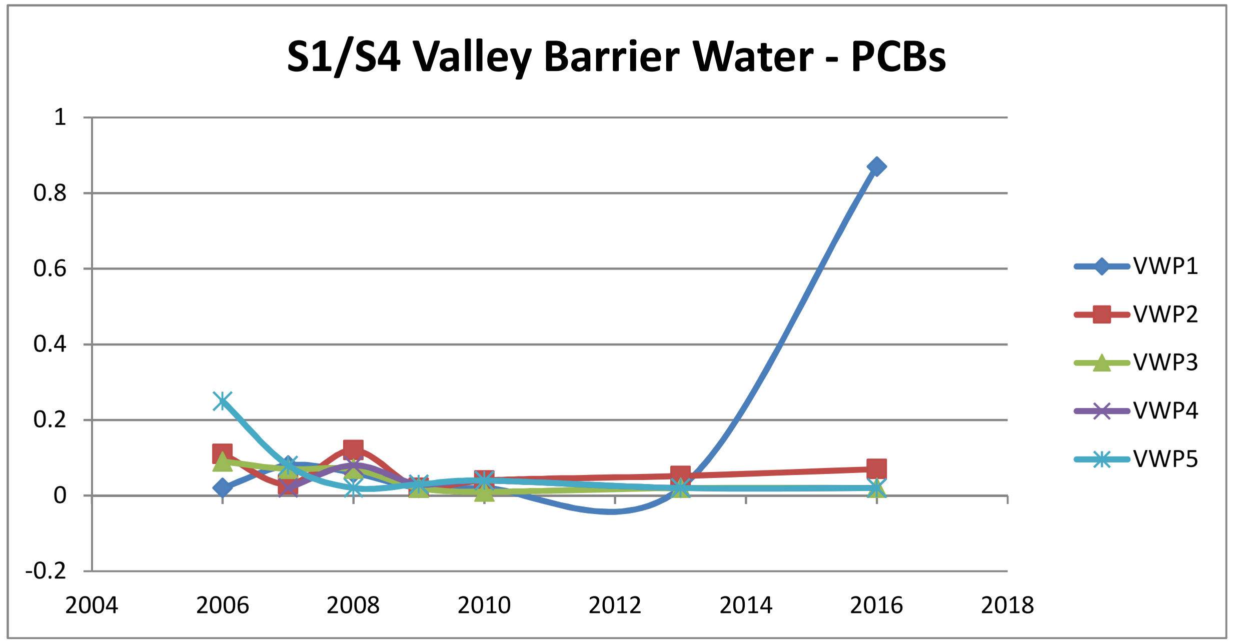
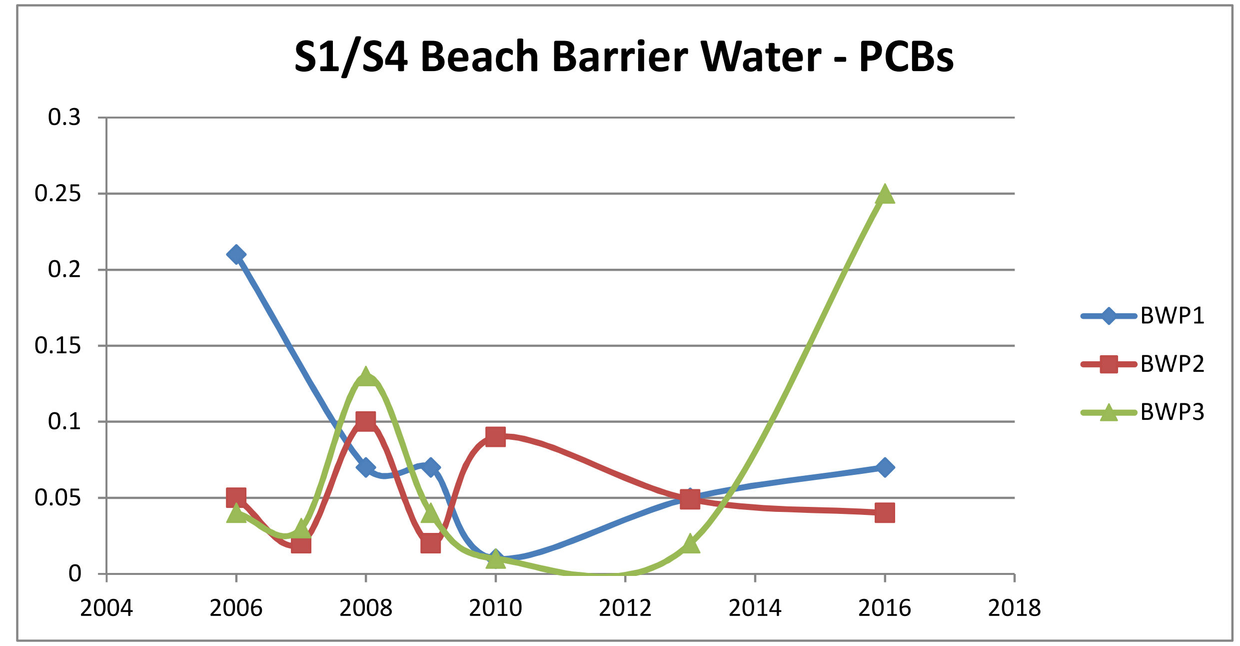
Table C19: PCB Barrier Historical Surface Water Analytical Results

Parameter	Year	S1/S4 ValleyBarrier					S1/S4 Beach Barrier			Furniture Dump Barrier
		VWP1	VWP2	VWP3	VWP4	VWP5	BWP1	BWP2	BWP3	VWP1
Total PCB (ug/L)	2006	0.02	0.11	0.09	-	0.25	0.21	0.05	0.04	-
	2007	0.08	0.03	0.07	0.02	0.08	-	0.02	0.03	0.53
	2008	0.06	0.12	0.07	0.08	0.02	0.07	0.1	0.13	0.12
	2009	0.02	0.02	0.02	0.03	0.03	0.07	0.02	0.04	0.21
	2010	0.02	0.04	<0.02	0.04	0.04	<0.02	0.09	<0.02	0.99
	2012									
	2013	<0.040	0.052	<0.040	<0.040	<0.040	<0.04	0.049	<0.040	2.3
	2016	0.87	0.07	0.02	0.02	0.02	0.07	0.04	0.25	-

Table C20: PCB Barrier Historical Surface Water Analytical Graphs





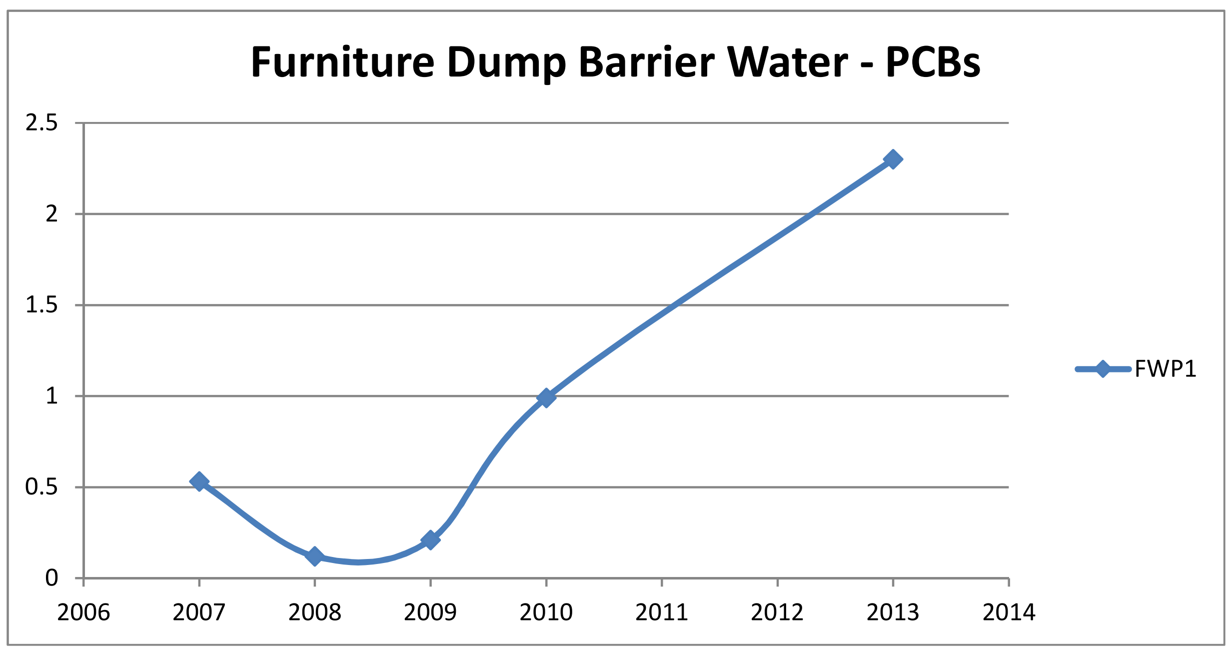
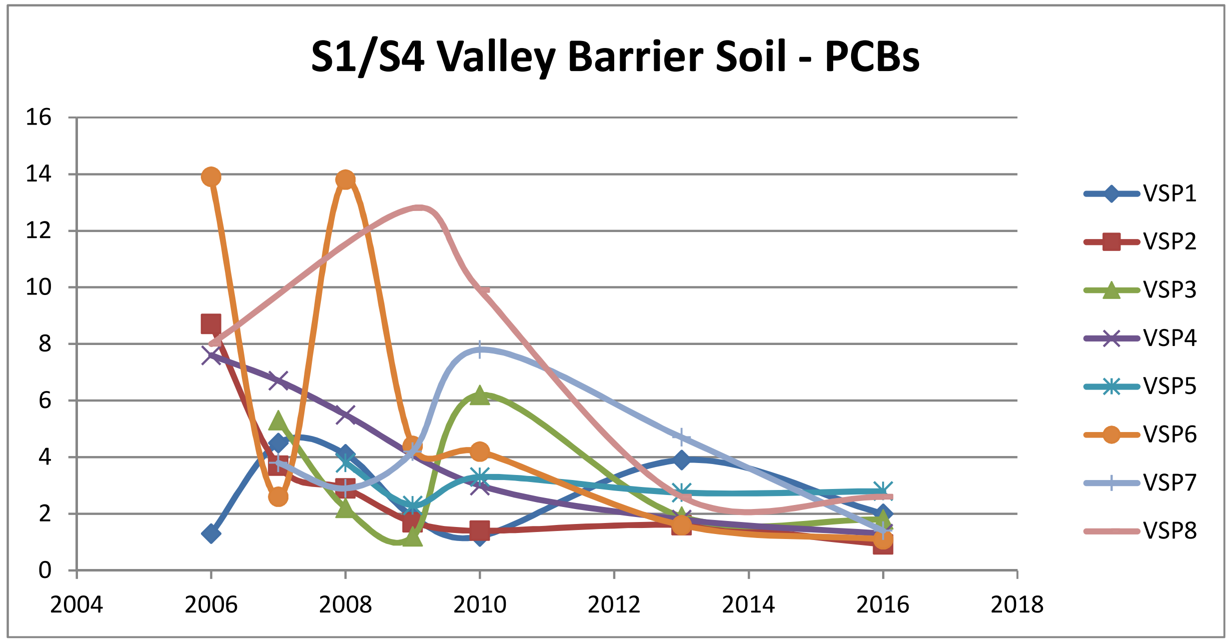
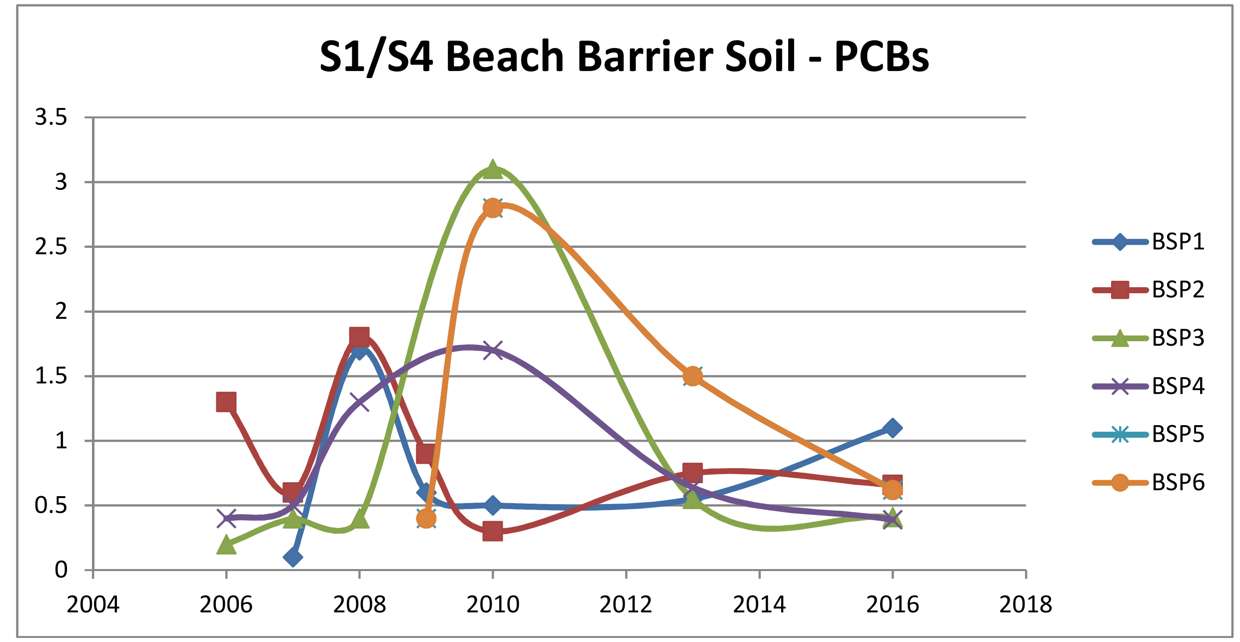


Table C21: PCB Barrier Historical Soil Analytical Results

Parameter	Year	S1/S4 Valley Barrier								S1/S4 Beach Barrier						Furniture Dump Barrier				
		VSP1	VSP2	VSP3	VSP4	VSP5	VSP6	VSP7	VSP8	BSP1	BSP2	BSP3	BSP4	BSP5	BSP6	FSP1	FSP2	FSP3	FSP4	FSP5
Total PCB (mg/kg)	2006	1.3	8.7	-	7.6	-	13.9	-	8	-	1.3	0.2	0.4	-	-	24	20	49	-	68
	2007	4.5	3.7	5.3	6.7	-	2.6	3.8	-	0.1	0.6	0.4	0.5	-	-	43	32	32	-	118
	2008	4.1	2.9	2.2	5.5	3.8	13.8	2.9	-	1.7	1.8	0.4	1.3	-	-	56	101	40	-	232
	2009	1.9	1.7	1.2	-	2.3	4.4	4.2	12.8	0.6	0.9	-	-	0.5	0.4	32	54	10.8	9.5	-
	2010	1.2	1.4	6.2	3	3.3	4.2	7.8	9.9	0.5	0.3	3.1	1.7	0.9	2.8	31	53	13.8	13.6	76
	2012																			
	2013	3.9	1.6	1.9	1.8	3.1;2.4	1.6	4.7	2.6	0.55	0.75	0.55	0.64	1.2;1.0	1.5	54.1	81.1	8.4	11.8	130;148
	2016	2.0	0.92	1.8	1.3	2.8	1.1	1.4	2.6	1.1	0.66	0.41	0.39	0.29	0.62	44	28	12	23	230

Table C22: PCB Barrier Historical Soil Analytical Graphs





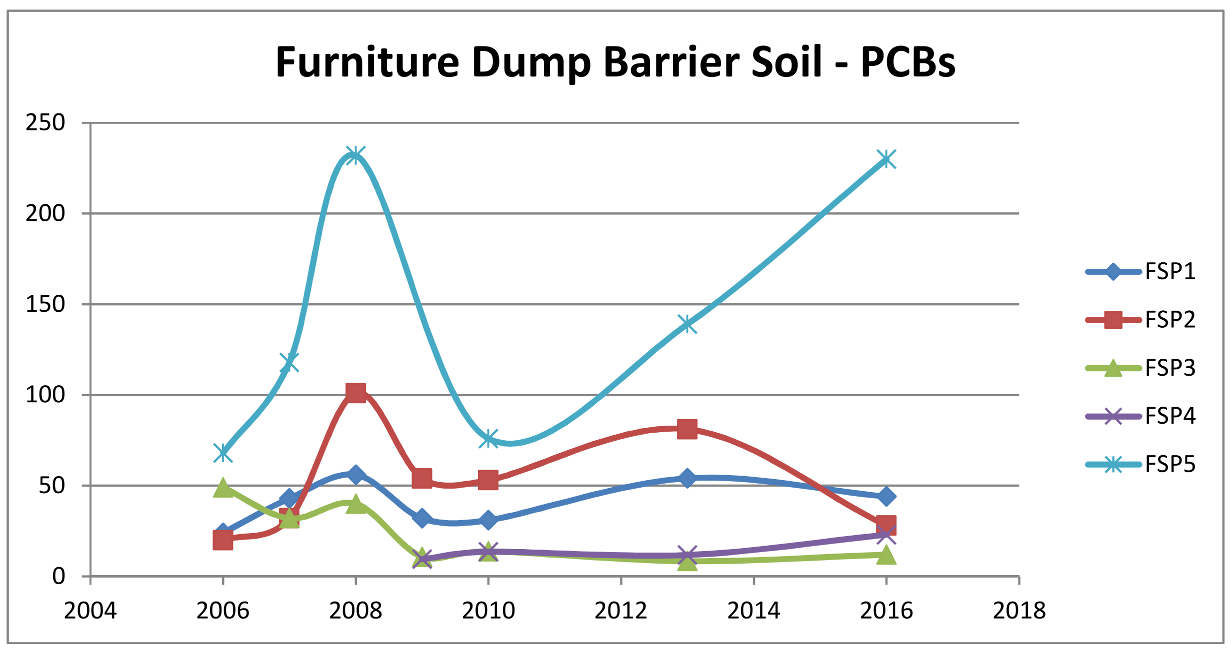


Table C23: Tier II Landfill VT-1 Thermistor Historical Data

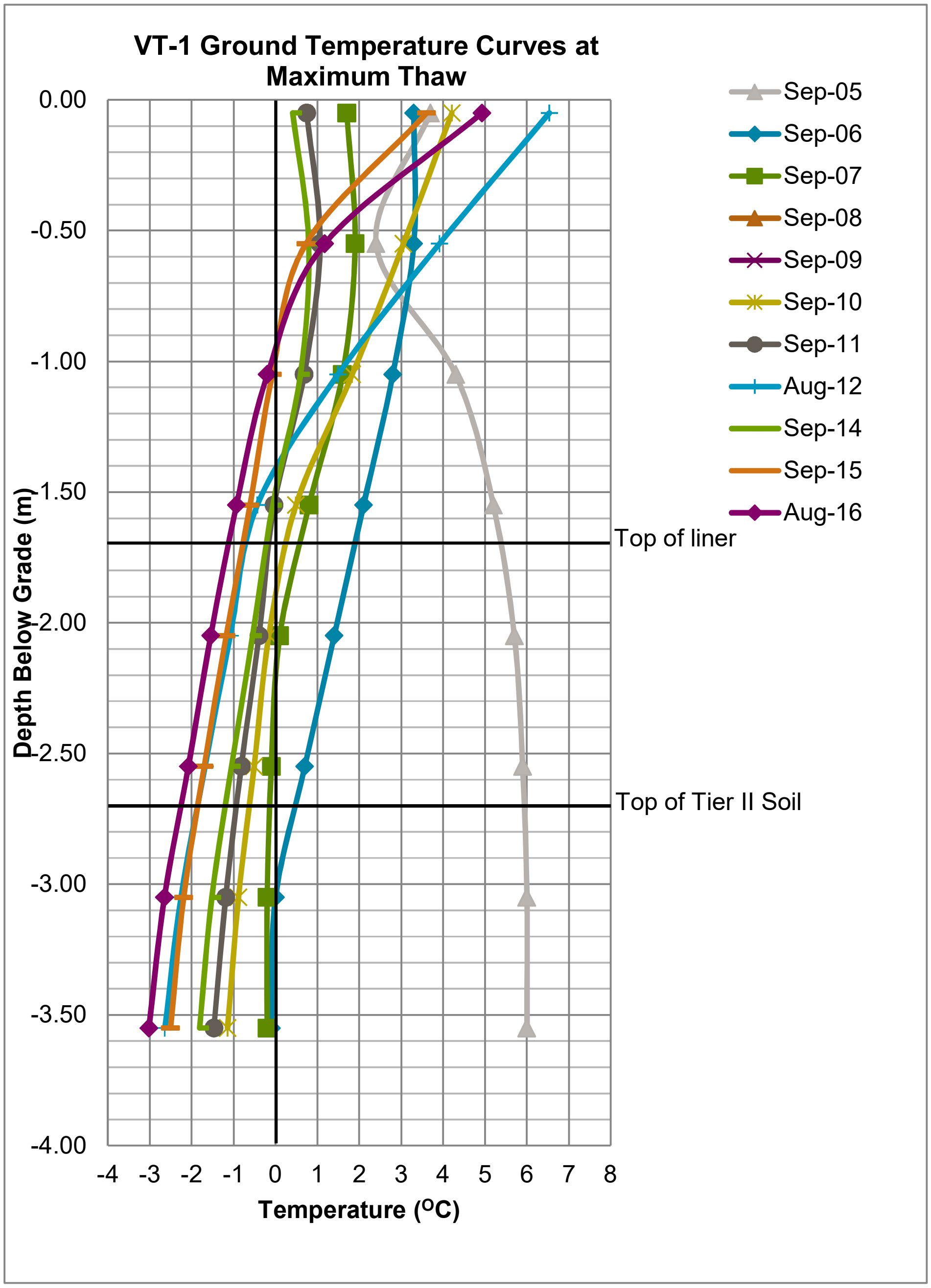


Table C24: Tier II Landfill VT-2 Thermistor Historical Data

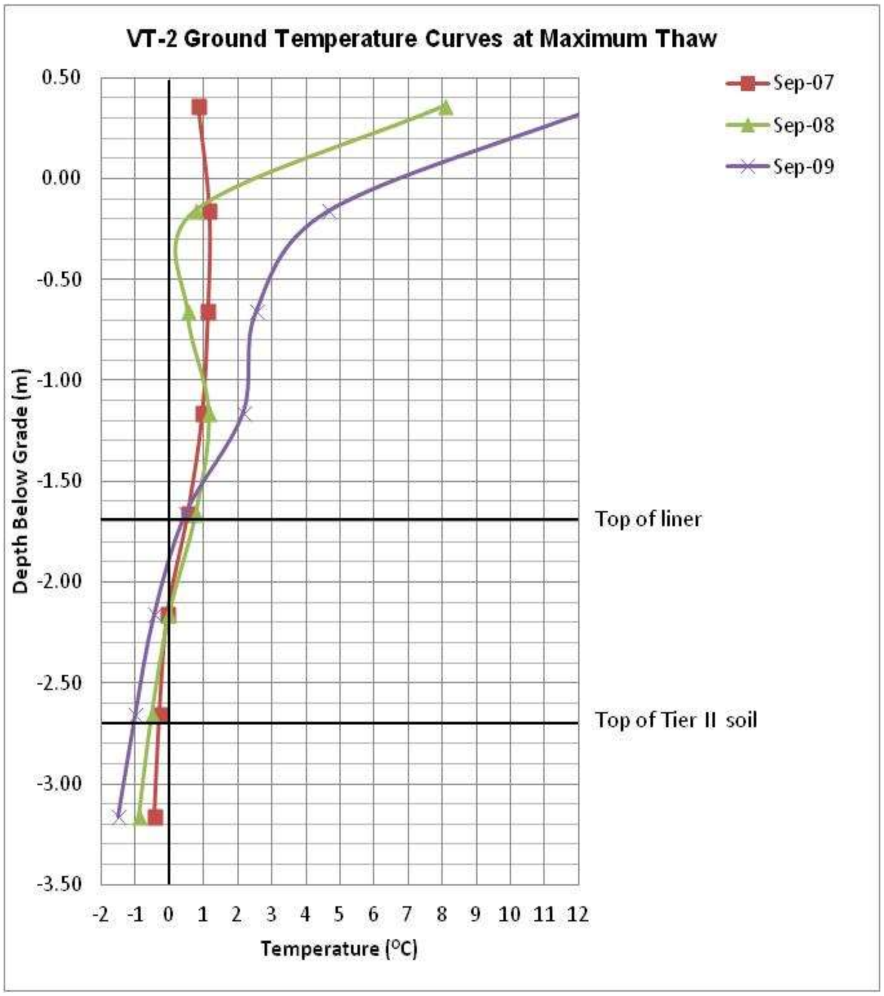


Table C25: Tier II Landfill VT-3 Thermistor Historical Data

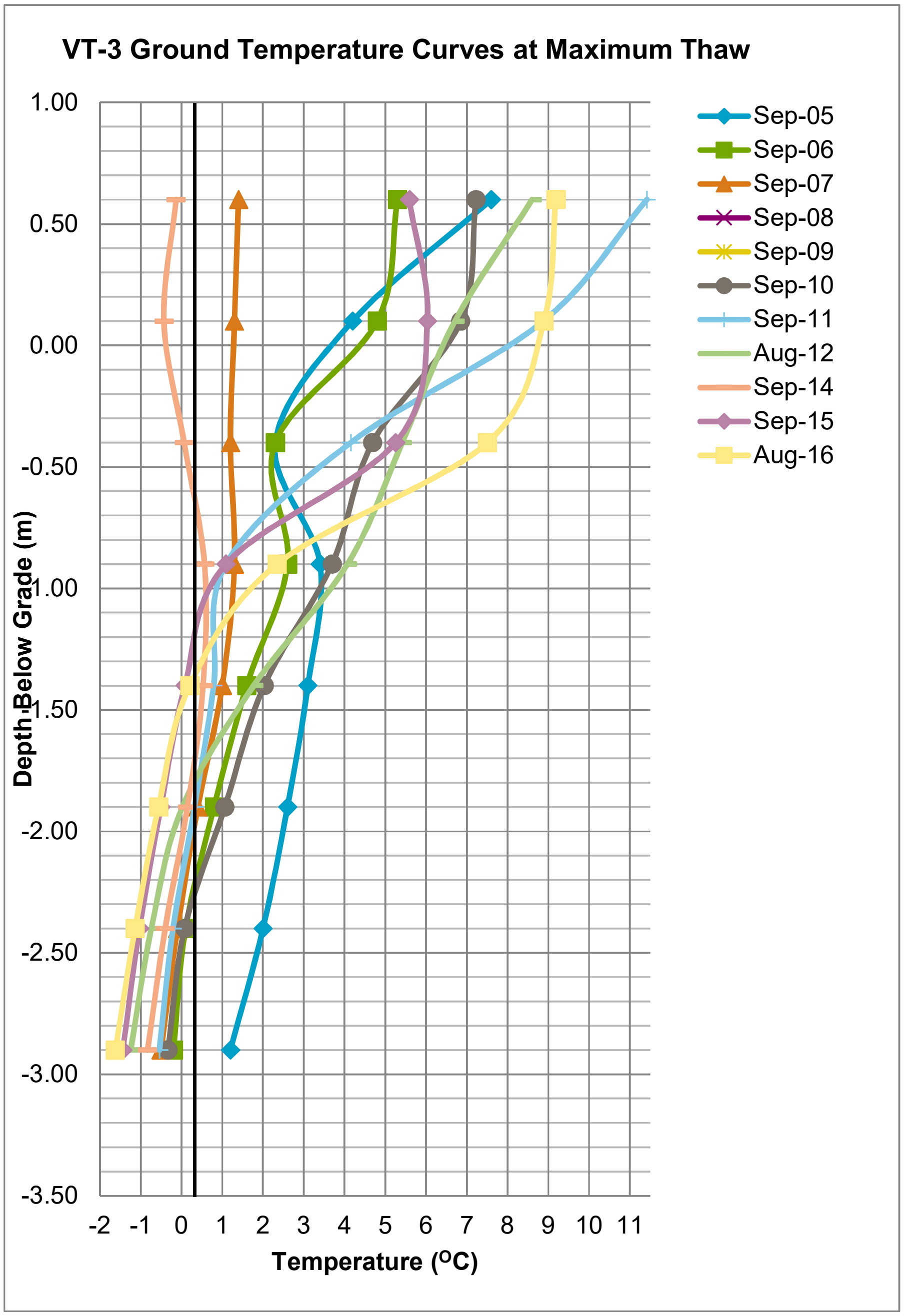
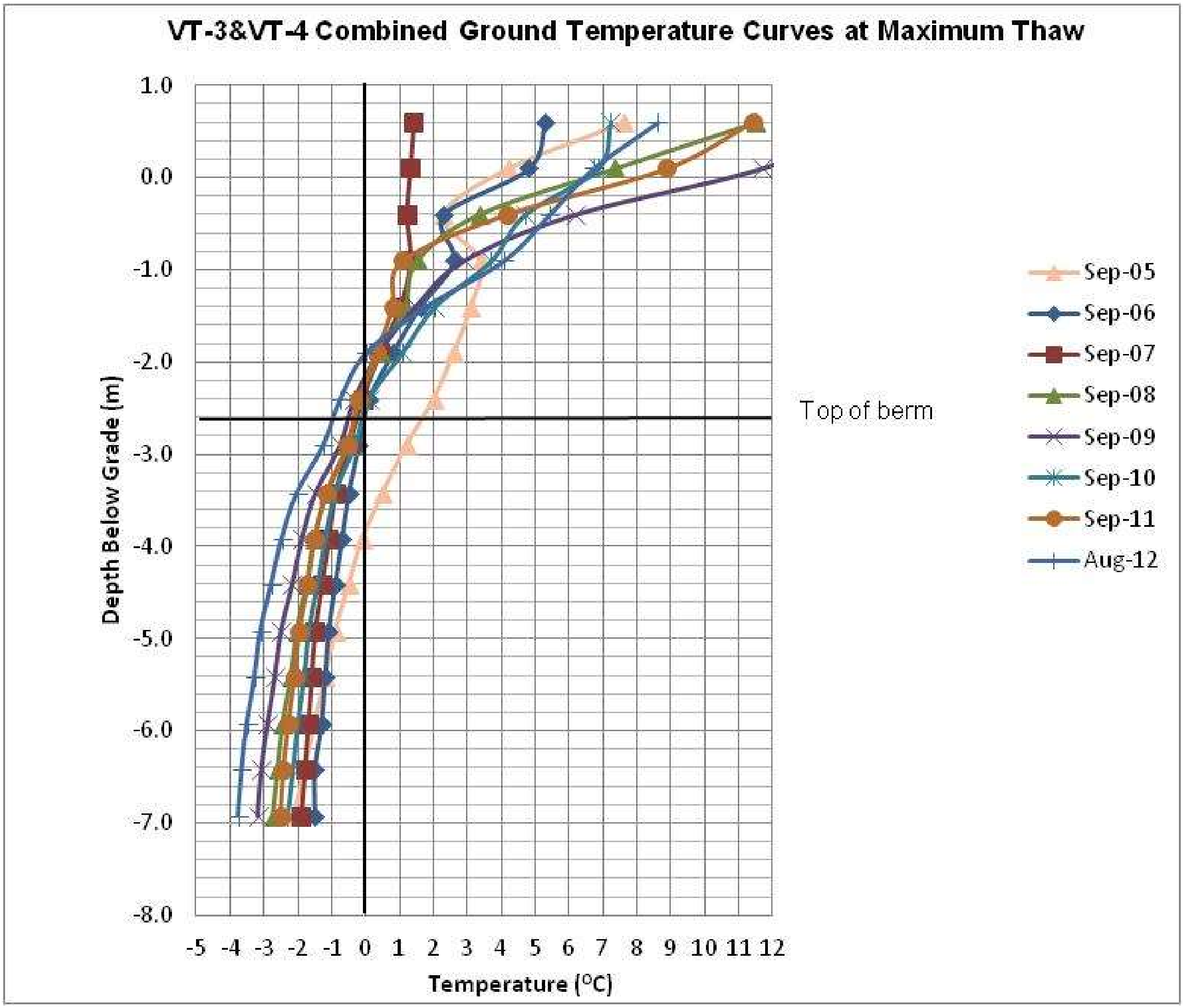


Table C26: Tier II Landfill VT-3 and VT-4 Thermistor Combined Historical Data



Appendix D

Failure Modes and Effects Analysis

Failure Mode Description	Effects	Pathways	Likelihood	Consequences: Environmental Impact		Special Considerations		Legal and Other Obligations		Consequence Costs		Media / Reputation		Human Health and Safety		Level of Confidence	Highest Risk Rating	Mitigation / Comments
				Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating			
East and West Camp Non-Hazardous Landfill																		
Significant Loss of Cover/Containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	- Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff) and altered drainage channel(s) leading to piping. - Animal burrowing. - Human disturbance. - Significant settlement and sinkholes due to voids within waste and/or non-compacted waste breaking down.	M	Mi	Mo	n/a	n/a	n/a	n/a	Mo	Mo-H	L	L	Mi	Mo	H	Mo	The likelihood has been scored in consideration that debris becoming significantly exposed but still within the subsurface would pose a higher physical hazard than the remaining surface structures which are clearly visible.
	Asbestos waste becomes exposed and an airborne hazard to humans	Same pathways as above for debris but also: - Asbestos bags ripped by debris or angular cobbles within cover or animal or human disturbance, asbestos particulate gets transported by water and accumulates at surface outside of the landfill or sufficiently exposed aerially to dry out and become airborne at a concentration exceeding the occupational exposure limit, and humans are present over a sustained period.	NL	n/a	n/a	n/a	n/a	Mo	L	Mo	L	Mi	L	Mo	L	M	L	Asbestos disposal sites normally have signage in place to guard against disturbance by humans but also as a warning in the event of containment loss. Adding signage may be prudent.
	Lead or PCB painted waste becomes sufficiently exposed to weather and be transported aerially or via water	Same pathways as for asbestos, minus bag ripping.	NL	Mi	L	L	L	Mo	L	Mo	L	Mi	L	Mo	L	M	L	Legal consequence associated with accumulating to point of regulatory exceedance. Signage, similar to asbestos, may be prudent.
	Tier I soil is sufficiently exposed for aerial dispersion to pose an ecological risk.	Same pathways as for debris and painted waste	NL	L	L	L	L	n/a	n/a	Mo	L	n/a	n/a	n/a	n/a	M	L	
Beach Non-Hazardous Landfill																		
Significant Loss of Cover/Containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	- Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff) and altered drainage channel(s) leading to piping. - Animal burrowing. - Ice jacking - Human disturbance. - Significant settlement and sinkholes due to voids within waste and/or non-compacted waste breaking down. - Flooding due to climate change, sea level rise and/or increase in surface water accumulation (from permafrost thaw and increased precipitation) with lake to west dramatically increasing in size/depth.	M	Mi	Mo	n/a	n/a	n/a	n/a	Mo	Mo-H	L	L	Mi	Mo	H	Mo	While the likelihood of debris becoming exposed is lower here than the Camp Landfill due to better geotechnical performance, the likelihood of human or wildlife being present at the landfill is higher than for the Camp.
	Asbestos waste becomes exposed and an airborne hazard to humans	Same pathways as above for debris but also: - Asbestos bags ripped by debris or angular cobbles within cover or animal or human disturbance, asbestos particulate gets transported by water and accumulates at surface outside of the landfill or sufficiently exposed aerially to dry out and become airborne at a concentration exceeding the occupational exposure limit, and humans are present over a sustained period.	NL	n/a	n/a	n/a	n/a	Mo	L	Mo	L	Mi	L	Mo	L	M	L	Human Health and Safety scored on the basis of exceeding occupational exposure limit
	Lead or PCB painted waste becomes sufficiently exposed to weather and be transported aerially or via water	Same pathways as for asbestos, minus bag ripping.	NL	Mi	L	n/a	n/a	Mo	L	Mo	L	Mi	L	Mo	L	M	L	Legal consequence associated with accumulating to point of regulatory exceedance and human health and safety on the basis of exceeding occupational exposure limit
	Tier I soil is sufficiently exposed for aerial dispersion to pose an ecological risk.	Same pathways as for debris and painted waste	NL	L	L	Mi	L	n/a	n/a	Mo	L	n/a	n/a	n/a	n/a	M	L	

Failure Mode Description	Effects	Pathways	Likelihood	Consequences: Environmental Impact		Consequences: Special Considerations		Consequences: Legal and Other Obligations		Consequences: Consequence Costs		Consequences: Media / Reputation		Consequences: Human Health and Safety		Level of Confidence	Highest Risk Rating	Mitigation / Comments
				Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating	Severity	Risk Rating			
Tier II Soil Landfill																		
Complete loss of containment such that Tier II soil becomes exposed to the environment	Contaminant uptake or exposure by receptors to point of posing an ecological or human health risk.	- Erosion completely through cover material or side slopes and berms, plus breaching of liner: through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff) and altered drainage channel(s). - Animal burrowing all the way through the cover material and liner. - Human disturbance. - Slope failure/significant side slope slumping with simultaneous damage to liner: due to build up of pore water pressure, possibly from loss of permafrost and melting of any ice lenses that may have developed in the fine within fine-grained soil while frozen, or due to patterned ground development in cap leading to lateral granular material distribution with coarse-grained edges to the patterns being a point of focus for surface water infiltration). - Frost wedge development through cover and breaching of liner due to cracks developing in the cover and accumulating water during thaw, with the crack growing and deepening over time through freeze thaw processes.	L	Mi	L	Mi	L	Mo	Mo	Mo	Mo	Mo	Mo	L	L		Mo	Patterned ground does appear to be forming in the west cap section, based on recent imagery. Segregation of grain sizes within the cap was noted in recent monitoring events.
Sufficient loss of containment for contaminants to migrate from landfill and accumulate downgradient	Contaminants accumulate d to point of posing risk to receptors via uptake or direct exposure.	-Loss of permafrost within landfill due to climate change coupled with cover erosion or settlement and liner breaching in the surface and side slopes allows precipitation to infiltrate, contaminants within soil to dissolve in groundwater and migrate out of the landfill footprint.	L	Mi	L	Mi	L	Mo	Mo	Mo	Mo	Mo	Mo	L	L		Mo	PCBs do not readily dissolve so are very unlikely to be taken up within groundwater to migrate out of the landfill. The HHERA has also demonstrated that Tier II concentrations of most of the metals do not pose an ecological or human health risk. There is a moderate chance of their being contaminant migration from the landfill due to the pathways noted but the low likelihood scored is driven by the HHERA results related to risk to receptors (and absence of receptors).
PCL Dump																		
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	- Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). - Animal burrowing. - Human disturbance.	L	L	L	n/a	n/a	n/a	n/a	Mi	L	L	L	L	L	M	L	Dump debris is in two lobes close to each other: 230 + 480 m^2
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	Same pathways as for debris exposure but also water migration through the dump.	NL	Mi	L	n/a	n/a	n/a	n/a	Mi	L	L	L	L	L	M	L	Likelihood of this posing a hazard has been evaluated as not likely based on Tier I PCB and Tier II copper being evaluated as posing negligible ecological or human health risk due to barren bedrock surrounding dump and very steep slope further downgradient.
North Slope Dump																		
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	- Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). - Animal burrowing. - Human disturbance. - Ice jacking.	NL	L	L	n/a	n/a	n/a	n/a	Mi	L	L	L	L	L	M	L	Dump is very small (380 m^2) and therefore poses negligible potential risk.
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	Same pathways as for debris exposure but also water migration through the dump.	NL	L	L	n/a	n/a	n/a	n/a	Mi	L	L	L	L	L	M	L	Likelihood of this posing a hazard has been evaluated as not likely because it is in the same barren bedrock setting as the PCL Dump where Tier I PCBs and Tier II copper were evaluated as posing negligible risk.

Failure Mode Description	Effects	Pathways	Likelihood	Consequences: Environmental Impact – Severity	Environmental Impact – Risk Rating	Special Considerations – Severity	Special Considerations – Risk Rating	Legal and Other Obligations – Severity	Legal and Other Obligations – Risk Rating	Consequence Costs – Severity	Consequence Costs – Risk Rating	Media / Reputation – Severity	Media / Reputation – Risk Rating	Human Health and Safety – Severity	Human Health and Safety – Risk Rating	Level of Confidence	Highest Risk Rating	Mitigation / Comments
Maintenance Dump																		
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	- Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). - Animal burrowing. - Human disturbance. - Ice jacking	NL	L	L	n/a	n/a	n/a	n/a	Mi	L	L	L	L	L	M	L	Remaining buried debris areas at dump are very small and therefore poses very low potential risk
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	Same pathways as for debris exposure but also water migration through the dump.	NL	L	L	n/a	n/a	n/a	na	Mi	L	L	L	L	L	M	L	Monitoring data, combined with the HHERA results, indicate no ecological impacts for this area. Cobalt may exceed the human health screening benchmark but it would require sustained presence of humans at that specific location to pose a risk.
Airstrip Landfill																		
Significant loss of cover/containment	Debris exposed to the point of posing a physical hazard to wildlife or humans	- Erosion of cover material through weather processes, including climate-change related increased precipitation (wind, rain, water run-on, water runoff). - Animal burrowing. - Human disturbance. - Ice jacking	M	Mi	Mo	Mi	Mo	n/a	n/a	Mo	Mo-H	L	L	Mi	Mo	M	Mo	There is a considerable amount of buried debris at this landfill, some of which is already partially exposed due to incomplete capping during remediation.
	Contaminated soil within the dump is exposed or migrates and accumulates to the point of posing a chemical hazard to the ecosystem or humans.	Same pathways as for debris exposure (except ice jacking) but also water migration through the dump.	M	Mi	Mo	Mi	Mo	n/a	n/a	Mo	Mo-H	L	L	L	L	M	Mo	Even in consideration of the HHERA results, this landfill is significant enough in size, has had very high levels of contaminants detected at it historically (including PCBs) and has existing erosion and slumping issues, with a steep slope that has not been covered or flattened. The downgradient vegetation relative lushness also indicates significant water movement through the landfill. The landfill is also positioned in a valley that is a migration corridor for polar bears and, because of its relative lush vegetation, is of higher importance ecologically. Compared to the Tier II landfill, it has more immediate receptors, and has no true containment.
	Hazardous level soil is exposed in landfill (CEPA PCBs)	Same pathways as for debris exposure except ice jacking.	L	Mi	L	Mi	L	Mo	Mo	Mo	Mo	L	L	Mi	L	M	Mo	Evaluated on the basis that CEPA PCBs were removed from surface in the past, suggesting a higher likelihood than typical for more exposure, especially given lack of cover.

Failure Mode Description	Effects	Pathways	Likelihood	Consequences: Environmental Impact – Severity	Environmental Impact – Risk Rating	Special Considerations – Severity	Special Considerations – Risk Rating	Legal and Other Obligations – Severity	Legal and Other Obligations – Risk Rating	Consequence Costs – Severity	Consequence Costs – Risk Rating	Media / Reputation – Severity	Media / Reputation – Risk Rating	Human Health and Safety – Severity	Human Health and Safety – Risk Rating	Level of Confidence	Highest Risk Rating	Mitigation / Comments
Site Buildings and Structures																		
Structure collapses into an area requiring access for maintenance or monitoring	Prevents ability to safely access and monitor or maintain residual risk areas	Progressive weakening due to weathering of structural members, increased by loss of envelope by precipitation (rotting) or wind.	NL	n/a	n/a	n/a	n/a	n/a	n/a	Mo	L	n/a	n/a	L	L	M	L	No structures are understood to be at risk of falling in such a manner as to limit necessary site access areas.
Building collapse (partial) while occupied	Harm to human or large wildlife	Rotting through precipitation weathering of envelope or windblown loss of envelope pieces, precipitation entry and structural members causing roof or walls or floors to collapse - while occupied, or in case of floor, due to loading.	L	Mi	L	n/a	n/a	L	L	Mi	L	Mi	L	Mi	L	M	L	The likelihood of collapse happening while someone is in it is very low, but could happen. Risk could possibly be partially mitigated with signage. Legal consideration relates to WSCC report filing in the case of medical treatment requirement and follow-up need to rectify.
Galbestos on billboards weathers to point of releasing asbestos fibres to become airborne risk.	Human standing nearby inhales asbestos fibres at a concentration above the occupational exposure limit.	Weather degradation of asphalt in which the asbestos is impregnated on the siding that causes the fibres to be released.	NL	n/a	n/a	n/a	n/a	Mo	L	Mo	L	n/a	n/a	Mo	L	M	L	Legal consideration relates to WSCC enforcement for asbestos exposure mitigation.
Piece(s) of a structure fly off when site is occupied and hit someone	Harm to human or large wildlife	Person or large wildlife walking close by during high wind, with wind loosening and prying away siding or envelope piece(s).	NL	Mi	L	n/a	n/a	L	L	Mi	L	Mi	L	Mi	L	M	L	Legal consideration relates to WSCC report filing in the case of medical treatment requirement and follow-up need to rectify.
PCB Barriers																		
Furniture Dump Barrier overtops	CEPA PCB contaminated soil migrates beyond barrier	- Large precipitation event (esp. related to climate change) causes flushing and large amount of soil is entrained and deposited in barrier filling it up. - Repeated weather related access problems prevents necessary maintenance from being completed. - Large precipitation event or very quick melt of heavy snowpack physically breaches the barrier, allowing unimpeded migration of contaminated sediment.	H	Mi	Mo	n/a	n/a	Mi	Mo	Mo	Mo-H	n/a	n/a	n/a	n/a	L	Mo	The unidentified source volume and location and the continued presence of CEPA level PCB being collected, combined with the expected climate change increases to precipitation and permafrost degradation make the future barrier performance extremely uncertain. There has been no design to account for funnel and barrier capacity - both hydrologic force and volume of sediment collected - and there is no backup or contingency within the system to provide additional control in the event of extreme precipitation under current climate conditions, or climate change increasing of precipitation. Given the continued high PCB concentrations, there is a significant risk of transformer oil - a dense, non-aqueous phase liquid (DNAPL) - in bedrock fractures, which may move deeper with active layer depth and saturation changes to be potentially discharged elsewhere.
	CEPA PCB contaminated soil migrates down cliff into ocean	-Same pathway as above, but larger scale precipitation and failure	L	Mo	Mo	Mi	L	Ma	Mo-H	Ma	Mo-H	Mo	Mo	n/a	n/a	L	Mo-H	
S1/S4 Beach Barrier overtops	PCB soil in excess of criteria is released to the ocean.	- Large precipitation event (esp. related to climate change) causes erosion and migration of contaminated soil upgradient, and large amount of soil is entrained and deposited in barrier, filling it up. - Climate change related increase in active layer depth and soil saturation levels results in slope failure/massive movement of soil. - Repeated weather related access problems prevents necessary maintenance from being completed.	H	Mi	Mo	Mi	Mo	Mo	Mo-H	Mo	Mo-H	L	Mo	n/a	n/a	L	Mo-H	The data indicates there is a considerable amount of CEPA/Tier II soil remaining upgradient of the barrier, and there has already been migration into the previously remediated soil areas.
PCB Storage Area																		
Does not prevent site visitors from accessing the site and opening the container.	Possible exposure by humans, regulatory non-conformance	- Signage loss, sea can left open or lock cut, containers are opened and there is exposure through dermal contact or inhalation of fine-grained particulates.	L	n/a	n/a	n/a	n/a	Mi	L	Mi	L	n/a	n/a	Mi	L	M	L	Mounting a camera at the storage area once it is operational may be prudent.
	Possible spillage of soil and exposure by wildlife, regulatory non-conformance	- Visiting humans open containers as per above pathways, and spill soil which leaks out of the container (wood bottom leaks).	L	Mi	L	n/a	n/a	Mi	L	Mi	L	n/a	n/a	Mi	L	M	L	
Inventory is not properly maintained or filed with Environment Canada	Regulatory non-compliance	- Improper management when new containers added (lack of training) - PCB labels on individual containers fall off or not placed originally - Insufficient time during site visit to update records - Updated records do not get sent to EC	M	n/a	n/a	n/a	n/a	Mi	Mo	n/a	n/a	n/a	n/a	n/a	n/a	H	Mo	

Table 1.2: Risk Matrix

Likelihood	Consequence Severity				
	Low (L)	*Minor (Mi)*	*Moderate (Mo)*	*Major (M)*	*Critical (C)*
Expected (E)	Moderate	Moderately High	High	Critical	Critical
High (H)	Moderate	Moderate	Moderately High	High	Critical
Moderate (M)	Low	Moderate	Moderately High	High	High
Low (L)	Low	Low	Moderate	Moderately High	Moderately High
Not Likely (NL)	Low	Low	Low	Moderate	Moderately High

Intolerable Region

ALARP Region

Broadly Acceptable Region

Table 1.3: Likelihood of Risk

Likelihood Class	Likelihood of Occurrence for Environmental and Public Concern Consequences over Assessment Period (500 yrs)
Not Likely (NL)	< 0.1% chance of occurrence
Low (L)	0.1 - 1% chance of occurrence
Moderate (M)	1 - 10% chance of occurrence
High (H)	10 - 50% chance of occurrence
Expected (E)	> 50% chance of occurrence

Table 1.4: Severity of Effects

Consequence Categories	Low	Minor	Moderate	Major	Critical
Environmental Impact	No impact.	Minor localized or short-term impacts.	Significant impact on valued ecosystem component.	Significant impact on valued ecosystem component and medium-term impairment of ecosystem function.	Serious long-term impairment of ecosystem function.
Special Considerations	Some disturbance but no impact to traditional land use.	Minor or perceived impact to traditional land use.	Some mitigatable impact to traditional land use.	Significant temporary impact to traditional land use.	Significant permanent impact to traditional land use.
Legal and Other Obligations	No non-compliance but lack of conformance with department policy requirement. Informal advice from a regulatory agency. No land claim or other agreement	Technical/ administrative non-compliance with permit, approval or regulatory requirement. Warning letter issued. Land claim or other agreement requires the Crown to satisfy administrative obligations (e.g. notification)	Breach of regulations, permits, or approvals (e.g. 1 day violation of discharge limits). Order or direction issued. Land claim or other agreement requires the Crown to respond, but no time frame is specified.	Substantive breach of regulations, permits, or approvals (e.g. multi-day violation of discharge limits). Prosecution. Land claim or other agreement requires the Crown to exercise its obligations within a specified time frame (i.e. 2-5 years)	Major breach of regulation--willful violation. Court order issued. Land claim or other agreement requires the Crown to exercise its obligations within a specified short time frame (i.e. 1-2 years)
Direct Costs	< $20 K	$20 K - $200 K	$200 K - $1 M	$1 M - $2 M	> $2 M
Community/ Media/ Reputation	Local concerns, but no local complaints or adverse press coverage.	Public concern restricted to local complaints or local adverse press coverage.	Heightened concern by local community, criticism by NGOs or adverse local/ regional media attention.	Significant adverse national public, NGO or media attention.	Serious public outcry/ demonstrations or adverse international NGO attention or media coverage.
Human Health and Safety	Low-level short-term subjective symptoms. No measurable physical effect. No medical treatment required.	Objective but reversible disability/impairment and/or medical treatment. Injuries requiring first aid or hospitalization.	Moderate irreversible disability or impairment to one or more people.	Single fatality and/or severe irreversible disability or impairment to one or more people.	Multiple fatalities.

Table 1.5: Level of Confidence

Confidence	Description
Low (L)	Do not have confidence in the estimate or ability to control during implementation.
Medium (M)	Have some confidence in the estimate or ability to control during implementation, conceptual level analyses.
High (H)	Have lots of confidence in the estimate or ability to control during implementation, detailed analyses following a high standard of care.

Appendix E

Remote Monitoring Methodology

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Our Reference

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Giselle Cotta, P.Eng.
Project Manager
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Dear Ms. Cotta:

Resolution Island: Remote Monitoring Methodology

AECOM Canada Ltd. (AECOM) was retained by Public Services and Procurement Canada (PSPC) to prepare the Operations Maintenance and Surveillance Plan for Resolution Island.   The OMS plan includes recommendations for the potential use of satellite imagery for monitoring remotely, particularly in the case of Phase 2 monitoring. This letter outlines the proposed methodology for monitoring via satellite imagery methods. The methodology has been written to be completed for either Phase 1 or Phase 2 and to respond to the action level triggers documented in the report.   It should be noted that the use of satellite imagery for remote monitoring is dependent on the whether the imagery collected during the baseline program provides sufficient visual resolution of the PCB barriers to allow them to be monitored remotely.

Remote monitoring would involve two levels of monitoring: the first level – Level 1 – would be done remotely. Should visual observations from Level 1 monitoring identify potential failure or conditions approaching failure, Level 2 monitoring, which consists of the traditional site visit monitoring, would be implemented.

1. Level 1: Visual Monitoring via Remote Sensing

The failure modes identified in the FMEA are mainly large-scale failures, and likely tied to extreme precipitation events or progressive increases in climate-change related precipitation and active layer deepening. All of the moderate or higher ranked failure modes can be visually monitored to the level required to assess potential failure or the need for corrective action or maintenance.

On behalf of CIRNAC in the NT region, AECOM completed a test case of using satellite imagery for visual monitoring at the Johnson Point site for its seventh year of monitoring, following observations related to general geotechnical site stability in the first five years of monitoring. The test case was successful in detecting the level of change that was considered necessary to evaluate any significant changes in performance at the landfills and other site features monitored. The following summarizes the recommendations and conclusions of that study.

The level of detail needed for visual monitoring and change detection via satellite imagery was such that automated remote sensing procedures would not work. The geotechnical/visual inspection therefore required completion by visual photo-interpretation of the satellite imagery.

Strictly speaking, the level of detail that can be documented via photo-interpretation does not allow for the identification of all of the features that are normally part of the visual inspection checklist under the AMSRP. There are scale limitations such that features like animal burrows, small sinkholes, and low levels of vegetation re-establishment cannot be seen. Also, the depth of features cannot be clearly ascertained, therefore, it cannot be known for sure whether, for example, an erosion channel has penetrated the full landfill cover and breached landfill containment. However, in AECOM's opinion, the limitations do not preclude the ability to ultimately complete an overall visual inspection and geotechnical evaluation of a landfill or other site feature's integrity, particularly when using the classification of failure used in the Resolution Island FMEA and evaluating according to the action level criteria that are proposed below. The degree of depth estimation for visual features can be improved with calibration of the imagery observed features with actual surveyed or recorded measurements in the field, as has been recommended for completion during the OMS baseline monitoring program.

The remote sensing method of visual inspection, is, however, dependent upon a GIS professional reviewing the imagery in meticulous detail and carefully digitizing features for comparison in subsequent years. The success of the methodology is therefore critically dependent on the person doing the imagery review and digitizing being extremely experienced and knowledgeable in the fields of geomorphology and terrain evaluation by remote sensing, particularly in northern, permafrost regions. The geotechnical engineer doing the actual evaluation related to performance must also be experienced in remote terrain evaluation

Satellite images of a pixel resolution of 0.3 m or better are required, which can be obtained through the WorldView 3 system. All the original image bands should be obtained in order to be able to enhance the visual display as required. The panchromatic band should be included, otherwise most of the erosion features will not be detected. The satellite images should be captured in summer, after snow melting in all depressions. To the extent possible, acquiring images under similar sun elevation and viewing angle allows for more consistent interpretation of results, particularly related to changes in elevation or depth. Given the high relief of the Resolution Island site, and in particular, the position of the PCB barriers, the locations needing accurate viewing must be considered when selecting sun elevation and viewing angle.

1.1 Action Level Triggers for Level 1 Monitoring

The action level triggers discussed below are the same ones used in the general OMS plan to identify potential corrective maintenance requirements; they are features that are both significant enough to be considered representative of failure but also features that are sufficiently large as to be visible via satellite imagery. The exception is for the PCB barriers, where, because of the potential uncertainty in remotely identifying when the sediment has reached the barrier top, and because of maintenance requirements should remote monitoring be used for Phase 1, a more conservative measure has been used to initiate action. An action level exceedance via Level 1 monitoring would trigger a Level 2 monitoring event, which is an on-site monitoring event.

1.1.1 Non-Hazardous Waste Landfills (East- and West-Camp and Beach)

Debris Exposure Posing Potential Physical Hazard: An excavation or hole in the ground is considered a significant safety hazard needing mitigation against entry or inadvertent falling into when it is greater than four feet or 1.2 m. To account for inability to accurately measure depth with the imagery, an angle of repose of 45 degrees could be assumed for the moist, loose sandy gravel cover material. This equates to a lateral surface opening radius of approximately 1.2 m or a rough opening size of 4.5 m^2. For the two non-hazardous waste landfills, the most likely failure mode is sinkhole development from differential settlement or piping leading to a roughly circular opening versus a linear one (which would be more of an erosional features). Thus, an approximate surface opening size of 4-5 m^2 could be used as a trigger to consider that an opening with likely debris exposure was sufficient to constitute a physical hazard in need of Level 2 monitoring. A second trigger could also be visual observation via remote sensing of protruding or exposed debris.

1.1.2 Tier II Soil Landfill

Soil Exposure or Contaminant Migration Posing Potential Chemical Hazard: The Tier II soil lies at 2.7 m depth below the landfill surface. The geomembrane is at 1.7 m below surface. The second failure mode in which there is a partial loss of containment sufficient to allow precipitation infiltration and facilitate contaminant migration out of the landfill is considered the more likely scenario for a Level 1 monitoring trigger. This type of failure would simultaneously also start to weaken the facility overall leading to a higher potential for the first failure mode of Tier II soil exposure within the landfill. Therefore, using the same considerations as above with respect to angle of repose of the cover material, but in consideration that failure at this landfill is more likely to be erosional (or slumping along the slope), a suggested trigger for Level 2 monitoring is an opening of approximately 1.2 m width visible via remote sensing.

1.1.3 Airstrip Landfill

Soil Exposure Posing Potential Chemical Hazard: AECOM has tracked the percentages of waste and soil types derived from landfill excavations for all of the DND DEW Line Sites as well as many of the CIRNAC northern military sites. Average values from this data are typically used for design estimates for new landfill excavations. These same values may be used as an estimate of the areal extent of severely eroded or slumped landfill that might yield exposure of Tier II level soil. Using the Tier II contaminant level estimates are considered conservative in the case of remote monitoring, recognizing that the HHERA has demonstrated that the Tier II concentrations of most DCC metals do not pose an environmental or human health risk. The average Tier II soil percentage is 20%. The implication for likelihood of contaminated soil presence due to significant loss of containment within the landfill is that approximately 20% of the landfill surface would need to be disturbed, or an area of roughly 780 m^2.

Debris Exposure Posing Potential Physical Hazard: The typical percentage of debris that is similarly carried for volume of debris to be derived from a landfill excavation is also 20%, thus, a physical hazard risk at the existing Airstrip Landfill may also be considered as a risk triggering Level 2 monitoring if an area approximately 1/5 of the overall landfill surface area becomes exposed.

1.1.4 PCB Barriers

Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction): Because the barriers lose significant effectiveness when sediment accumulates up to an elevation of approximately half the filter box height, Level 1 action level trigger is therefore considered to be when the sediment reaches 75% of the filter height. The height trigger value can be correlated to a lateral accumulation based on the detailed topographic information collected during baseline.

In addition to the barriers themselves, visual monitoring for erosion or movement is recommended for the CEPA and Tier II soil remaining upgradient of the S1/S4 Beach barrier. The action level trigger is defined as the visual mass movement of 25% or more of the impacted soil over a 25 m distance downslope or greater.

1.2 Level 1 Monitoring Frequency

Phase 1 Monitoring: Should remote monitoring be selected for use during Phase 1 monitoring to potentially replace on-site monitoring, then the overall Level 1 monitoring frequency would be consistent with that of the PCB barriers at five-year intervals.

Phase 2 Monitoring: Level 1 (remote) monitoring would be completed in response to a moderate precipitation event, consistent with overall Phase 2 monitoring requirements.

It is recommended that imagery be collected early in summer (after freshet) to allow for a site visit that season if required.

2. Level 2 Monitoring via Site Visit

An exceedance of any one of the above noted action level triggers should prompt Level 2 Monitoring, which is visiting the site. The particulars are described in more detail for each of failure below.

Notes:

1. Thermal monitoring – downloading of ground temperature data from the Tier II Landfill – is recommended for all Level 2 monitoring site visits, regardless of whether the Tier II Landfill performance is the purpose of the site visit. The data will provide useful information on the level of climate change affecting the site, which may help inform changes to likelihood for failure pathways at other site features.
2. Similarly, chemical monitoring is recommended during Level 2 Monitoring to confirm previously identified monitoring trends and, in the case of Phase 2 monitoring, that Phase 1 Exit Criteria continue to be met.

2.1 Non-Hazardous Waste Landfills (East- and West-Camp and Beach)

2.1.1 Debris Exposure Posing Potential Physical Hazard:

- Visually inspection of the Level 1 recorded feature of note. Record dimensions, ideally by survey. Document debris types, angularity, and other physical hazard risk-related issues.
- Complete the full geotechnical visual inspection of the landfill, as per the AMSRP, and evaluate geotechnical stability.
- Evaluate whether corrective actions are required and, if so, suitable corrective actions.
- Respond according to suggested Maintenance and Corrective Actions documented below as required.

2.2 Tier II Soil Landfill

2.2.1 Soil Exposure or Contaminant Migration Posing Potential Chemical Hazard:

- Visually inspection of the Level 1 recorded feature(s) of note that is compromising landfill integrity. Record dimensions, particularly depth, and note whether the geomembrane is visible and/or is breached.
- Collect ground temperature data to record whether the Tier II soil and/or containment berms are still frozen.
- Complete the full geotechnical visual inspection of the landfill, as per the AMSRP, evaluate geotechnical stability.
- Evaluate potential corrective measures. If landfill containment has been breached based on the visual assessment, respond according to suggested Maintenance and Corrective Actions documented below.
- Collect soil samples at the previous monitoring locations.
- If Tier II soil is suspected to be exposed within the landfill, collect soil sample at suspected exposure location(s) and document lateral extent.
- Evaluate soil according to HHERA benchmark values to determine if exposure poses risk.
- As required based on results of soil sampling, consider need for further Maintenance and Corrective Actions documented below.

2.3 Airstrip Landfill

2.3.1 Soil Exposure Posing Potential Chemical Hazard:

- Visually inspection of the Level 1 recorded feature(s) of note. Record dimensions, particularly depth of landfill surface opening.
- Complete the geotechnical visual inspection of the landfill, as per the AMSRP, evaluate geotechnical stability.
- Evaluate potential corrective measures.
- Collect soil samples at the previous monitoring locations.
- Collect soil samples at the exposed location.
- Evaluate soil concentrations according to HHERA benchmark values to determine if exposure poses risk.
- As required based on results of soil sampling, consider need for Maintenance and Corrective Actions documented below.

2.3.2 Debris Exposure Posing Potential Physical Hazard:

- Visually inspection of the Level 1 recorded feature of note. Record dimensions, ideally by survey. Document debris types, angularity, and other physical hazard risk-related issues.
- Complete the geotechnical visual inspection of the landfill, as per the AMSRP, evaluate geotechnical stability and likelihood for worsening.
- Evaluate potential corrective measures. If Level 2 visual inspection confirms that landfill has been disturbed to the extent of the Level 1 trigger, respond according to suggested Maintenance and Corrective Actions documented below as possible.
- As required, respond according to suggested Maintenance and Corrective Actions documented below.

2.4 PCB Barriers

2.4.1 Barrier Overtopping Potential Chemical Hazard (or Regulatory Infraction):

- Document volume of soil present and visually inspect barriers for integrity.
- Collect soil samples to asses PCB levels of sediment and filter material for containerization requirements.
- Complete maintenance as per below.

3. Maintenance and Corrective Actions

Maintenance will primarily be in response to observations during surveillance, particularly Level 2 On-Site Monitoring.

A stepped approach to decision making should be implemented when determining the appropriate action required to address maintenance requirements. Stepped response levels include: 1) Monitor Only; and 2) Corrective Maintenance. These are described in more detail below.

3.1 Monitoring Only

Moving from Level 1 to Level 2 monitoring is a monitoring-related corrective response. The triggering of Level 2 monitoring and the recommended Level 2 monitoring methods are described above. Should the Level 2 monitoring confirm a hazard is present requiring corrective action, then corrective maintenance would be implemented as per section 3.2 below. Should Level 2 monitoring indicate conditions approaching but not yet at an action level trigger or failure in need of correction action, then the recommended course of action would be to increase monitoring frequency, either Level 1 or Level 2, as appropriate.

3.2 Corrective Maintenance

Corrective maintenance can range from work that can be addressed by site inspection personnel during the scheduled Level 2 Monitoring, possibly with support from local contractors, up to higher level maintenance that would require dedicated mobilization of contractor personnel and equipment.

Table 1 below lists corrective maintenance options for the remaining monitored site features in the event of potential failure, listed stepwise according to increasing cost and effort. Step 1 measures are those that are considered achievable during the scheduled Level 2 Monitoring visit. Step 2 are items that may require a dedicated, short term, fly-in site visit once additional supplies are obtained. Step 3 are measures that would require a dedicated mobilization of contractor crew, with potential camp, heavy equipment, and the advance securing of necessary Water Licence and Land Use Permit/Quarry Permit. Note that the PCB Barriers require maintenance as a standard part of Level 2 Monitoring, separate from their potential failure. Their maintenance requirements are also described in Table 1 below.

Table 1: Corrective Maintenance

Item	Step 1	Step 2	Step 3
Camp and Beach Non-Hazardous Waste Landfills: Sufficient Loss of Containment for Debris Exposure Posing Physical Hazard	Provide visual cue of hazard with any available site materials. • Cut off or flag protruding debris. • Manually fill/flatten abrupt settlement openings. • Place overtop of physical hazard and weigh down with rocks or manually placed soil any plywood or siding sheets that can be pulled from unused buildings and sufficiently secured from being blown away. Spray paint or flag rocks.	Place a dedicate barrier or marker of hazard presence. • Erect signage and snow fencing or some easily erected barrier around hazard. • Manually, or with equipment easily flown to site, pack down surrounding cover edges to provide gentle relief around opening.	Replace lost cover material. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum). • As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established). • Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.
Tier II Soil Landfill: Partial Loss of Containment Leading to Migration and Downgradient Chemical Hazard	Prevent further deterioration of geomembrane and loss of permafrost. • Manually remove angular cobbles and replace (from the sides of the eroded cover wall) some fine-grained material (or any available geotextile) over the geomembrane to protect it from further damage. • Following cushioning of geomembrane, manually shovel fill over the exposure to prevent further loss of frozen conditions due to albedo effect with black geomembrane and geotextile.	Fix geomembrane and overlying cushion material. • Weld patch onto damaged geomembrane or place layer of bentonite overtop of exposure. • Replacement geotextile overtop. • Place sand overtop of geotextile (fly in bags of monitoring well filter sand and bentonite). Note that the practicality of this would depend on the size of opening.	Replace lost cover material. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum). • As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established). • Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.
Tier II Soil Landfill: Full Loss of Containment Leading to Soil Exposure Within Landfill	There is unlikely to be any easy repairs to such a significant failure in these steps.		Repair: • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence). • Mobilize, erect, and operate temporary camp. • Mobilize equipment and contractor staff, including specialized geomembrane contractor. • Repair geomembrane (weld patch, with remove of surrounding to sufficiently expose full breach). • Develop borrow area(s) capable of providing bedding sand, well-graded sand and gravel cover (and possibly well-graded silt-sand and gravel if berms are also in need of repair). Extract borrow for repairs. • Replace geotextile and bedding sand. • As needed, replace and saturate as needed low-permeability berm material. • Replace overlying cover.
Airstrip Landfill: Sufficient Loss of Containment for	Provide visual cue of hazard with any available site materials. • Cut off or flag protruding debris.	Place a dedicate barrier or marker of hazard presence. • Erect signage and snow fencing or some easily	Replace lost cover material. • Secure necessary permits for remedial maintenance work (Land

Item	Step 1	Step 2	Step 3
Debris Exposure Posing Physical Hazard	• Manually flatten abrupt settlement openings.	erected barrier around hazard. • Manually, or with equipment easily flown to site, pack down surrounding cover edges to provide gentle relief around opening.	use permit/quarry permit at minimum). • As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established). • Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.
Airstrip Landfill: Sufficient Containment Loss for Exposed Soil or Migrated Soil Posing Chemical Hazard.	There is unlikely to be any actions that can be taken during a Level 2 monitoring site visit.	Place a temporary overlying cover. • Place geomembrane, secured in place by rocks, overtop of exposed contaminated soil.	Replace lost cover material. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit at minimum). • As needed mobilize, erect, and operate any required worker support facilities such as a temporary camp (secure in advance water licence if camp to be established). • Mobilize equipment and contractor staff capable of excavating, hauling, placing and compacting fill.
Furniture Dump and S1/S4 Beach Barriers: Standard Level 2 Monitoring Maintenance	• Manually dig up soil accumulating within the funnel and gate section and place in containers. • As required, within the gate section, replace all 1200 R filters, and cartridge gravel and granular activated carbon. • If established during previous Level 2 monitoring event, inspect PCB storage area.	• Move filled soil containers (sling via helicopter) from the barrier areas and place at a secure storage location. • Establish PCB storage area and place within all soil containers with soil exceeded CEPA levels. Label and inventory soil containers and register with EC.	• Mobilize a contractor team and sealift to remove soil containers for shipment and off-site disposal.
Furniture Dump PCB Barrier: CEPA Level Soil Migrates Beyond Barrier	• Manually dig up soil accumulating within the funnel and gate section and beyond to the extent possible and place in containers. • As required, within the gate section, replace all 1200 R filters, and cartridge gravel and granular activated carbon. • If established during previous Level 2 monitoring event, inspect PCB storage area. • Make all possible barrier repairs if migration was due to a breach.	• Complete additional manual (or via equipment that can be flown in) excavation of soil beyond barrier with containerization, as possible. • Complete all necessary barrier repairs. • Move filled soil containers (sling via helicopter?) from the barrier areas and place at a secure storage location. • If not previously completed, establish PCB storage area and place within all soil containers with soil exceeded CEPA levels. Label and inventory soil containers and register with EC.	Install new upgraded barriers with additional capacity and potentially additional engineering remedial design for potential source containment or cutting off migration potential towards barriers. This would require an intermediate step of significant subsurface investigation for source identification and assessment of potential for capture or isolation. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence). • Mobilize, erect, and operate temporary camp. • Mobilize equipment and contractor staff, • Remove or upgrade existing barriers, as appropriate, and install new remedial solutions. • Demobilize from site, removing soil containers as wells.
Furniture Dump PCB Barrier:	This would be an emergency response situation with additional supplies and personnel brought to site immediately. • Manually dig up soil accumulating within the funnel	• Mobilize a contractor with equipment to site ASAP to complete additional repairs and soil removal. • Mobilize an engineering team to assess remedial	Install new upgraded barriers with additional capacity +/- additional engineering remedial design for potential source containment or cutting off migration potential towards barriers.

Item	Step 1	Step 2	Step 3
CEPA Level Soil Migrates Beyond Barrier into Ocean	and gate section and beyond to the extent possible and place in containers. • As required, within the gate section, replace all 1200 R filters, and cartridge gravel and granular activated carbon. • If established during previous Level 2 monitoring event, inspect PCB storage area. • Make all possible barrier repairs if migration was due to a breach. • Place spill collection materials (silt fence or curtain) along or near shoreline. • File Spill Report.	options and prepare a remedial design for implementation ASAP. • Assess alternate, more permanent and secure remedial options, as per Step 3 above.	• Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence). • Mobilize, erect, and operate temporary camp. • Mobilize equipment and contractor staff, • Remove or upgrade existing barriers, as appropriate, and install new remedial solutions. • Demobilize from site, removing soil containers as wells.
S1/S4 Beach Barrier: Tier I and Possibly Tier II soil is Released to Ocean	This would be an emergency response situation with additional supplies and personnel brought to site immediately. • Manually dig up soil accumulating within the funnel and gate section and beyond to the extent possible and place in containers. • As required, within the gate section, replace all 1200 R filters, and cartridge gravel and granular activated carbon. • Make all possible barrier repairs if migration was due to a breach. • Place spill collection materials (silt fence or curtain) along or near shoreline. • File Spill Report.	• Mobilize a contractor with equipment to site ASAP to complete additional repairs and soil removal. • Mobilize an engineering team to assess remedial options and prepare a remedial design for implementation ASAP. • Assess potential need for alternate, more permanent and secure remedial options, as per Step 3 above.	Install new upgraded barriers with additional capacity +/- additional engineering remedial design for potential source containment or cutting off migration potential towards barriers. • Secure necessary permits for remedial maintenance work (Land use permit/quarry permit and water licence). • Mobilize, erect, and operate temporary camp. • Mobilize equipment and contractor staff, • Remove or upgrade existing barriers, as appropriate, and install remedial solutions. • Demobilize from site, removing soil containers as wells.

The above-noted methods can be used to substitute for on-site monitoring on occasion for Phase 1 and regularly for Phase 2. However, documentation of achieving both Phase 1 and Phase 2 Exit Criteria requires that a site-visit be completed for the end of each Phase for the PCB barriers at minimum. Previously collected monitoring data from 2005 onwards may be used to document achievement of Phase 1 Exit Criteria for chemical risk at the Tier II Landfill and the Airstrip Landfill.

Yours sincerely,

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Appendix F

Baseline Monitoring Cost Estimate and Method Cost Comparison

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Our Reference

60579718 (500.7)

Giselle Cotta, P.Eng.
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Dear Giselle Cotta:

Resolution Island: Cost Estimate Details for Long Term Monitoring

AECOM Canada Ltd. (AECOM) was retained by Public Services and Procurement Canada (PSPC) to prepare the Operations Maintenance and Surveillance (OMS) Plan for Resolution Island. The OMS plan includes the recommendations for Long Term Monitoring. This letter is meant to be read as an addendum to the separately issued Resolution Island Operations, Maintenance and Surveillance report (AECOM, 2020).

The long-term monitoring will include a baseline program to complete field and desktop work required to provide sufficient baseline information. This Baseline Year can be completed at any time before the first occurrence of scheduled LTM.

The Resolution Island LTM Plan currently includes Phase 1 monitoring, with traditional site monitoring at specified frequencies. When the Phase 1 exit criteria is achieved, the site would move to Phase 2 LTM. The Phase 2 LTM may be completed using remote monitoring (i.e. review of current satellite imagery compared to established baseline imagery at specified frequency), or continuing with traditional site inspections.

Baseline Monitoring and Site Preparation

A single baseline monitoring event is required to prepare the site for future monitoring requirements. This baseline event would include desktop imagery preparation, and a site visit to conduct detailed surveying at areas of interest (including but not limited to: PCB Barriers, Landfills, Dumps, and Buildings), and installation of visual markers. The markers will provide a visual reference that can be used during future imagery comparisons and for imagery orthorectification.

The field program for the Baseline year is assumed to consist of a five-day program, with two engineers, a surveyor, and two wildlife monitors, with charter aircraft access to site daily. No allowance has been made for standby or weather days during the baseline field program.

The Baseline year also includes detailed preparation of baseline imagery files that would provide the reference for future years monitoring. This is a desktop exercise and includes the procurement of the desired satellite imagery.

Additionally, climate performance benchmark development would be completed during the baseline program. This would include the statistical analysis and discussion related to the site-specific climate conditions and development of the site-specific values to use as monitoring triggers and for exit criteria in Phase 2 monitoring.

Additional cost assumptions for the Baseline Monitoring event include:

- Engineering team consists of two people that will mobilize to Iqaluit from the south
- Surveying will be completed by a local Iqaluit surveyor subcontractor with both traditional and drone survey methods

- Daily charter flights to Resolution Island for five days
- One all terrain vehicle (ATV) will be brought to site to supplement the available ATVs on-site already
- Two wildlife monitors will provide support for five days
- No environmental laboratory samples will be required to be collected
- Reporting costs include the preparation of a Work Plan, site specific Health and Safety Plan, Year One Long Term Monitoring Report, and Baseline Imagery Report

The estimated cost of the Baseline Monitoring Event is $200,900.65. A detailed budget is included in Attachment 1.

Phase 2 Monitoring

When all items of interest at Resolution Island meet the exit criteria for Phase 1 monitoring, it will transition to Phase 2 monitoring. Phase 2 monitoring will be completed at intervals specified by specific climate events, as defined in the Baseline Monitoring program and the Climate Performance Benchmark Development.

The Phase 2 monitoring could be completed by traditional on-site inspection or by remote imagery monitoring.

Traditional Monitoring

Traditional monitoring would include chartering an aircraft to the site, and completing visual observations of the specified areas of interest (including but not limited to: PCB Barriers, Landfills, Dumps, and Buildings). These observations would be compared with previous site visit reports to document the condition of the areas of interest. Monitoring would consist of a two-person engineering team accessing the site by charter aircraft for two days. No allowance has been made for standby or weather days during the monitoring program.

Additional cost assumptions for traditional monitoring include:

- Engineering team consists of two people that will mobilize to Iqaluit from the south
- Daily charter flights to Resolution Island for two days for each monitoring event
- One all terrain vehicle (ATV) will be brought to site to supplement the available ATVs on-site already
- Two wildlife monitors will provide support for two days
- No environmental laboratory samples will be required to be collected
- Reporting costs include the preparation of a Work Plan, site specific Health and Safety Plan, and the Long Term Monitoring Report

A traditional monitoring event, using current costs, is estimated to be $79,794.95. The detailed budget estimate is included in Attachment 2.

Remote Monitoring

Phase 2 monitoring could be completed by remote imagery comparison. Satellite imagery would be procured. This imagery would then go through detailed review, and comparison to the baseline imagery and markers that were installed at the specific areas of interest during the Baseline program. For the purposes of this cost estimate, there is be no field component, however remote imagery monitoring may trigger the need to go to site to further investigate site conditions that are evident in the imagery.

Reporting would include the detailed imagery comparison and review of publicly available weather data to confirm rainfall and climate conditions over the monitoring period.

Additional cost assumptions for remote monitoring include:

- Disbursements would be limited to the procurement of satellite imagery
- Reporting costs include imagery comparison and summary in a Long-term Monitoring Report.

Completing one event of long-term monitoring using the remote methods is estimated to cost $30,600.50, using current costs and technologies. A detailed budget estimate is included in Attachment 3.

Yours sincerely,

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