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GROUNDWATER FLOW MODELLING OF THE NEAR SURFACE DISPOSAL FACILITY

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Revision 5

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M. Klukas
Environ Assessment Analyst

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Groundwater Flow Modelling of the Near Surface Disposal Facility

Revision 2

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Canadian Nuclear Laboratories Ltd.
Chalk River Laboratories
286 Plant Road, Building 457
Chalk River, ON
K0J 1J0

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1.0 INTRODUCTION

1.1 Background

Canadian Nuclear Laboratories (CNL) is proposing to construct a Near Surface Disposal Facility (NSDF) for the disposal of radioactive waste at Chalk River Laboratories (CRL) (the NSDF Project). To support the future plans for the CRL site, CNL identified the need for a disposal facility capable of accepting radioactive waste from legacy waste management areas, current operations, and decommissioning projects at CRL and its other business locations.

The NSDF Project is designed to include an engineered containment mound (ECM), built at a near-surface level on the CRL site, located in Renfrew County, Ontario (see Figure 1.1). The facility is expected to be operational for approximately 50 years and will be expandable to receive up to 1,000,000 cubic metres (m^3) of low-level radioactive waste. The placement of the wastes in the ECM will be completed in stages as following:

- Stage 1, with a design capacity of 525,000 m^3 to accommodate wastes currently in storage and to be generated over the next 20 to 25 years. During this period a sacrificial liner is to be placed over the Phase 2 area; and
- Stage 2, during which the design fill capacity is expanded to 1,000,000 m^3 to accommodate wastes expected to be generated following the first stage.

This capability will allow for the inclusion of waste from future operations, decommissioning, and remediation at CRL and off-site CNL facilities (e.g., Whiteshell Laboratories), as well as commercial wastes (i.e., from hospitals, universities, and laboratories) if needed. The main physical works related to the NSDF Project are the ECM that will contain the waste, the waste water treatment plant (WWTP) and supporting infrastructure.

1.2 Objectives

CNL retained Golder Associates Ltd. (Golder) to assist in completing an environmental assessment of the NSDF Project. The work described in this report was completed as a part of the technical support for hydrogeological aspects of the environmental assessment, including evaluation of the short-term (operations phase) and long-term (closure and post-closure phase) potential project-related effects to the groundwater flow regime. Results of the hydrogeological assessment are incorporated into the overall environmental impact assessment, documented in Section 5.3.2 of the NSDF Project Environmental Impact Statement (EIS) (Golder 2017) (note that the contaminant transport component of the assessment was completed by CNL). This analysis includes evaluation of groundwater flow pathways from the NSDF Project site (i.e., the NSDF Project footprint, where Project activities would be undertaken including proposed facilities, buildings and infrastructure), and the rates of groundwater flow from the NSDF Project components to downstream receptors.

1.3 Scope of Work

The following tasks were completed in order to meet the above objectives:

- **Review of Existing Data** – Data provided by CNL were reviewed. These included geological contact data, groundwater elevations, stream flow data, groundwater quality data, and reports that detail the existing conceptual hydrogeological model of the NSDF Project site and surrounding areas. Design data for the ECM and WWTP exfiltration gallery were also reviewed.

- **Construction and Calibration of the Current-Conditions Groundwater Flow Model** – Following a review of the data and conceptual model, a groundwater flow model was constructed and calibrated to typical groundwater conditions (i.e., groundwater elevations and flow directions). A separate model calibration to high water table conditions was also completed.
- **Construction of the Operations and Post-closure Groundwater Flow Simulations** – The calibrated groundwater flow model was adapted to evaluate the potential impacts associated with the NSDF Project during operations and under post-closure conditions.
- **Sensitivity Analysis** – The tasks noted above were completed for the "base case" model parameterization. In order to evaluate the potential uncertainty associated with the predictive simulations, a sensitivity analysis was completed using the base case as a point of comparison.

This document is organized as follows: Section 2 provides an overview of the conceptual hydrogeological model, which serves as the basis for the numerical model; Section 3 outlines the construction and calibration of the groundwater flow model; Section 4 presents the operations phase and post-closure phase simulations; while a summary of the assessment is provided in Section 5.

2.0 PHYSICAL SETTING

The physical setting of the CRL site has been described in detail in numerous historical investigations (CNL 2016b was the primary reference used herein) as well as in Section 5.3 of the NSDF Project EIS (Golder 2019). This section summarizes the key findings from those investigations that relate to the conceptual hydrogeological model, including the site topography and drainage, geology, and groundwater conditions.

2.1 Topography and Drainage

The CRL site and surrounding area lies within the Ottawa River watershed. A number of drainage basins exist within the CRL site, including the Perch Lake Basin, which encompasses the location of the NSDF Project. The topography of the lower portion of the Perch Lake basin where the NSDF Project site is located is shown in the context of the CRL site topography on Figure 2.1. Ground surface elevation within the basin ranges from approximately 197 metres above sea level (mASL) at the crest of the hill south of Plant Road and east of the East Swamp, to 156 mASL at the outlet for Perch Lake.

As shown on Figure 2.1, several significant surface water features are located within the Perch Lake Basin (which has an overall drainage area of approximately 6,289,000 m^2), including Main Stream, T-16 Stream, East Swamp Stream, Perch Lake, and Perch Creek. Wetlands are a predominant feature of the basin. These are found in the low-relief areas east of Main Stream and north of Perch Lake, as well as in the vicinity of the East Swamp Stream. East Swamp Stream and T-16 Stream flow into Main Stream, which discharges to Perch Lake. Perch Lake drains through the outlet at Perch Creek, which in turn discharges to the Ottawa River. A number of gauging stations record monthly flow volumes in these surface water features at the locations shown on Figure 2.1. Review of these data completed by others indicates that September is considered to be representative of low-flow conditions, and April is considered to be representative of high-flow conditions (CNL 2016b).

Previous studies have identified the portions of East Swamp Stream that are upstream (i.e., north) of the East Swamp Stream Weir to be dominated by groundwater discharge, and portions of the East Swamp Stream downstream (i.e., south) of the weir to be dominated by groundwater recharge. Similarly, T-16 Stream is also considered to be dominated by groundwater recharge.

2.2 Geology

CNL completed previous studies in support of proposed geological waste management facilities at the CRL site in which data on the geological environment were compiled and used to develop a descriptive geosphere model of the site. These studies are documented in CNL's Geologic Waste Management Facility Descriptive Geosphere Site Model Report (CNL 2016c) and Geologic Waste Management Facility Integrated Geosynthesis Report (CNL 2016d). Data presented in these reports forms the basis of the current geological and hydrostratigraphic interpretations at the site (including hydraulic response testing of the overburden and shallow bedrock), and provides context on the anticipated evolution of the geological conditions at the CRL site over the assessment timeframe (10,000 years). A description of the CNL Chalk River Site geology also is provided in Section 5.3 of the NSDF Project EIS (Golder 2019). This information is repeated herein for completeness in the context of this modelling report. Regardless, the reader is referred to the CNL documents for further details.

2.2.1 Regional Geological Conditions

The CRL site is located within the Central Gneiss belt of the Grenville Structural Province of the Canadian Shield. Bedrock in the area consists of highly altered gneissic rock and felsic igneous rock (upper amphibolite to granulite grade metamorphism under dynamic ductile conditions during the Grenville Orogeny) of late Precambrian-early Paleozoic age (Figure 2.2). Structurally, the CRL site is located within the Ottawa-Bonnechere Graben or rift valley, which trends from northwest to southeast from Lake Nipissing to the St. Lawrence River occupying a 60 kilometre (km) wide by 70 km long area. The Ottawa River occupies the eastern bounding fault of the rift valley, with the CRL site located on the western edge of the river. Secondary faulting (also oriented northwest to southeast) has a considerable effect on surface drainage and bedrock topography (CNL 2016b, CNL 2016c) in the vicinity of the NSDF Project site. Historical glaciations have generated a knobby bedrock surface (CNL 2016b, CNL 2016c), which outcrops in several locations in the region.

Bedrock in the area consists of highly altered gneissic rock and felsic igneous rock (upper amphibolite to granulite grade metamorphism under dynamic ductile conditions during the Grenville Orogeny) of late Precambrian-early Paleozoic age. Bedrock at the CRL site has been grouped into 3 main assemblages as shown on Figure 2.2 (from CNL 2016a). The bedrock within the Perch Lake basin and the NSDF Project site has been mapped as quartz monzonitic, monzonitic, and monzodioritic gneisses of Assemblage B. Assemblage C (composed of granitic, granodioritic, and leucodioritic gneisses) has been mapped at the bedrock surface under the eastern portion of the NSDF Project site, while a mafic dyke has been mapped near the north-west corner of the Project Site. Transitions between these relatively low permeability rock types are not expected to be significant to this assessment.

The regional surficial geology of the CRL site is shown on Figure 2.3 (from King and Killey 1994). A widespread, but thin deposit of glacial till, overlies the bedrock in most areas where overburden is present (Catto et al. 1982). Following the last glacial retreat, the early post-glacial Ottawa River covered most of the CRL site and deposited fluvial sands and silts throughout the region. These fluvial deposits filled the depressions in the bedrock and glacial till surfaces. A brief period of Aeolian reworking of the fluvial sands into dune and sheet deposits occurred as the

Ottawa River dropped to its current level and location. Recent sediment accumulation has been in the form of organic deposits in the low-lying and wetland areas of the region. The thickness of the unconsolidated sediments is variable as a result of the variable bedrock topography and the historical location of the Ottawa River. In general, the sediments are thickest towards the centre of the rift valley and thinnest to the west and east towards the bounding faults. As shown on Figure 2.3, surficial geology within the low lying areas of the Perch Lake Basin is predominately composed of recent organic soils. Sand and glacial till are present at surface near topographic highs, such as the NSDF Project site.

2.2.2 Local and NSDF Project Site Geological Conditions

The local geological conditions in the following subsection describe the lower portion of the Perch Lake Basin, and the NSDF Project site on the basis of previous investigations of the waste management areas, and recent drilling at the NSDF Project site.

2.2.3 Bedrock Topography and Geology

A bedrock topography map (Figure 2.4) was generated for the NSDF Project site using stratigraphic data provided by CNL, Golder (2016a) borehole and geophysics data, and AMEC (2017a, 2017b and 2018) borehole data. Logs for the boreholes completed in 2016 and 2017 are provided for reference in Appendix A. The bedrock topography is dominated by the ridge that delineates the eastern boundary of the Perch Lake Basin and the depression or valley that runs from the northwest corner of Waste Management Area A, to the south east towards Perch Creek. The bedrock ridge reaches an elevation of approximately 192 mASL and dips to the northwest and southeast, to an elevation of 165 mASL at Plant Road and 155 mASL at Perch Creek. The bedrock valley is comprised of a western portion that slopes irregularly from north to south and a southern portion that slopes irregularly from east to west. These two portions meet just north of where Main Stream discharges to Perch Lake. Bedrock in that area is at an elevation of 120 mASL. The northwestern portion of the NSDF Project site is underlain by a spur from the bedrock valley, at an elevation of 151 mASL. The ridge that delineates the western boundary of the Perch Lake Basin is shown reaching an elevation of 175 mASL at the limit of the map on Figure 2.4.

Two main fracture or faulting zones are present in the CRL site: the Mattawa Fault, which lies below the Ottawa River and consists of the northeast boundary of the property, and; the Maskinonge Lake lineament in the southwest area of the property. Within the Perch Lake basin a moderate probable fracture zone extends from approximately east to west through the upper portion of the basin (Raven Beck Environmental Ltd. 1994). Bedrock within the Perch Lake Basin and surroundings is primarily composed of quartz monzonitic, monzonitic, and monzodioritic gneisses with some occurrence of granitic-granodioritic, and leucodioritic gneisses (CNL 2016a).

A total of 66 historical measurements of hydraulic conductivity have been made in the upper 50 m of bedrock throughout the CRL site (including within the Perch Lake Basin), as summarized in Table 2.1. The geometric mean hydraulic conductivity from these tests was 5.2×10^{-8} m/s, with a range of 2×10^{-11} m/s to 7.8×10^{-4} m/s. The fracture porosity of the bedrock is estimated to range from 0.0002 to 0.005 (CNL 2016b, CNL 2016c).

Recent investigations by AMEC (2017a, 2018) included the advancement of 18 boreholes to depths of up to 13.2 m below the top of the bedrock surface. Borehole logs included in AMEC (2017a and 2018) indicate that the upper several metres of bedrock generally consist of a pink gneiss, with the exception of boreholes W7, W8, BH2-1, BH2-6, and GH1-4, in which diorite was logged. This transition in rock types in the eastern portion of the NSDF Project site appears to be consistent with the mapping shown on Figure 2.2.

Interpretation of hydraulic response testing of the bedrock completed at the NSDF Project site by AMEC and Golder has been summarized in AMEC (2017a) and AMEC (2017b). In addition to the 66 site-wide tests noted above a total of 41 hydraulic response tests were completed in the bedrock at 24 borehole locations within the NSDF Project site. Of these tests, 26 were suitable for analysis and interpretation and the remainder were not analyzable due to slow recovery or instrument malfunction. Hydraulic conductivity was found to range from $2.3x10^{-9}$ to $1.5x10^{-5}$ m/s with a geometric mean of $1.4x10^{-7}$ m/s, which is within the range of values from historical testing, as noted above. No significant trend in hydraulic conductivity with depth is observed through the tested interval; however, at depths greater than 6 m below the top of the bedrock surface the hydraulic conductivity did not exceed $2x10^{-6}$ m/s.

2.2.4 Overburden Geology

The overburden geology at the NSDF Project site consists primarily of fine sands, underlain locally by glacial till. The sands are interpreted to be the result of aeolian reworking of precursor fluvial sands and silts laid down in the late Pleistocene/early Holocene period by an early phase of the Ottawa River. Unconsolidated glacial and post-glacial deposits in the Perch Lake Basin (which includes the Local Study Area (LSA) and NSDF Project site) have been subdivided into six main units:

- glacial till;
- basal sand and gravel;
- clayey silt;
- middle sand;
- interstratified silt and sand; and
- upper sand.

More recent organic deposits are also present in the Basin, but are not considered substantial hydrostratigraphic units.

The total thickness of the unconsolidated deposits is shown by an isopach map on Figure 2.5. The thickness of the unconsolidated sediments is generally lowest on the eastern bedrock ridge (in the vicinity of the NSDF Project site). The thickness of these sediments increases to the west and is highest in the bedrock valley, reaching over 36 m in the bedrock low. Within the area of the NSDF Project site unconsolidated deposits are locally thicker in the area to the north and east, reaching over 26 m thick at the northern terminus of the bedrock ridge (Figure 2.5). Elsewhere on the CRL site, overburden thickness ranges from 0 m to greater than 25 m, being greatest in topographic lows (Raven Beck Environmental Ltd. 1994). Logging of overburden at the 2016 and 2017 boreholes was not sufficient to delineate the conceptual model geological units (per the list above). Therefore, interpolation of the overburden surfaces in the area of the ECM was based on the assumption that the till thickness was at least 1 m, with the remaining overburden thickness comprised of upper sand.

Hydraulic testing of the overburden has been completed using multiple methods on each of the stratigraphic units. These are provided in the discussion below along with additional details on the characterization of the overburden units.

Glacial Till

The thickness of the glacial till unit within the NSDF Project site is shown by an isopach on Figure 2.6a. Glacial till covers a large portion of the bedrock surface and is thickest in the areas of the bedrock lows. Glacial till thins to the east towards the bedrock ridge. Where present, glacial till is generally less than 12 m thick, but reaches thicknesses of up to 15 m within the bedrock valley, and 24 m in the area to the north of the eastern bedrock ridge. Glacial till is locally thicker along a line that extends from the northern edge of the eastern bedrock ridge to the south of the East Swamp, ending approximately 250 m northeast of where the East Stream meets the Main Stream. In this area, the glacial till ranges from 3 to 8 m in thickness. Within the southern portion of the NSDF Project site (where bedrock is close to ground surface) the till is generally less than 1 m thick.

Glacial till within the Perch Lake Basin consists of poorly sorted boulders, cobbles, and gravel in a silty sand to sandy silt matrix (Golder 2016a), with no visible stratification (CNL 2016b). Grain size analyses indicate a low silt content (less than 10%) and a negligible clay content (CNL 2016b).

A total of 42 single well response tests have been completed in the glacial till across the CRL Site and the resulting mean hydraulic conductivity is 1.5×10^{-6} m/s with a one log standard deviation of 4.0×10^{-7} to 5.8×10^{-6} m/s. The results of permeameter tests indicate that vertical hydraulic conductivity may be almost five times lower than these values. However, as only five permeameter tests have been completed and no visible layering is present in the till, this unit is not considered anisotropic (CNL 2016b).

Interpretation of hydraulic response testing of the till completed at the NSDF Project site by AMEC and Golder has been summarized in AMEC (2017a) and AMEC (2017b) (see table 2.1). Till hydraulic conductivity was found to range from $5.7x10^{-7}$ to $1.6x10^{-5}$ m/s with a geometric mean of $1.6x10^{-6}$ m/s based on the results of hydraulic response tests completed at 14 locations. Two additional tests were completed at the bedrock overburden interface, resulting in a slightly higher range of hydraulic conductivity (from 7.2×10^{-6} to 3.1×10^{-5} m/s).

Basal Sand and Gravel

A basal sand and gravel unit overlies the glacial till in a limited area of the western portion of the Perch Lake Basin. The areal extent and thickness of this unit is shown by an isopach map on Figure 2.6b. This unit ranges from 3.5 to 5.5 m in thickness within the bedrock valley to the north of Perch Lake and Perch Creek. The unit has also been found to underlie Waste Management Area A and the South Swamp, in thicknesses ranging from 1 to 4 m. This unit is not present in the NSDF Project site.

Given the limited extent of this unit, testing of the basal sand and gravel has been limited. Sand within this unit is characterized as a moderately to poorly sorted medium sand (CNL 2016b). The mean vertical hydraulic conductivity of the basal sand and gravel is 1.1×10^{-4} m/s based on the results of two permeameter tests. The porosity of this unit has not been measured, but is assumed to be 0.38 (CNL 2016b).

Clayey Silt

The thickness and areal extent of the clayey silt unit is shown as an isopach map on Figure 2.6c. The clayey silt is generally present in the southwest portion of the Perch Lake Basin, where there are depressions in the surfaces of the till and the bedrock. Where present, the clayey silt is generally less than 2 m thick, but is more than 5 m thick in the bedrock depression approximately 200 m north of Perch Lake. North of the NSDF Project site, the clayey silt unit ranges in thickness from 0.5 to 1.5 m, being thickest to the east along Emergency Route 3.

Clayey silt in the Perch Lake Basin is fluvial in origin and consists of laminations of coarser and finer fractions. The clay content of this unit, as determined through grain size analysis, is less than 20% by weight (CNL 2016b). Given the laminated nature of this material, a degree of hydraulic conductivity anisotropy is expected. The vertical mean hydraulic conductivity of this unit, based on the results of 12 permeameter tests, is 5.5×10^{-9} m/s, with a one log standard deviation ranging from 4.6×10^{-10} to 6.5×10^{-8} m/s. The horizontal hydraulic conductivity of this unit has been inferred from the results of six single well response tests. The mean horizontal hydraulic conductivity is 1.3×10^{-7} m/s, with a one log standard deviation ranging from 3.5×10^{-8} to 4.3×10^{-7} m/s.

Middle Sand

The extent and thickness of the middle sand unit is shown by an isopach map on Figure 2.6d. As with the other sedimentary units, the middle sand is thickest in the areas of the bedrock depressions. This unit generally fills the bedrock valley and ranges in thickness from 2 m to 9 m in this area. Middle sand is also present in the southern portion of Reactor Pit 2 (up to 4 m in thickness) and on the northern and southern flanks of the eastern bedrock ridge that delineates the Perch Lake Basin (up to 3 m in thickness in the south and 2 m thickness in the north).

The middle sand has been classified as moderately well sorted fine sand through the results of grain size analyses. The vertical mean hydraulic conductivity of this unit, based on the results of 53 permeameter tests, is 8.7×10^{-6} m/s, with a one log standard deviation ranging from 3.6×10^{-6} m/s to 2.1×10^{-5} m/s. The horizontal hydraulic conductivity of this unit is 7.8×10^{-5} m/s, based on the geometric mean of the results of 13 borehole dilution tests (CNL 2016b). The porosity of this unit is 0.38 (CNL 2016b).

Interstratified Silt and Sand

The extent and thickness of the interstratified sand and silt unit is shown by an isopach map on Figure 2.6e. Where present, this unit is generally less than 0.4 m thick, but can reach thicknesses of up to 2 m locally (i.e., near the point of discharge from Perch Lake to Perch Creek and to the south and west of Waste Management Area A). This unit has been encountered in the northern portion of the NSDF Project site at thicknesses of less than 0.4 m.

The interstratified silt and sand consists of alternating layers of fine to very fine sand and sandy silts. Individual layers are on the order of several centimetres (CNL 2016b). The vertical mean hydraulic conductivity of this unit, based on the results of 14 permeameter tests, is 3.6×10^{-8} m/s, with a one log standard deviation ranging from 1.76×10^{-9} m/s to 7.5×10^{-7} m/s. Due to the limited thickness of this unit, only one single well response test was completed and the mean horizontal hydraulic conductivity of 1.8×10^{-5} m/s is estimated from the results of grain size analyses (CNL 2016b). The one log standard deviation of horizontal hydraulic conductivity based on the grain size analyses ranges from 5.5×10^{-6} to 8.6×10^{-5} m/s. The measured porosity of this unit is 0.39 (CNL 2016b).

Upper Sand

The upper sand unit is the uppermost sand unit in the Perch Lake Basin. The base of the upper sand unit is defined by either the top of the interstratified silt and sand unit, or by an inferred contact with the middle sand. The thickness of the upper sand unit is shown as an isopach map on Figure 2.6f. The unit is thickest where the bedrock valley abuts the bedrock ridge that delineates the western boundary of the Perch Lake Basin. In this area, the unit can be up to 13 m thick. The upper sand unit is also locally thicker through an area extending from Plant Road, south through Reactor Pit 1 and Reactor Pit 2, then extending west through the southern portion of Waste Management Area A. In this area the unit reaches thicknesses of up to 10 m. The upper sand unit is present

in the NSDF Project site, at a relatively uniform thickness of approximately 1 m. There is a localized area to the immediate south west of the NSDF Project site, where the upper sand thickness increases to approximately 5 m.

In comparison to the middle sand, the upper sand is slightly coarser and better sorted (CNL 2016b). The vertical mean hydraulic conductivity of this unit, based on the results of 103 permeameter tests, is 1.4×10^{-5} m/s, with a one log standard deviation ranging from 5.3×10^{-6} to 3.8×10^{-5} m/s. The horizontal hydraulic conductivity of this unit is 4.8×10^{-5} m/s, based on the geometric mean of the results of 38 borehole dilution tests (CNL 2016b). The porosity of this unit is 0.38 (CNL 2016b).

2.2.5 Future Evolution of Site Geology

Previous studies completed by CNL in support of proposed geological waste management facilities at the CRL site include discussion on the long-term future evolution of geological conditions (CNL, 2016c). Although the focus of these studies is on factors that influence the deep geological setting (as compared to the shallow geological setting of the NSDF) over timeframes on the order of 100,000 years (as compared to the shorter NSDF assessment timeframe of 10,000 years) the presented information is relevant to the current assessment. The natural processes identified as having potential to influence the geological conditions at the CRL site include glaciation (glacial erosion and deposition of surficial material, glacial loading, permafrost formation, changes in sea level, changes in topography, isostatic adjustment, post-glacial effects such as flooding), tectonism (fault rupture or reactivation) and volcanism. A summary of the findings for each of these factors is provided as follows:

- Long-term future climate predictions indicate that the next major glaciation will occur at least 60,000 years after the present time. Therefore, the effects of glacial erosion, permafrost, and associated changes to the groundwater flow system are expected to be minimal over the NSDF assessment timeframe (10,000 years);
- The potential for fault reactivation at the NSDF site exists, but the effects are expected to be minimal on the existing system. Evidence from bedrock fractures that have been subjected to historical tectonic stresses and glacial loading and unloading indicates that the rock is inherently stable. No evidence of post-glacial structural disruption has been found. A detailed seismic analysis of the site was completed as a part of the design package (AECOM 2018d), which discusses the potential for future seismic events in greater detail.
- Volcanic activity and orogenic events are not considered to be factors that could potentially influence the geological setting over the assessment timeframe.

In consideration of the above findings, the primary factors influencing the future geological evolution in the vicinity of the CRL site over the 10,000-year assessment timeframe are erosion and deposition of the overburden and weathering of the shallow bedrock. The future climate will be the primary natural control on these factors. Golder's 2019 report entitled "*Climate Change Assessment for the Near Surface Disposal Facility Project*" provides an assessment of long-term future climate for the CRL site, which concludes that the climate will be warmer (by up to 8 degrees C) and wetter (by up to 20%) in the early portion (the first 1,000 years) of the assessment timeframe. Because of the uncertainty associated with estimating future climate in the long-term the predictions are limited to this early portion of the assessment timeframe.

Given the uncertainty associated with future climate predictions, one approach to evaluating future geological changes to the CRL site is to qualitatively extrapolate future conditions based on historical geological evolution. This assumes that processes that have in the past (and at present) influenced the geological conditions will continue to do so in the future. The recent geological evolution has been primarily controlled through glacial activity;

the last major deposition of sediment in Perch Lake basin occurred during the draining of Glacial Lake Agassiz via the early post-glacial Ottawa River, which ceased approximately 9,800 years before present (Teller, 1988). Since that time the geological setting in the Perch Lake Basin has been stable, as indicated by the development of organic deposits in Perch Lake (Boyko-Diakonow and Terasmae, 1975). Because glacial activity has been the primary factor influencing the near-surface geological evolution at the site, and glacial activity is not expected to occur within the assessment timeframe (CNL 2016c), it is inferred that the geological conditions will be relatively stable over the assessment timeframe. Groundwater Conditions

A description of the CNL Chalk River Site hydrogeology is provided in Section 5.3 of the NSDF Project EIS (Golder 2017). This information is repeated herein for completeness in the context of this modelling report. Regardless, the reader is referred to the NSDF Project EIS for further details.

2.2.6 Groundwater Elevations

The water table elevation within the NSDF Project site, and throughout the lower Perch Lake Basin is shown on Figure 2.7a. A summary of the NSDF Project site groundwater elevation data is provided in Table 2.2. Elevation contours shown on Figure 2.7a were generated based on average water levels from historical information in the areas outside the NSDF Project site and from more recent information in the NSDF Project site (AMEC 2017a; AMEC 2018). The seasonal high water table elevation within the NSDF Project site is shown on Figure 2.7b. The high water table elevation contours were generated based on the maximum groundwater elevation from the transducer records collected by AMEC between October 2016 and June 2018. On average, the maximum value from the transducer record was 1.2 m above the average values, and approximately 3 m above the minimum value. The high water table position occurred in April or May at most locations. Elsewhere within the Perch Lake Basin the water table elevation is expected to vary seasonally by 1 m to 2 m (depending on location), with the high water table position occurring in April and May (CNL 2016b). It should be noted that the transducer record lengths vary at individual wells depending on the date of installation. For the most recent installations the transducer records span a period of approximately 6 months. Figure 2.7c provides a “snapshot” of the seasonal high water table elevation from April 26, 2018 when the most recent seasonal high elevation was measured for most wells. A comparison of Figures 2.7b and 2.7c shows that the groundwater elevations and flow directions are similar for the absolute maximum and snapshot (April 26, 2018) readings.

Within the Lower Perch Lake Basin, groundwater flow within the overburden is influenced by local topography (and bedrock topography) and is interpreted to be primarily horizontal (CNL 2016b). In the overburden deposits, groundwater flow occurs mainly within the basal sand and gravel, middle sand, and upper sand units where present (CNL 2016b). As the silty clay and interstratified silt and sand units that separate these aquifers are not continuous throughout the valley, groundwater elevations, groundwater flow directions, and horizontal hydraulic gradients are not differentiated between units. The available data includes monitoring wells located at the peak of the bedrock ridge to the northeast of the ECM (e.g., W8, PH17-005, PH17-008, PH17-009, BH2-6, etc.). Data from these locations indicate the presence of a northeast to southwest groundwater divide corresponding to the topographic high along the ridge. Hydrogeological mapping of the CRL site completed by Raven Beck Environmental Limited (1994) also infers the presence of a groundwater divide along this ridge.

The depth to the water table within the NSDF Project site was calculated based on the average groundwater elevation data from transducers (collected between October 2016 and June 2018). Average groundwater depths ranged from 0.06 metres below ground surface (m bgs) (at SH-4) to 15.95 m bgs (at PH17-001). The seasonal high water table elevations range from 0.26 meters above ground surface (m ags) (at W-4) to 15.43 m bgs

(at PH17-001). The average water table depth across the NSDF Project site is 4.81 m bgs under average groundwater conditions, and 3.61 m bgs under seasonal high water table conditions. Depth to the water table is generally greatest near the top of the bedrock ridge, and decreases to the south, west, and north, towards the low-lying wetland areas.

2.2.7 Groundwater Flow Directions

Within the NSDF Project site, groundwater flow to the north of the Powerline Cut is generally to the northwest towards the East Swamp. In this area hydraulic gradients are low, and minor variations in groundwater elevations can result in a component of groundwater flow towards the northeast for the northernmost portion of the NSDF study area. Based on the transducer records from the PH-series monitoring wells, these reversals in groundwater flow direction are sustained for a period of less than a month. To the south of the Powerline Cut groundwater flow is generally to the southwest and south towards the Perch Lake Swamp and Perch Creek. Within the southern portion of the Perch Lake Basin, groundwater flow is generally towards Perch Lake to the south with a component of flow to the southeast towards Perch Creek.

The bedrock ridges and topographic highs at the eastern and western boundaries of the Perch Lake Basin act as groundwater (and surface water) divides. A groundwater divide is also present to the north, along Plant Road (CNL 2016b). The shallow groundwater flow system is expected to be recharged through precipitation at these topographic highs. Groundwater discharge generally occurs at the surface water features within the low-lying portions of the Perch Lake Basin. Groundwater springs are observed in the East Swamp stream to the north of Powerline Road and in Perch Creek, downstream of the Perch Lake Outlet Weir. Based on stream gauge data groundwater discharge to the East Swamp stream to the north of Powerline Road was observed to range from 25 m^3/day to 770 m^3/day during low-flow periods. Groundwater discharge to Perch Creek during low-flow periods (i.e., September, when runoff is minimized and flows in the streams are dominated by groundwater discharge) is estimated to be approximately 790 m^3/day based on the difference in average flow measurements between the Perch Lake Outlet Weir and the Perch Creek weir (see Section 2.1 of this report). It is noted that the East Swamp Stream south of Powerline Road and the T-16 Stream act as sources of groundwater recharge to the upper sand unit, however, no quantitative estimates are available for these areas.

Surface water within the East Swamp receives groundwater discharge from the Chemical Pit (CNL 2014) and to a lesser degree from Reactor Pit 2. Groundwater flow from the Chemical Pit to the East Swamp follows a relatively short groundwater flow path, with a travel time of approximately four months. Groundwater from Waste Management Area A, and the most of Reactor Pit 2 discharges to surface water in the South Swamp (CNL 2015a and CNL 2015b).

2.2.8 Hydraulic Gradients

Horizontal hydraulic gradients within the NSDF Project site were calculated based on average groundwater levels collected by AMEC in between October 2016 and June 2018 and the groundwater elevation mapping shown on Figure 2.7a. The horizontal hydraulic gradient within the overburden in the northern portion the NSDF Project site was approximately 0.04 metres per metre (m/m) to the northwest (between W2-S and PH17-003). In the southern portion of the NSDF Project site the horizontal hydraulic gradient is approximately 0.05 m/m to the southwest in the overburden between BH-15-8 and SH-5 and approximately 0.07 m/m to the southwest in the bedrock between W4 and BH2-3.

Under high water table conditions (as shown on Figure 2.7b) the horizontal hydraulic gradient within the overburden in the northern portion of the NSDF Project site is increased to approximately 0.05 m/m to the northwest (between W2-S and PH17-003). In the southern portion of the NSDF Project site the horizontal hydraulic gradient to the southwest in the overburden (between BH15-8 and SH-5) is 0.05 m/m (unchanged from average conditions), while the horizontal hydraulic gradient to the southwest in the bedrock (between W4 and BH2-3) is increased to 0.09 m/m.

Vertical hydraulic gradients between the overburden and the bedrock were calculated for monitoring well pairs W2-S/D and BH2-2S/D based on groundwater elevation data collected between December 2017 and June 2018. At W2-S/D downward vertical gradients of 0.13 m/m and 0.16 m/m, under average and high water table positions respectively, from the overburden to the bedrock were calculated, indicating recharging conditions at the topographic high. At BH2-2S/D a downward gradient of 0.03 m/m was calculated under average water table conditions. A very slight upward gradient of 0.006 m/m was calculated at this location under high water table conditions. From June 2017 to December 2017, vertical gradients at BH2-S/D were predominately downwards, while vertical gradients at this location were predominately upwards between December 2017 and June 2018.

Average horizontal hydraulic gradients measured in low-lying portions of the Perch Lake Basin range from 0.006 to 0.03 m/m in the area between Reactor Pit 2 and the South Swamp (CNL 2016b). The average horizontal hydraulic gradient is slightly higher, 0.05 m/m, between the South Swamp and Perch Lake Swamp, as measured between AA-183 and PLS-44. In the aquifers underlying the Perch Lake swamp, the average horizontal hydraulic gradients decrease in a southerly direction, from 0.009 m/m (between PLS-44 and PLS-36) to 0.002 m/m (between PLS-32 and PLS-39). Average horizontal hydraulic gradients were found to increase slightly (to 0.006 m/m) between PLS-39 and the zone of groundwater discharge at Perch Creek. In general, the horizontal hydraulic gradients observed in the low-lying areas of the Basin are lower than those observed at the NSDF Project site.

3.0 MODEL CONSTRUCTION AND CALIBRATION

3.1 Modelling Approach

The objective of the numerical modelling was to estimate the potential influence of the NSDF Project components (ECM, stormwater management (SWM) ponds, and WWTP) on local hydrogeological conditions during operations and post-closure conditions. To achieve this objective, a deterministic approach was used where a 3D numerical (MODFLOW) groundwater model was constructed and calibrated to represent the “best estimate” of groundwater flow conditions based on the conceptual model described above. The calibrated model was subsequently adapted to include the NSDF Project so that it could be used for the predictive simulations. In order to address the uncertainty associated with the “best estimate” configuration, a sensitivity analysis was completed, which involved perturbation of some of the key model input parameters and comparison to the base case results.

3.2 Code Description

MODFLOW-2005 (Harbaugh 2005) was used to complete the simulations. MODFLOW is a multi-purpose three-dimensional groundwater flow code developed by the United States Geological Survey. It is modular in nature and uses the finite difference formulation of the groundwater flow equation in its solution. Visual MODFLOW® (Version 4.6.0.156) was used as the numeric flow engine for the simulations presented in this report. The MODFLOW-NWT solver was used to solve the groundwater flow equations (Niswonger et al. 2011). MODPATH (Pollock 1989), a companion code to MODFLOW, was used to complete the particle tracking analyses necessary to illustrate the flow paths from the WWTP and ECM components of the NSDF Project. General modelling assumptions are provided in Table 3.1.

3.3 Model Construction

3.3.1 Model Extent and Discretization

The extents of the numerical model are illustrated on Figure 3.1. The model extends from Plant Road in the north (corresponding to the location of an interpreted groundwater flow divide), eastwards to the topographic divide located approximately 2 km east of Waste Management Area A. The southern model boundary is defined by Perch Creek and Perch Lake. Main Stream and an interpreted groundwater flow divide between Main Stream and Plant Road form the western limits of the model.

The model grid was discretized horizontally into 5 m by 5 m grid cells in the central portions of the model domain, transitioning to a 10 m by 10 m cell size on the edges. Vertically, the model is discretized into 23 numerical layers, ranging in thickness from 0.1 m to 25 m. The total number of grid cells was 1,209,800. Details on vertical discretization are provided with reference to the hydrostratigraphic units in Section 3.3.3 below.

3.3.2 Boundary Conditions

The model flow boundaries are illustrated on Figure 3.1. As shown in the figure, constant head boundaries were specified for Main Stream, T-16 Stream, Perch Creek, the North Shore of Perch Lake, and the north-eastern portion of the model domain. Portions of East Swamp Stream downstream of the weir are dominated by groundwater recharge, whereas portions upstream of the weir are dominated by groundwater discharge. As such, the East Swamp Stream has been represented in the model using drain boundaries (which only permit the discharge of groundwater) for the upstream portions and constant head boundaries for the downstream portions. Swampy areas (defined by CNL mapping) were assigned drain boundary conditions at ground surface elevation to allow for groundwater to discharge at these locations). Elevations of all boundaries are based on LiDAR data (surface topography), with the exception of the north-eastern constant head model boundary, which was specified at an elevation of 164 mASL based on the interpreted groundwater elevations in that area. No flow boundaries were assigned to the remaining portions of the model perimeter that correspond to inferred groundwater flow divides, as indicated on Figure 3.1. Recharge, a boundary condition applied to the top of the model domain, is discussed later in Section 3.3.3.2.

3.3.3 Hydrostratigraphy and Parameterization

3.3.3.1 Material Properties

Figure 3.2 and Table 2.1 show the hydrostratigraphic parameterization of the model, as described below. Based on groundwater velocity calculations completed by CNL (CNL 2016b), values corresponding to the geometric mean plus one log standard deviation ("GM+1LSD") of the measured hydraulic conductivities were used as a starting point for model parameterization. These were adjusted and refined through the calibration process until an acceptable model calibration was achieved (this is discussed further in Section 3.4). Final (i.e., calibrated) model parameters are provided on Figure 3.2, and compared to measured values in Table 2.1. The model values were generally less than the GM+1LSD value; for sand units (where the primary groundwater flow pathways occur), the calibrated model value was approximately 30%-40% lower. Anisotropy ratios assigned to the hydrostratigraphic units in the model were generally within the ranges of measured data. The hydraulic conductivity values applied in the model are summarized below with respect to the model layering.

- Model Layers 1 through 3 represent the upper sand unit from ground surface to the underlying geological contact. The total thickness of this unit across three numerical layers ranged from 1 m in the northern portions of the model to approximately 12 m along portions of Main Stream. The hydraulic conductivity distribution of this unit was based on the existing conceptual model (detailed in Section 2.0) and ultimately resulted from the model calibration process. Three zones of hydraulic conductivity were used in the model to represent the upper sand unit, with horizontal hydraulic conductivity ranging from 3.0×10^{-5} to 1.7×10^{-4} m/s and vertical hydraulic conductivity ranging from 1×10^{-5} m/s to 5×10^{-5} m/s. Total porosity is a measure of the total pore space per unit volume of material and effective porosity is a measure of the connected pore space per unit volume (i.e., the total volume available for fluid flow). The total and effective porosities assigned to this unit were 0.38 and 0.3, respectively.
- Model Layer 4 represents the interstratified silt and sand unit. Model thickness of this unit ranged from zero to 2.7 m. Horizontal hydraulic conductivity of this unit was 6×10^{-5} m/s, with a vertical hydraulic conductivity of 6×10^{-7} m/s (i.e., the horizontal to vertical anisotropy ratio is 100:1). The total and effective porosities assigned to this unit were 0.39 and 0.3, respectively.
- Model Layers 5 and 6 represent the middle sand unit. Model thickness of this unit ranged from zero to 11 m. Horizontal hydraulic conductivity of this unit was 1×10^{-4} m/s, with a vertical hydraulic conductivity of 2×10^{-5} m/s (i.e., the horizontal to vertical anisotropy ratio is 5:1). The total and effective porosities assigned to this unit were 0.38 and 0.3, respectively.
- Model Layers 7 and 8 represent the clayey silt unit. Model thickness of this unit ranged from zero to 10 m. Horizontal hydraulic conductivity of this unit was 9.5×10^{-7} m/s, with a vertical hydraulic conductivity of 5.5×10^{-9} m/s (i.e., the horizontal to vertical anisotropy ratio is 173:1). The total and effective porosities assigned to this unit were 0.48 and 0.3, respectively.
- Model Layers 9 and 10 represent the basal sand unit. Model thickness of this unit ranged from zero to 3 m. Horizontal hydraulic conductivity of this unit was 1.2×10^{-4} m/s, with a vertical hydraulic conductivity of 1.0×10^{-4} m/s (i.e., the horizontal to vertical anisotropy ratio is 1.2:1). The total and effective porosities assigned to this unit were 0.38 and 0.3, respectively.

- Model Layers 11 and 12 represent the till. Model thickness of this unit ranged from approximately 0.2 m to 38 m. Horizontal hydraulic conductivity of this unit was $9.0x10^{-7}$ m/s, with a vertical hydraulic conductivity of $7.0x10^{-7}$ m/s (i.e., the horizontal to vertical anisotropy ratio is 1.3:1). The total and effective porosities assigned to this unit were 0.26 and 0.2, respectively.
- Model Layers 13 through 23 represent the bedrock. This unit is divided into two subunits: the upper bedrock, which is comprised of a continuous 6 m thick layer below the overburden-bedrock contact (Layers 13 through 18), and the lower bedrock (Layers 19 through 23), which is comprised of a 44 m thick layer that underlies the upper bedrock. Horizontal and vertical hydraulic conductivity was $9.0x10^{-7}$ m/s for the upper bedrock and $4x10^{-8}$ m/s for the lower bedrock (i.e., the horizontal to vertical anisotropy ratio is 1:1). The total and effective porosities assigned to the bedrock units were equivalent and equal to 0.001.

A minimum numerical layer thicknesses of 0.1 m was maintained. Where the hydrostratigraphic unit thickness was less than this value the material properties of the underlying unit were applied.

3.3.3.2 Recharge

An infiltration (groundwater recharge) boundary was applied at the top surface of the groundwater flow model. The distribution of recharge rates was estimated using methods outlined in Ontario Ministry of the Environment (MOEE) guidance documents (MOEE 1995). The MOEE approach involves partitioning the available surplus water (i.e., total precipitation minus evapotranspiration) into runoff and recharge components based on several physical factors: slope, surficial soil type, and land use. Rasterized maps of the study area were created in a GIS platform for slope percentage (based on LiDAR data), soil type (based on provincial mapping data), and land use (based on provincial mapping data) on a 5 m by 5 m grid. “Infiltration factors” were assigned to each raster grid element based on the MOEE guidance tables, and the three maps were summed to create a map of the total infiltration factor. This was multiplied by the surplus water amount (300 mm/yr for the CNL site; CNL 2016b) to create a spatially-variable recharge distribution map, which was applied to the groundwater flow model. It should be noted that recharge applied over the East Swamp and Perch Lake Swamp areas will report to the drain cell boundaries representing these features in areas where the drain cells are saturated.

The slope, surficial soil type, and land use rasters and the infiltration factors assigned to each raster component are provided on Figure 3.3. This figure also provides the groundwater recharge distribution resulting from the calculation described above. As shown on the figure, surficial recharge ranged from 100 mm/yr to 245 mm/yr (equivalent to 33% to 80% of the available surplus amount).

Subsequent adjustments were made to one of the recharge zones within the NSDF Project site to improve model calibration to the average and high water table condition (as discussed in Section 3.4). This area is shown as the dark purple coloured zone on Figure 3.3, as indicated by the label. This area was originally estimated to be 135 mm/yr based on the MOEE methodology but was later assigned a value of 165 mm/year based on calibration to the average water table condition and a value of 400 mm/yr for calibration to the high water table condition.

3.4 Model Calibration

Calibration of the groundwater flow model involved refinement of the material properties of the main hydrostratigraphic units until the simulated hydraulic head distribution and rates of groundwater flow to and from surface water boundaries compared reasonably well with measured conditions in the study area.

Historical groundwater elevation data was used as targets for model calibration. These data were comprised of a set of average measured groundwater elevations at over 20,400 measurements from 1,500 monitoring points at 374 spatial locations spanning the period from 1982 to 2018. Due to the varying frequency of groundwater level measurement collection between monitoring locations these data represent time-averaged conditions, and are not representative of a single “snapshot”. Groundwater elevation data from recently installed monitoring locations within the NSDF Project site comprised the primary calibration targets (as provided in Table 2.2). At these locations the average value up to the most recent available groundwater elevation measurement (from the transducer data collected during the June 2018 monitoring event) was used as the target value. This calibration set is referred to as the average water table condition.

The model was also calibrated to a seasonal high water table condition where the model output was compared to the maximum observed groundwater elevation for each monitoring well. This was achieved through increasing the surficial recharge rate from 165 mm/yr to 400 mm/yr within the predominate recharge zone located in the ECM area (see Figure 3.3). The maximum observed groundwater elevations used in the high water table assessment are limited to the wells with transducer records only (in the NSDF area). It should be noted that the maximum groundwater elevations occurred on different dates depending on the well, with dates ranging from 11 April, 2017 (at W7 and W8) to 4 September, 2017 (at W2-D). This reflects the variability in hydraulic characteristics at the different monitoring locations, both as a function of the material in which the monitoring well is situated and its degree of connectivity to infiltration from surface or other hydraulic boundaries (e.g., Perch Lake Swamp).

Low-flow periods from monthly streamflow volume data at monitored streams within the model domain were also used to check model calibration for the average water table condition. In particular, the measured flows at the East Swamp Stream weir (which span from 1957 to 2015) were used for this purpose, as the full catchment of the stream is included within the model domain. The remaining streamflow data (for catchments not entirely within the groundwater flow model) were used to estimate the equivalent recharge rate for the catchment, which was compared against the average recharge applied to the groundwater flow model.

Groundwater velocity calculations completed by others (CNL 2016b), which were based on tracking measured tritium concentrations in groundwater between Reactor Pit 2 and Perch Creek through time, were compared to the simulated advective travel times in the average water table condition model. As indicated in CNL 2016b, Reactor Pit 2 is the primary source of tritium in the Perch Creek Basin. As such, groundwater flow particles were released from this location in the model and forward-tracked through the flow system to the downgradient receptor. It should be noted that advective particle tracking does not consider the effect of dispersion.

The results of the model calibration are summarized on Figure 3.4a and Figure 3.4b (showing plan view contours of the simulated water table and calibration statistics for the average and high water table conditions), Figure 3.5 (showing the simulated water table in cross-section for the average and high water table condition), Figure 3.6 (comparing simulated and observed baseflow and recharge), and Figure 3.7 (comparing simulated groundwater flow paths and mapped tritium plume).

Simulated groundwater elevations are compared to the calibration targets for the monitoring locations within the vicinity of the NSDF Project site in Table 2.2. A review of the above figures and tables allows for the following observations:

- The overall calibrated average water table model achieved a normalized root mean squared (nRMS) error of 1.3%, with an absolute mean difference of 0.34 m and a residual mean error of -0.08 m (Figure 3.4a). For the NSDF-area piezometers, the nRMS error was 2.8%, with an absolute mean difference of 0.69 m and a residual mean error of -0.08 m.
- On Figure 3.4b the residual error map and statistics encompass the maximum observed groundwater elevation at NSDF-area piezometers, and (due to infrequent measurements) average values for the remaining CRL Site water level data. The high water table simulation achieved a normalized root mean squared (nRMS) error of 1.2%, with an absolute mean difference of 0.30 m and a residual mean error of 0.07 m (Figure 3.4b). For the NSDF-area piezometers, the nRMS error was 3.2%, with an absolute mean difference of 0.86 m and a residual mean error of 0.13 m.
- The simulated head was generally within 0.5 m of the measured value, and was within a range of -2.0 m to 2.3 m across all data for the mean water table condition. For the high water table model, the simulated head was generally within 0.5 m of the measured value, and was within a range of -1.5 m to 3.5 m across all data. A review of the spatial distribution of residual error (Figure 3.4a and Figure 3.4b) does not show any significant spatial bias.
- A visual comparison of the simulated (Figure 3.4a) and measured (Figure 2.7) groundwater head distribution and groundwater flow paths show that the simulated groundwater flow patterns are reasonable. Groundwater flow is generally simulated to follow surface water divides, with convergence towards the surface water features.
- Table 2.2 compares the simulated groundwater elevation to recent observations for the NSDF Project site wells. The model results are acceptable given the average calibration target and the seasonal range in observed groundwater elevations for the monitoring locations. Due to limitations in the period of record for the most recently installed wells (the PH-series) it is unknown whether the range in observed groundwater elevations is representative of typical seasonal variability.
- Groundwater discharge to the portion of East Swamp Stream upstream of the weir was estimated to be 70 m^3/d (Figure 3.6). This is within the lower portion of the range of measured September flows (25 m^3/d to 770 m^3/d) from the East Swamp Stream weir (as discussed above September is taken to represent the low-flow period for the CNL property; CNL 2016b). For the portion of East Swamp Stream downstream of the weir, the net recharge to groundwater from the constant head boundary was 97 m^3/d. Though no quantitative estimates are available for this portion of the stream, this result is in general agreement with the conceptual model discussed in Section 2.1.
- The estimated net infiltration rate based on September flows from East Swamp Stream, Inlet 2, Perch Lake Outlet, and Perch Creek weirs ranged from 100 mm/yr (at the Perch Lake Outlet Weir) to 222 mm/yr (at the East Swamp Stream Weir). The average recharge rate applied over the model domain was 159 mm/yr, which is within the range of estimates from streamflow data during the low flow period (Figure 3.6). Variability

in the equivalent recharge estimates could reflect differences between infiltration characteristics of the individual basins and/or variation in the periods of record.

- The simulated advective particle tracks released from Reactor Pit 2 and the East Stream Swamp follow a similar pathway to the interpreted groundwater flow path based on the tritium data (Figure 3.7). The simulated groundwater velocity compares well to the estimated velocity calculated based on tritium travel times between Reactor Pit 2 and monitor PLS-32 (CNL 2016b).

The mass balance within the overall model was acceptable from a numerical convergence perspective, with a global mass balance error of less than 0.01%. Based on the calibration statistics in combination with the general patterns of groundwater flow and the checks on model recharge and groundwater flow paths noted above, the simulated groundwater elevations provide a reasonable match to observed conditions in the site. The calibrated groundwater model, as described above, is subsequently used as the basis for construction of the forecast groundwater model (presented in Section 4.0 below).

4.0 FORECAST SIMULATIONS

4.1 NSDF Project Design

Detailed documentation of the proposed design of the NSDF Project is provided in AECOM (2019b), while an overview illustration of the design is provided on Figure 4.1. This is referred to as the “100% design”, and it is anticipated that no refinements to the design will be made. The proposed (100%) NSDF Project design consists of an excavation and regrading on the face of the hill to the east of East Swamp Stream that will form a base grade for the ECM. Along the southwestern portion of the ECM (in the area shown on Figure 4.1) overburden will be removed and replaced with compacted granular material for liquefaction mitigation purposes. Under current (average) conditions the water table elevation beneath the ECM is below the elevation of the primary liner over the western portion of the ECM, and above the primary liner over the eastern portion of the ECM, reaching a maximum of approximately 4 m above the liner elevation in the area of well PH-17-007. Construction of the ECM will require excavation into bedrock along the eastern reach of the ECM. This will be performed by blasting, which will also serve to establish an enhanced zone of permeability in the bedrock beneath the ECM. This will have the effect of increasing drainage of the bedrock and lowering groundwater elevations beneath the facility such that a minimum separation distance of 1.5 m between the water table and the primary liner elevation is achieved (AECOM 2019c) (referred to as the blast-damaged zone). The purpose of the minimum separation distance of 1.5 m is to facilitate the ECM base grade excavation and clay liner construction, especially where the compacted clay layer is founded on native fine sand to silty fine sand soils (AECOM 2019a). If saturated at the founding elevation of the clay liner, these soils can become very loose/weak under the live loading of the construction equipment. The minimum separation distance is not intended for contamination attenuation purposes. Control of contaminant migration from the ECM is provided by the proposed liner and the Leachate Collection System without any reliance on the underlying native soils and soil fill conditions.

An impermeable liner will extend from the base of the excavation to the crest of the berm surrounding the ECM. This will incorporate a leachate collection system, which, during the operations phase of the NSDF Project, will capture leachate from waste placed in the ECM as well as surface runoff from open or active cells. The collected leachate and runoff from the active cell will be sent to a WWTP, which will discharge treated water to both Perch Lake and an exfiltration gallery near the East Swamp. Discharge water generated by the operations

facility (not in contact with the waste) will be sent to a leaching bed located to the north of the WWTP infiltration area.

A sacrificial liner will be installed over the Phase 2 (northern) area of the ECM during operation of Phase 1. This, combined with the impermeable liner over the Phase 1 area, will have the effect of limiting recharge to the water table and thereby lowering groundwater elevations in the ECM area.

The ECM will be comprised of 10 waste cells. Construction of the ECM will be such that only one cell is active at a given time during operations. Upon filling of each waste cell a cover will be installed that will effectively limit the infiltration into the ECM to zero. Following cover placement, runoff from the top surface of the ECM will be directed to one of three lined ponds via a perimeter ditch. The ponds are designed with outflows that will direct water towards East Swamp and Perch Lake Swamp. Estimates of water collection volumes and surface runoff from the ECM (completed by others) were used as inputs for the groundwater flow modelling in this assessment (AECOM 2018b and 2018c).

4.2 Modelling Approach

As discussed in Section 1.2, the objective of the hydrogeological modelling was to estimate the groundwater flow pathways and rates of groundwater flow from the NSDF Project site to downstream receptors. This was accomplished by using the calibrated groundwater flow model as a starting point and making subsequent modifications to the model to represent the NSDF Project site under operating and post-closure condition, as described below.

4.2.1 Operating Conditions

The blast-damaged zone was incorporated into both the operations and post closure models through modification of the hydraulic conductivity of the bedrock within the footprint of the zone as shown on Figure 4.1. For the purposes of this assessment the modified hydraulic conductivity zone was extended vertically 3 m below the subgrade. It is noted that the potential influence of the blasting was estimated to extend 3 m below the bottom of the overburden and bedrock excavation, and that the elevation of the subgrade is (in most places) 1 m to 2 m higher than the bottom of the excavation. As such, the base of the blast-damaged zone within the groundwater model was (conservatively) specified approximately 1 m to 2 m higher than the estimated depth of blast influence. The blast damaged zone was assigned a hydraulic conductivity of $1x10^{-4}$ m/s (representing an increase of 2,500 times the intact bedrock hydraulic conductivity as applied in the model. This lies within the 1,000 to 10,000 times increase for the intact bedrock range provided by AECOM (2019c).

The liquefaction mitigation measure along the southwest portion of the ECM was incorporated into the model as an independent material zone with a hydraulic conductivity of $1x10^{-3}$ m/s (representing coarse granular fill material) throughout the full depth of the overburden. The coarse granular fill material was present for all operations and post-closure simulations.

During operating conditions approximately 2,190 m^3/year of sanitary water is sent to the leaching bed and applied in the model as surficial recharge at the leaching bed location. Further, approximately 11,000 m^3/year of contact water and leachate will be collected within ECM operating cell, which is sent to the WWTP for treatment and discharged via a combination of the WWTP exfiltration gallery and Perch Lake outfall (AECOM 2018a, 2018b, 2018c). It is anticipated that the majority of water collection will occur during the spring, summer, and autumn with less collection occurring in the winter. The relative portion of discharge routed to the exfiltration gallery and

Perch Lake outfall will depend on the volume of discharge and groundwater table elevations and is therefore unknown. Based on preliminary groundwater flow simulations it is anticipated that the capacity of the exfiltration gallery will be equivalent to approximately half of the contact water and leachate collection rate. As such, two scenarios were evaluated using the groundwater model under the operating conditions. These are illustrated on Figure 4.2 and summarized below.

Operations Scenario A –Discharge to the WWTP Outfall under Average Water Table Conditions

The objective of this simulation was to evaluate the groundwater elevations and flow directions under normal operating conditions. This was represented in the Operations Scenario A model based on the following criteria:

- Phase 1 is active, a sacrificial liner is in place over Phase 2, and active leachate collection is occurring. The presence of the phase 1 development and sacrificial liner was represented as zero infiltration over these areas.
- Approximately 11,000 m^3/year of water collected within the footprint of one open cell, with half of this volume applied in the model as surficial recharge at the WWTP exfiltration gallery location. It was assumed that the recharge would occur over a 4-month period for the purposes of calculation of a recharge rate to apply to the steady-state simulation.
- The natural/background infiltration distribution in the model was representative of the average water table condition.
- Zero infiltration is applied over the footprint of the open and closed cells (precipitation is being collected via the liner).
- Runoff is collected from the remaining nine cells at a rate corresponding to the average annual precipitation (839 mm/yr) and an equivalent volume is applied as recharge in the model to the SWM pond outfall areas. This conservatively assumes zero loss of water through evaporation, or leakage along the perimeter ditches.
- The area of closed cells (9 total) is approximately 104,400 m^2, corresponding to approximately 87,600 m^3/yr of runoff collection.

Operations Scenario B – All WWTP Discharge Directed to Perch Lake

The objective of this scenario was to evaluate the groundwater conditions for the case where no discharge is applied to the exfiltration gallery. This was represented based on the following criteria:

- The infiltration area for the exfiltration gallery was restored to average “natural” conditions (i.e., 165 mm/yr), under the assumption that all WWTP effluent is directed to Perch Lake.
- The natural/background infiltration distribution in the model was representative of the high water table condition.
- Remaining conditions are unchanged from Operations Scenario A.

4.2.2 Post-closure Conditions

Three scenarios were evaluated using the model under post-closure conditions. The “high water table” calibrated groundwater flow model was used as a starting point and subsequently modified as described below to complete the post-closure simulations.Illustrations of the scenarios are provided on Figure 4.2.

Post Closure – Final Cover Intact

- A final cover is in place above the waste in the ECM, extending to the crest of the berm surrounding the ECM. In this area zero recharge is applied in the groundwater flow model.
- Runoff that occurs from precipitation falling on the final cover is directed to the SWM ponds. Approximately 94,000 m^3/yr of runoff is divided equally and directed to the SWM ponds, based on the mean annual precipitation (839 mm/yr) and the total area of closed cells (approximately 112,000 m^2). It is assumed that during the post-closure period the pond liners will no longer be effective, and the runoff collecting in the ponds will infiltrate through the bottom of the pond.
- The infiltration areas for the water treatment plant outfall, leaching bed and SWM pond overflows were restored to average “natural” conditions (i.e., 165 mm/yr).

Post Closure – Final Cover Compromised

- The final cover is assumed to be compromised resulting in infiltration through the mound into the waste materials. The rate of infiltration was assumed to be 0.3 m/yr, which is equivalent to the mean net precipitation minus the evapotranspirational losses at the Chalk River Laboratory site, as estimated previously by others (CNL 2016b).
- The base liner is assumed to remain intact resulting in a “bathtub” effect with spillover along the low point of the base liner, located in the southern portion of the ECM. For the purposes of this scenario it was assumed that the spillover would occur in areas along the downslope side of the perimeter berm bounded laterally by the lowermost 2 m of the liner edge along the berm crest (illustrated as the grey-shaded area on Figure 4.2).
- For this scenario the surface runoff from the ECM was assumed to have a negligible impact on local groundwater conditions, and no additional water was applied beyond the natural surficial recharge.

Post Closure – Final Cover and Liner Compromised

- Both the final cover and liner are assumed to be compromised resulting in infiltration through the waste materials and into the underlying geological materials. As with the previous scenario the rate of infiltration was assumed to be 0.3 m/yr.

4.3 Results

The results of the forecast simulations are presented on Figures 4.3 through Figure 4.7 in terms of the groundwater flow paths and travel times from key areas and changes in the elevation of the simulated groundwater table. Figure 4.8 provides an illustration of the simulated groundwater table elevation for all scenarios. Figure 4.9 compares the simulated water table elevation to the top of the clay liner beneath the ECM. A review of the results in the above noted figures allows for the observations:

- For the operations period scenario A (where discharge to the WWTP exfiltration gallery occurs) groundwater particles released from the WWTP exfiltration gallery area travel towards the west, ultimately discharging via a short flow path to the East Swamp, or via a longer flow path to the East Swamp Stream. The majority of particles discharge to the East Swamp immediately downgradient from the WWTP exfiltration gallery area, whereas the remaining particles follow a deeper flow path and discharge at the East Swamp Stream after approximately three years (see Figure 4.3).
- For Operations Scenario A and B (i.e., scenarios where the SWM ponds are lined) there was localized drawdown in the simulated water table in the vicinity of the SWM Ponds. The maximum drawdown for all scenarios was approximately 1 m and was limited to the area of SWM Pond 1. The extent of the drawdown beneath the lined ponds is limited by infiltration applied at the pond spillover location (i.e., immediately downgradient of the pond locations).
- For the Post-closure Scenario with an intact final cover (i.e., the scenario where runoff is directed to the SWM ponds, and the pond liners are compromised) there were localized rises in the simulated water table in the vicinity of the SWM ponds. The maximum rise was approximately 2 m in the vicinity of the northern SWM pond (Figure 4.5). The extent of the rise in water table was limited to the area located between the northern SWM pond and the boundary of East Swamp, extending approximately 50 m northwest of the northern SWM pond (as defined by the -1 m drawdown contour). The simulated change in groundwater elevation in the area of the ponds remained below ground surface (under high water table conditions). As such, the infiltration of runoff applied in the pond areas is anticipated to have a limited impact on the surface water regime. Simulated changes to groundwater discharge at surface water features are discussed further as a part of sensitivity analysis 8 in Section 4.4.
- Collection of water (infiltration and/or runoff) over the ECM footprint resulted in a lowering of the water table for all simulations, though this was generally limited to the local footprint of the ECM and the area to the north east of the ECM (i.e., towards the groundwater flow divide). The maximum simulated reduction in groundwater elevation occurred over the central and eastern portions of the ECM, to a maximum of approximately 7 m for average water table conditions and 9 m for high water table conditions. The magnitude and distribution of water table lowering was approximately equal among the high water table condition scenarios (Operations Scenario B, and the Post-closure scenarios). For the Post-closure Scenario where the cover and liner were assumed to be compromised the recharge applied over the ECM footprint (300 mm/yr) was less than the recharge applied over the same area in the “high water table” calibrated model; this resulted in a lowering of the water table of up to approximately 8 m in the northern portion of the ECM compared to high water table conditions (see Figure 4.7).

- For the Post-closure Scenario where the final cover was assumed to be compromised the groundwater particles follow a flow path towards the south-southeast, with the majority of particles discharging to Perch Creek (a small portion of the particles released from the westernmost and easternmost spillover area locations discharged at surface to the Perch Lake Swamp). Groundwater travel times between the ECM and Perch Creek ranged from approximately 5 years to 15 years with the majority of particles arriving between approximately 7 and 10 years (Figure 4.6). Based on the position of the water table the groundwater particles began at the spillover location travelling through the till unit, then transitioned to the travelling through the upper sand units before reaching their ultimate discharge location. An example of a conservative (i.e., early-arriving) groundwater particle is illustrated on Figure 4.6 (see the path with points marked from A through D). At this location the groundwater particle reaches Perch Creek in approximately six years, and has a groundwater velocity ranging from 0.15 m/d to 0.26 m/d depending on its position in the groundwater flow path.
- Between the ECM and Perch Creek a similar groundwater particle flow path to that described above was simulated for the Post-closure Scenario where the final cover and liner were assumed to be compromised. Some particles that originated from the northwestern perimeter of the ECM travelled through a longer flow path to the west before ultimately discharging to Perch Lake. The conservative example illustrated on Figure 4.7 is based on a flow path from the southern end of the ECM to Perch Creek, where groundwater velocities ranged from 0.12 m/d to 0.25 m/d (depending on the position along the flow path). Groundwater travel times between the ECM and Perch Creek ranged from approximately 6.5 to 12 years.
- Simulated groundwater pathway flow rates from the spillover location to Perch Creek were approximately 141 m^3/d for the Post-closure Scenario with a compromised cover (as measured from the groundwater discharge location in Perch Creek). Of this, approximately 92 m^3/d originates from the ECM leachate (i.e., the spillover) and 49 m^3/d originates from upgradient sources (see Figure 4.6).
- For the Post-closure scenario with a compromised cover and liner, the simulated groundwater pathway flow rates from the ECM location to Perch Creek were approximately 137 m^3/d (as measured from the groundwater discharge location in Perch Creek). Of this, approximately 92 m^3/d originates from the ECM leachate and 45 m^3/d originates from upgradient sources (see Figure 4.7).
- As shown on Figure 4.8, minor localized changes to the directions of groundwater flow occur in the vicinity of the NSDF Project site as a result of captured and/or redirected water, while the overall (global) groundwater flow paths are the same as under current conditions (i.e., the average and high water table calibrated model).
- As shown on Figure 4.9 the simulated water table remains beneath the threshold value of 1.5 m below the primary liner elevation for all scenarios. In general, the minimum separation distance between the liner and the simulated water table occurred in the southern portion of the ECM.

4.4 Sensitivity Analysis

4.4.1 Definition of Sensitivity Simulations

The results presented above were completed using the best estimates of input parameters. Additional simulations were completed in order to examine the sensitivity of model results to some of the key controlling parameters of the hydrogeological system and assumptions made in the development of the conceptual model. The Post-closure Scenario where the final cover is assumed to have been compromised was used as a starting point for evaluation

of the sensitivity of the model to selected input parameter variation (note that it was also necessary to vary input parameters in the calibrated model in order for comparisons to be made). A total of nine sensitivity scenarios were evaluated, which addressed potential variation in the hydraulic conductivity of the bedrock and sand units, the recharge distribution, the position of the model boundary, and various aspects of the ECM design (e.g., the liner, blast zone, cover evapotranspiration, and exfiltration gallery flow). A summary of the sensitivity runs is provided below.

- **Sensitivity Run 1 (SR1)** – *Global increase in the hydraulic conductivity of the upper portion of the bedrock unit*. In this sensitivity run the horizontal and vertical hydraulic conductivity of the uppermost 6 m of the bedrock was increased throughout the model domain from $9x10^{-7}$ m/s to $1.8x10^{-6}$ m/s (i.e., doubling the value in the calibrated model).

- **Sensitivity Run 2 (SR2)** – *Local increase in the hydraulic conductivity of the upper portion of the bedrock unit*. In this sensitivity run the hydraulic conductivity of the uppermost 6 m of the bedrock was increased in all areas where the bedrock elevation was above 164 mASL. This area encompasses most of the hill to the southeast of the East Swamp where the NSDF Project site is located. As was the case for SR1, the upper 6 m of the bedrock unit were assigned horizontal and vertical hydraulic conductivities of $1.8x10^{-6}$ m/s in this area.

- **Sensitivity Run 3 (SR3)** – *Global increase in the hydraulic conductivity of the upper sand units*. In this sensitivity run the horizontal and vertical hydraulic conductivities of the upper sand, interstratified sand and silt, and middle sand units was made equivalent to the geometric mean plus one log standard deviation values (refer to Table 2.1).

- **Sensitivity Run 4 (SR4)** – *Global 30% increase in the surficial recharge*. In this sensitivity run the recharge rate applied to the uppermost surface of the model was increased uniformly by 30%. For the Post-closure Scenario the recharge over the footprint of the ECM remained as zero, and the amount of recharge applied to the spillover location was unchanged.

- **Sensitivity Run 5 (SR5)** – *Lateral extension of the model boundary.* This sensitivity run was completed to evaluate the potential influence of the no-flow boundary located to the east of the ECM in the base case model. For this simulation the active area of the model domain was expanded to include the area shown on Figure 4.10. As shown on the figure this includes the eastern portion of the hill where the ECM is located to Perch Creek. To capture the outflow of groundwater towards Perch Creek additional constant head boundaries were added within the expanded model area at elevations based on topography. Surficial recharge within the expanded area was specified according to the methods described in Section 3.3.3.2.

- **Sensitivity Run 6 (SR6)** – *Compromised Sacrificial Liner over Phase 2*. The sacrificial liner was assumed in the base case operations simulations to reduce infiltration to zero over the Phase 2 portion of the ECM. This sensitivity run was completed to evaluate the potential increase in groundwater elevations beneath the ECM should surficial infiltration occur in the area of the sacrificial liner (i.e., if the liner is compromised). This was represented in the sensitivity simulation by applying a surficial recharge of 300 mm/yr over the Phase 2 footprint (corresponding to average annual precipitation less evapotranspiration) and “high water table” recharge conditions over the remaining portions of the model.

- **Sensitivity Run 7 (SR7) –** *Blast-damaged zone hydraulic conductivity.* A zone of enhanced permeability in the bedrock beneath the ECM will be achieved through blasting of the bedrock during construction of the facility. AECOM (2019c)estimated that for the Chalk River site the increase in hydraulic conductivity within the blast damage zone would be on the order of 1,000 to 10,000 times that of the intact rock. A hydraulic conductivity of $1x10^{-4}$ m/s was applied for the base case simulations, representing an increase of approximately 2,500 times that of the intact rock (*note: the intact rock was assigned a hydraulic conductivity of $4x10^{-8}$ m/s whereas the upper 6 m of bedrock was assigned a hydraulic conductivity of $9x10^{-7}$ m/s in the calibrated model*). An additional five simulations were completed to evaluate the relative sensitivity of the model results to the blast-damage zone hydraulic conductivity value, with blast zone hydraulic conductivities ranging from $6x10^{-4}$ m/s (15,000 times that of the intact rock) to $1x10^{-6}$ m/s (25 times that of the intact rock). It should be noted that these simulations were completed without the presence of the coarse granular fill material for liquefaction mitigation.

- **Sensitivity Run 8 (SR8) –** *Evapotranspiration applied to ponds in Post-closure*. For the post-closure simulation with an intact final cover it was conservatively assumed that 100% of the mean annual precipitation (839 mm/yr) would be collected and infiltrated at the SWM ponds during the post-closure period. A more realistic approach would be to consider evapotranspiration (ET) losses from the vegetated cover system. This sensitivity simulation was completed using the post-closure model to evaluate the groundwater conditions when ET is considered in the calculation of the SWM pond infiltration rate. This was represented in the model by assuming 50% of the mean annual precipitation from the ECM footprint (47,000 m^3/yr) would contribute to runoff and occur as infiltration to the SWM pond outfall locations, distributed equally.

- **Sensitivity Run 9 (SR9) –** *Increase in recharge applied at Exfiltration Gallery.* Discharge of treated effluent from the WWTP will be routed to both the exfiltration gallery and Perch Lake such that groundwater elevations in the vicinity of the exfiltration gallery will remain below ground surface (i.e., no overland flow will occur as the result of this discharge). In order to address the uncertainty in the relative portion of discharge to the exfiltration gallery and Perch Lake this sensitivity simulation was completed using five alternative discharge rates applied to the exfiltration gallery ranging from 10 m^3/d to 75 m^3/d. All simulations were completed using the high water table configuration of the model.

- **Sensitivity Run 10 (SR10) –** *Groundwater Discharge Location.* Consideration was given to the uncertainty associated with the discharge location of seepage from the ECM area. Potential future changes to the location of the groundwater discharge zone at Perch Creek over the assessment timeframe are unknown. This scenario evaluates the hypothetical case where the discharge location occurs at the current edge of Perch Lake Swamp (in the vicinity of the toe of the ECM, approximately 340 m closer to the ECM as compared to the current location of the creek).

4.4.2 Results of Sensitivity Simulations

The sensitivity simulations that evaluated model sensitivity to baseline input parameters (i.e., SR1 through SR5) resulted in slight changes to the goodness of fit to model calibration data, though in all cases the results were reasonable. For SR5, the groundwater flow divide (which is assumed to follow the topographic divide along the hill where the ECM is located) was reproduced in the model (see Figure 4.10). Results of the sensitivity simulations are illustrated on Figures 4.11 through Figure 4.19. A summary of these results is provided below.

- In general, the overall groundwater flow paths from the ECM to Perch Creek estimated using the sensitivity simulations are similar to the results of the calibrated model (shown on Figure 4.6).
- For SR1 and SR2 (increase in the bedrock hydraulic conductivity) the lateral extent of the lowering of the water table beneath the ECM was slightly decreased over the base case simulation, and generally remained within the footprint of the facility. For SR1 and SR2 the maximum lowering of the water table occurred towards the northeast portion of the ECM, in a similar manner to the base case. For SR1 and SR2 the water table position was lower compared to the base case, and therefore remained below the threshold separation of 1.5 m below the primary liner.
- For SR3 (increase in the sand hydraulic conductivity), the extent and magnitude of water table lowering was similar to the base case, as was the position of the water table relative to top of the clay liner. Based on the groundwater particle tracking the travel time between the ECM and Perch Creek was reduced compared to the base case. This reduction was estimated to be on the order of one year (approximately 14%).
- For SR4 (increase in recharge) the extent and magnitude of water table lowering is similar to the base case, as was the position of the water table relative to the top elevation of the clay liner. .
- For SR5, the extent of lowering of the water table was similar to the Base Case scenario, with a localized portion of the drawdown extending beyond the original model boundary. This indicates that the no-flow boundary condition at the northeastern edge of the model has a limited effect on the results of the simulation.
- The rate of upgradient groundwater flow through the pathway from the ECM to Perch Creek varied between the simulations. For all sensitivity runs, the upgradient groundwater flow was similar to the base case (i.e., 42 m^3/d for SR1, 41 m^3/d SR2, 51 m^3/d for SR3, 57 m^3/d for SR4, 39 m^3/d for SR5, compared to 49 m^3/d for the base case).
- For SR6 groundwater elevations below the ECM are increased relative to the Operations A Scenario. However, a separation of greater than 1.5 m between the primary liner and the water table was maintained. The travel time and particle tracks from the exfiltration gallery to the East Swamp and East Swamp stream were similar to Operations Scenario A. For each of the five scenarios evaluated as a part of SR7 the simulated groundwater elevation was compared to the elevation of the primary liner within the footprint of the ECM. The simulated water table elevation remained within the design criteria (i.e., greater than 1.5 m separation was maintained between the primary liner and the water table) for Scenarios 1 and 2 of SR7. For Scenarios 3 and 4, where the blast-influenced rock was assigned a hydraulic conductivity of 250 and 200 times that of competent rock, the simulated water table was within 1.5 m of the primary liner elevation over a localized area on the eastern margin of the ECM and was more than 2 m below the primary liner elevation over the remaining portion of the ECM. For Scenario 5, where the blast-influenced rock was assigned a hydraulic conductivity of 25 times that of the competent rock, the simulated water table was within 1.5 m of the primary

liner elevation over the northeastern portion of the ECM. Interpretation of the groundwater model results indicates that a 1.5 m separation between the primary liner and the water table is expected to be maintained under post-closure conditions provided a bedrock hydraulic conductivity of $5x10^{-5}$ m/s or more is achieved through blasting within a 3 m thick zone beneath the ECM subgrade (this represents an increase of 1,250 times the intact bedrock hydraulic conductivity as applied in the model).

- For SR8, the assumption that 50% of the mean annual precipitation is available for runoff resulted in localized increases in groundwater elevation on the order of up to 2 m (e.g., beneath Pond 1) compared to the current conditions (calibrated) model. This water table response is of a similar magnitude although reduced spatial extent as compared to the base case post closure simulation (See Figure 4.5). For SR8, the extent of groundwater mounding (as defined by a 1 m rise in groundwater elevation) was limited to the area directly beneath the pond. The assumption regarding ET translates to changes in the simulated groundwater discharge/recharge to model boundaries. For the post-closure scenario (without ET effects) the additional runoff collection resulted in an overall increase in groundwater discharge in the lower Perch Lake Basin of 149 m^3/d compared to the calibrated (high water table) groundwater model. Much of this was from changes in calculated groundwater discharge/recharge at East Swamp and Perch Lake Swamp. Following the inclusion of evapotranspiration in the runoff collection volumes an overall decrease in groundwater discharge of 52 m^3/d was calculated for the lower Perch Lake Basin, At East Swamp the addition of ET resulted in a reduction to groundwater discharge of approximately 32% upstream of the weir and an increase in infiltration of 31% downstream of the weir. Compared to the high water table (calibrated) model the Post Closure simulation with ET resulted in an overall decrease in groundwater discharge to model boundaries of approximately 52 m^3/d. When ET was not considered an increase in overall discharge of 149 m^3/d was calculated.
- For SR 9 groundwater elevations below the ECM are unchanged from the Operations A Scenario. The travel times and particle tracks from the exfiltration gallery to the East Swamp and East Swamp Stream are similar to Operations Scenario A. At higher rates of flow (over 60 m^3/d) a small portion of particle pathlines trend towards the north-east boundary of the model. This path results from localized mounding of the water table at the exfiltration gallery (while still below ground surface). This pathway is characterized by particles migrating vertically downwards, and travelling through the bedrock towards the north-eastern boundary over long travel times (approximately 25 years). It should be noted that this sensitivity scenario was evaluated using the high water table configuration of the model, which is applicable to a relatively short period (approximately 1 month) of seasonal variability in the water table.
- For SR10 an explicit groundwater simulation was not completed. Rather this scenario was evaluated qualitatively based on the results of the post-closure simulation with a compromised liner. For the case where groundwater discharge occurs in the vicinity of the northern edge of Perch Lake Swamp, the travel time through the groundwater flow pathway is estimated to be approximately 2 years (represented by pathway A-B on Figure 4.6).

The response of the model to variability in some of its key input parameters has been evaluated through a sensitivity analysis and used as an analogue for model uncertainty. Model uncertainty could be reduced through collection of additional data. In particular, long-term records of groundwater elevation in the NSDF area would help to refine the model calibration dataset, and therefore improve model calibration.

5.0 SUMMARY

Canadian Nuclear Laboratories (CNL) is proposing to construct the NSDF Project for the disposal of radioactive waste at the CRL site. The NSDF Project is designed as an engineered containment mound (ECM), built at a near-surface level on the CRL site. The facility is expected to be operational for approximately 50 years and will be expandable to receive up to 1,000,000 cubic metres (m^3) of low-level radioactive waste. The current assessment is based on the "100% project design", which involves excavation and regrading of the overburden and bedrock in the NSDF Project site and replacement of overburden with coarse granular fill material where necessary for liquefaction mitigation. An enhanced permeability zone in the bedrock beneath the ECM will be established through blasting to promote drainage and lower groundwater elevations beneath the facility. The design incorporates placement of a double liner and leachate collection system beneath the ECM, and a final cover (installed at closure).

As a part of the work being completed to support the EIS for the NSDF Project, a conceptual model was developed for the study area that identified the key hydrostratigraphic units controlling groundwater flow, the hydraulic properties of these units, and the directions and rates of groundwater flow. The general findings from this assessment indicated that groundwater flow primarily occurs through the sandy overburden units (the Upper Sand, Middle Sand, and Basal Sand/Till), whereas the bedrock is considered to be of low transmissivity. Groundwater flow patterns generally follow topography, with recharge occurring in the upland areas and with the ultimate discharge location at Perch Lake or Perch Creek. Groundwater recharge and discharge occurs locally in streams within the lower Perch Lake basin.

Hydrogeological modelling was completed to estimate the groundwater flow pathways from the ECM, and the rates of groundwater flow from the NSDF Project site to downstream receptors. This was accomplished by constructing a groundwater flow model based on the conceptual model and calibrating it to the existing conditions. Calibration involved an iterative process where steady-state model runs were completed with adjustments to the model input parameters (within acceptable ranges) until model results provided an acceptable match to observed conditions (groundwater elevations, groundwater flow directions, baseflow estimates, and advective flow paths from the Reactor Pit 2 source area). It should be noted the model calibration dataset included groundwater elevations collected via transducer from October 2016 through June 2018 in the area of the ECM. Both average water table conditions and high water table conditions (based on the period of record noted above) were considered as a part of the model calibration. After an acceptable model calibration was achieved, the calibrated model was then modified to represent the NSDF Project site under operations and post-closure conditions and steady-state simulations were completed to evaluate the changes in groundwater flow patterns and water table elevations from the NSDF Project site. Three operations phase scenarios and three post-closure phase scenarios were evaluated with the model. The main findings from the forecast simulations are presented below:

- For Operations Scenario A (when the WWTP exfiltration gallery is operational) groundwater particles released from the WWTP exfiltration gallery area travel towards the west, ultimately discharging at the East Swamp. The majority of groundwater particles arrive at East Swamp within a year of travel time.
- For the simulations where runoff is directed to the SWM ponds, localized mounding of the water table on the order of 1 m occurred in the area of the ponds. The extent of the rise in the water table was limited to the area directly beneath the SWM ponds. Simulated groundwater elevations in this area remained below ground surface under high water table conditions. As such, the infiltration and runoff applied to the pond areas is anticipated to have a negligible impact on the surface water regime.

- Collection of water (infiltration and/or runoff) over the ECM footprint resulted in a lowering of the water table for all simulations, though this was generally limited to the footprint of the ECM and the area northeast of the ECM towards the groundwater flow divide. The maximum simulated reduction in groundwater elevation occurred over the central and eastern portions of the ECM, to a maximum of approximately 7 m for average water table conditions and 9 m for high water table conditions.
- For the Post-closure Scenario where the final cover was assumed to be compromised the groundwater particles follow a flow path from the ECM towards the south-southeast, with discharge occurring to Perch Creek. For the majority of particles groundwater travel times between the spillover location and Perch Creek ranged from approximately 7 years to 10 years, with travel initially through the till and transitioning into the upper sand units (the overall range in travel times was approximately 5 to 15 years). For this simulation the groundwater pathway flow rates from the spillover location to Perch Creek were approximately 141 m^3/d for the Post-closure Scenario with a compromised cover. Of this, approximately 92 m^3/d originates from the ECM leachate (i.e., the spillover) and 49 m^3/d originates from upgradient sources based on the groundwater discharge occurring to Perch Creek within particle the flow path. It should be noted that this simulation was based on the “high water table” condition, and travel times noted above would be longer for the average water table condition.
- For the Post-closure Scenario where the final cover and liner were assumed to be compromised the groundwater particles follow a similar flow path to that described above. Groundwater travel times between the spillover location and Perch Creek ranged from approximately 6.5 years to 12 years for the majority of groundwater particles. For this simulation the groundwater pathway flow rates from the base of the ECM to Perch Creek were approximately 137 m^3/d for the Post-closure Scenario with a compromised cover. Of this, approximately 92 m^3/d originates from the ECM leachate and 45 m^3/d originates from upgradient sources.
- Minor localized changes to the directions of groundwater flow occur in the vicinity of the NSDF Project site as a result of captured and/or redirected water, while the overall (global) groundwater flow paths are the same as under current conditions.
- The simulated water table remains beneath the threshold value of 1.5 m below the primary liner for all Scenarios. The separation between the top of the clay liner and the water table generally ranged from 2 m to 9 m. In general, the least separation occurred in the southern portion of the ECM.

The results summarized above reflect the groundwater conditions forecast using best estimates of the key controlling input parameters. Additional simulations were completed in order to examine the sensitivity of model results to some of those parameters. The findings from these sensitivity simulations are summarized below:

- **SR1 – Global Increase in the Bedrock Hydraulic Conductivity**. For this simulation the hydraulic conductivity of the upper 6 m of bedrock was increased by a factor of 2. Results showed that the lateral extent of the lowering of the water table beneath the ECM was slightly decreased over the base case simulation, and generally remained within the footprint of the ECM. The simulated water table position was lower for SR1 compared to the base case, and therefore remained below the threshold separation of 1.5 m below the top of the clay liner.

- **SR2 – Global Increase in the Bedrock Hydraulic Conductivity**. For this simulation the hydraulic conductivity of the upper 6 m of bedrock was increased by a factor of 2 compared to the base case simulation where bedrock was above elevation 164 mASL. Results of this simulation were similar to SR1.
- **SR3 – Increase in the Sand Hydraulic Conductivity**. For this simulation the main sand units (Upper Sand, Interstratified Sand and Silt, and Middle Sand) were assigned hydraulic conductivity values at the geometric mean plus one log standard deviation (based on the available measured values). The extent and magnitude of water table lowering is similar for this simulation as compared to the base case. Based on the groundwater particle tracking the travel time between the ECM and Perch Creek was reduced compared to the base case and was estimated to be on the order of one year (approximately 14%).
- **SR4 – Global 30% Increase in Recharge**. The extent and magnitude of water table lowering for the case where recharge was globally increased by 30% was similar to the base case.
- **SR5 – Lateral Extension of Model Boundary**. For this simulation the model boundary was extended laterally to the east to evaluate the influence of the no-flow boundary near the ECM. Results of this simulation indicate that the extent of lowering of the water table was similar to the Base Case scenario, and therefore that the no-flow boundary condition at the northeastern edge of the model has a limited effect on the model results.
- **SR6 – Compromised Sacrificial Liner over Phase 2**. This sensitivity run was completed to evaluate the potential increase in groundwater elevations beneath the ECM should surficial infiltration occur in the area of the sacrificial liner (i.e. should the liner become compromised). Results of this simulation show that though groundwater elevations increased beneath the ECM a separation of greater than 1.5 m between the primary liner and the water table was maintained and groundwater travel times from the exfiltration gallery to the East Swamp were unchanged.
- **SR7 – Hydraulic Conductivity of the Blast-Damaged Zone.** This sensitivity run was completed to evaluate the model sensitivity of the hydraulic conductivity of the blast-damaged zone. Results of the simulation indicate that the water table remained within the design criteria (i.e., at least 1.5 m separation from the primary liner) throughout the footprint of the ECM when the blast-induced hydraulic conductivity was at least 2,500 times that of the intact rock For blast-zone hydraulic conductivity values ranging from 1,250 to 250 times that of the intact rock the design criteria was met throughout the ECM footprint with the exception of a localized area on the southeastern margin. At 25 times that of the competent rock, the simulated water table was within 1.5 m of the primary liner elevation over the northeastern portion of the ECM.
- **SR8 – Evapotranspiration Applied to Pond Infiltration.** This sensitivity run was completed to evaluate the model sensitivity to the recharge rate applied to SWM pond liners during the post-closure period. The assumption regarding ET translates to changes in the simulated groundwater discharge/recharge to model boundaries. For the post-closure scenario (without ET effects) the additional runoff collection resulted in an overall increase in groundwater discharge in the lower Perch Lake Basin of 149 m^3/d compared to the calibrated (high water table) groundwater model. Much of this was from changes in calculated groundwater discharge/recharge at East Swamp and Perch Lake Swamp. Following the inclusion of evapotranspiration in the runoff collection volumes an overall decrease in groundwater discharge of 52 m^3/d was calculated for the lower Perch Lake Basin. At East Swamp the addition of ET resulted in a reduction to groundwater discharge of approximately 32% upstream of the weir and an increase in infiltration of 31% downstream of the weir.

- **SR9 –** *Increase in recharge applied at Exfiltration Gallery.* For this simulation the recharge applied to the exfiltration gallery was varied to address the uncertainty in the relative portion of discharge to the exfiltration gallery and Perch Lake. This scenario was evaluated using high water table conditions. Results of the simulations indicated that groundwater pathways and travel times are similar to Operations Scenario A. It was noted that at higher exfiltration gallery flow rates (greater than 60 m^3/d) a small portion of groundwater particles the resulting particle tracks were directed to the northern model boundary due to localized groundwater mounding beneath the exfiltration gallery.
- **SR10 -** This scenario was evaluated qualitatively based on the results of the post-closure simulation with a compromised liner to quantify the changes to groundwater travel times for an alternative groundwater discharge location. For the case where groundwater discharge occurs in the vicinity of the northern edge of Perch Lake Swamp, the travel time through the groundwater flow pathway is estimated to be approximately 2 years.
- For the post-closure period simulations with a compromised cover over the ECM (SR1 through SR5)the rate of upgradient groundwater flow through the pathway from the ECM to Perch Creek was similar for all simulations, ranging from 39 m^3/d to 57 m^3/d (compared to a base case value of 49 m^3/d).
- In general, the overall groundwater flow paths from the ECM to Perch Creek estimated using the sensitivity simulations are similar to the results of the calibrated model (i.e., current conditions at the site).

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7.0 LIMITATIONS

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Hydrogeologic investigations and groundwater modelling are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that groundwater systems are complex, and invariably limited data are available for the purposes of hydrogeological evaluation. A groundwater model uses the laws of science and mathematics to draw together the available data into a mathematical or computer-based representation of the essential features of an existing hydrogeologic system. While the model itself obviously lacks the detailed reality of the existing hydrogeologic system, the behaviour of a valid groundwater model reasonably approximates that of the real system. The validity and accuracy of the model depends on the amount of data available relative to the degree of complexity of the geologic formations and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of a reality and the model described herein is not an exception.

The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and geoscience professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates Ltd. should be requested to re-evaluate the findings of this report, and to provide amendments as required.

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CNL NEAR SURFACE DISPOSAL FACILITY
GROUNDWATER FLOW MODELLING
REVISION 2

Report Signature Page

GOLDER ASSOCIATES LTD.

Nicholas Bishop, M.Sc., P.Eng.
Geological Engineer

Scott Donald, M.A.Sc., P.Eng.
Principal

NB/SD/nb/wlm/ng

https://golderassociates.sharepoint.com/sites/10467g/4350 gw modelling/11. gw report 2019 update/5. final report/gal058-1547525 nsdf gw modelling report rev2.docx

TABLES

Measured Values									
Material	Geometric Mean Hydraulic Conductivity (m/s)		Kh:Kv	Min. Kh (m/s)	Max. Kh (m/s)	GM+1LSD Hydraulic Conductivity (m/s)			Total Porosity
	Horizontal	Vertical				Horizontal	Vertical	Kh:Kv	
Historical Testing throughout the CRL Property (CNL, 2016b)									
Upper Sand	4.8E-05	1.4E-05	3.4	-	-	1.4E-04	3.8E-05	3.7	0.38
Interstratified Sand and Silt	1.8E-05	3.6E-08	500	-	-	8.6E-05	7.5E-07	115	0.39
Middle Sand	7.8E-05	8.7E-06	9.0	-	-	1.6E-04	2.1E-05	7.6	0.38
Clayey Silt	1.3E-07	5.5E-09	24	-	-	4.3E-07	6.5E-08	7	0.48
Basal Sands	1.0E-04	1.1E-04	0.9	-	-	1.7E-04	1.4E-04	1.2	0.38
Till	1.5E-06	-	-	-	-	5.8E-06	-	-	0.26
Bedrock (upper 50 m)	5.2E-08	-	-	2.0E-11	7.8E-04	3.0E-06	-	-	0.0002 to 0.005
Recent Testing in the NSDF Area (AMEC, 2016, 2017, 2018)									
Till	1.6E-06	-	-	5.7E-07	1.6E-05	4.3E-06	-	-	-
Bedrock	1.4E-07	-	-	2.3E-09	1.5E-05	1.3E-06	-	-	

Calibrated Model Values

Material	Hydraulic Conductivity (m/s)			Porosity	
	Horizontal	Vertical	Kh:Kv	Total	Effective
Upper Sand	3.0E-5 to 1.7e-04	1.0E-5 to 5.0E-5	3 - 3.4	0.38	0.3
Interstratified Sand and Silt	6.0E-05	6.0E-07	100	0.39	0.3
Middle Sand	1.0E-04	2.0E-05	5.0	0.38	0.3
Clayey Silt	9.5E-07	5.5E-09	173	0.48	0.3
Basal Sands	1.2E-04	1.0E-04	1.2	0.38	0.3
Till	9.0E-07	7.0E-07	1.3	0.26	0.2
Upper Bedrock	9.0E-07	9.0E-07	1	0.001	0.001
Bedrock	4.0E-08	4.0E-08	1	0.001	0.001

Table 2.2 - Summary of NSDF-Area Groundwater Elevation Data

Well	Transducer Data Start Date	Ground Surface Elevation (mASL)	Unit Screened	Groundwater Elevation (mASL)				Model Results			
				Average	Minimum	Maximum	Maximum	Average Conditions (mASL)	Difference (m)	High Water Table Value (mASL)	Difference (m)
BH-15-6	25-Oct-2016	174.63	Overburden/Shallow Rock	173.58	170.12	174.42	174.42	173.66	0.07	173.94	-0.48
BH-15-7	26-Oct-2016	173.93	Overburden	171.01	170.23	172.85	172.85	171.11	0.11	171.69	-1.17
BH-15-8	26-Oct-2016	173.95	Overburden	166.80	165.30	167.92	167.92	166.60	-0.21	166.89	-1.03
BH2-2S	14-Oct-2016	163.76	Shallow rock	162.31	161.61	162.97	162.97	162.22	-0.09	162.35	-0.62
BH2-2D	14-Oct-2016	163.8	Deep Rock	162.22	161.11	162.99	162.99	162.22	0.00	162.35	-0.63
BH2-3	14-Oct-2016	157.29	Shallow Rock	156.81	156.39	157.14	157.14	157.18	0.37	157.46	0.32
BH2-6	18-Oct-2016	191.66	Deep Rock	185.20	182.58	186.73	186.73	185.01	-0.18	187.94	1.21
BH2-7	18-Oct-2016	191.26	Shallow Rock	186.06	183.86	189.16	189.16	185.37	-0.68	188.72	-0.44
SH-4	14-Oct-2016	156.4	Overburden / Top of Rock	156.34	156.07	156.53	156.53	156.58	0.23	156.93	0.39
SH-5	19-Oct-2016	160.96	Overburden	158.10	157.46	159.35	159.35	158.58	0.47	158.60	-0.75
SH-6	19-Oct-2016	174.67	Overburden	169.11	168.51	169.93	169.93	168.46	-0.64	168.76	-1.17
W1A	09-Dec-2016	188.86	Shallow Rock	184.01	179.06	185.66	185.66	182.83	-1.17	185.24	-0.42
W1B	09-Dec-2016	188.28	Deep Rock	184.01	174.21	185.65	185.65	183.74	-0.27	185.61	-0.04
W2-D	30-Nov-2016	188.6	Shallow Rock	177.55	168.83	178.87	178.87	178.28	0.73	180.54	1.68
W2-S	30-Nov-2016	188.6	Overburden	178.50	177.11	180.06	180.06	178.27	-0.23	180.53	0.48
W3	30-Nov-2016	171.99	Overburden	169.64	169.17	170.44	170.44	170.48	0.85	170.64	0.20
W4	07-Dec-2016	171.51	Shallow Rock	171.00	168.50	171.77	171.77	171.13	0.13	171.46	-0.32
W5	06-Dec-2016	165.06	Shallow Rock	162.36	160.63	164.23	164.23	164.45	2.09	164.80	0.57
W6	30-Nov-2016	184.78	Overburden	175.96	174.17	177.65	177.65	177.39	1.43	179.70	2.05
W7	09-Dec-2016	180.56	Shallow Rock	176.45	174.98	178.74	178.74	177.83	1.39	179.73	0.99
W8	09-Dec-2016	193.16	Deep Rock	186.98	180.36	190.67	190.67	186.66	-0.32	189.81	-0.86
PLS-16	25-Nov-2016	157.7	Overburden (East Swamp)	157.55	153.34	157.94	157.94	157.52	-0.02	157.64	-0.30
PLS-17	25-Nov-2016	159.01	Overburden (East Swamp)	158.32	156.71	158.96	158.96	158.45	0.13	158.47	-0.49
PH17-001	22-Dec-2017	185.94	Overburden	169.95	169.68	170.47	170.47	172.29	2.34	173.32	2.85
PH17-002	22-Dec-2017	181.74	Overburden	168.21	167.92	168.69	168.69	167.11	-1.10	167.34	-1.35
PH17-003	22-Dec-2017	169.99	Overburden	168.86	168.43	169.68	169.68	168.67	-0.19	168.81	-0.87
PH17-004	22-Dec-2017	179.2	Overburden	169.42	169.11	169.83	169.83	170.03	0.62	170.50	0.67
PH17-005	15-Dec-2017	193.77	Shallow rock	182.50	181.92	183.58	183.58	183.87	1.36	187.09	3.51
PH17-006	12-Dec-2017	190.56	Deep Rock	187.68	186.85	189.39	189.39	186.16	-1.52	188.62	-0.77
PH17-007	12-Dec-2017	189.31	Deep Rock	186.14	185.64	186.96	186.96	185.82	-0.32	187.50	0.55
PH17-008	08-Dec-2017	195.39	Deep Rock	188.96	187.91	191.01	191.01	189.20	0.24	191.72	0.71
PH17-009	06-Dec-2017	191.27	Deep Rock	190.41	190.27	190.60	190.60	188.38	-2.03	190.84	0.24
PH17-010	22-Dec-2017	171.32	Overburden	168.16	167.85	169.03	169.03	167.90	-0.26	168.07	-0.96

All transducer data continues through to 5-Jun-2018

"shallow" = < 6 m below top of rock

Table 3.1
Summary of Model Assumptions

Numerical Model (MODFLOW)

- Flow is laminar and steady, and is governed by Darcy's Law.
- Groundwater flow is represented by an equivalent porous media.
- Hydraulic heads are vertically averaged within a given model layer.
- Groundwater travel times are simulated using advective particle tracks, which does not account for dispersive or diffusive processes.

Conceptual Model

- The geometric mean plus one log standard deviation of the measured hydraulic conductivities were used as a starting point for model parameterization
- The conceptual model was based upon geologic data compiled by CNL, and provided to Golder. This includes data received up to June 2018.
- The lower bedrock unit is represented by a low hydraulic conductivity value, and groundwater flow is dominated by the overburden and upper bedrock units.

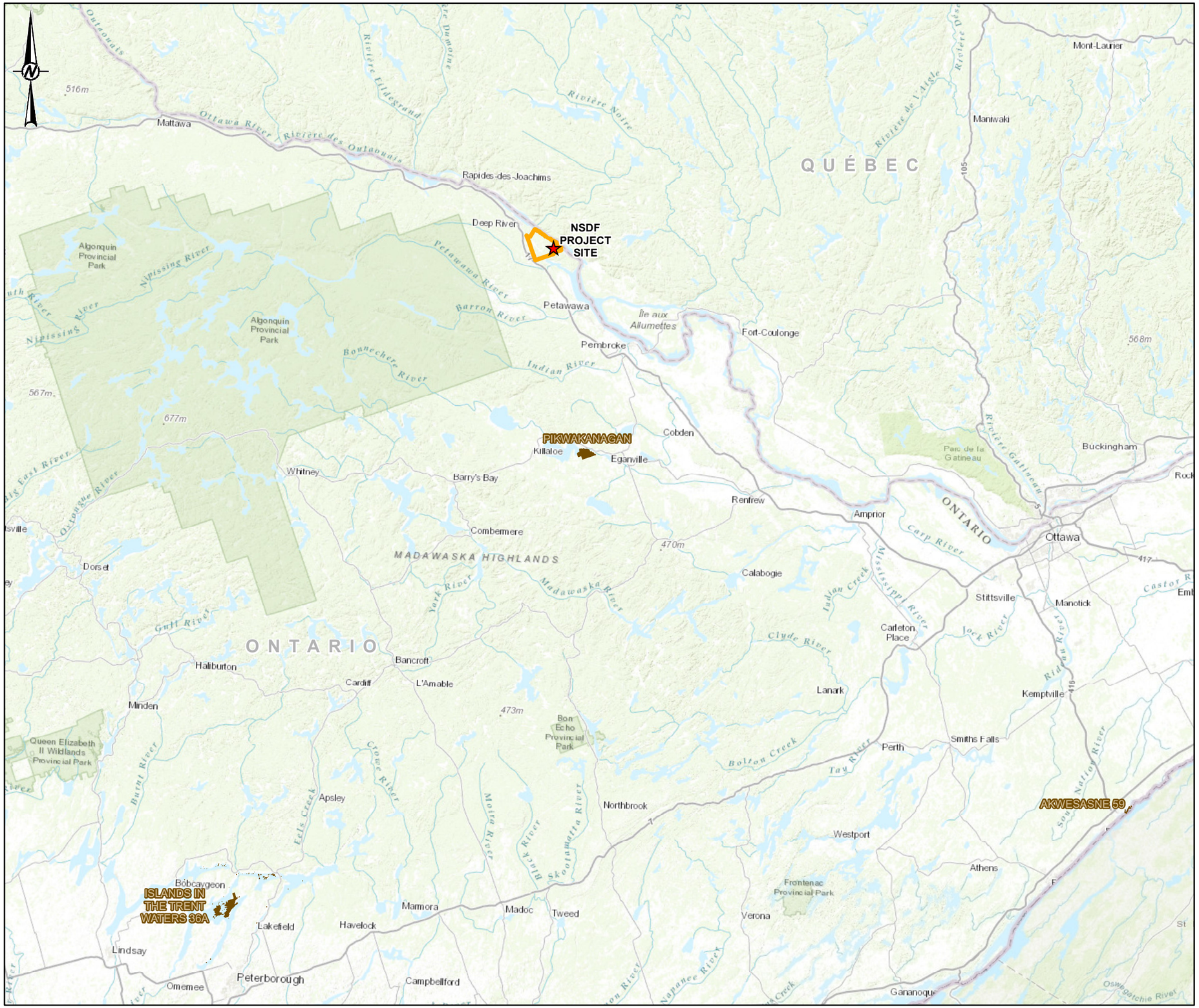
Calibration

- Average and maximum groundwater elevations were used in the calibration process (where available). These are assumed to be representative of typical conditions. For NSDF-area wells the data were based on average readings from transducer measurements up to June 2018. Record lengths varied for each individual transducer.
- Recharge estimates reflect deeper recharge and discharge characteristics of the groundwater flow system, and do not account for shallow infiltration and intermittent discharge (i.e. interflow).
- A "regionalized" approach to model calibration was employed, such that parameter values were established for the hydrostratigraphic units on a regional scale, with the exception of the Upper Sand, which was represented using three unique hydraulic conductivity zones.

Forecast Simulations

- No evapostranspirational or leakage losses are considered when applying redirected runoff from closed cells of the NSDF
- 0.3 m/yr infiltration occurs through the compromised engineered cover as a part of the "failed cover" and "failed cover and liner" scenarios
- The base liner and intact cover are 100% impermeable for all other scenarios
- Flow rates at the WWTP exfiltration gallery are assumed to occur over 4 months of the year.

FIGURES



LEGEND

- NSDF PROJECT SITE
- CRL PROPERTY
- FIRST NATION RESERVE

25 0 25

1:1,000,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. HIGHWAYS AND FIRST NATION RESERVES MNRF 2016
2 PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
REGIONAL OVERVIEW

CONSULTANT
Golder Associates

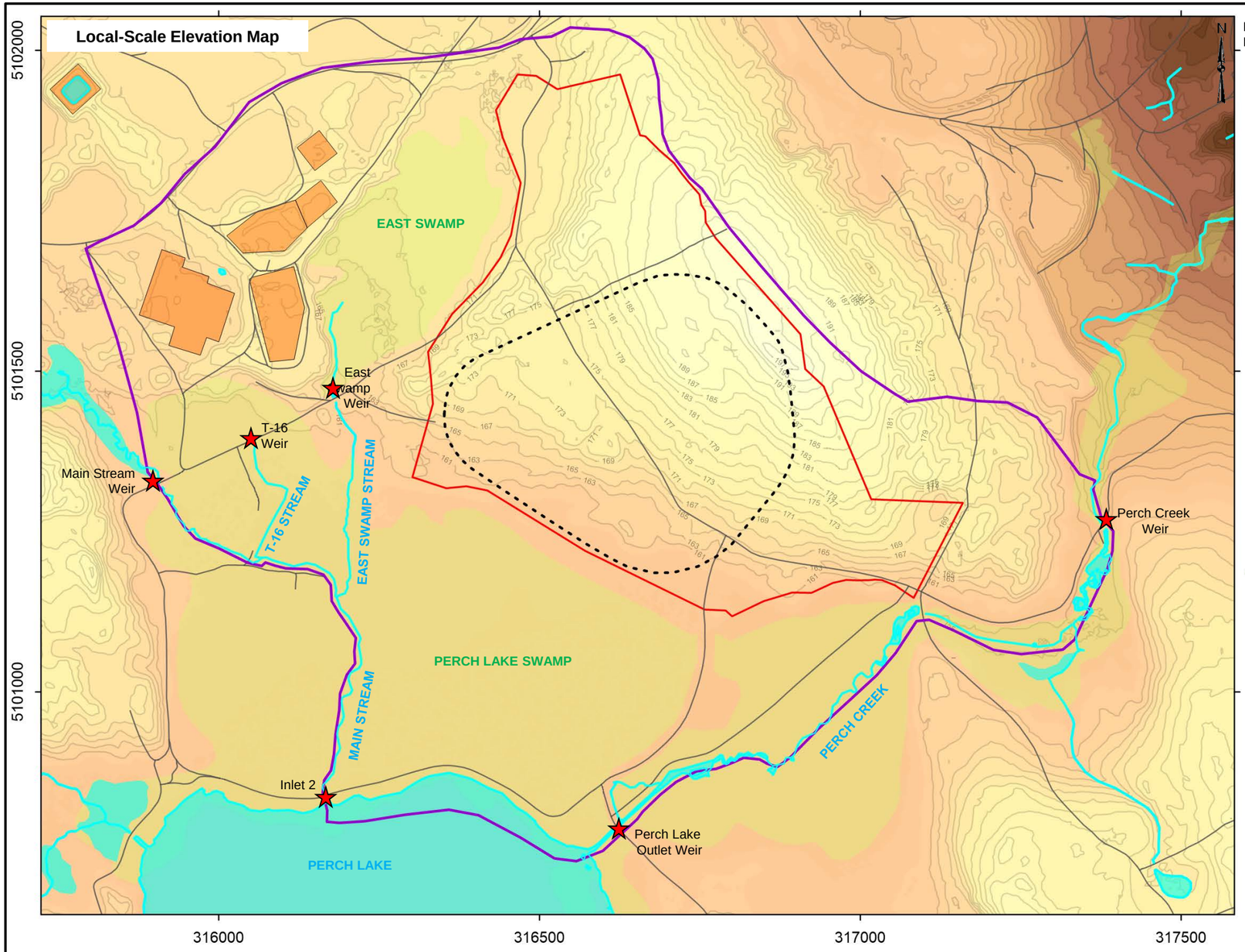
YYYY-MM-DD	JULY 2019
DESIGNED	SO
PREPARED	SO
REVIEWED	MM
APPROVED	AB

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0001	2	**1.1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

S:\Clients\Canadian_Nuclear_Laboratories\NSDF\99_PROJ\1547525_NSDF_EIS\40_PROD\0001_EIS_Section_11\1547525-0001-G-0003.mxd

Local-Scale Elevation Map



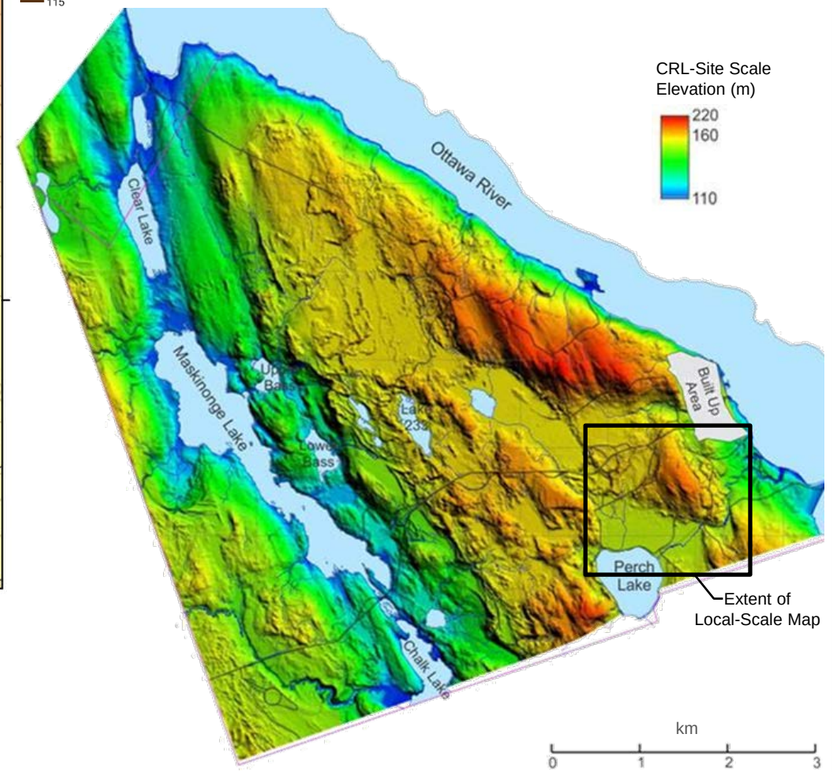
Local-Scale Elevation (mASL)

199
195
191
187
183
179
175
171
167
163
159
155
151
147
143
139
135
131
127
123
119
115

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Wetland
- Waste Management Area
- Weir Location

CRL-Site Scale Elevation Map



CRL-Site Scale Elevation (m)

220
160
110

km

0 1 2 3

CLIENT
CANADIAN NUCLEAR LABORATORIES LTD.

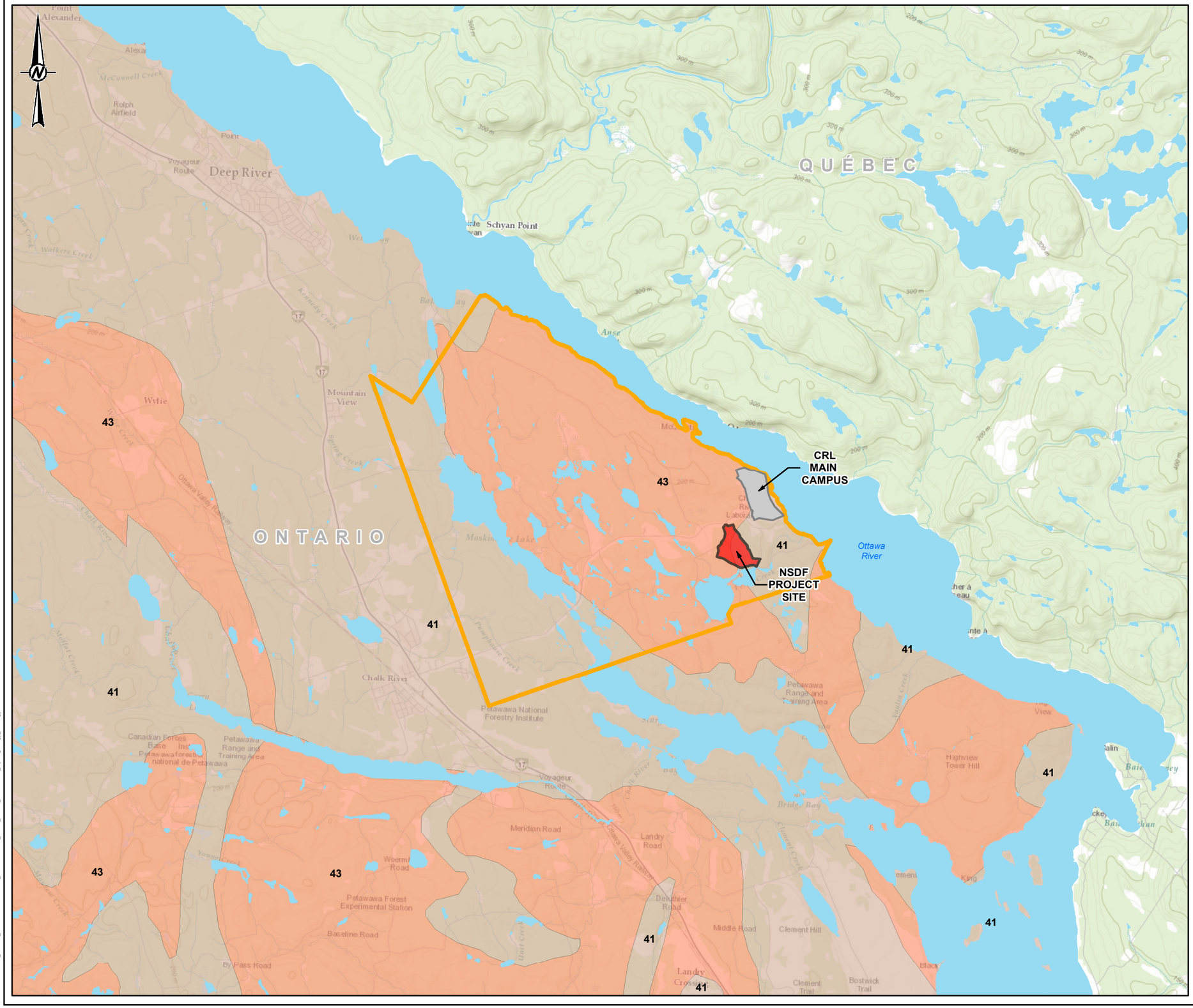
PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

CONSULTANT
Golder Associates

YYYY-MM-DD	2019-07-18
PREPARED	MIB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
TOPOGRAPHY AND DRAINAGE

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	2.1



LEGEND

- NSDF PROJECT SITE
- CRL MAIN CAMPUS
- CRL PROPERTY

BEDROCK GEOLOGY

- 43 FELSIC IGNEOUS ROCKS
- 41 MIGMATITIC ROCKS AND GNEISSES OF UNCERTAIN PROTOLITH

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. BEDROCK GEOLOGY OF ONTARIO OBTAINED FROM ONTARIO GEOLOGICAL SURVEY (OGS) AND MINISTRY OF NORTHERN DEVELOPMENT MINES(MNDM), JUNE 2010
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

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PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
BEDROCK GEOLOGY

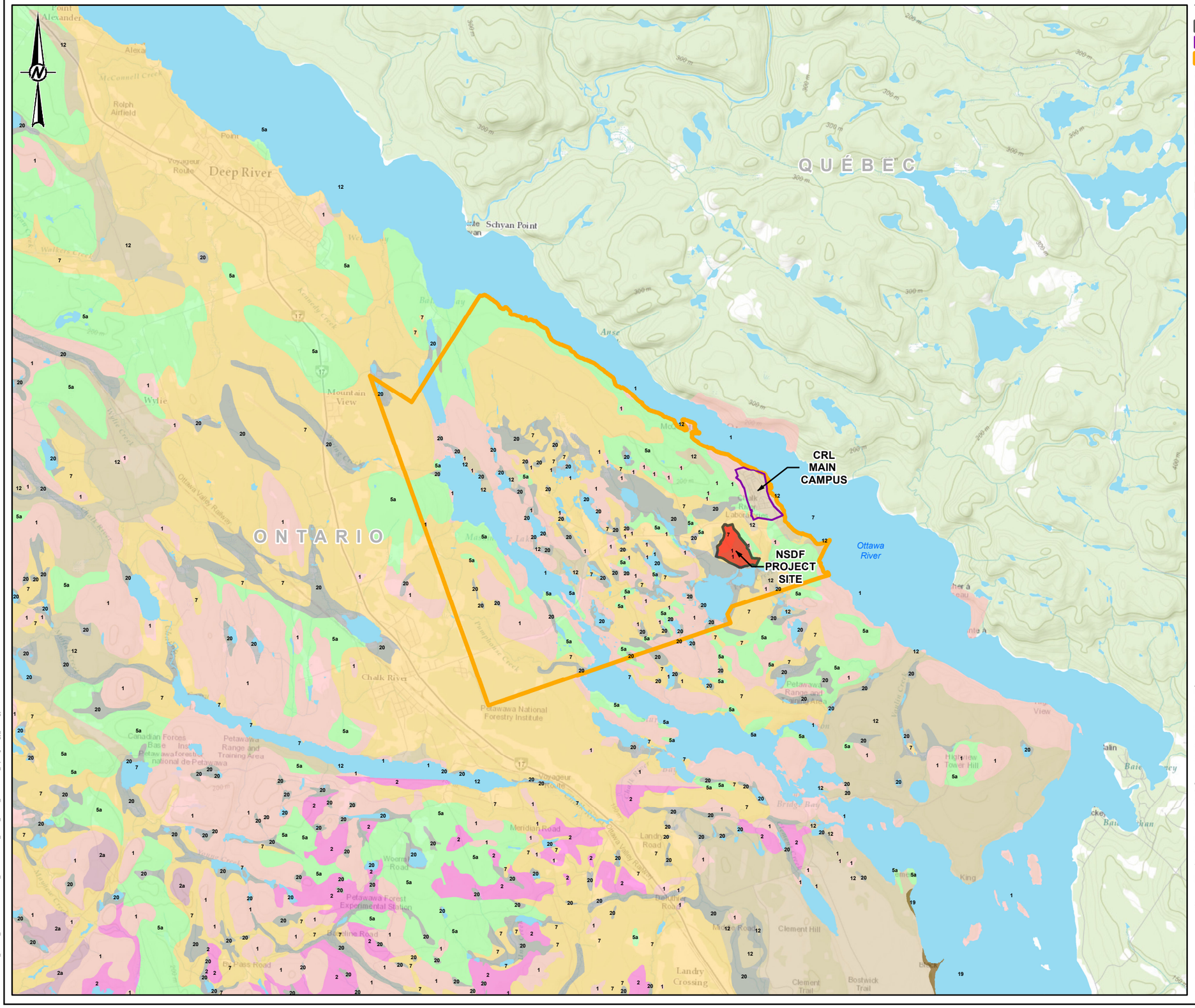
CONSULTANT
Golder Associates

YYYY-MM-DD	JULY 2019
DESIGNED	SO
PREPARED	SO
REVIEWED	MB
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0001	2	**2.2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0

S:\Clients\Canadian_Nuclear_Laboratories\NSDF\99_PROJ\1547525_NSDF_EIS\40_PROD\0008_Hydrogeology_Geology\1547525-0008-CH-0001.mxd



LEGEND

- NSDF PROJECT SITE
- CRL MAIN CAMPUS
- CRL PROPERTY

SURFICIAL GEOLOGY

- 1: PRECAMBRIAN BEDROCK
- 2: PRECAMBRIAN BEDROCK-DRIFT COMPLEX
- 2A: MAINLY TILL VENEER
- 5A: SHIELD-DERIVED SILTY TO SANDY TILL
- 7: GLACIOFLUVIAL DEPOSITS
- 12: OLDER ALLUVIAL DEPOSITS
- 19: MODERN ALLUVIAL DEPOSITS
- 20: ORGANIC DEPOSITS

2.5 0 2.5

1:75,000 KILOMETRES

REFERENCE(S)

1. BASEMAP:SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
2. SURFICIAL GEOLOGY OF ONTARIO OBTAINED FROM ONTARIO GEOLOGICAL SURVEY (OGS) AND MINISTRY OF NORTHERN DEVELOPMENT MINES(MNDM), JUNE 2010
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE18N

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PROJECT

NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE

SURFICIAL GEOLOGY

CONSULTANT

Golder Associates

YYYY-MM-DD	JULY 2019
DESIGNED	SO
PREPARED	SO
REVIEWED	MB
APPROVED	

PROJECT NO.	CONTROL	REV.	FIGURE
1547525	0001	2	**2.3**

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

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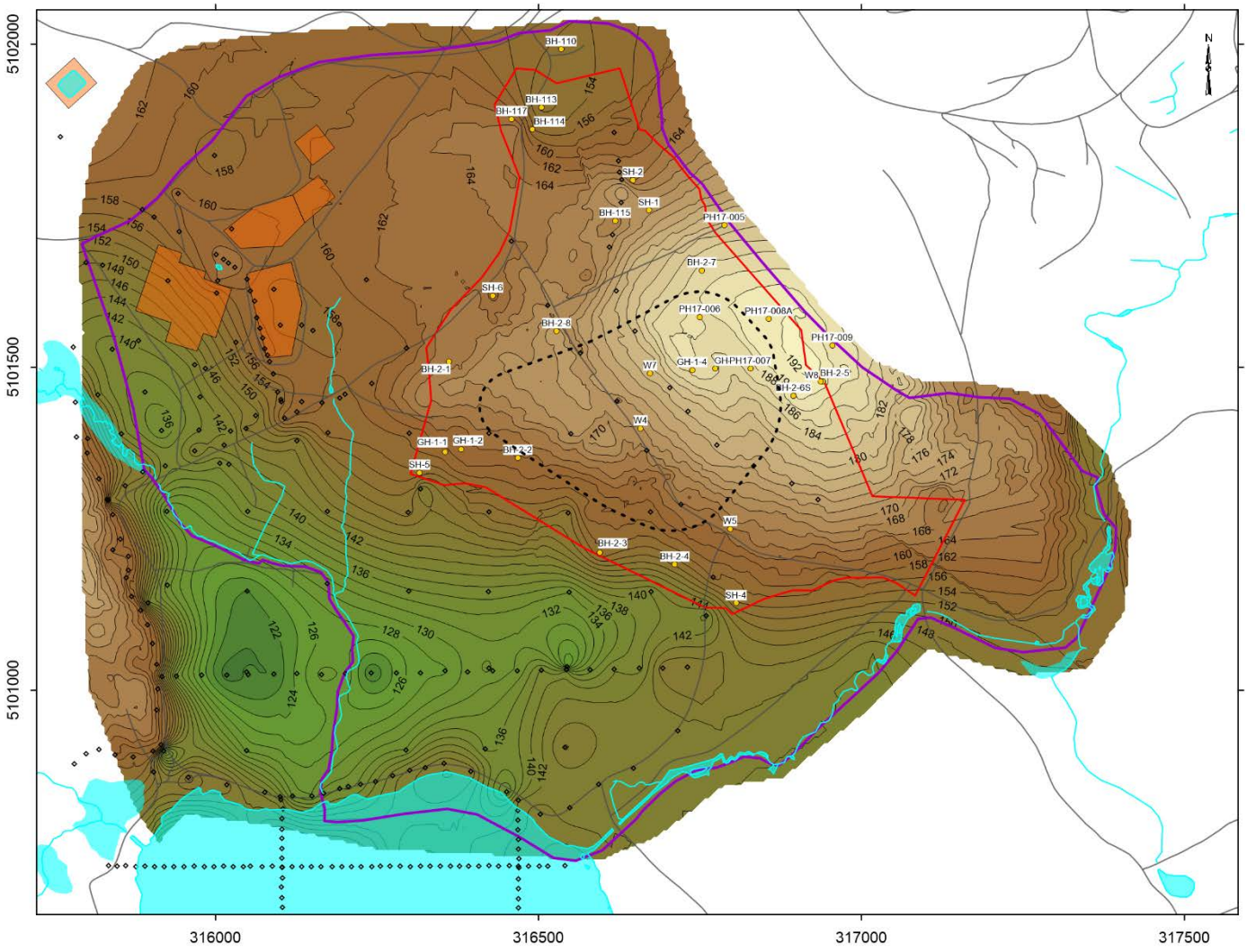

Bedrock Topography (m asl)

195
190
185
180
175
170
165
160
155
150
145
140
135
130
125
120
115
110
105

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Pre-NSDF Project Geological Surface Data Point
- NSDF Project Geological Surface Data Point

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NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

CONSULTANT
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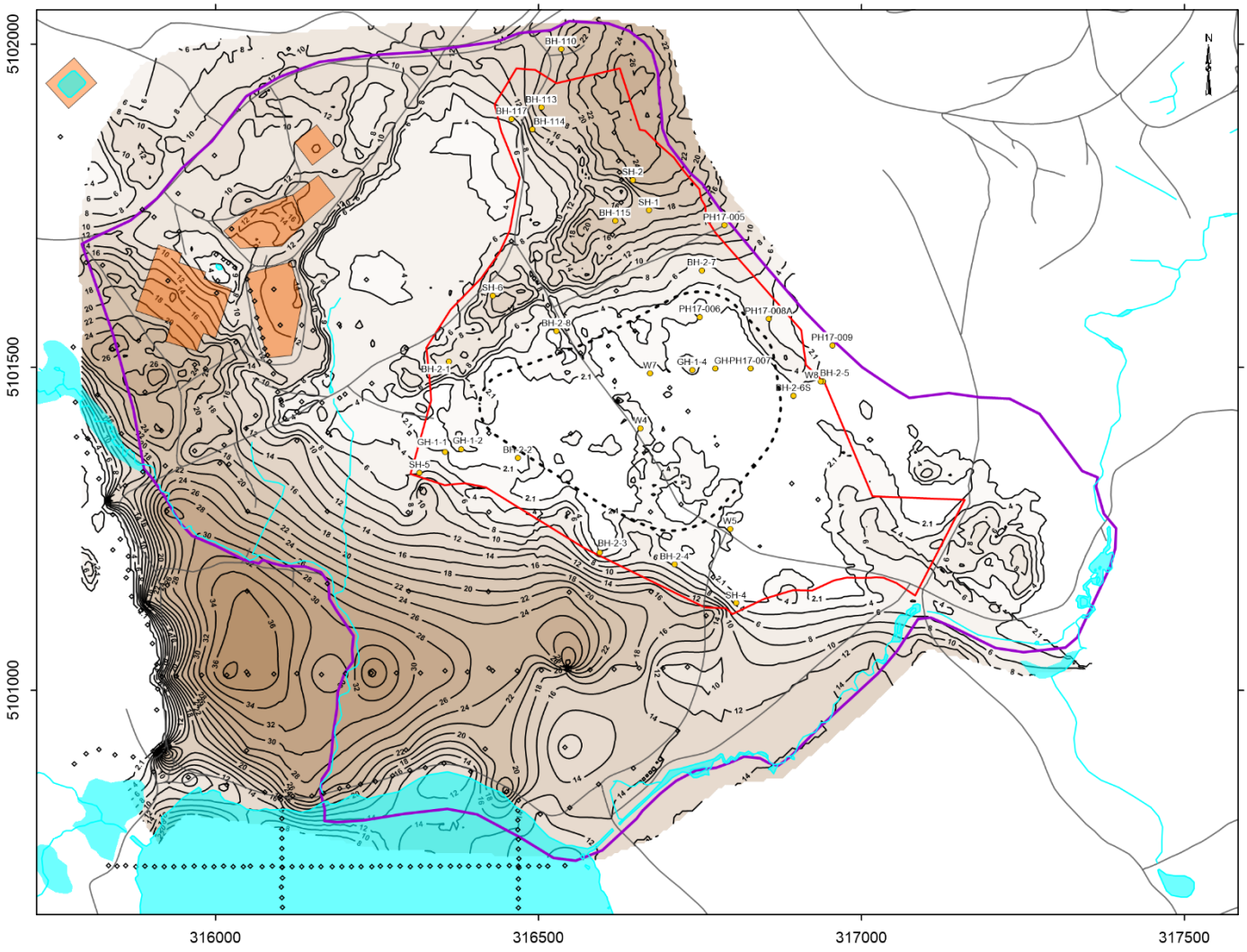
PREPARED	MIB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
BEDROCK TOPOGRAPHY MAP

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.4**



Overburden Thickness (m)

40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Pre-NSDF Project Geological Surface Data Point
- NSDF Project Geological Surface Data Point

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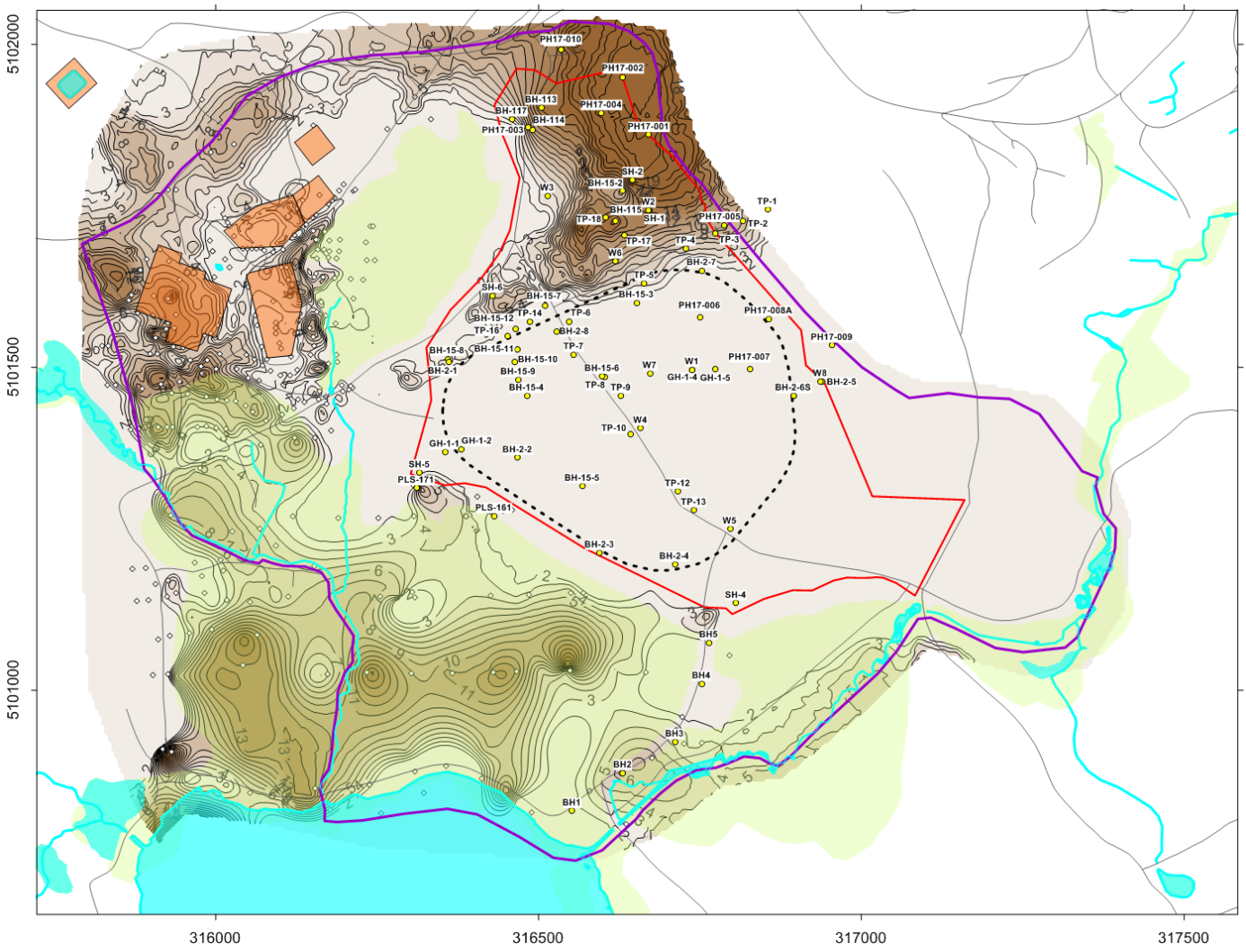
PREPARED	MIB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
ISOPACH MAP – OVERBURDEN

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.5**



Till Thickness (m)

16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point
- Geological Surface Data Point (NSDF Area)

Note:
Till thickness was assumed to be at least 1 m in the area of the ECM (see Section 2.2.4 of the report text).

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NEAR SURFACE DISPOSAL FACILITY
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PREPARED	MIB
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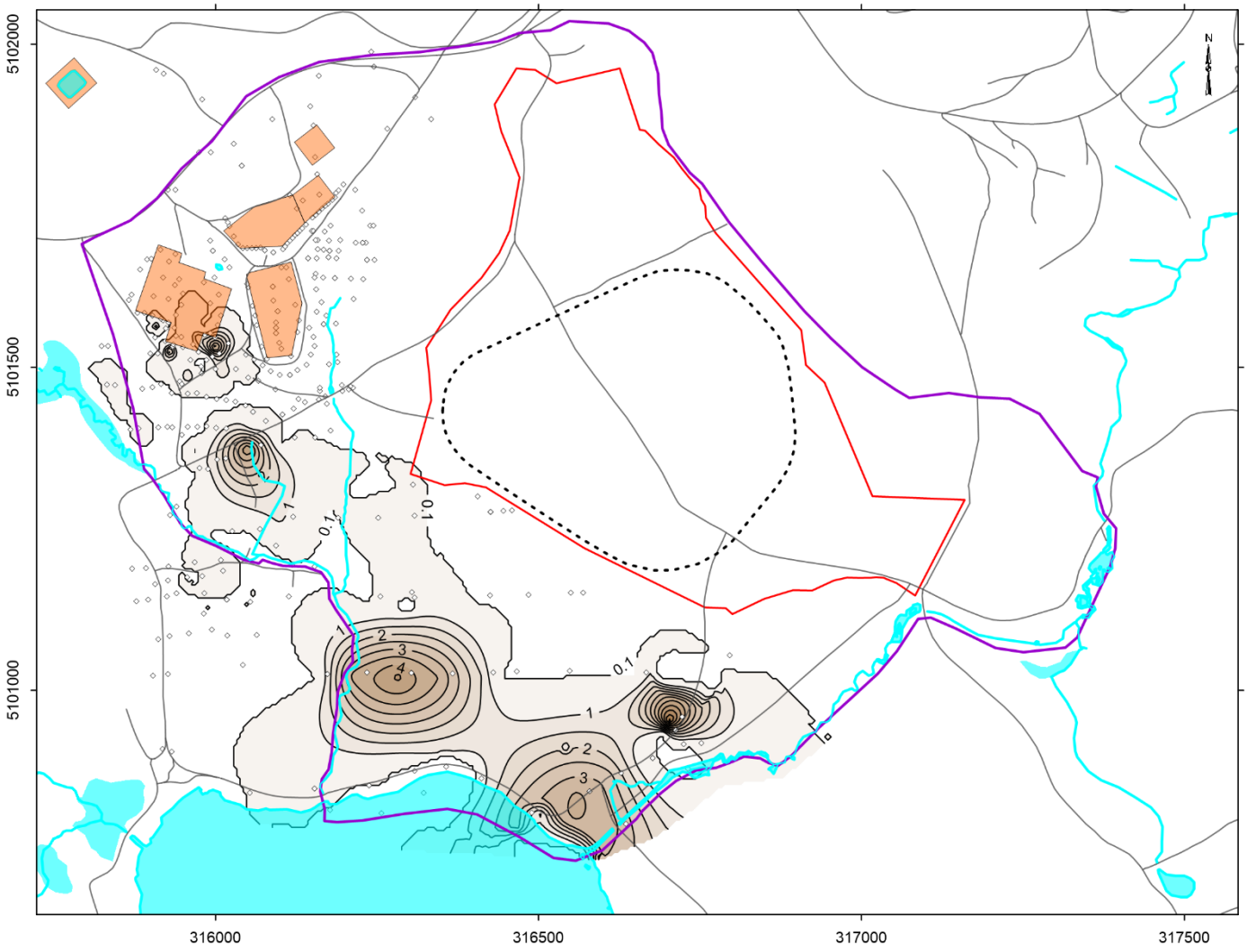
REVIEW	SD
APPROVED	SD

TITLE
ISOPACH MAP – TILL

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.6A**



Basal Sand Thickness (m)

6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.1
0

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point

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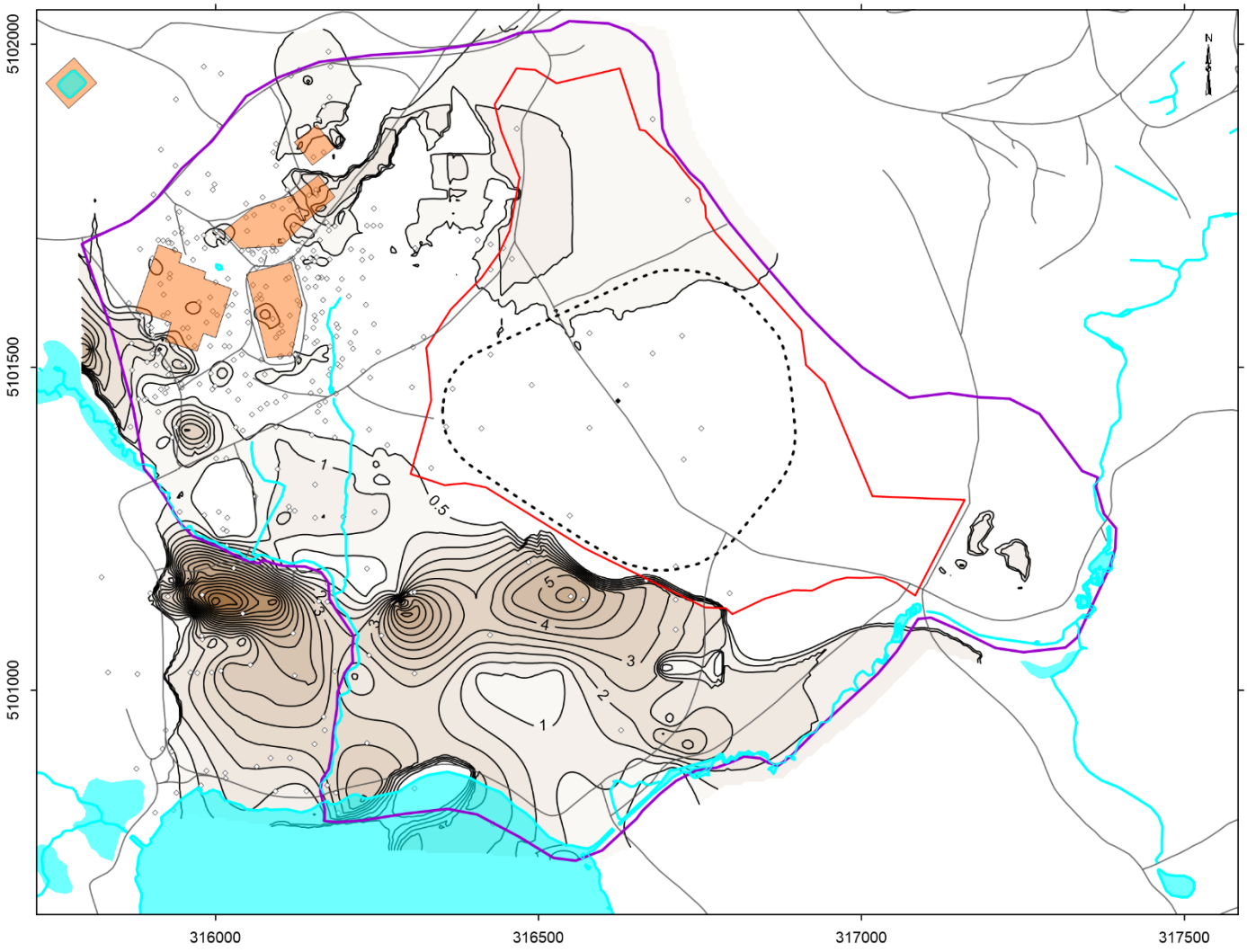
TITLE
ISOPACH MAP – BASAL SAND

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.6B**



Clayey Silt Thickness (m)

10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point

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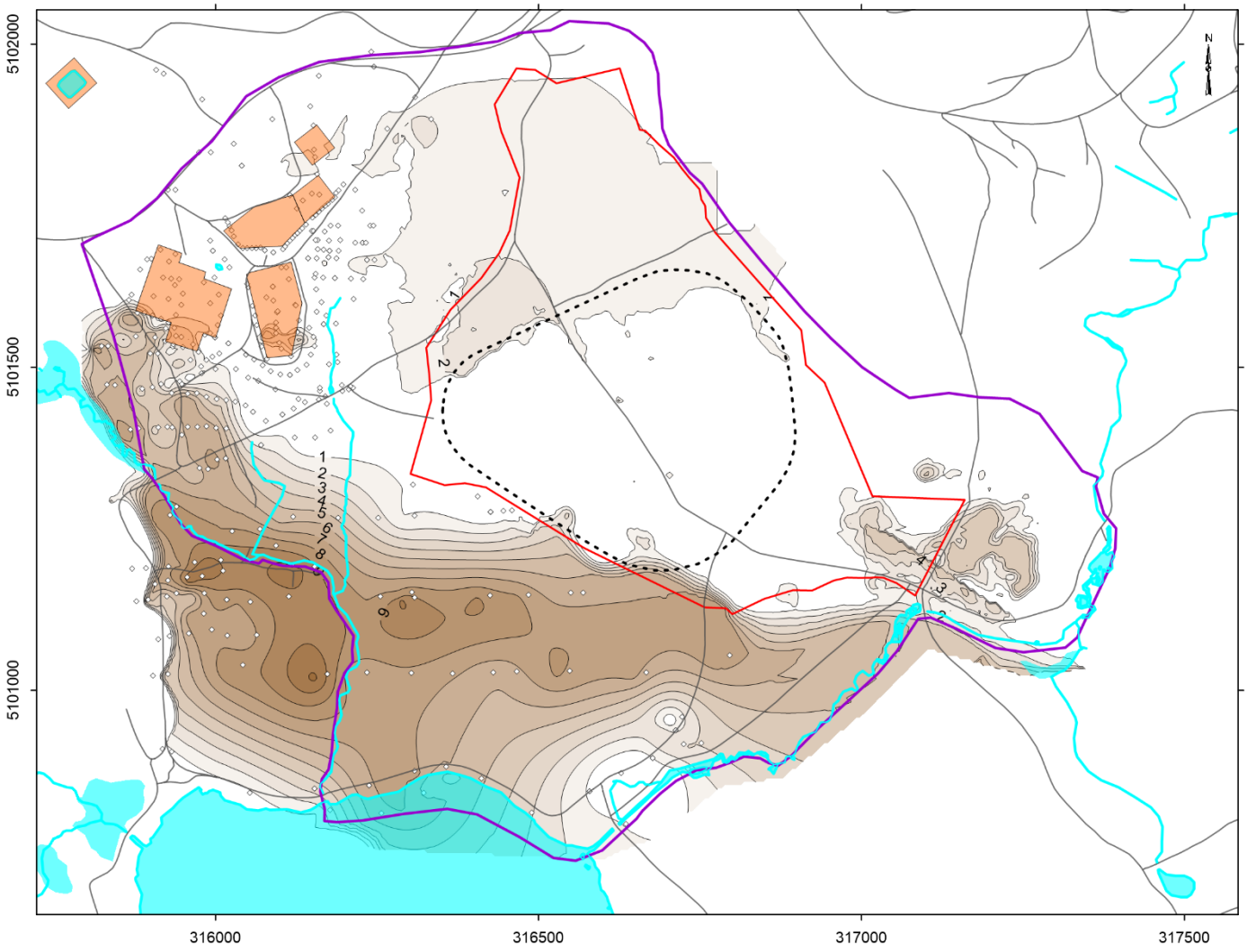
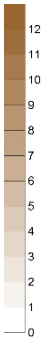
TITLE
ISOPACH MAP – CLAYEY SILT

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.6C**



Middle Sand Thickness (m)



LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point

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NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

CONSULTANT
Golder Associates

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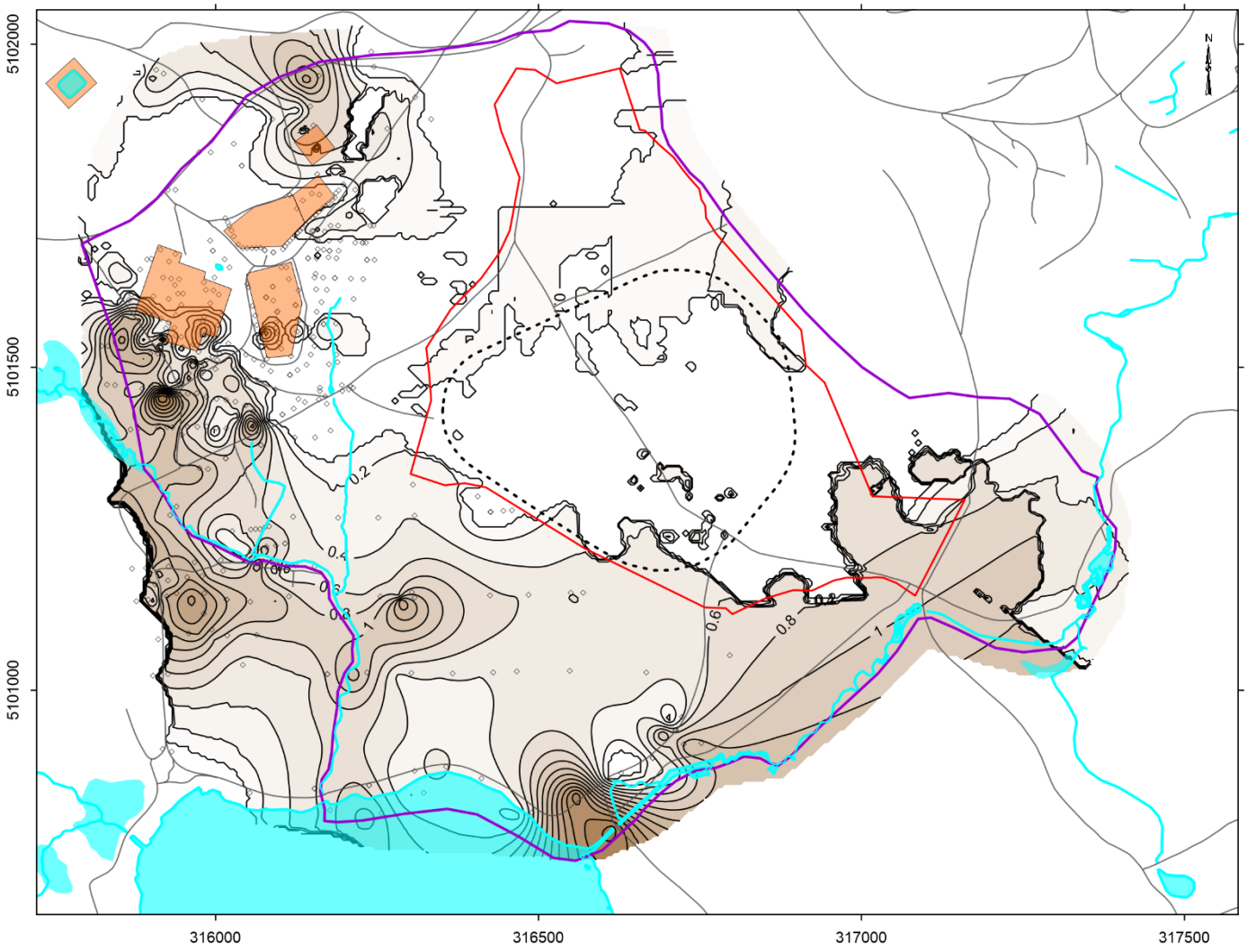
PREPARED	MIB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
ISOPACH MAP – MIDDLE SAND

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.6D**



Interstratified Sand and Silt Thickness (m)

2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0.1
0

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point

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CHALK RIVER, ONTARIO

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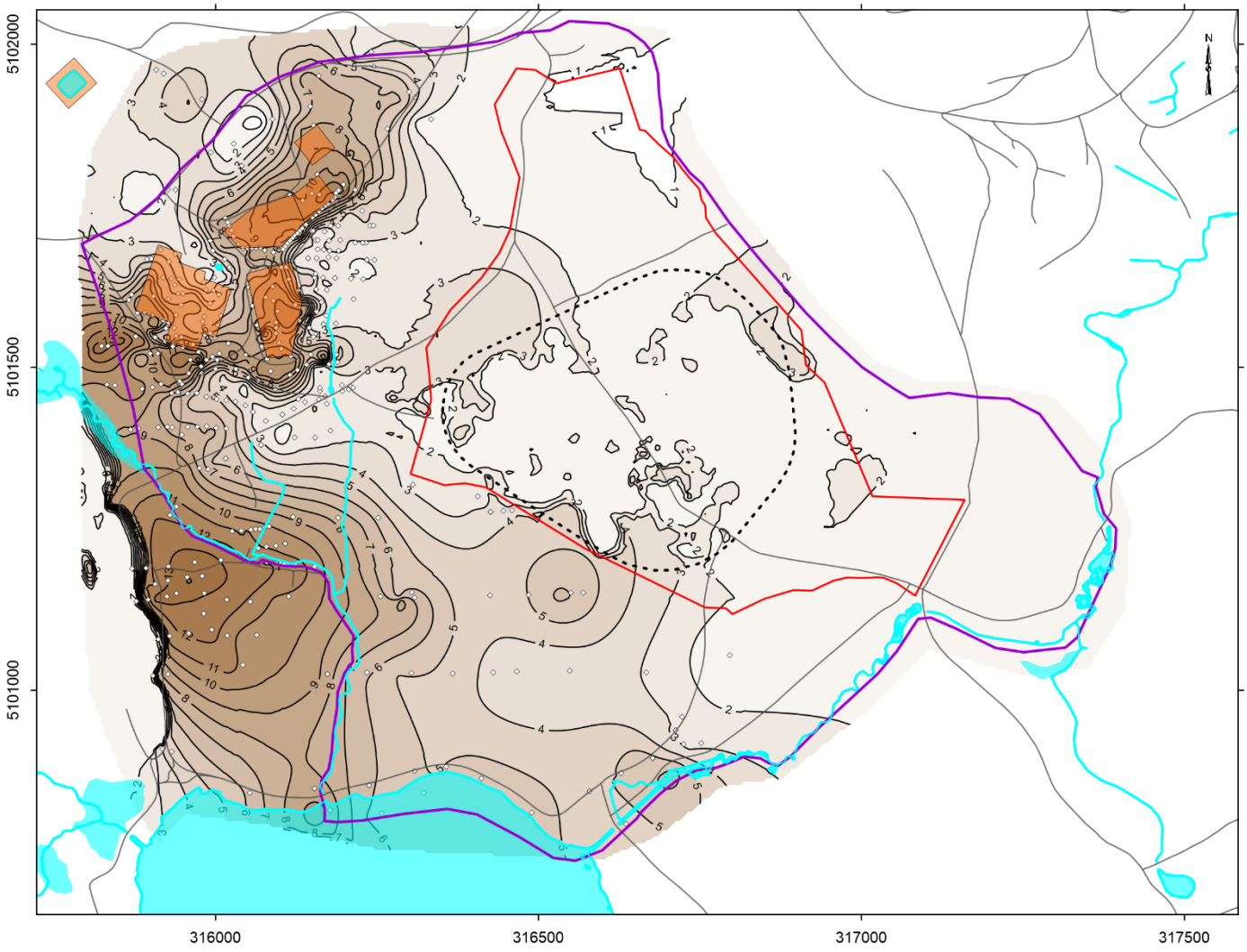
PREPARED	MIB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
ISOPACH MAP – INTERSTRATIFIED SAND AND SILT

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.6E**



Upper Sand Thickness (m)

14
13
12
11
10
9
8
7
6
5
4
3
2
1

LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Geological Surface Data Point

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NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

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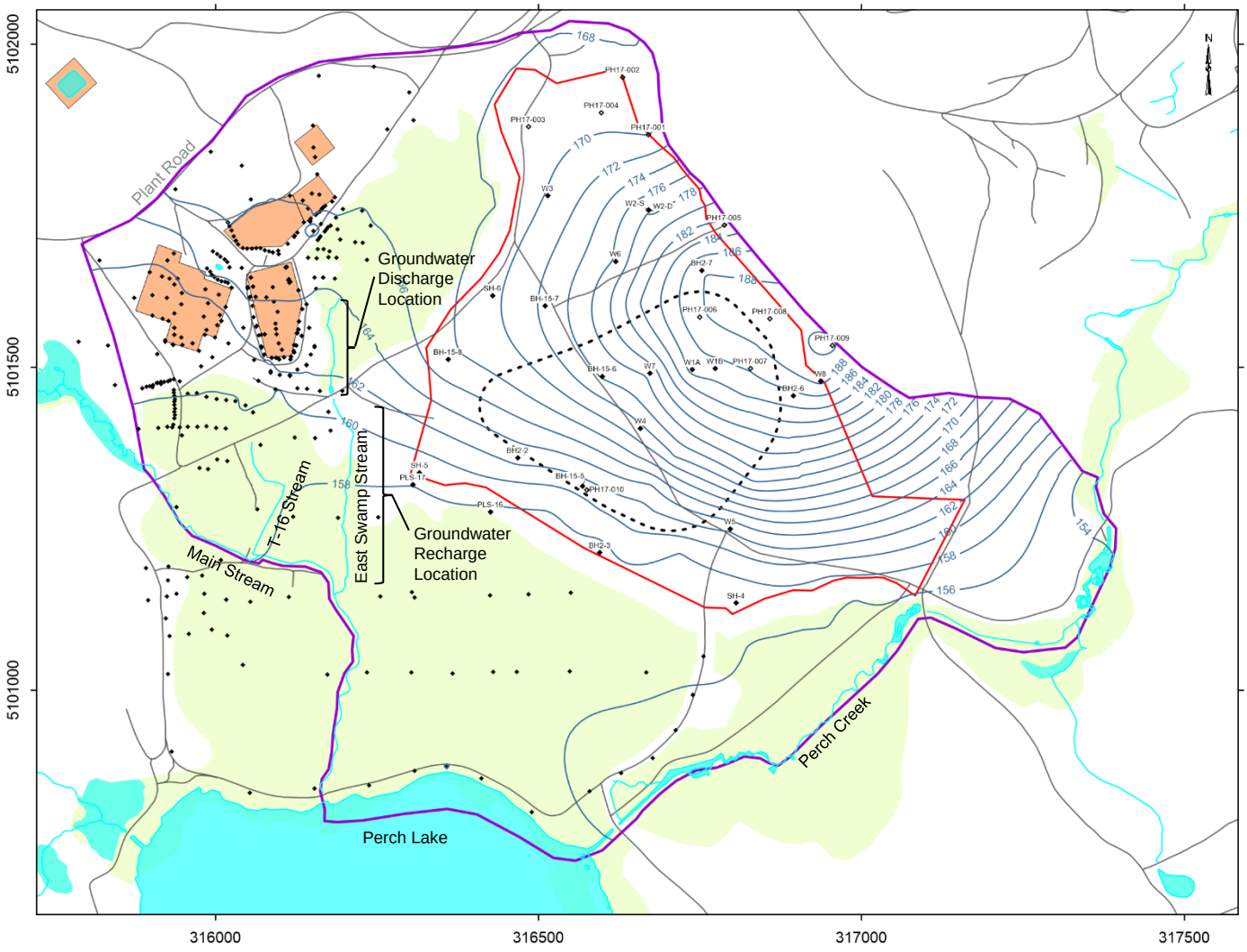
PREPARED	MIB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
ISOPACH MAP – UPPER SAND

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.6F**



LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waste Management Area
- ◇ Groundwater Table Data Point

Notes:

1. For the NSDF-Area wells average groundwater elevations were calculated for the period of record of the available transducer data, including data to June 2018. Periods of record varied between transducers.

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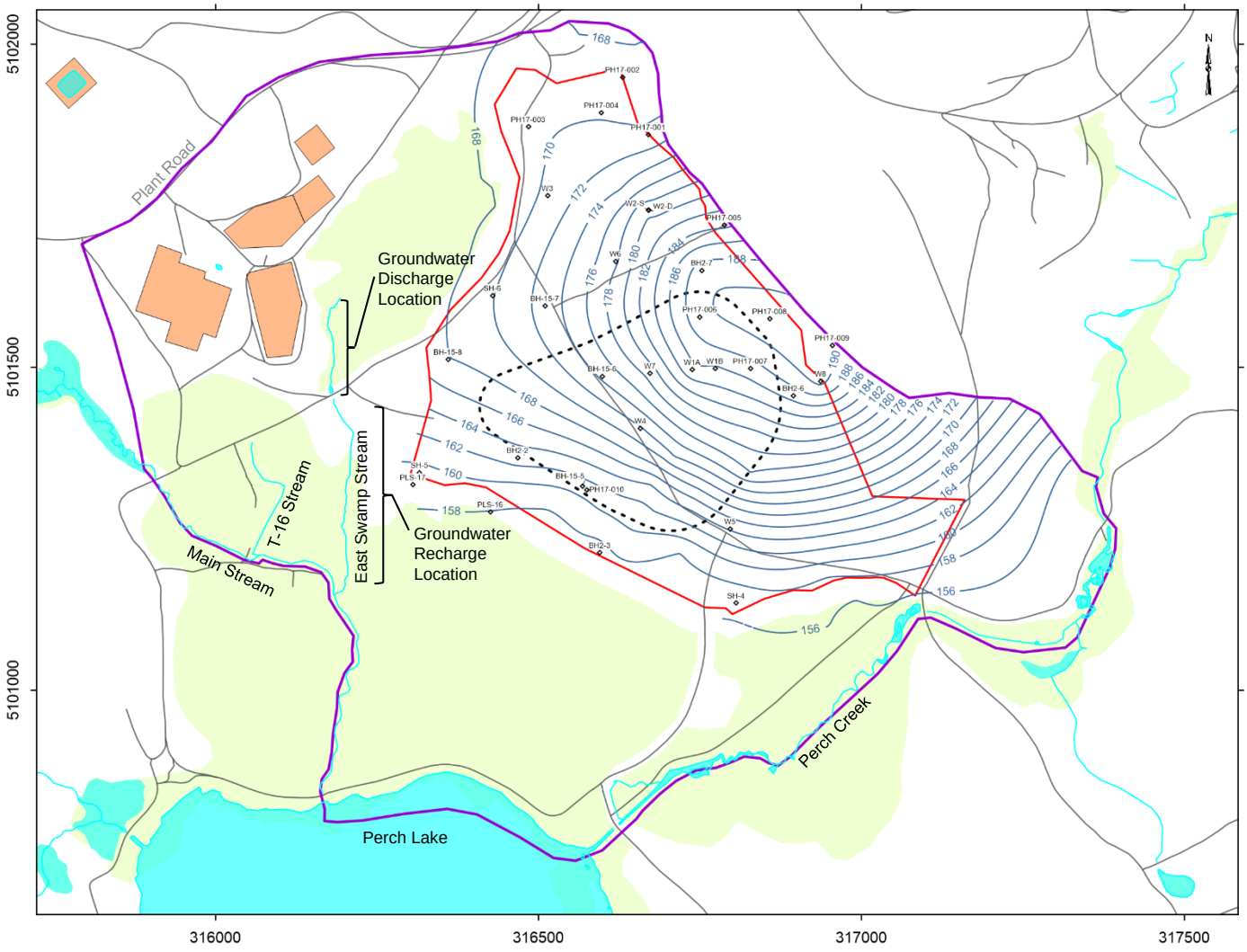
PREPARED	NFB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
AVERAGE GROUNDWATER TABLE ELEVATION MAP

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.7A**



LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waste Management Area
- ◇ Groundwater Table Data Point

Notes:

1. For the NSDF-Area wells maximum groundwater elevations were calculated for the period of record of the available transducer data, including data to June 2018. Periods of record varied between transducers.

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NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

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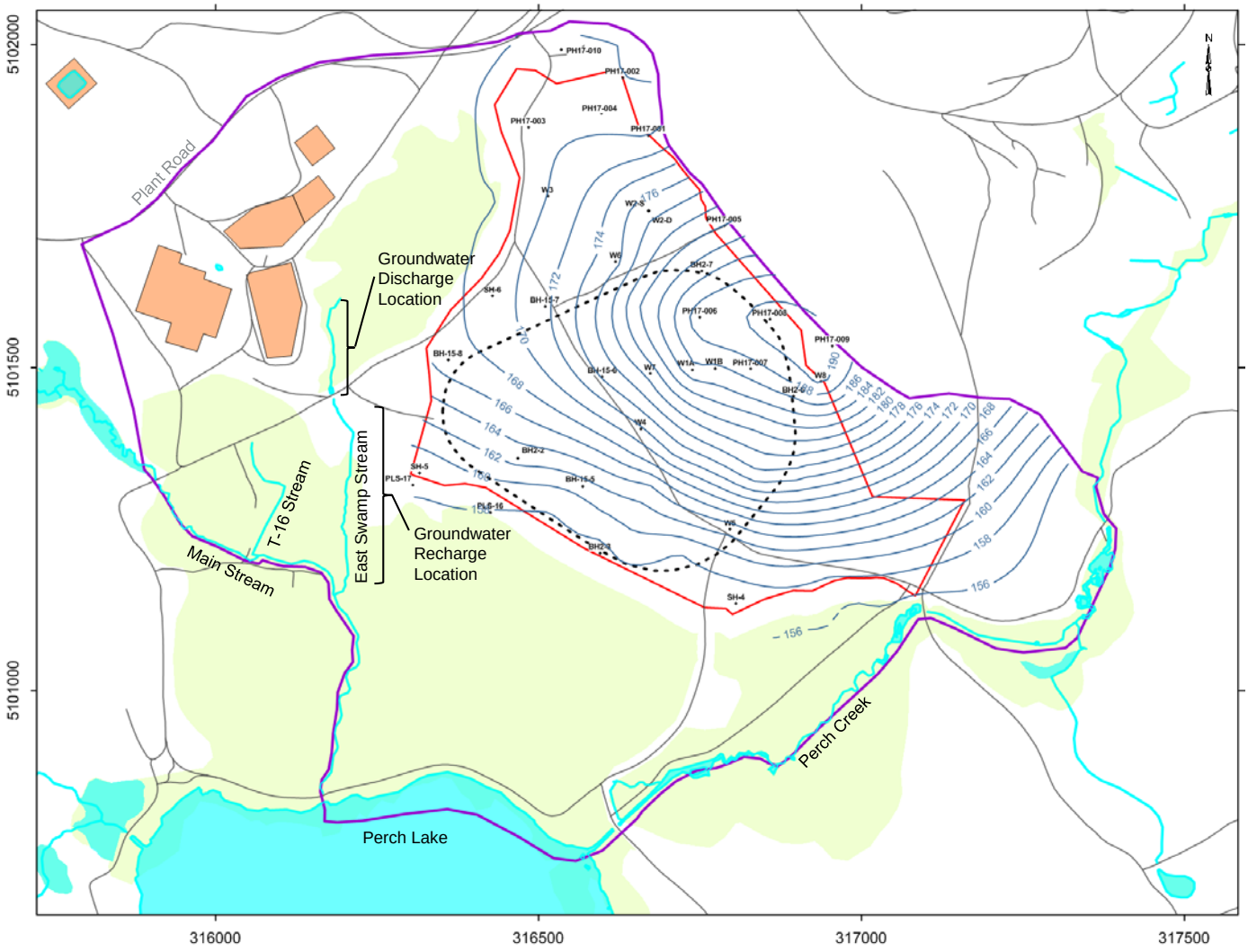
PREPARED	NFB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
HIGH GROUNDWATER TABLE ELEVATION MAP

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.7B**



LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waste Management Area
- ◇ Groundwater Table Data Point

Notes:

1. For the NSDF-Area wells groundwater elevations were based off of the closest transducer reading to April 26, 2018 at 12:00 pm for each monitoring well, which generally corresponds to the most recent groundwater elevation maximum.

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NEAR SURFACE DISPOSAL FACILITY
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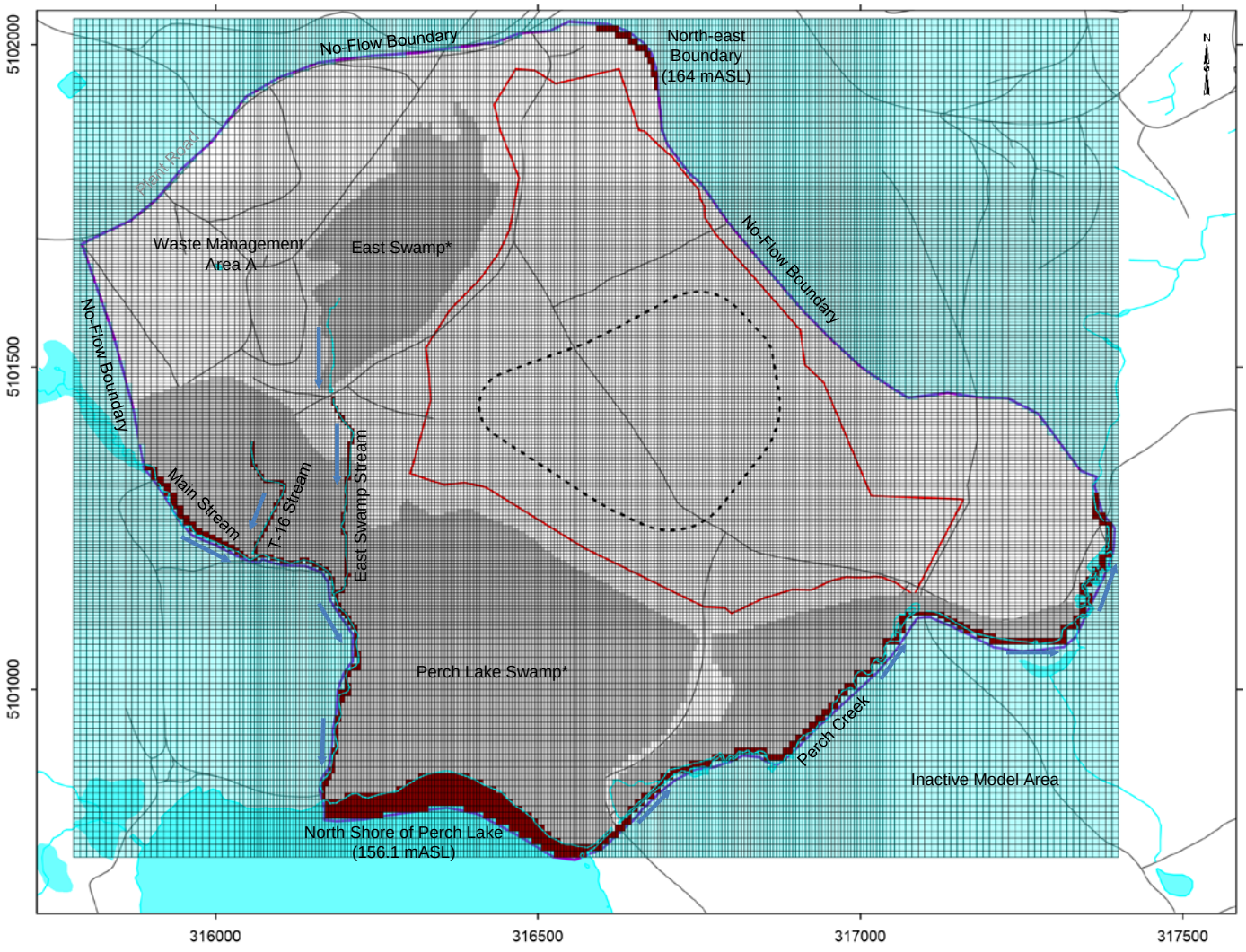
PREPARED	NFB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
GROUNDWATER TABLE ELEVATION MAP
April 26, 2018

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**2.7C**



LEGEND

- Model Boundary
- Roads
- ECM Location
- NSDF Boundary
- Stream
- Waterbody
- Waste Management Area
- Model Constant Head Boundary
- Model Drain Boundary
- Model Inactive Area
- Model Grid
- Direction of Surface Water Flow

Notes:

1. * Swamp drain boundaries were set based on ground surface elevation.
2. Boundary elevations range from 159.9 mASL to 156.9 mASL for the Main Stream, 159.6 mASL to 158.8 mASL for the T-16 Stream, 161.74 mASL to 157.8 mASL for the Lower East Swamp Stream, and 156.1 mASL to 152.7 mASL for Perch Creek

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NEAR SURFACE DISPOSAL FACILITY
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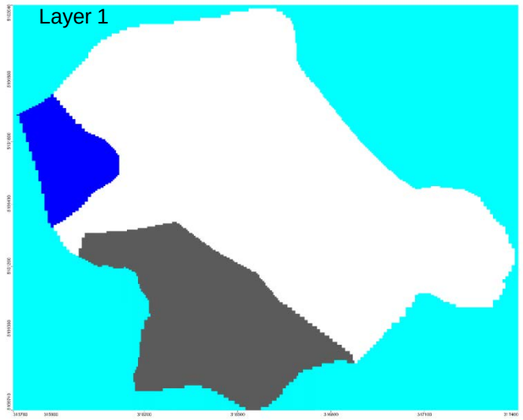
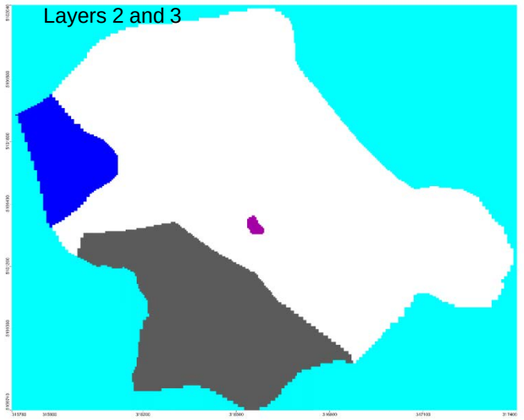
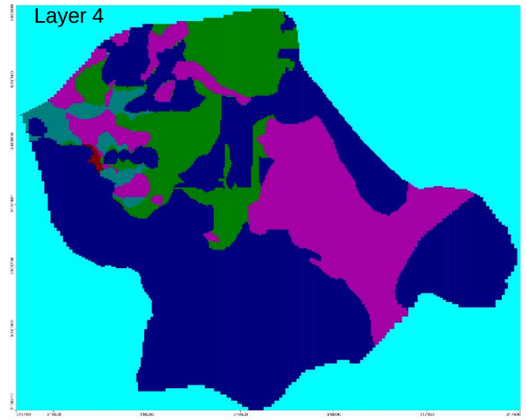
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
GROUNDWATER FLOW MODEL EXTENTS, GRID AND BOUNDARY CONDITIONS

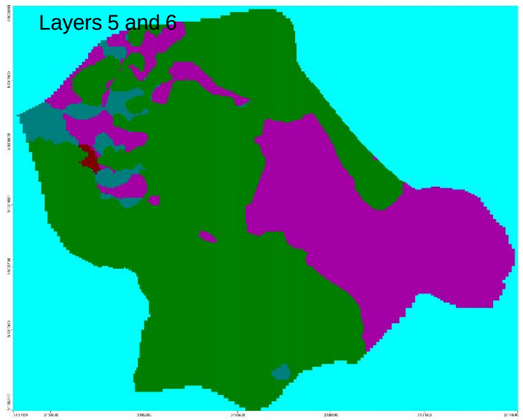
PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**3.1**

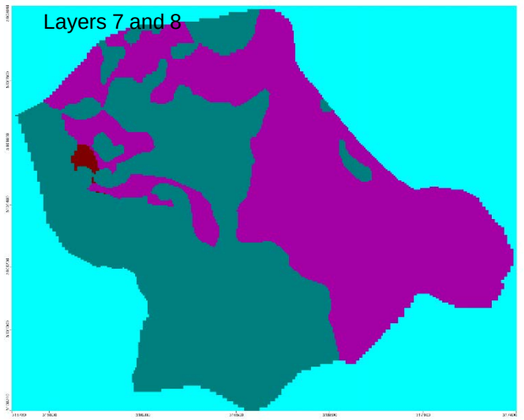


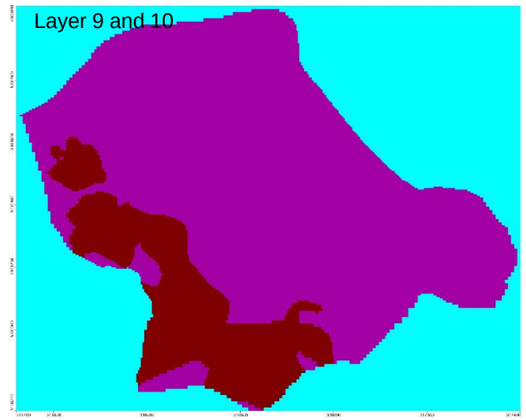


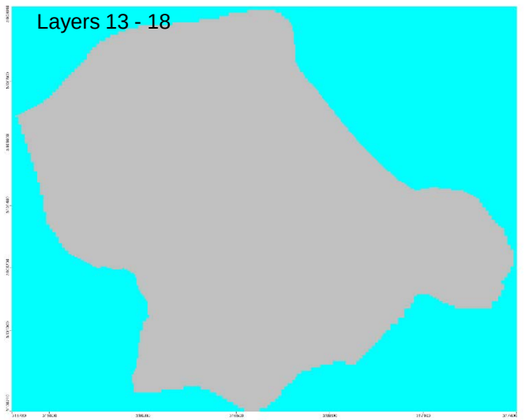


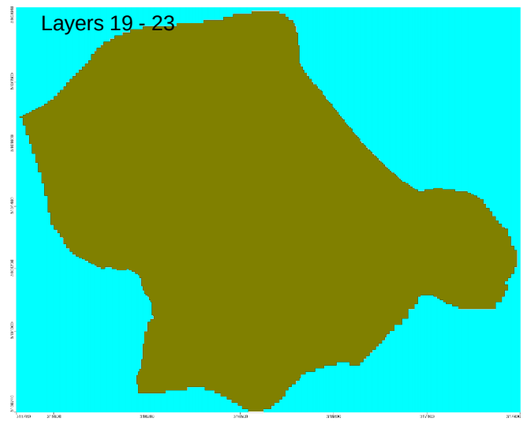
LEGEND
- Inactive Model Area
- Upper Sand (Zone 1)
- Upper Sand (Zone 2)
- Upper Sand (Zone 3)
- Interstratified Sand and Silt
- Middle Sand
- Clayey Silt
- Basal Sand and Gravel
- Till
- Upper Bedrock
- Lower Bedrock











Material	Hydraulic Conductivity (m/s)		Kh:Kv	Porosity	
	Horizontal	Vertical		Total	Effective
Upper Sand (Zone 1)	1.0E-04	3.0E-05	3.3	0.38	0.3
Upper Sand (Zone 2)	1.7E-4	5.0E-5	3	0.38	0.3
Upper Sand (Zone 3)	3.0E-5	1.0E-5	3.4	0.38	0.3
Interstratified Sand and Silt	6.0E-05	6.0E-07	100	0.39	0.3
Middle Sand	1.0E-04	2.0E-05	5.0	0.38	0.3
Clayey Silt	9.5E-07	5.5E-09	173	0.48	0.3
Basal Sands	1.2E-04	1.0E-04	1.2	0.38	0.3
Till	9.0E-07	7.0E-07	1.3	0.26	0.2
Upper Bedrock	9.0E-07	9.0E-07	1	0.001	0.001
Lower Bedrock	4.0E-08	4.0E-08	1	0.001	0.001

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PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

CONSULTANT
Golder Associates

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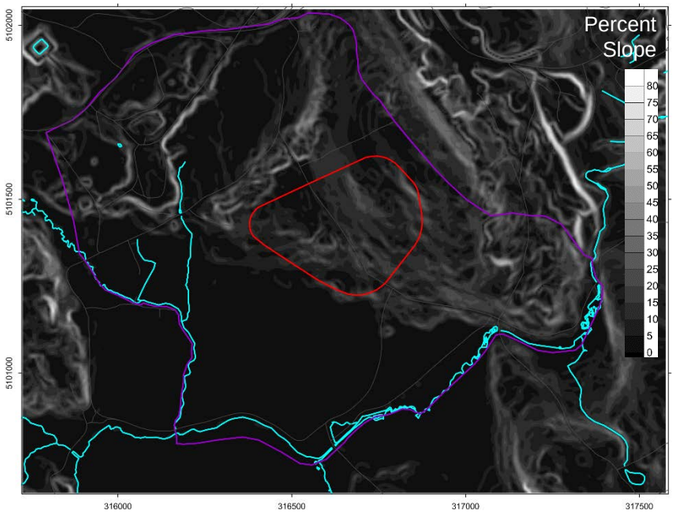
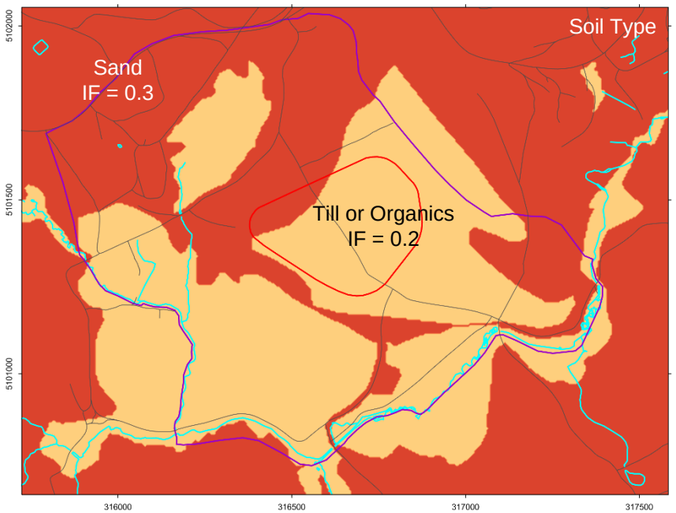
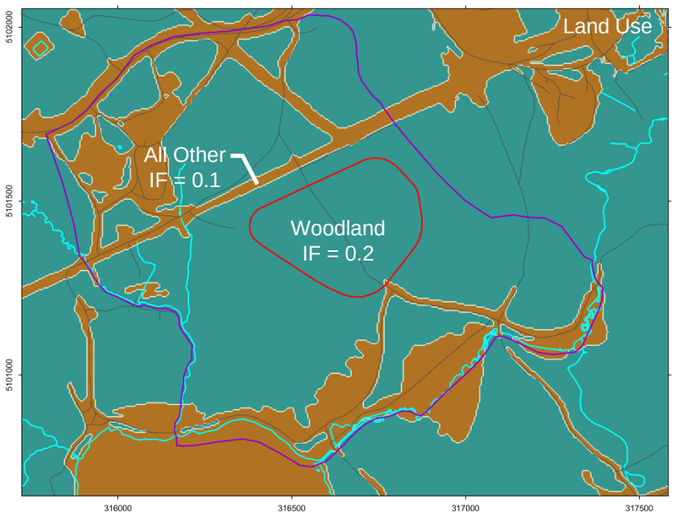
PREPARED	NFB
DESIGN	NFB
REVIEW	SD
APPROVED	SD

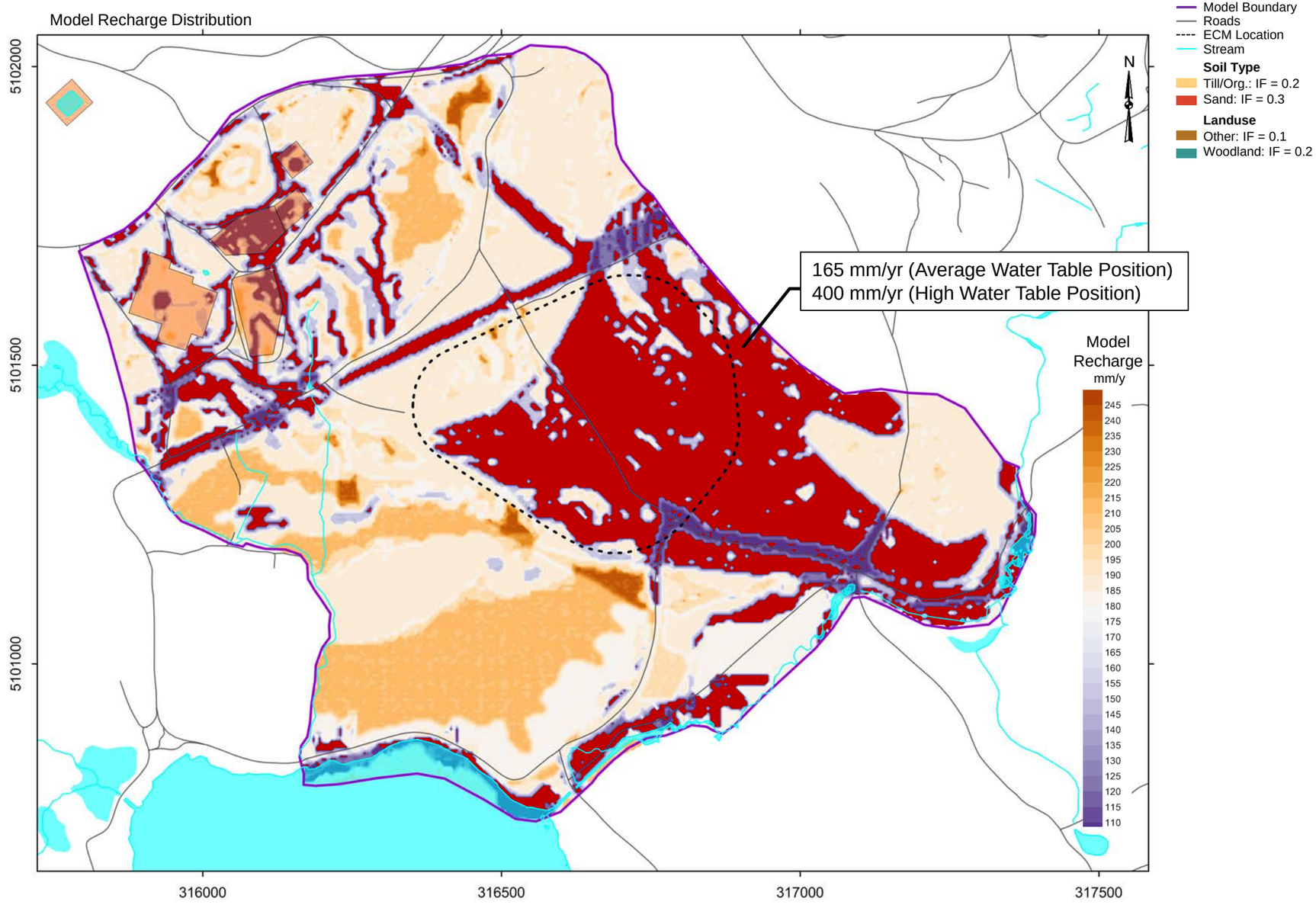
TITLE
MODEL LAYER HYDRAULIC CONDUCTIVITY DISTRIBUTION

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	3.2









NOTES:

1. IF = Infiltration Factor.
2. Infiltration Factors assigned based on MOEE (1995) guidance document.
3. Infiltration factors were assigned based on slope according to the table below:

Slope Percent	Infiltration Factor
0.06	0.30
0.06-0.28	0.25
0.28-0.38	0.20
0.38-2.8	0.15
2.8-4.7	0.10
>4.7	0.05

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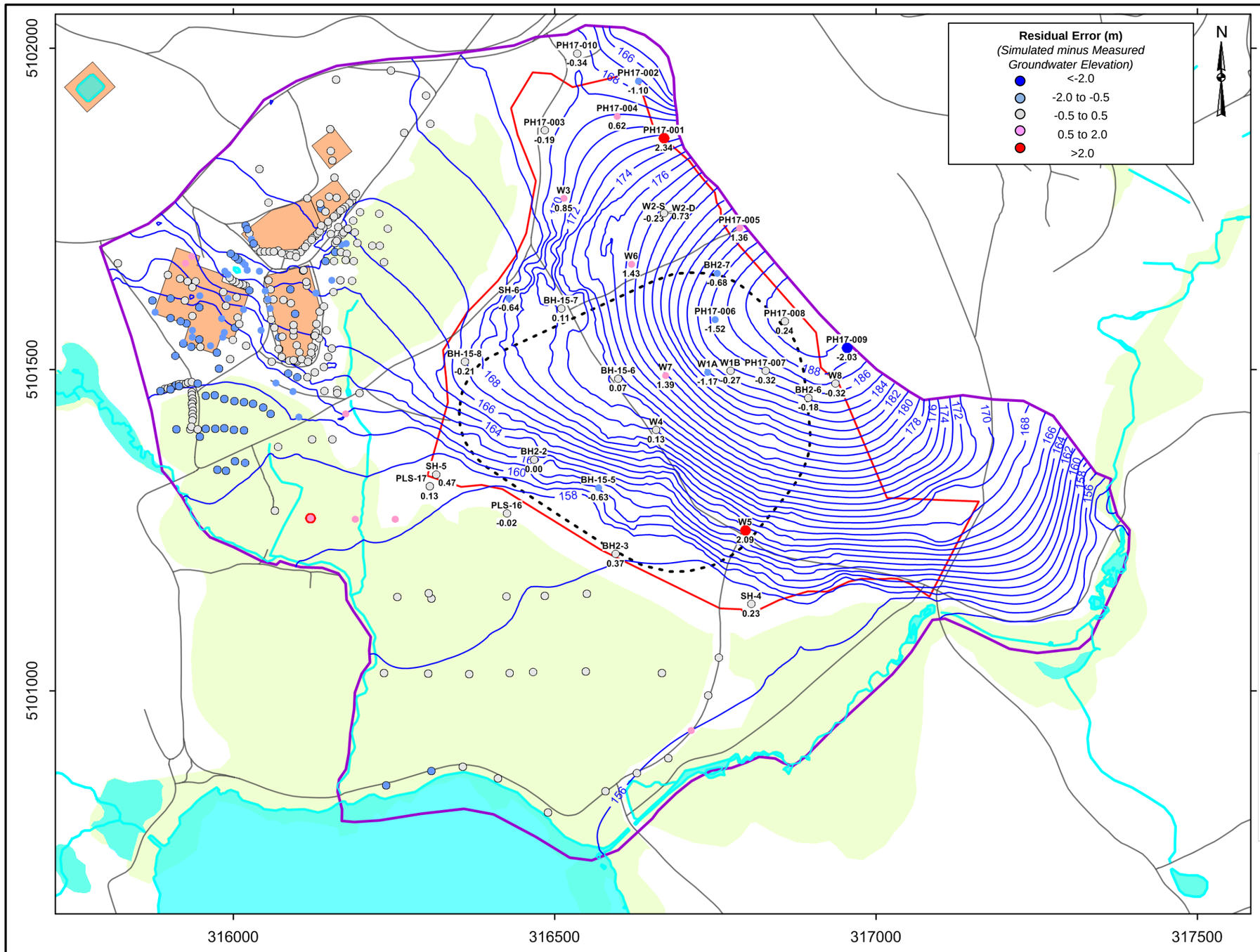
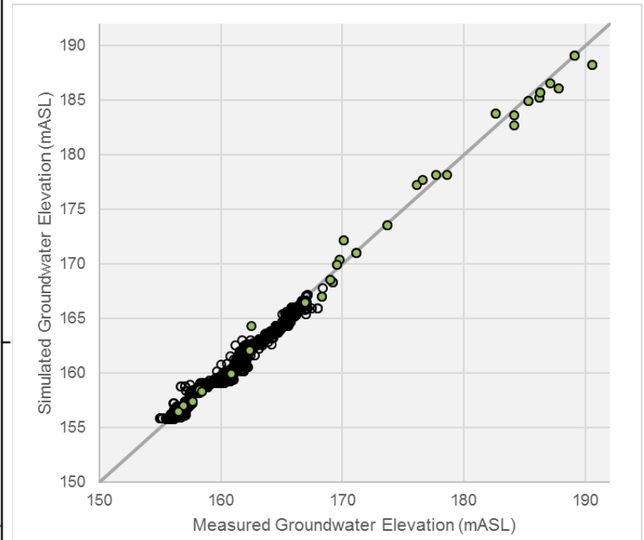
PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
MODEL RECHARGE DISTRIBUTION

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	3.3





All Data	NSDF Area Data
Normalized RMSE: 1.3%	Normalized RMSE: 2.8%
Residual Mean Error: -0.08 m	Residual Mean Error: 0.08 m
Abs. Residual Mean: 0.34 m	Abs. Residual Mean: 0.69 m
Number of Data Points: 1,583	Number of Data Points: 33

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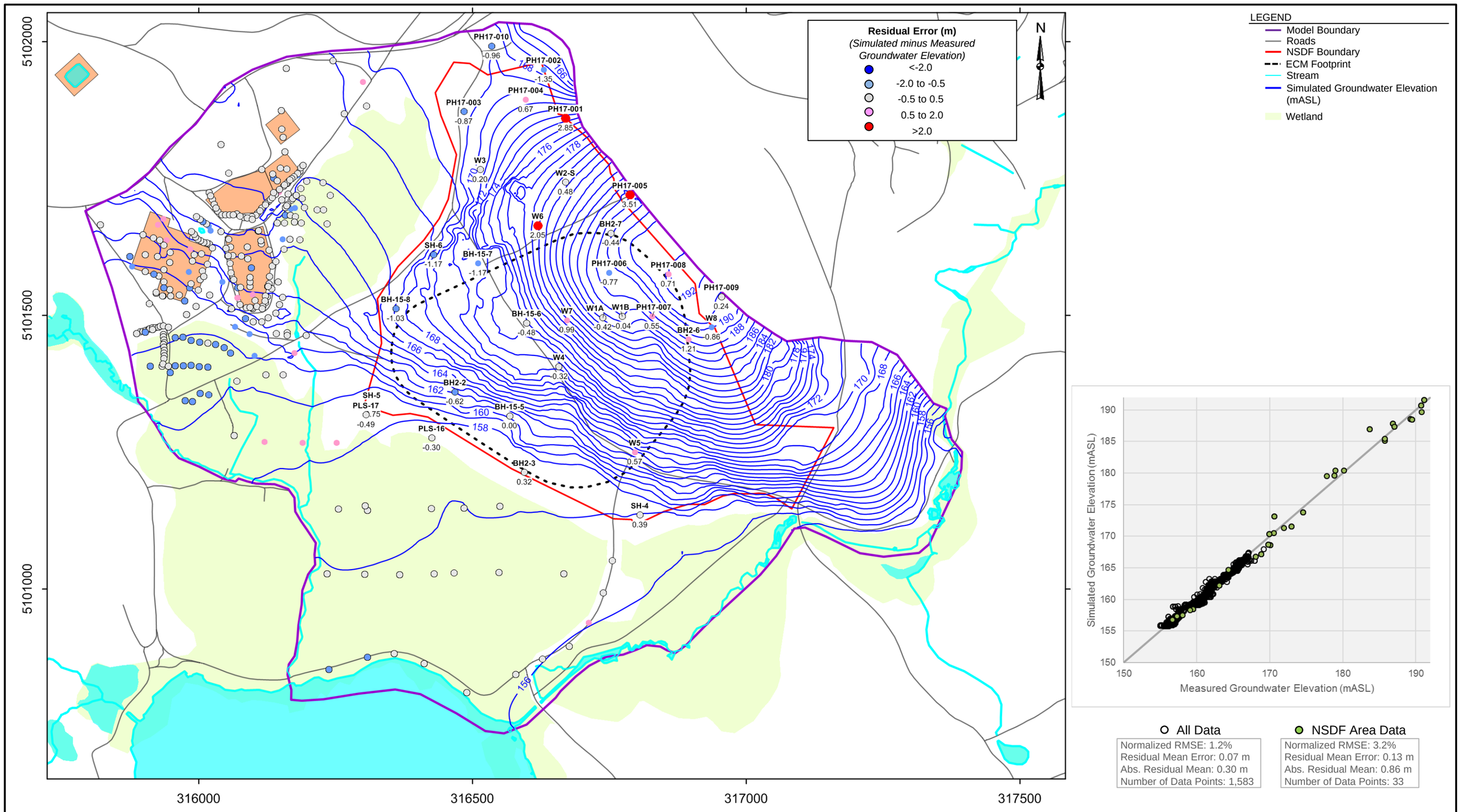
PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
MODEL CALIBRATION (AVERAGE WATER TABLE POSITION) – HYDRAULIC HEAD DISTRIBUTION

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	3.4A



All Data	NSDF Area Data
Normalized RMSE: 1.2%	Normalized RMSE: 3.2%
Residual Mean Error: 0.07 m	Residual Mean Error: 0.13 m
Abs. Residual Mean: 0.30 m	Abs. Residual Mean: 0.86 m
Number of Data Points: 1,583	Number of Data Points: 33

NOTES:
1) Target groundwater elevations from NSDF –area wells represents maximum elevations from range of transducer data.

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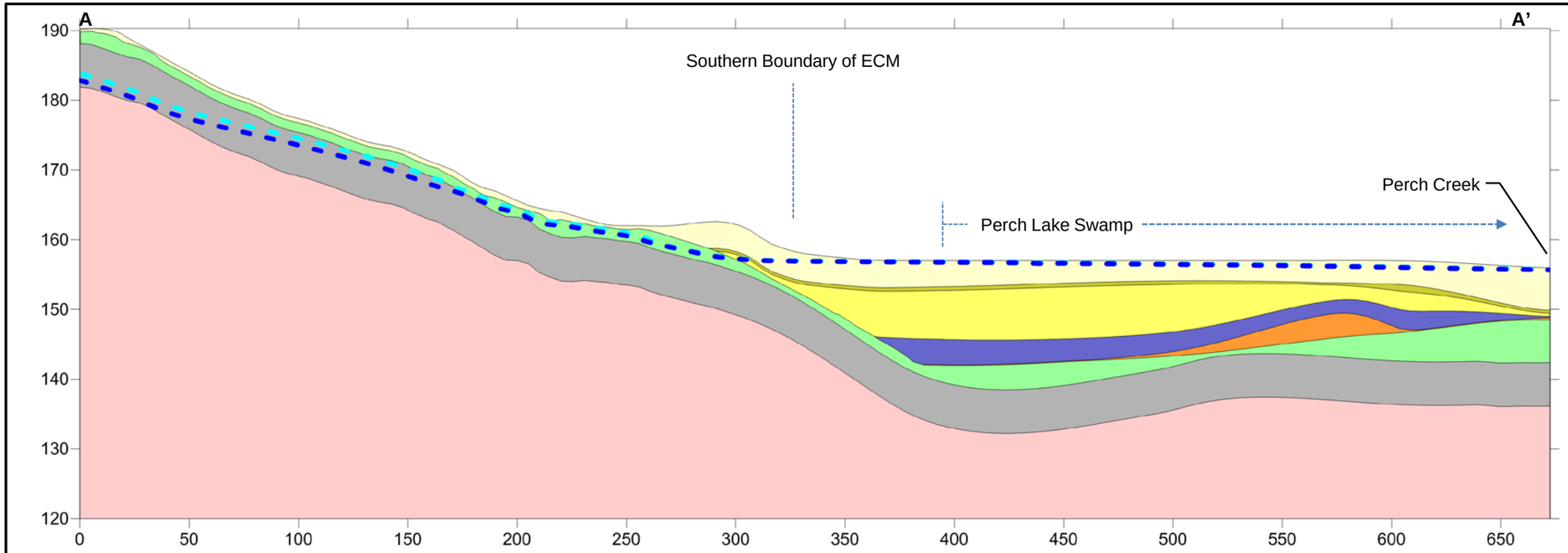
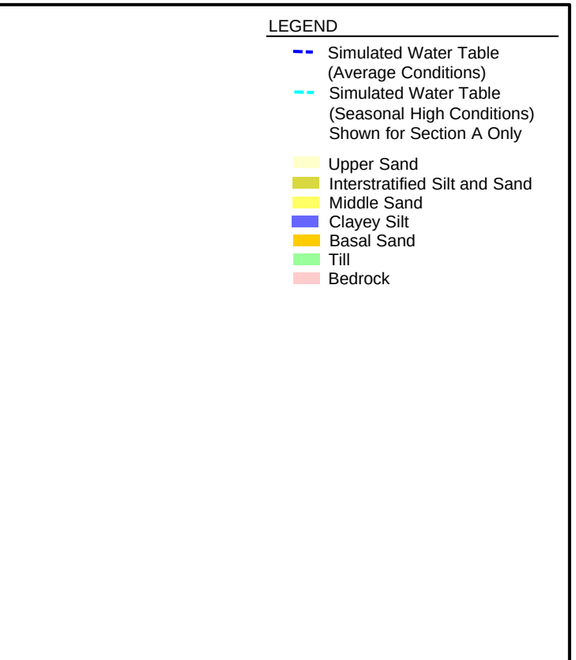
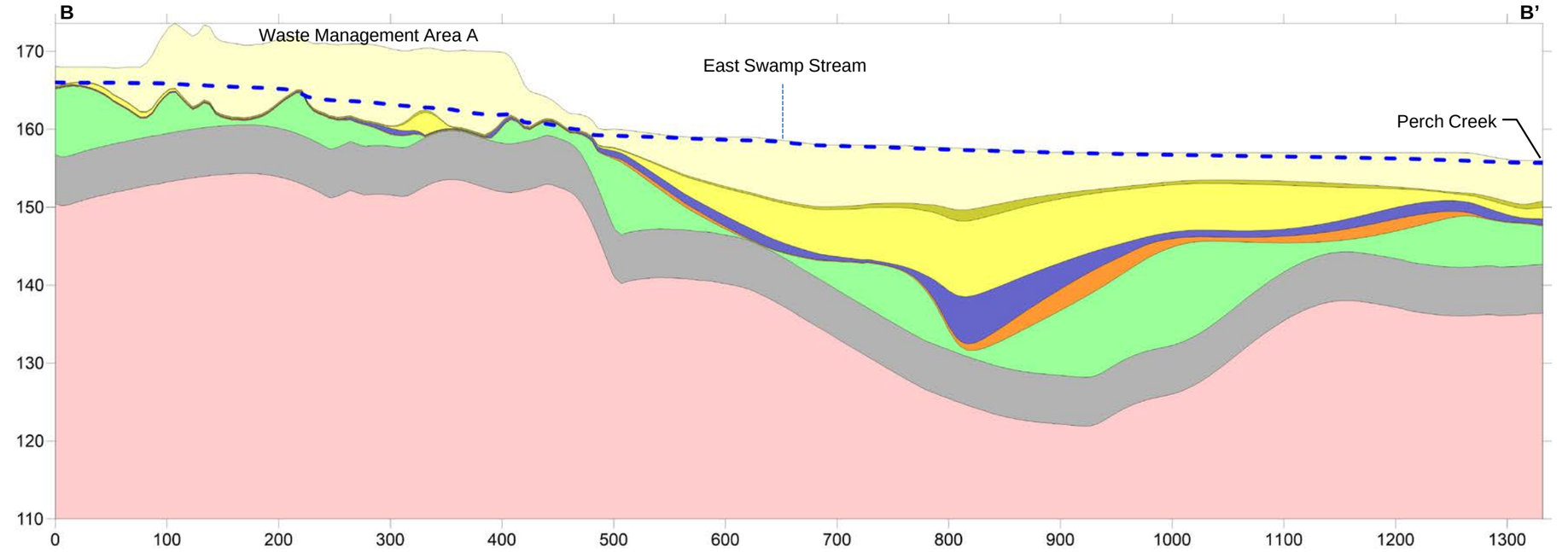
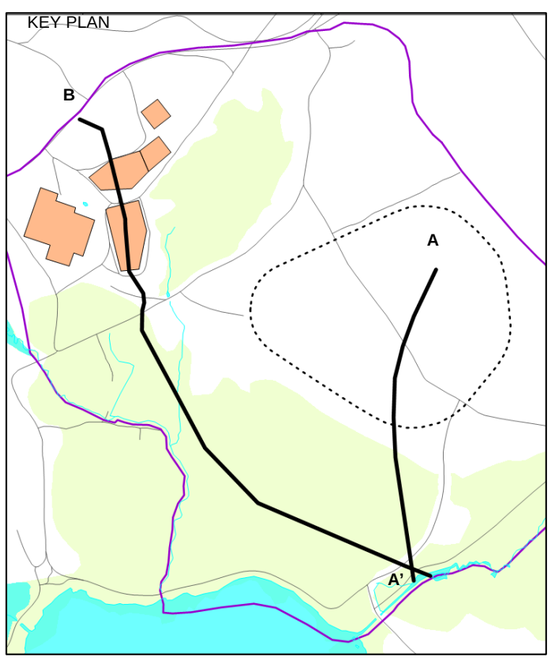
TITLE
MODEL CALIBRATION (HIGH WATER TABLE POSITION) – HYDRAULIC HEAD DISTRIBUTION

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	3.4B









NOTES:
1) Vertical exaggeration is 3.0.
2) The high water table position line is obscured by the average water table line over the lower portion of Cross-Section A

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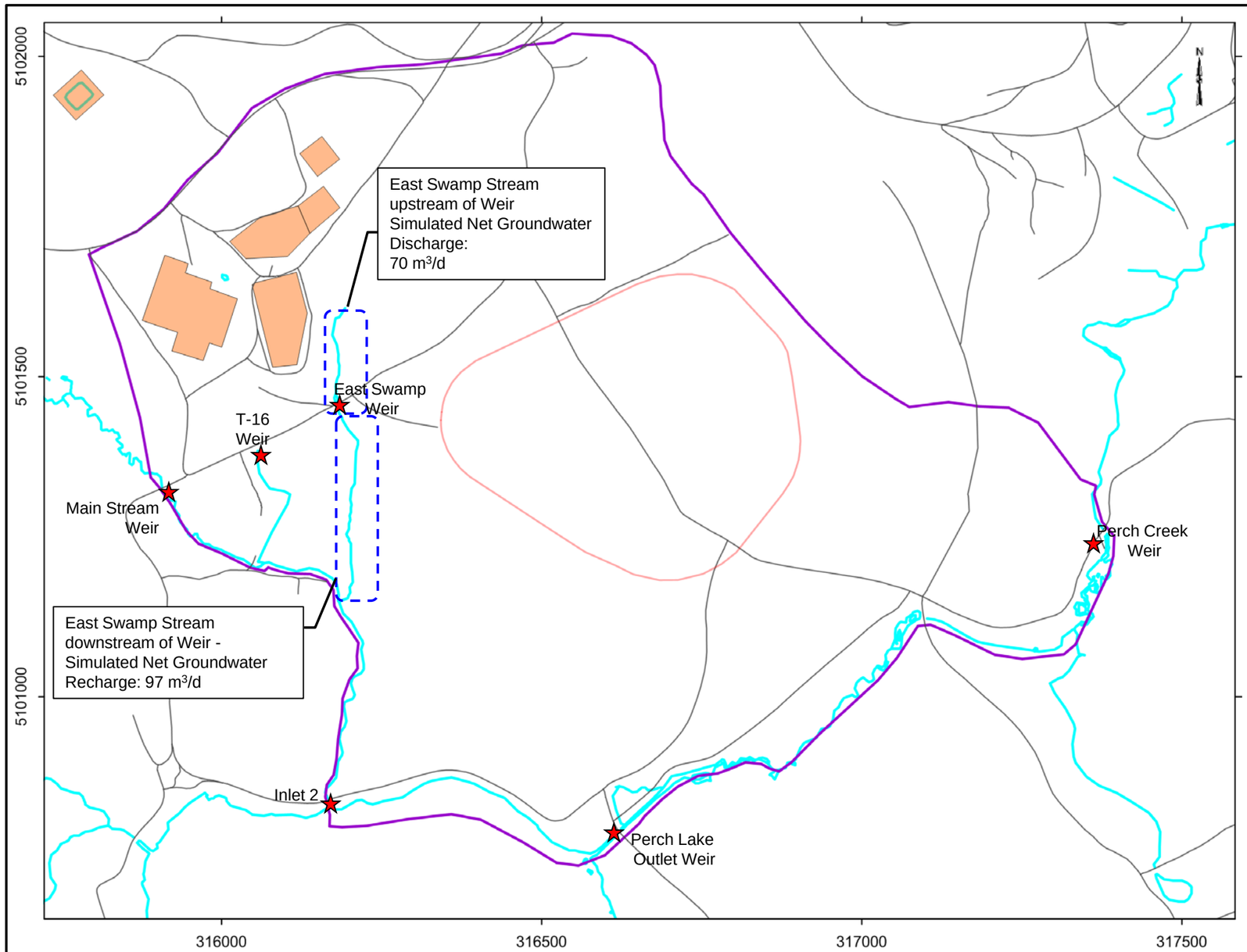
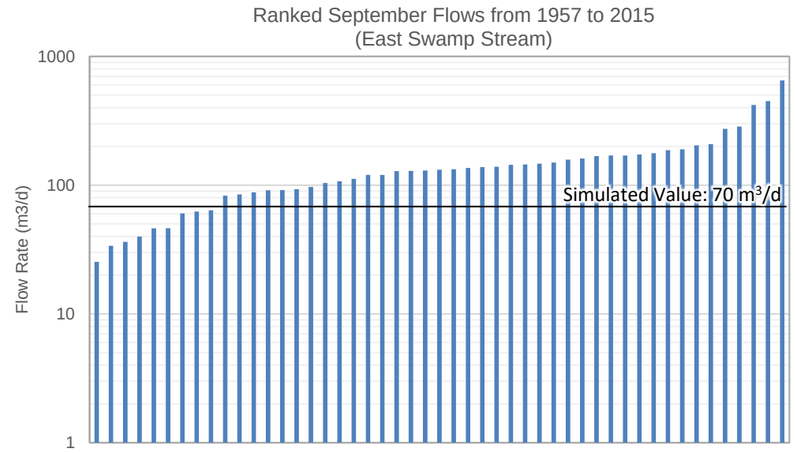
PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
HYDROSTRATIGRAPHIC CROSS-SECTIONS WITH SIMULATED WATER TABLE ELEVATION

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	3.5



LEGEND
- Model Boundary
- Roads
- ECM Location
- Stream
- Waterbody
- Waste Management Area



Comparison of Estimated Recharge and Model Recharge

	Period of Record	Approximate Drainage Area (m^2)	Flow Estimate (m^3/d)*	Equivalent Recharge (mm/yr)	Average Model Recharge (mm/yr)**
East Swamp Stream Weir	1957 - 2015	244,800	149	222	159
Inlet 2	1968 - 2015	3,272,000	1,386	155	
Perch Lake Outlet Weir	1967 - 1993	6,081,000	1,671	100	
Perch Creek Weir	1992 - 2015	7,340,000	2,360	117	

NOTES:

* Average September flow rate over period of record.
** The total recharge applied in the model divided by the model area.

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TITLE
MODEL CALIBRATION – STREAM BASEFLOW

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	3.6

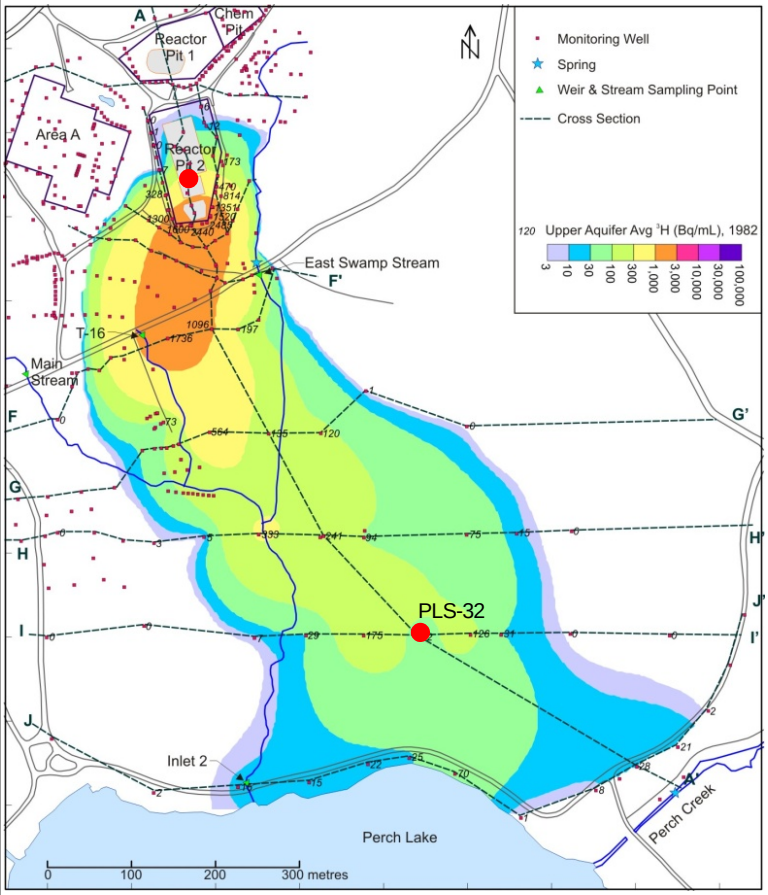
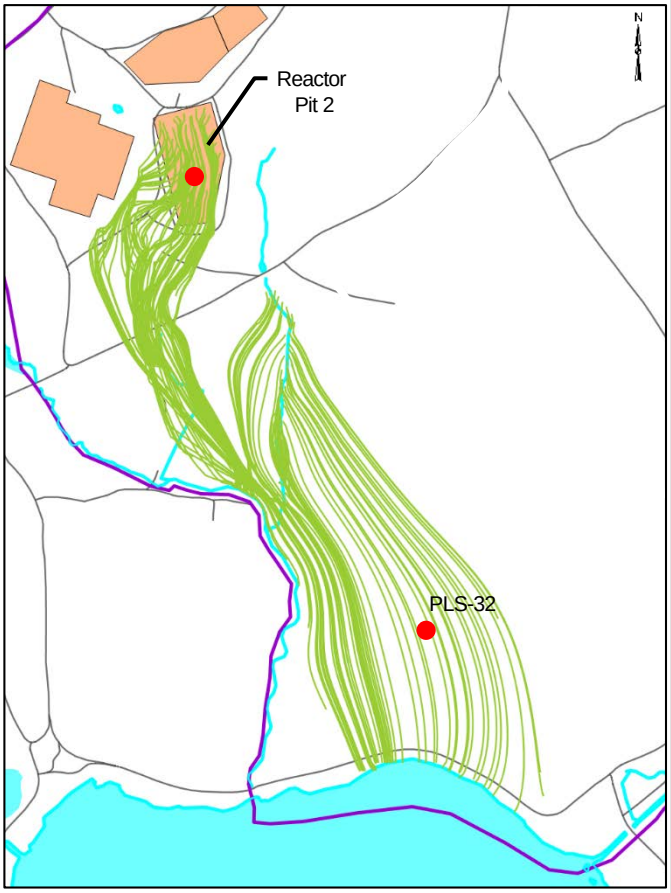


Figure 34 from CNL (2016b). Groundwater tritium concentrations in the Upper Sand Aquifer, the Middle Sand Aquifer, and the Basal Sand and Gravel Aquifer, 1982. This corresponds to a timeframe of approximately 25 years following release of mass from the RP2 area.



Simulated advective flow paths from RP2 after 25 years. Completed using MODPATH (does not consider dispersion).

	Average Velocity Between Reactor Pit 2 to PLS-32 (m/d)
Estimate Based on CNL, 2016	0.25
Groundwater Flow Model	0.26

LEGEND

- Simulated Groundwater Flow Path
- Model Boundary
- Roads
- Stream
- Waterbody
- Waste Management Area

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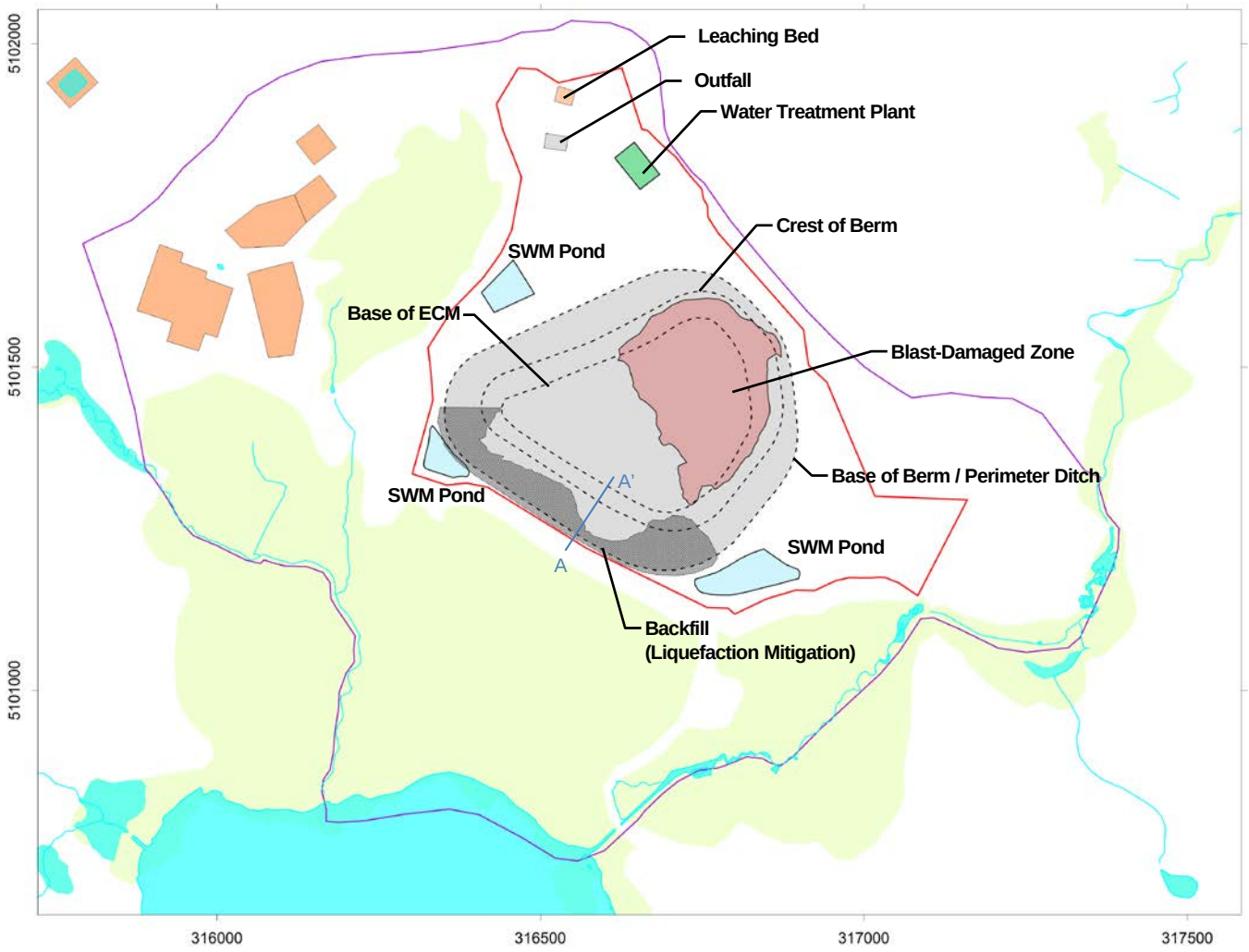
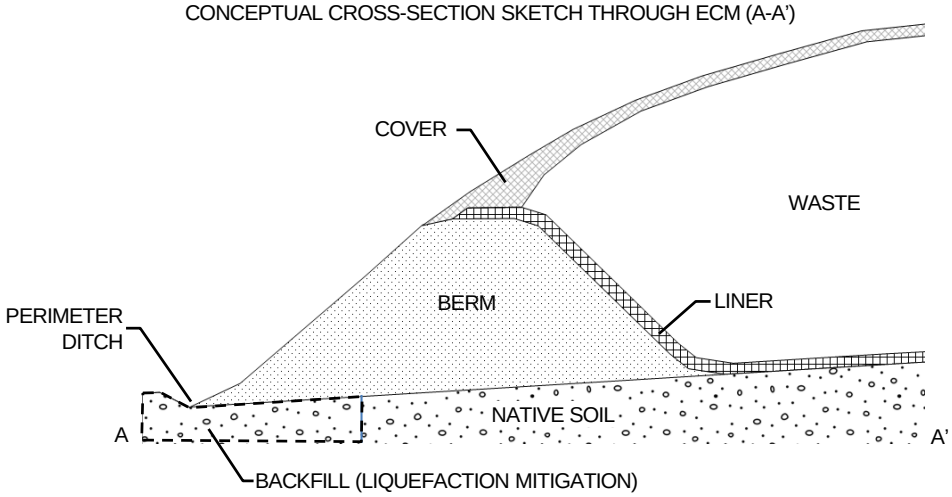
TITLE
MODEL CALIBRATION – COMPARISON OF GROUNDWATER FLOW PATHS AND TRITIUM PLUME MAPPING

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**3.7**



CONCEPTUAL CROSS-SECTION SKETCH THROUGH ECM (A-A')



LEGEND

- Model Boundary
- ECM
- NSDF Boundary
- Stream
- Wetland
- Waterbody
- Waste Management Area
- Blast Damaged Zone

NOTES:

1) Cross-sectional sketch for illustrative purposes only. Drawing is not to scale.
2) Cell locations shown in plan-view image are approximate.
3) Refer to AECOM (2018) for NSDF design details.

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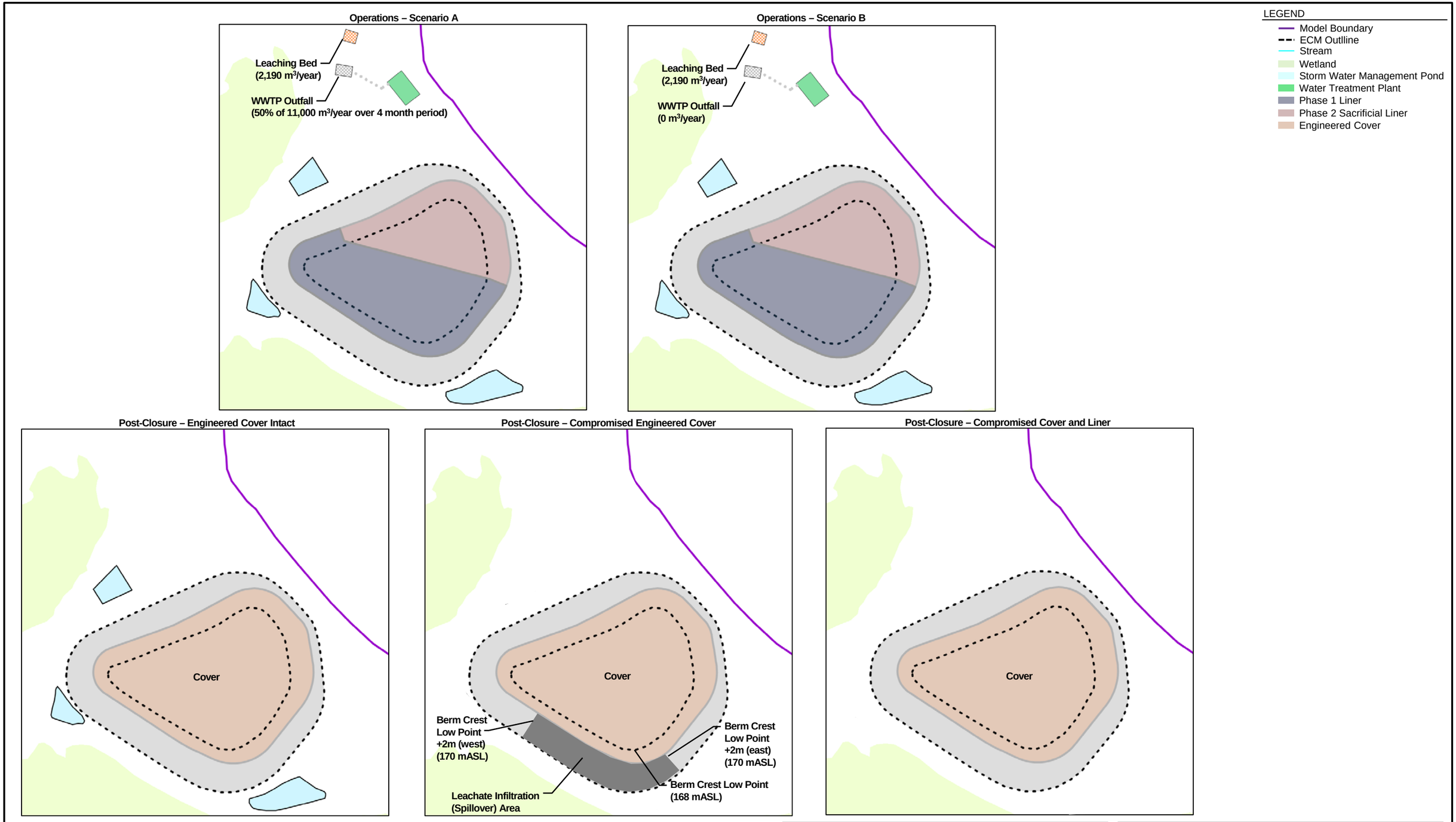
TITLE
SIMPLIFIED NSDF LAYOUT

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.1**



Notes:

1) For Operations Scenario A the 11,000 m3 discharge at the exfiltration gallery is applied over a 4 month period
2) For Operations Scenario B all treated effluent was assumed to be routed to Perch Lake (i.e., no discharge was applied to the exfiltration gallery)

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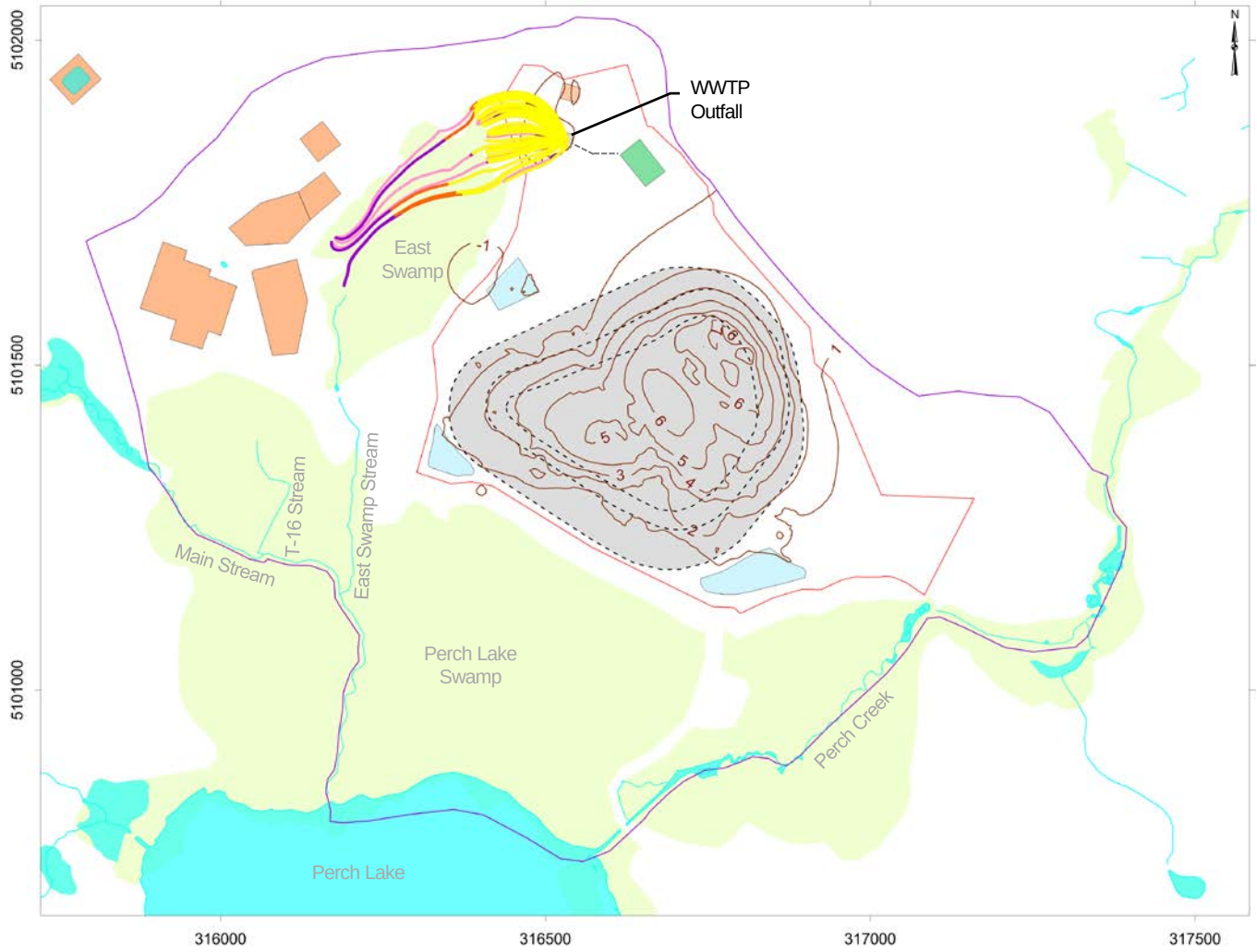
TITLE
GROUNDWATER MODELLING SCENARIOS

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	4.2



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- ECM Outline
- Waste Management Area
- Swamp

NOTES:

1) Scenario A represents the case where 1 cell is active, 11,000 m^3 is collected in the ECM with half of this volume discharged to the WTP exfiltration gallery over a four month period;
2) Recharge distribution is representative of long term average conditions
3) Runoff collection and re-routing to SWM ponds for the remaining cells;
4) Particle traces are shown from the WTP infiltration area;

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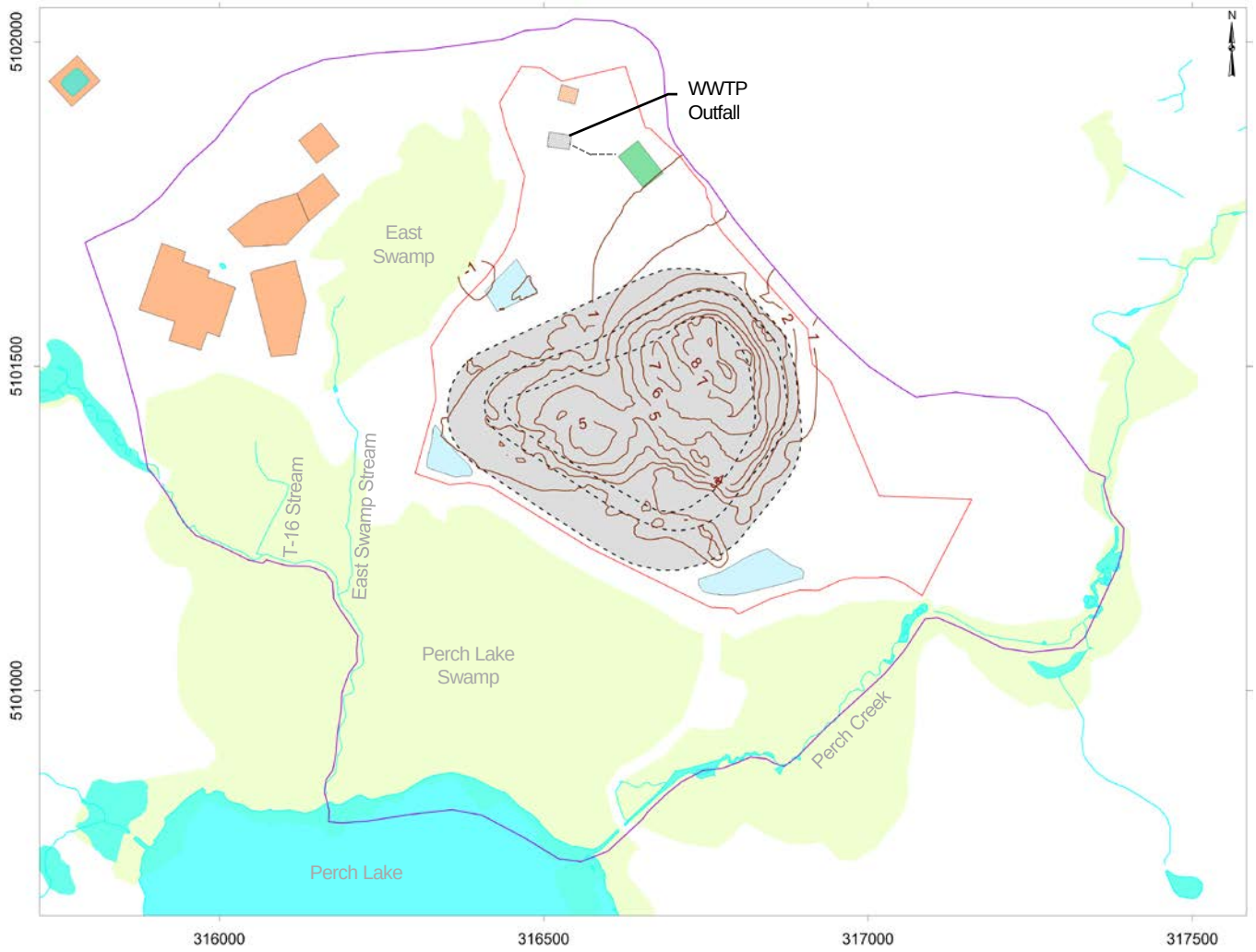
TITLE
Groundwater Flow Model Results – Operations Scenario A

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.3**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Stream
- ECM Outline
- Waste Management Area
- Swamp

NOTES:

1) Scenario B represents the case where 1 cell is active, and all water collected in the open cell is treated at the WTP and pumped to Perch Lake
2) Recharge distribution is representative of seasonal high water table conditions
3) Runoff collection and re-routing to SWM ponds for the remaining cells

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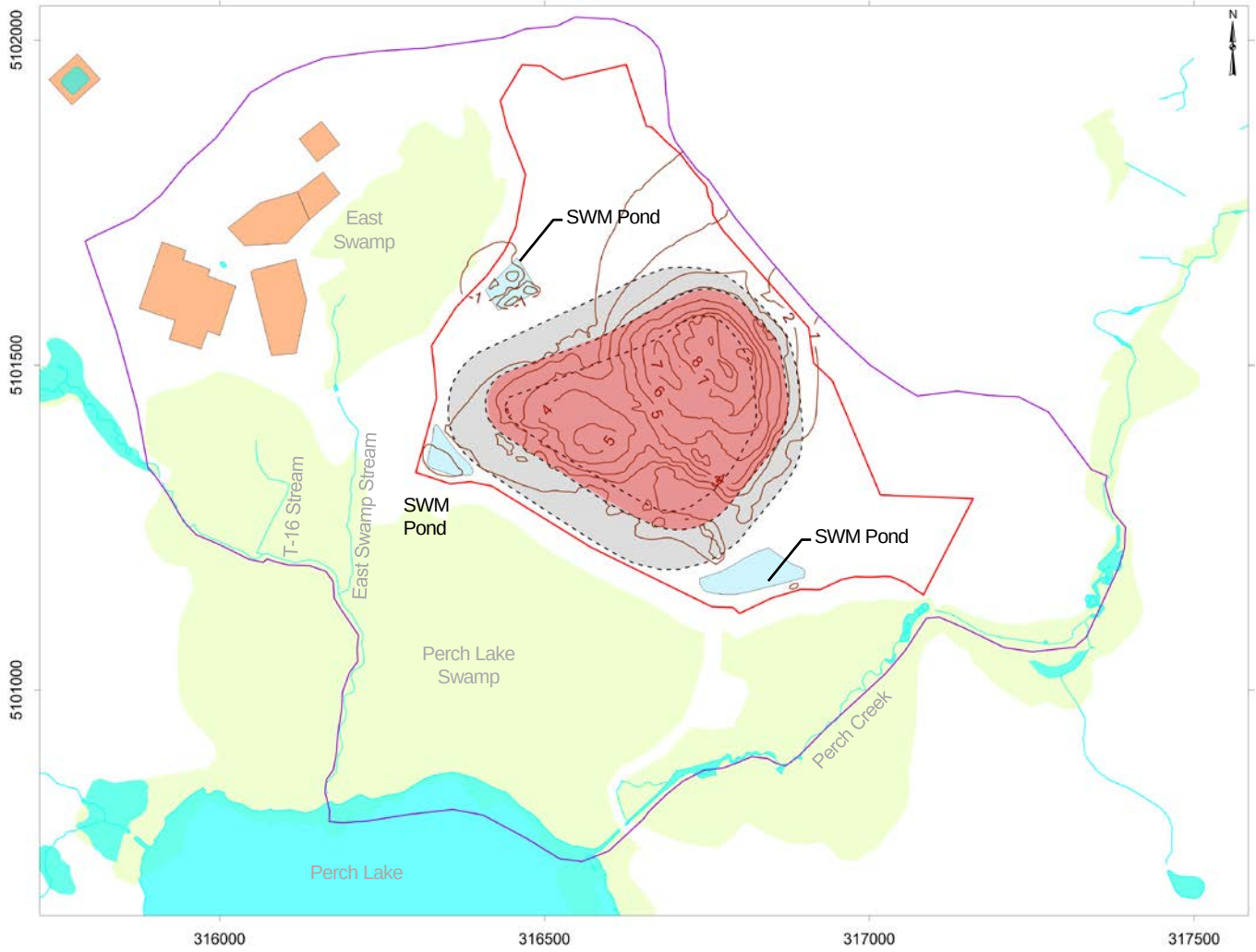
TITLE
Groundwater Flow Model Results – Operations Scenario B

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.4**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Stream
- ECM Outline
- Closed Cells
- Waste Management Area
- Swamp

NOTES:

1) All cells are closed with zero infiltration occurring over the ECM footprint.
2) Surface runoff from ECM directed to surface water ponds. Infiltration occurs through the base of the ponds bottoms as their liners are assumed to be compromised

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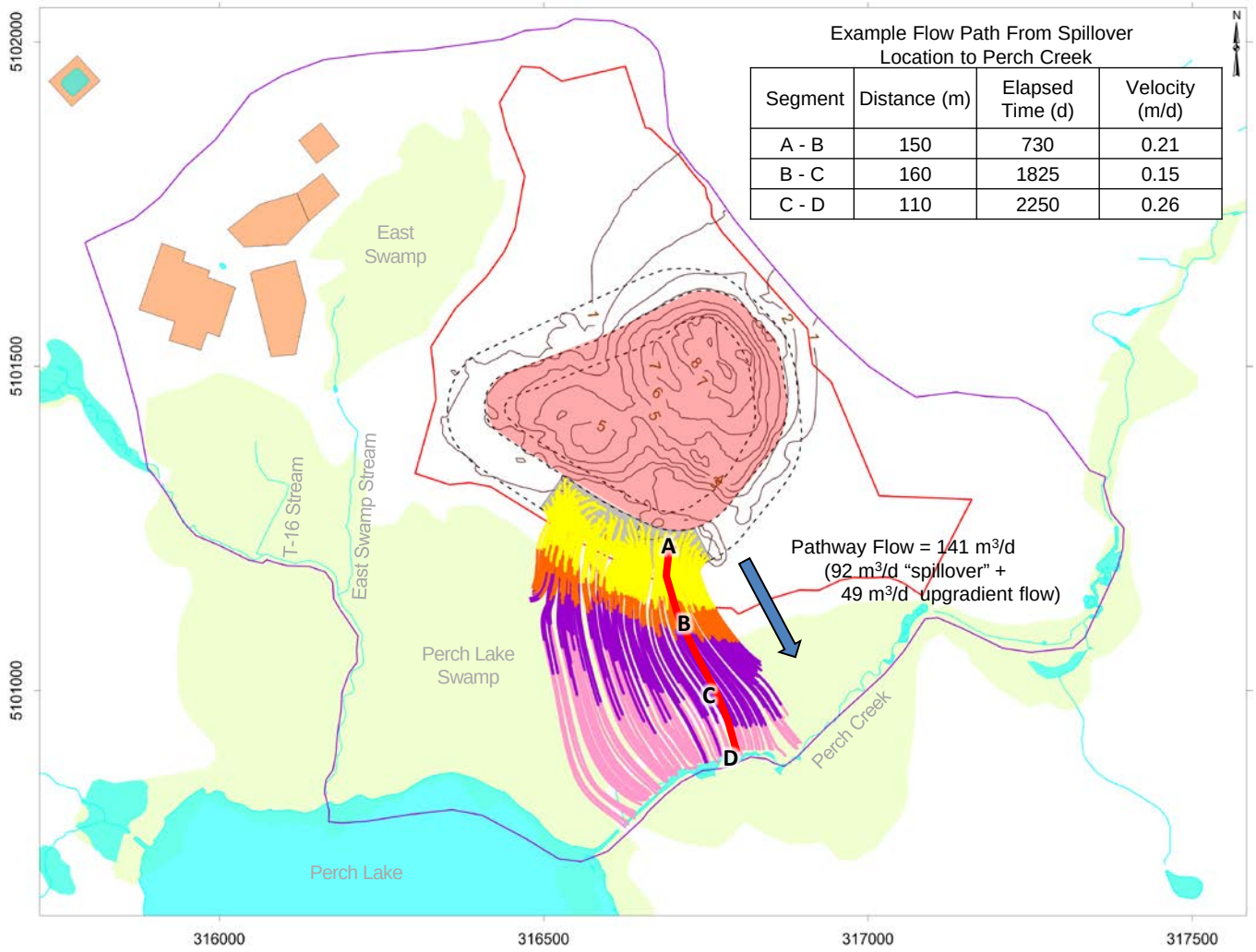
TITLE
Groundwater Flow Model Results – Post Closure with Final Cover Intact

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.5**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- ECM Outline
- Spillover Infiltration Area
- Closed Cells
- Waste Management Area
- Swamp

NOTES:

1) Natural/background infiltration the exfiltration gallery and ponds;
2) No runoff collection;
3) 0.3 m/yr infiltration occurs through the cover. This is applied as infiltration at the spillover location.

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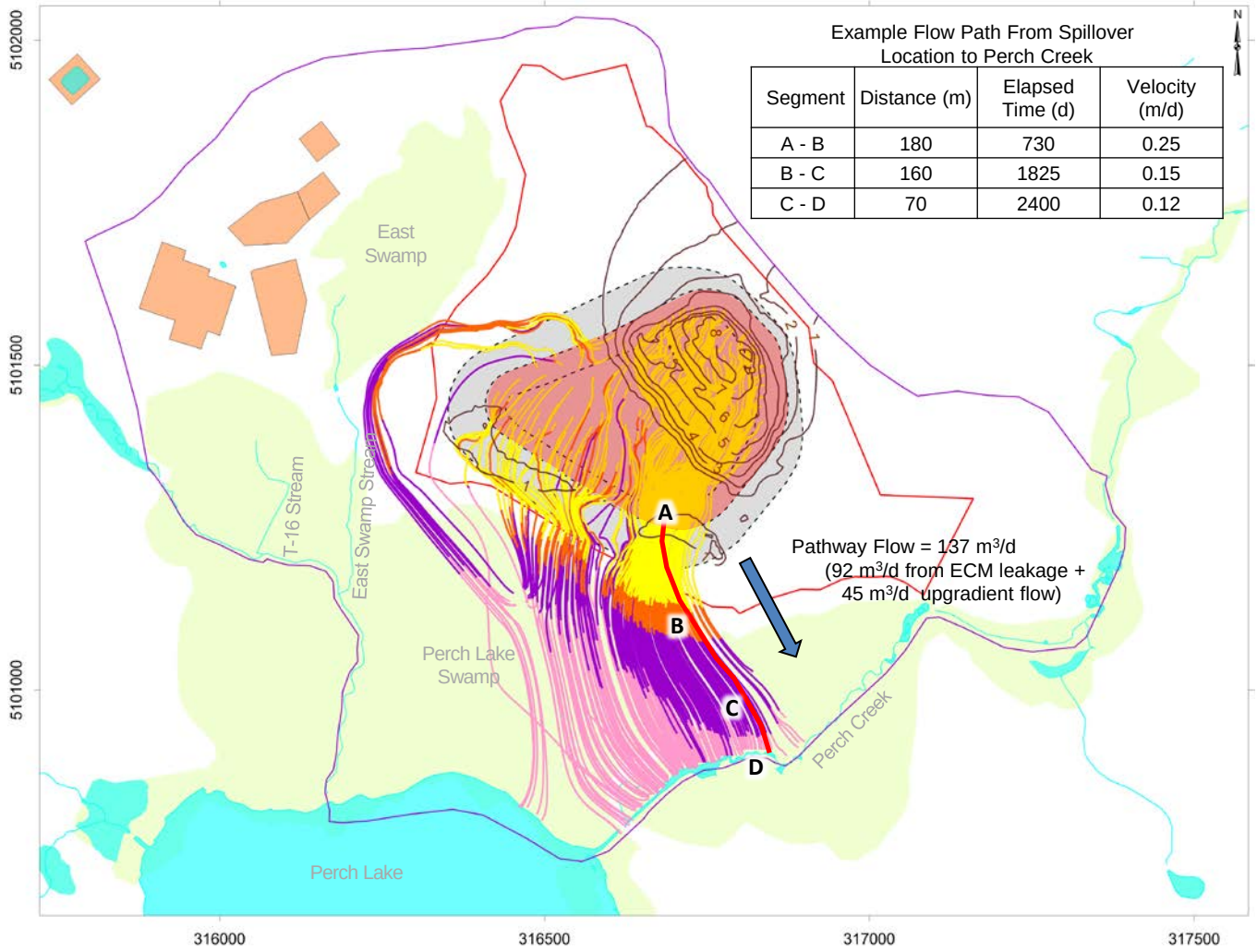
TITLE
Groundwater Flow Model Results – Post Closure with Compromised Final Cover

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.6**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- ECM Outline
- Spillover Infiltration Area
- Closed Cells
- Waste Management Area
- Swamp

NOTES:

1) Natural/background infiltration the exfiltration gallery and ponds;;
2) No runoff collection;
3) 0.3 m/yr infiltration occurs through the cover, which is applied throughout the ECM footprint.

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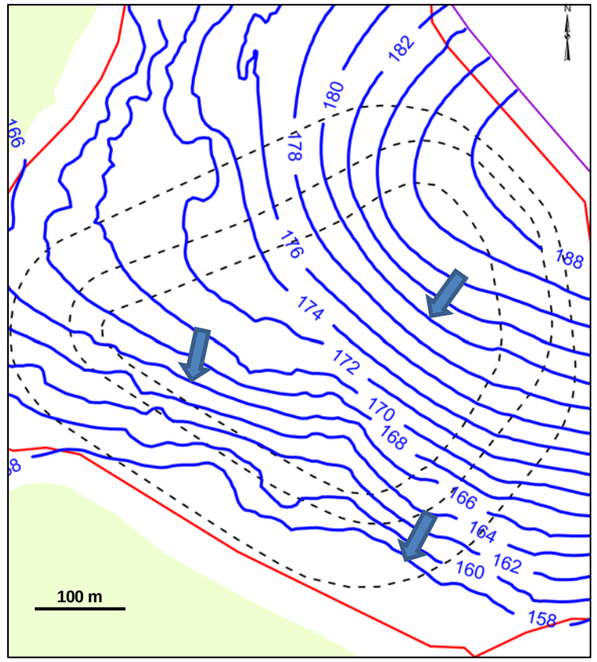
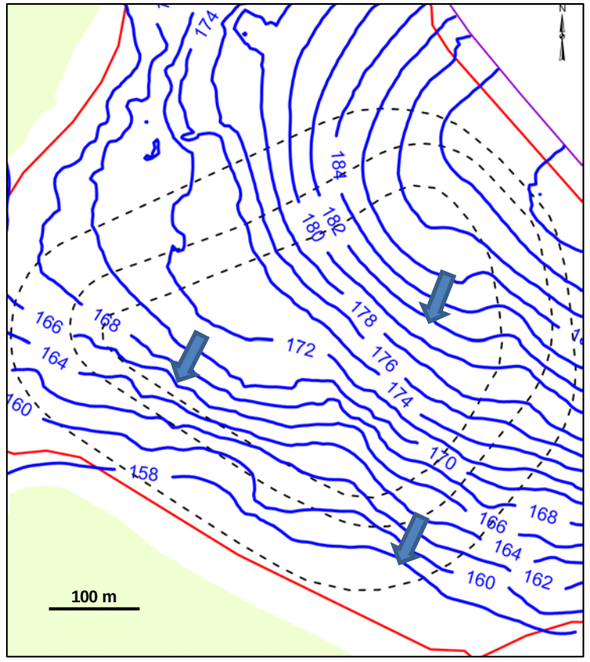
TITLE
Groundwater Flow Model Results – Post Closure with Compromised Final Cover and Liner

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.7**

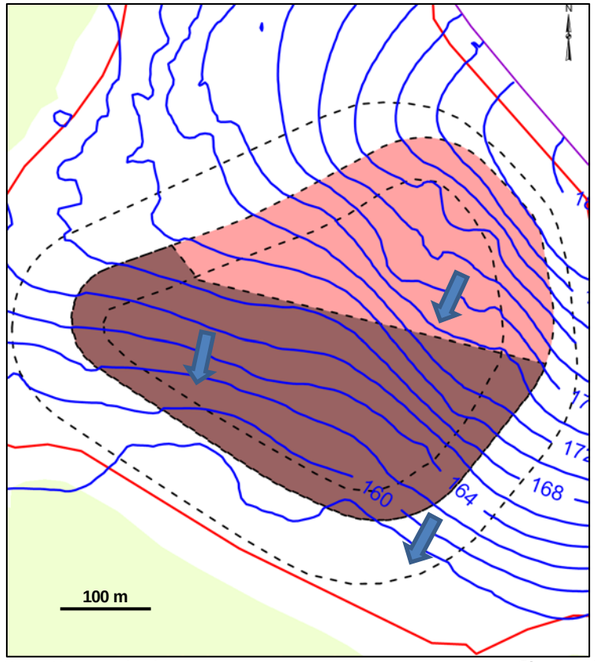
Calibrated Model (No Facility) – Average Conditions



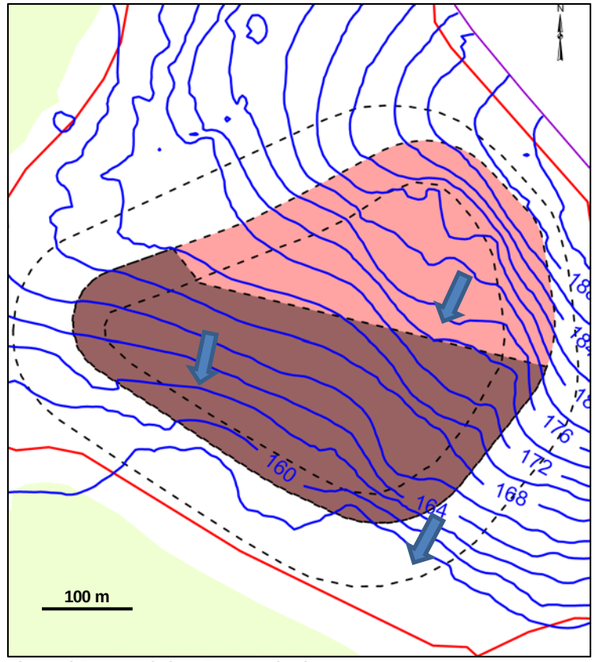
Calibrated Model (No Facility) – High Water Table Conditions



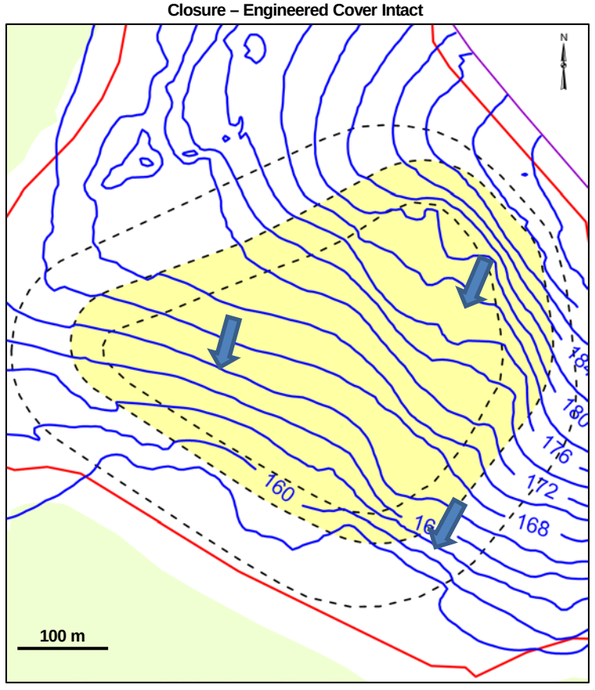
Operations – Scenario A



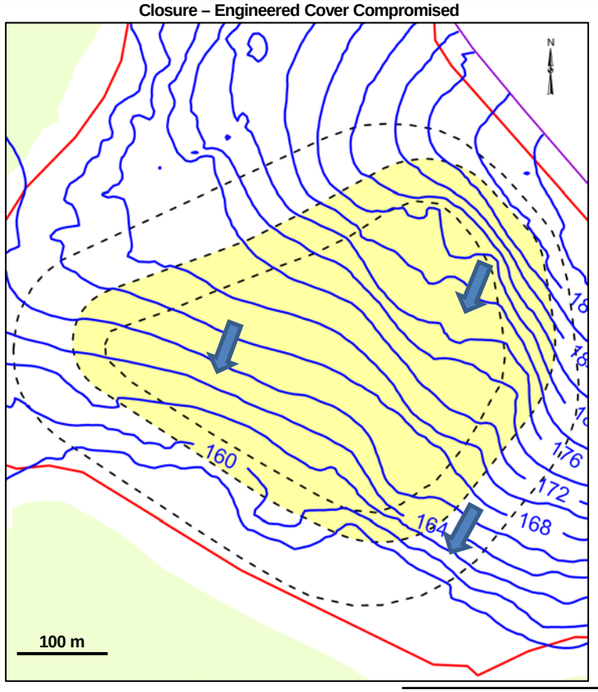
Operations – Scenario B



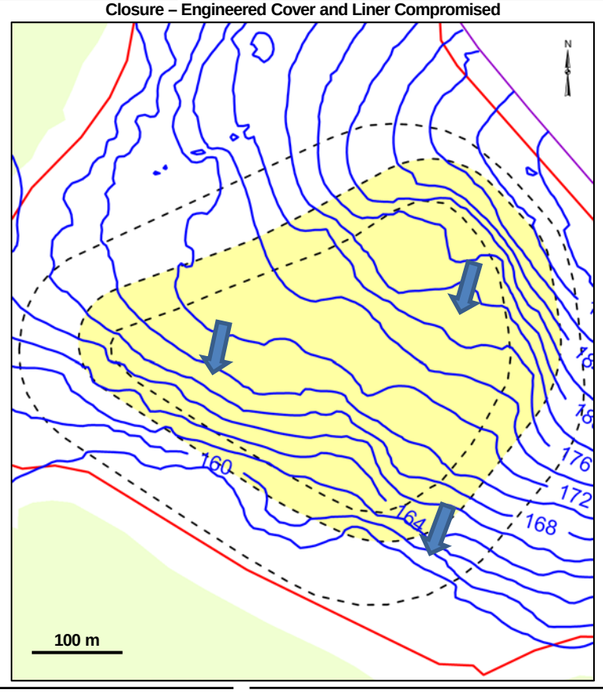
Closure – Engineered Cover Intact



Closure – Engineered Cover Compromised



Closure – Engineered Cover and Liner Compromised



LEGEND

- Model Boundary
- ECM Outline
- Simulated Groundwater Table Elevation
- Stream
- NSDF Study Area
- Wetland
- Phase 1 Liner
- Phase 2 Sacrificial Liner
- Closed Cells
- Interpreted Groundwater Flow Direction

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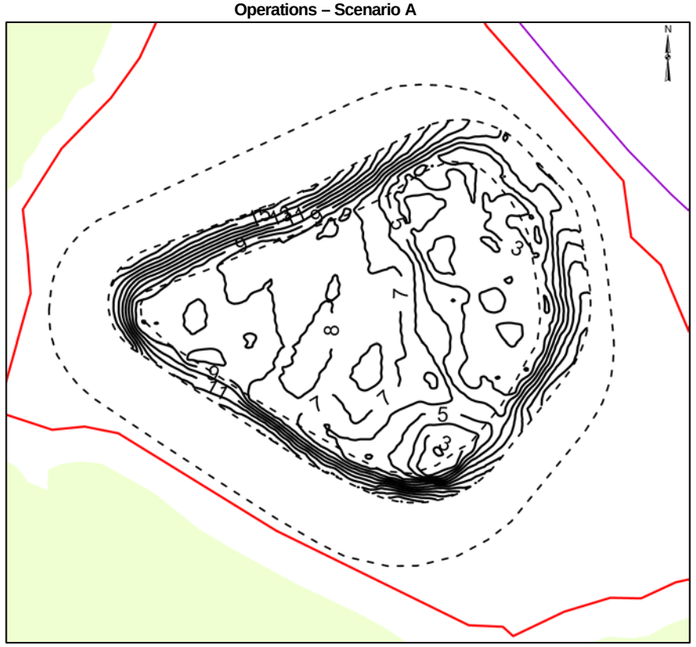
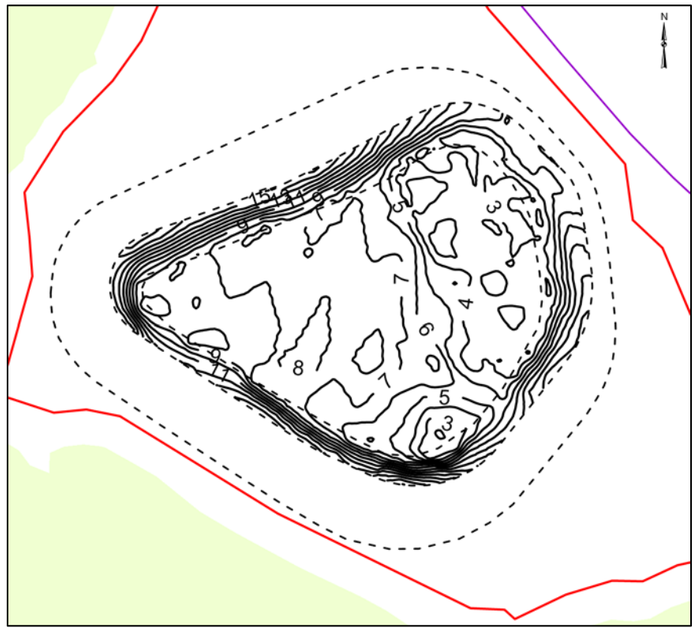
TITLE
SIMULATED GROUNDWATER TABLE ELEVATION – CALIBRATED MODEL AND ALL FORECAST SCENARIOS

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	4.8

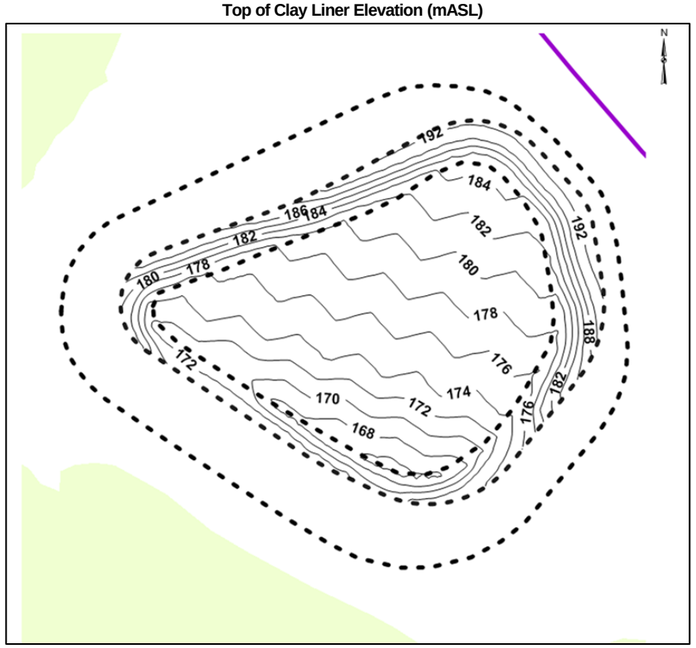
Operations – Scenario A



Operations – Scenario B

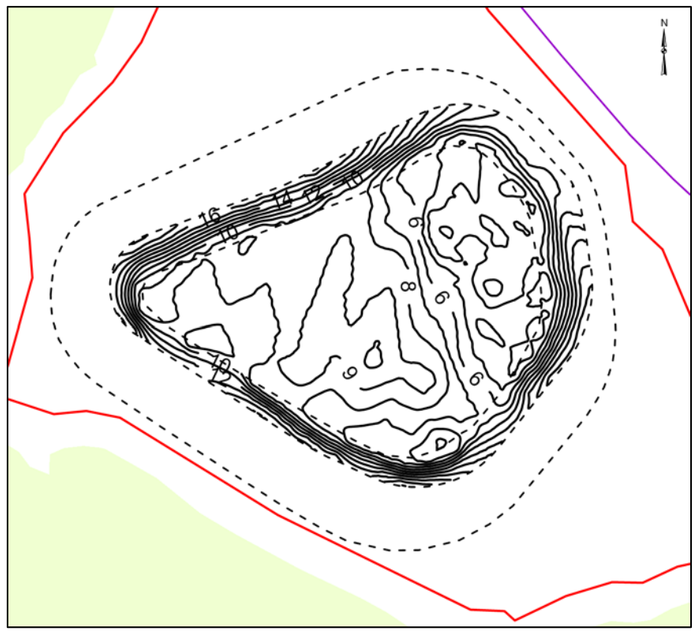


Top of Clay Liner Elevation (mASL)

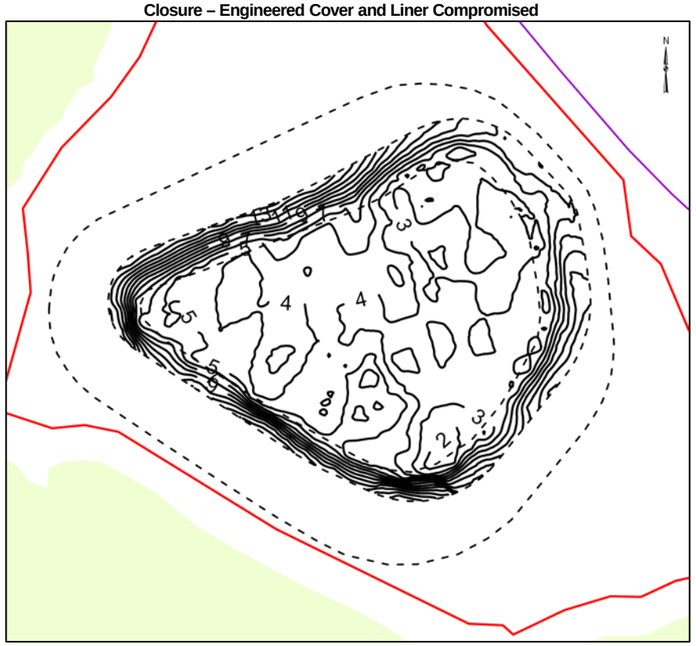


Closure – Engineered Cover Intact

Closure – Engineered Cover Compromised



Closure – Engineered Cover and Liner Compromised



LEGEND

- Model Boundary
- ECM Outline
- NSDF Study Area
- Top of Clay Liner minus Simulated Water Table
- Wetland

Notes:

1. Maps calculated as the difference between the top of the primary liner (shown on the image to the right) and the simulated water table elevations (shown on Figure 4.8).

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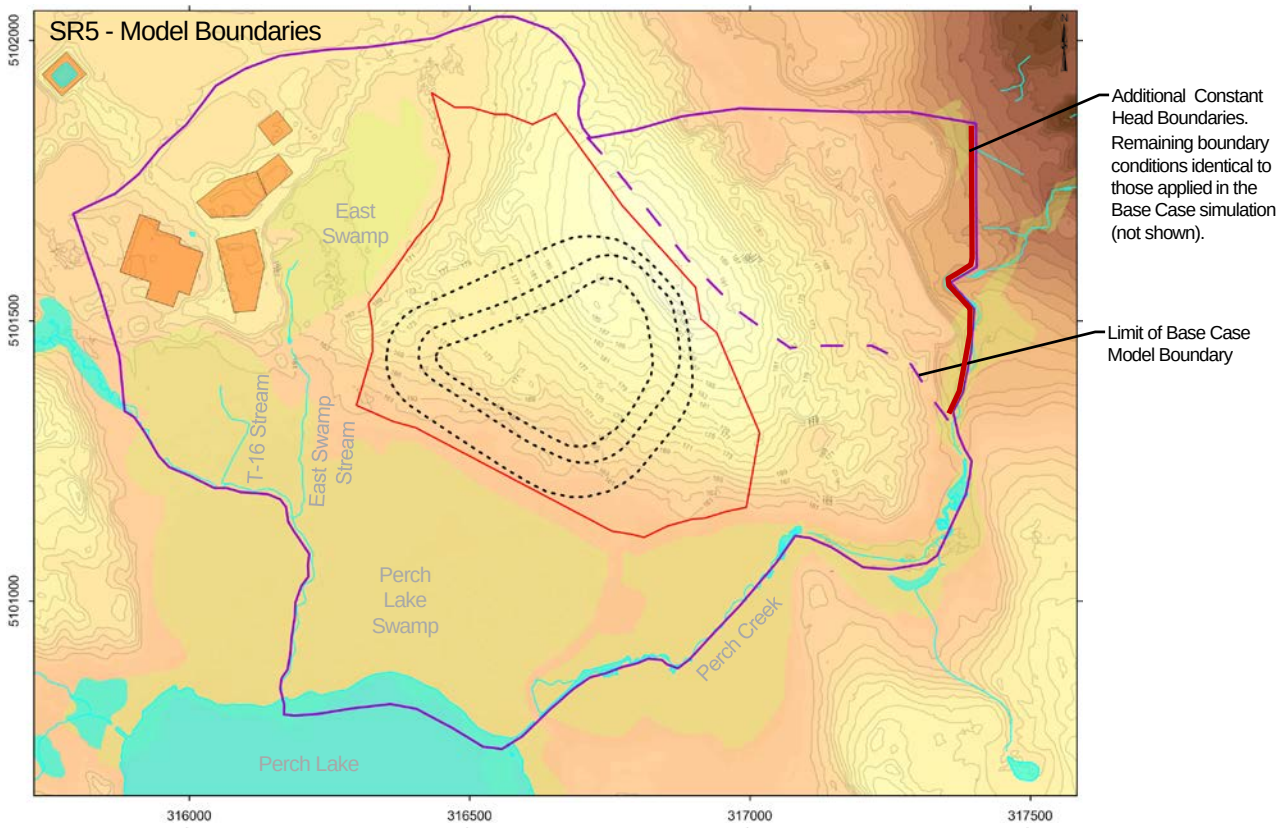
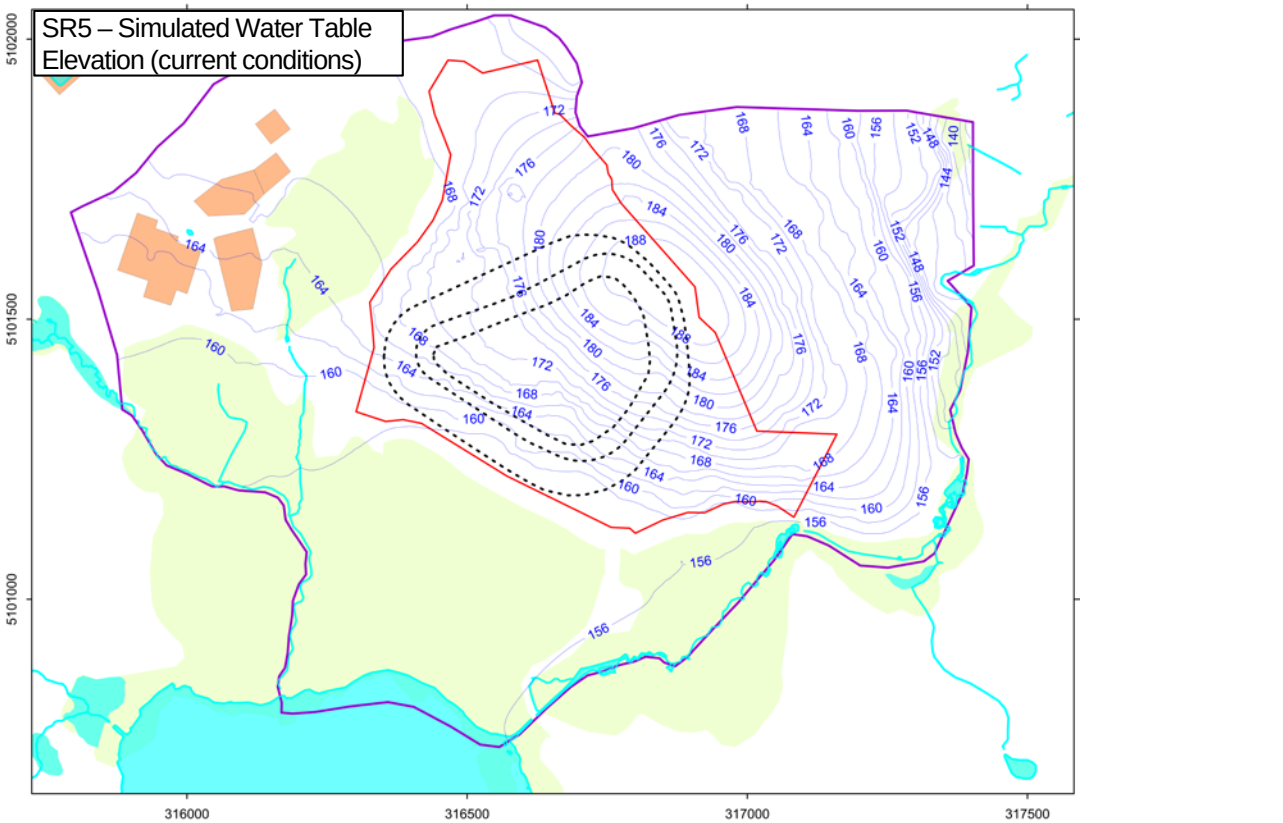
APPROVED	SD

PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
COMPARISON OF SIMULATED WATER TABLE ELEVATION AND TOP OF CLAY LINER ELEVATION

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	4.9





LEGEND

- Model Boundary
- Original Model Boundary
- Simulated Water Table Elevation
- Stream
- WMA
- Swamp
- ECM Outline
- NSDF Boundary

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NEAR SURFACE DISPOSAL FACILITY
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REVIEW	SD
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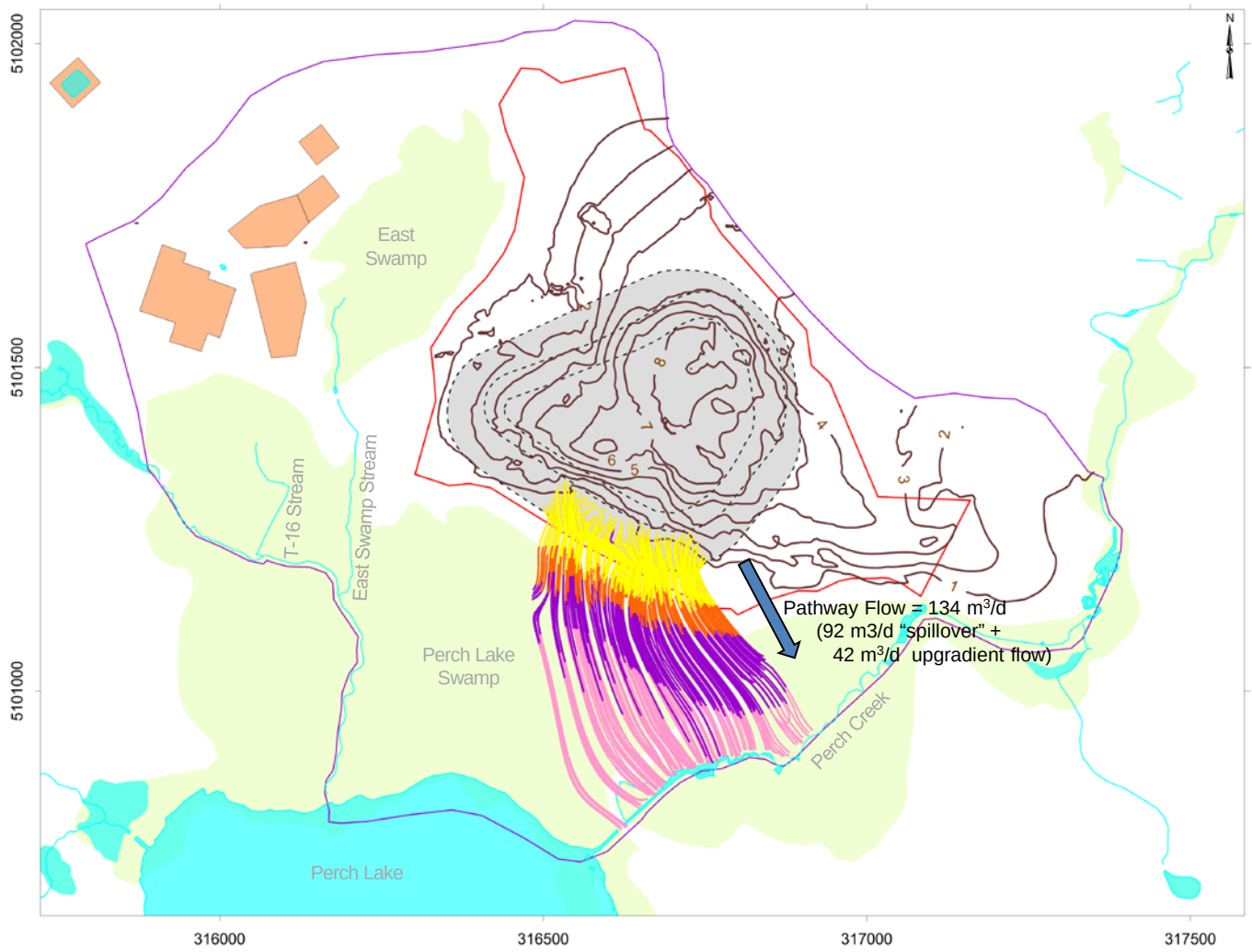
TITLE
Model Setup of SR5 (Lateral Expansion of Model Boundary)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.10**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- NSDF Boundary
- ECM Outline
- Waste Management Area
- Swamp

NOTES:

1) Refer to Figure 4.6 for a comparison with the results from the base case model;
2) SR1 corresponds to a global increase in hydraulic conductivity of the upper 6 m of the bedrock;
3) Particle traces are shown originating from the spillover location.

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PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

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PREPARED	CWT
DESIGN	NFB
REVIEW	SD
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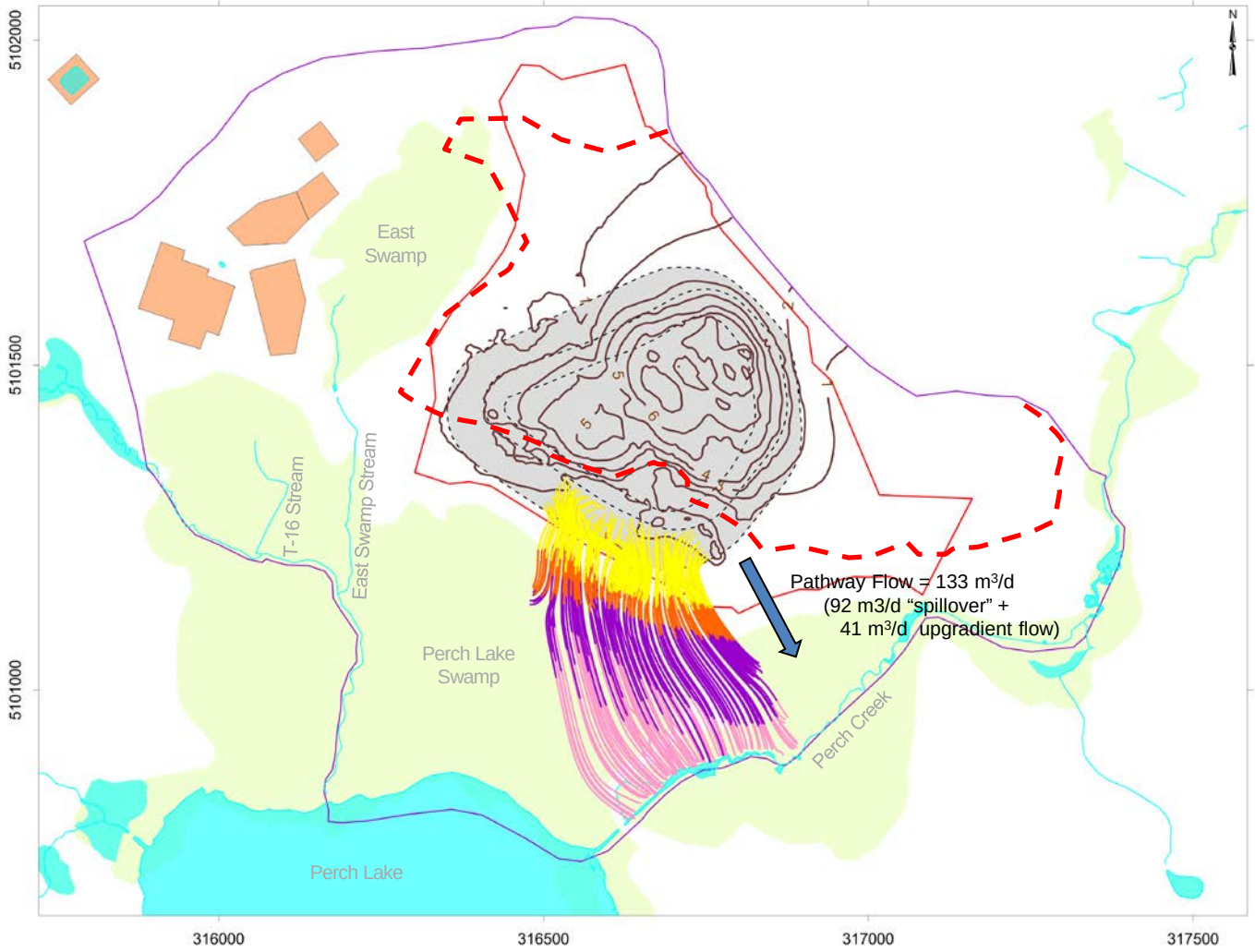
TITLE
Groundwater Flow Model Results – SR1 (Global Increase in Upper Bedrock Hydraulic Conductivity)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.11**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Extent of Local Increase in Bedrock Hydraulic Conductivity
- Stream
- ECM Outline
- NSDF Boundary
- Waste Management Area
- Swamp

NOTES:

1) Refer to Figure 4.6 for a comparison with the results from the base case model;
2) SR2 corresponds to a local increase in hydraulic conductivity of the upper 6 m of the bedrock (where the bedrock elevation is above 164 mASL);
3) Particle traces are shown originating from the spillover location.

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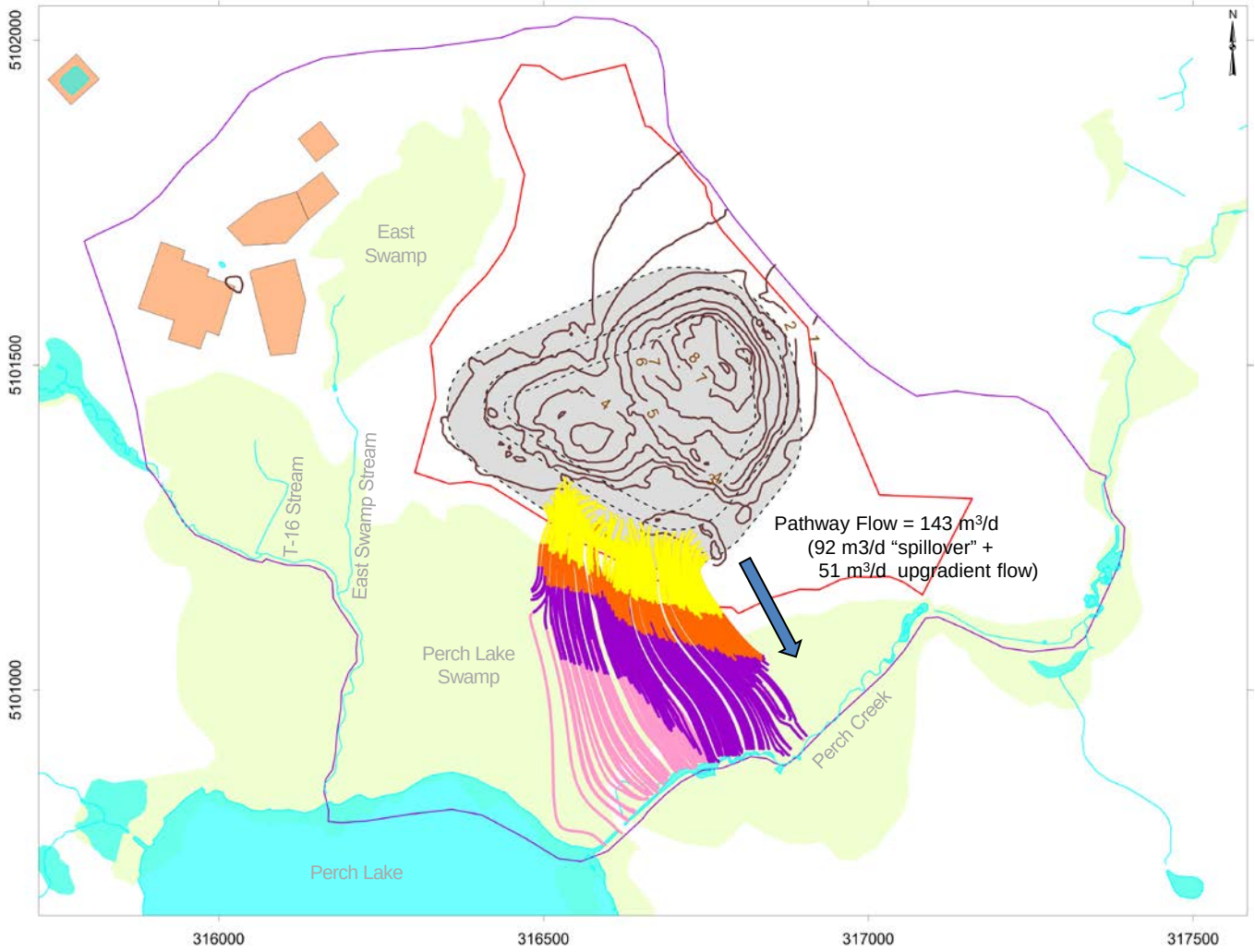
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
Groundwater Flow Model Results – SR2 (Local Increase in Upper Bedrock Hydraulic Conductivity)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.12**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)

Groundwater Particle Traces
- 0 to 1-year
- 1 to 2-year
- 2 to 5-year
- Steady-State

- Stream
- ECM Outline
- NSDF Boundary
- Waste Management Area
- Swamp

NOTES:
1) Refer to Figure 4.6 for a comparison with the results from the base case model;
2) SR3 corresponds to a global increase in hydraulic conductivity of the sand units;
3) Particle traces are shown originating from the spillover location.

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NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

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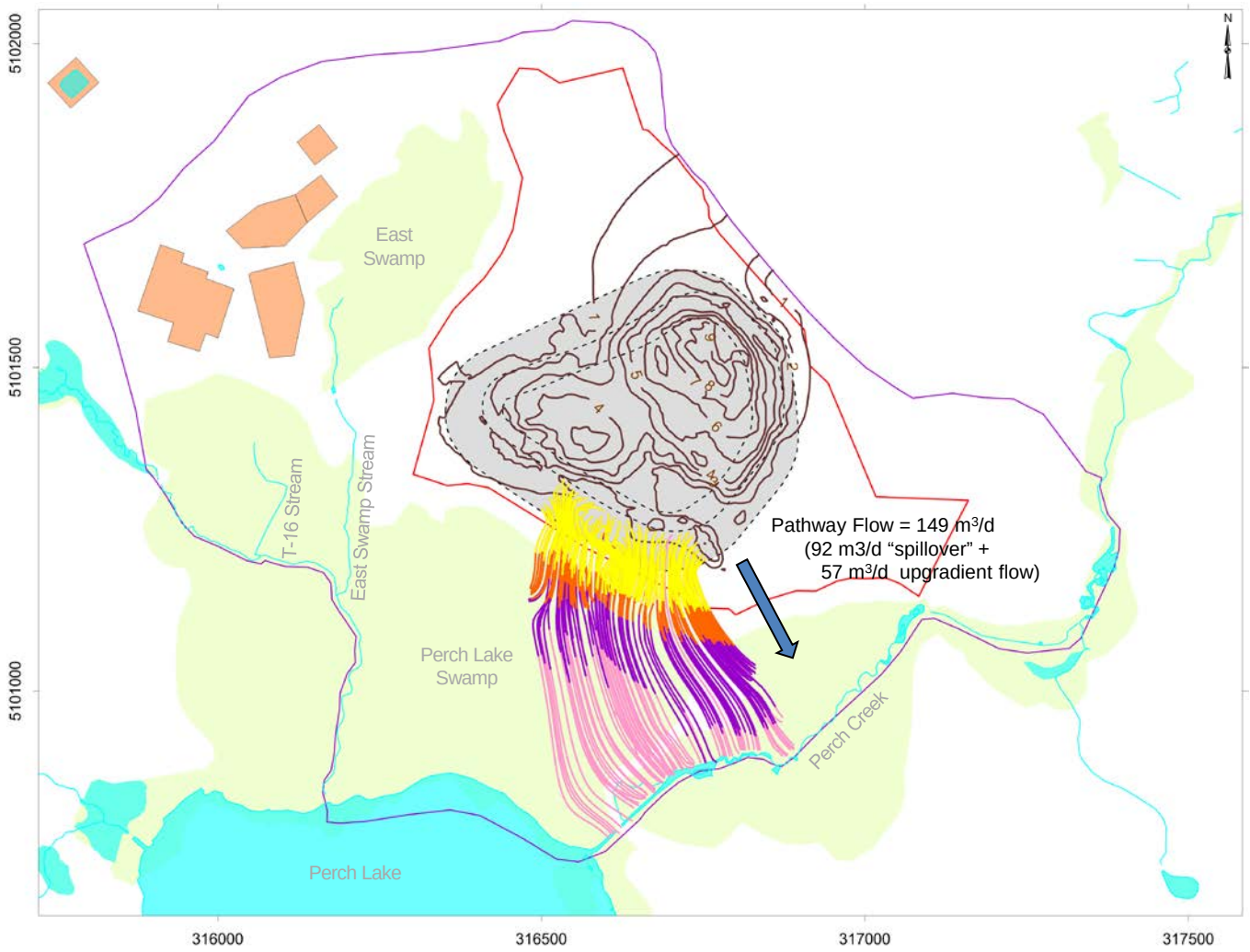
PREPARED	CWT
DESIGN	NFB
REVIEW	SD
APPROVED	SD

TITLE
Groundwater Flow Model Results – SR3 (Global Increase in Sand Hydraulic Conductivity)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.13**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- ECM Outline
- NSDF Boundary
- Waste Management Area
- Swamp

NOTES:
1) Refer to Figure 4.6 for a comparison with the results from the base case model;
2) SR4 corresponds to a global 30% increase in surficial recharge;
3) Particle traces are shown originating from the spillover location.

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REVIEW	SD
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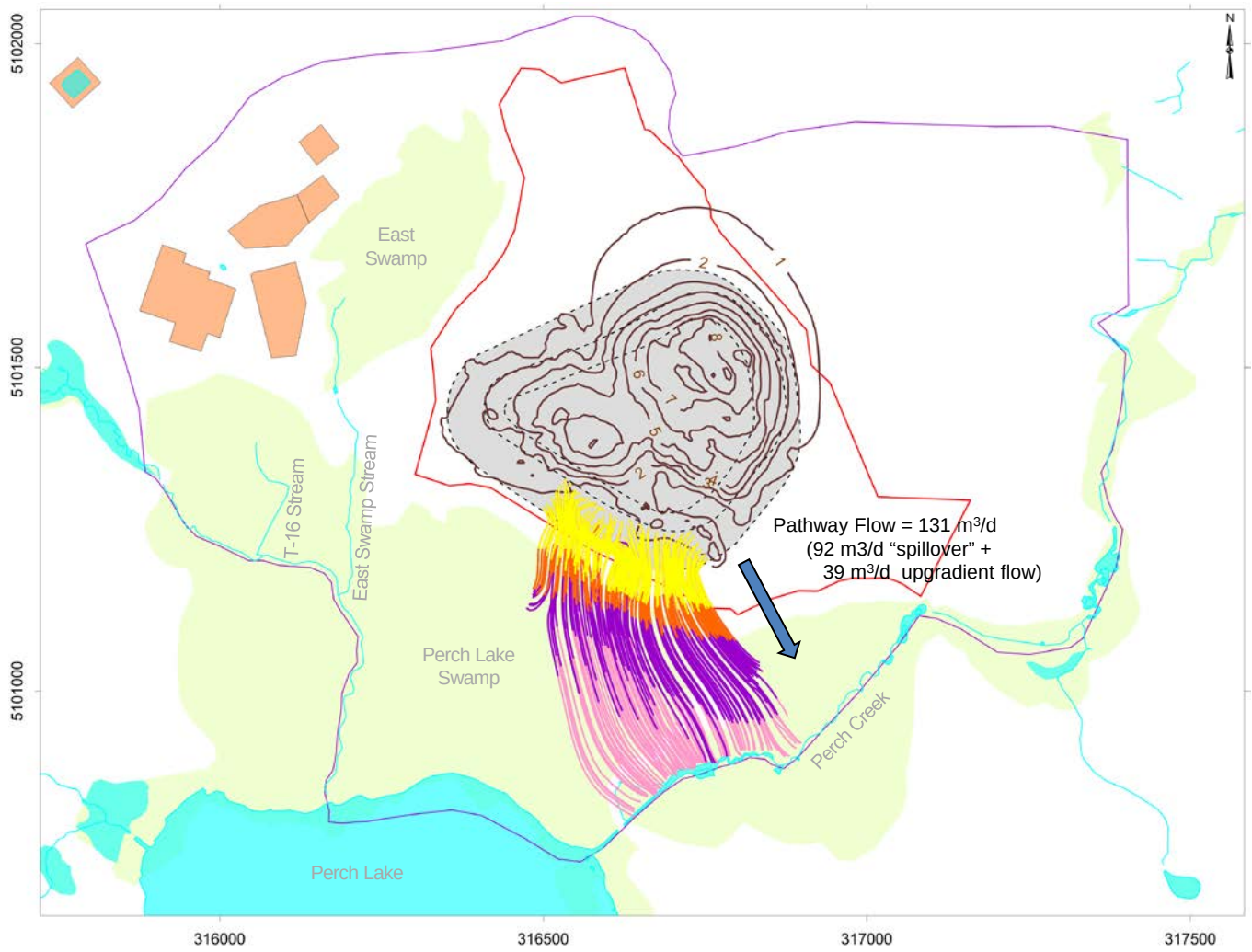
TITLE
Groundwater Flow Model Results – SR4 (Global 30% Increase in Recharge)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.14**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- ECM Outline
- NSDF Boundary
- Waste Management Area
- Swamp

NOTES:
1) Refer to Figure 4.6 for a comparison with the results from the base case model;
2) SR5 corresponds to an extension of the model domain;
3) Particle traces are shown originating from the spillover location;

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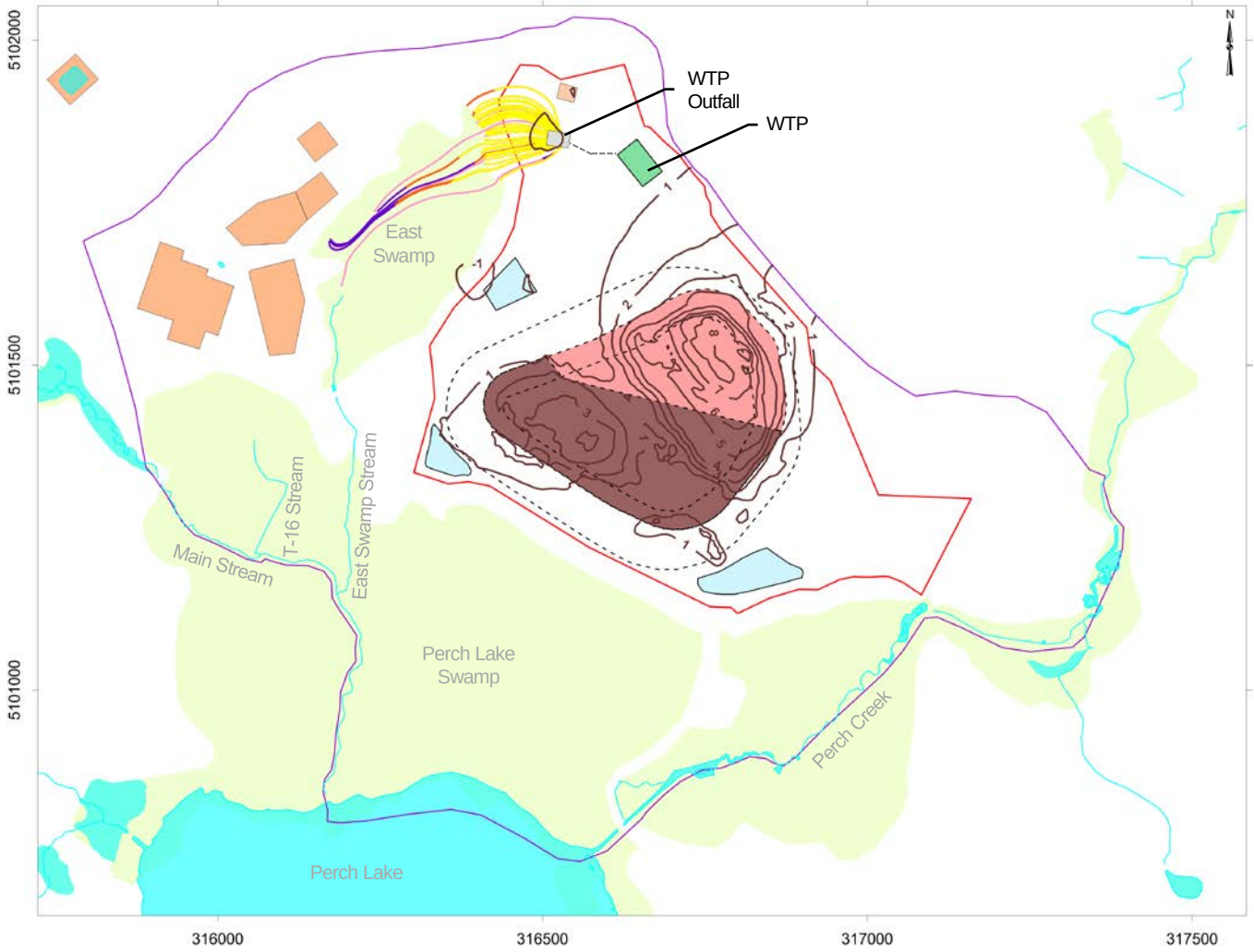
TITLE
Groundwater Flow Model Results – SR5 (Lateral Expansion of Model Boundary)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.15**



LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Groundwater Particle Traces
  - 0 to 1-year
  - 1 to 2-year
  - 2 to 5-year
  - Steady-State
- Stream
- Phase 1 Liner
- Phase 2 Sacrificial Liner
- ECM Outline
- Waste Management Area
- Swamp

NOTES:
1) SR6 is based on Operations Scenario A, though with 300 mm/yr infiltration applied over the phase 2 ECM area to represent a compromised sacrificial liner;
2) For this simulation the high water table condition was applied
3) Particle traces are shown from the WTP exfiltration gallery;

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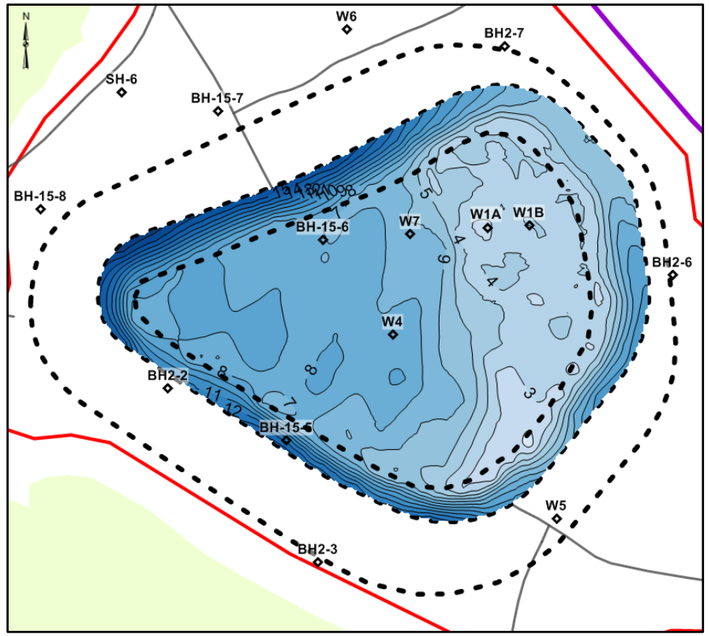
PREPARED	CWT
DESIGN	NFB
REVIEW	SD
APPROVED	SD

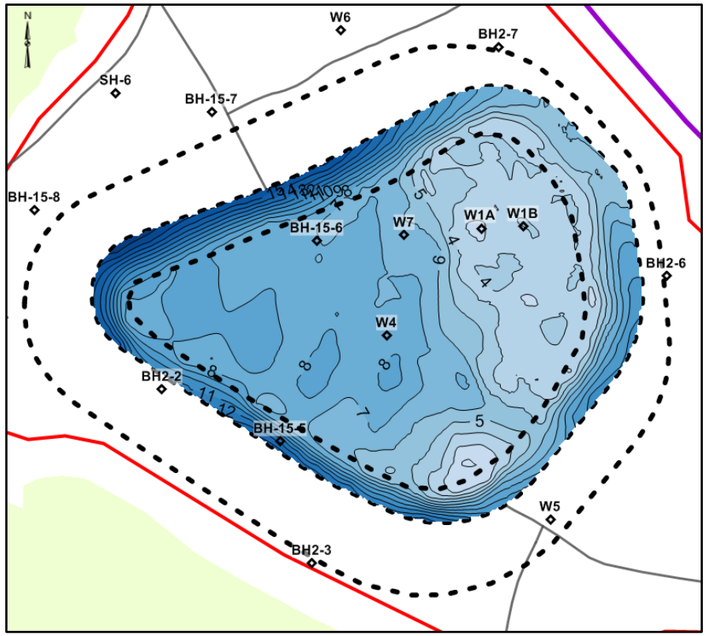
TITLE
Groundwater Flow Model Results – SR6 (Compromised Sacrificial Liner)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.16**

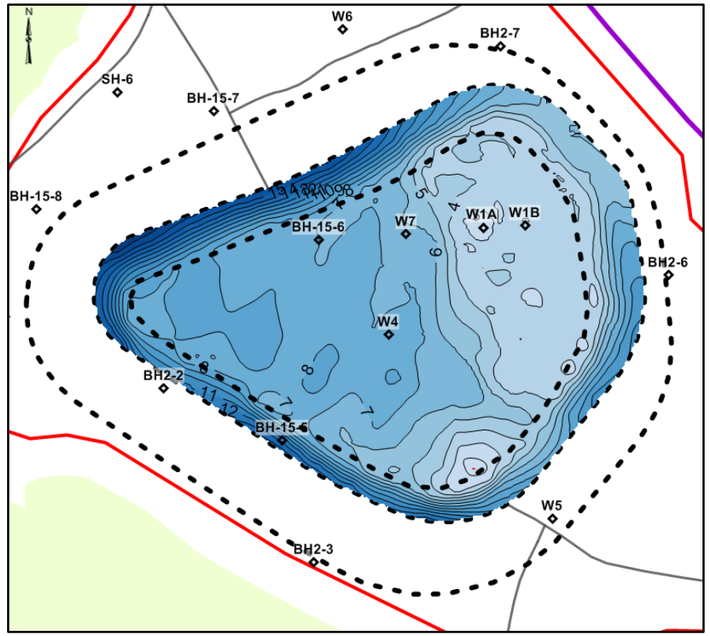
SCENARIO 1 – BLAST ZONE $6x10^{-4}$ m/s



SCENARIO 2 – BLAST ZONE $1x10^{-4}$ m/s



SCENARIO 3 – BLAST ZONE $5x10^{-5}$ m/s



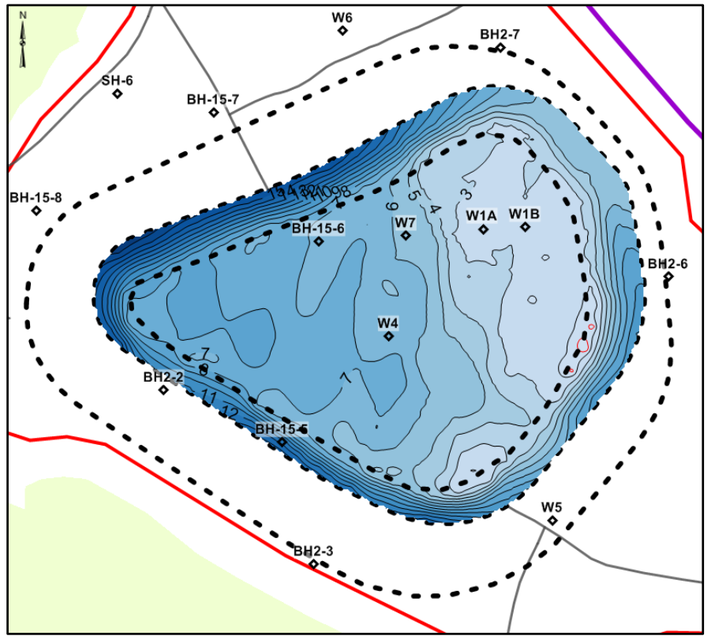
LEGEND

- Model Boundary
- Extent of ECM Berm
- Swamp
- Roads (existing)
- NSDF Boundary
- Monitoring Well Location

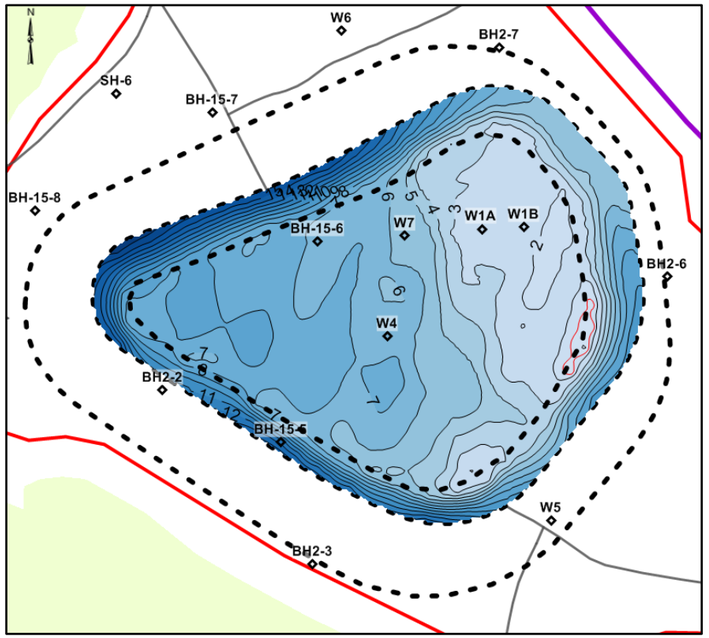
Separation between the Primary Liner and the Simulated Water Table (m)

15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1.5, 1, 0, -1, -2, -3

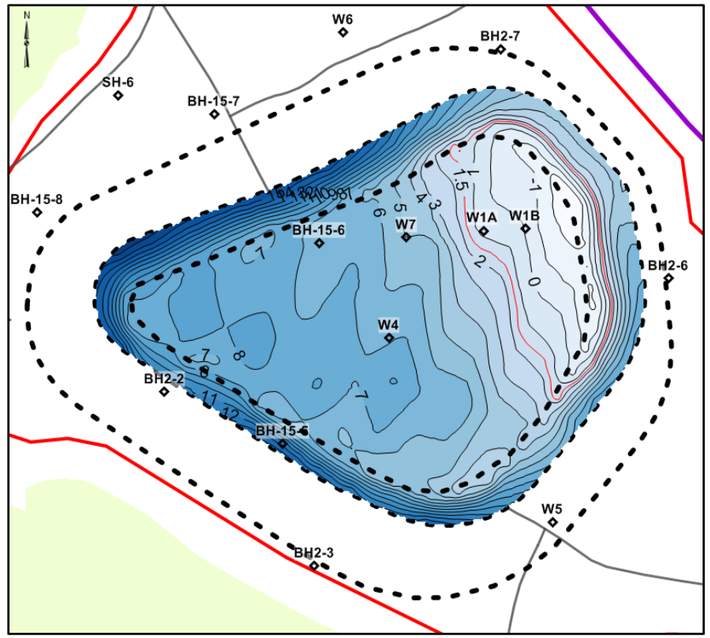
SCENARIO 4 – BLAST ZONE $1x10^{-5}$ m/s



SCENARIO 5 – BLAST ZONE $8x10^{-6}$ m/s



SCENARIO 6 – BLAST ZONE $1x10^{-6}$ m/s



Scenario	Blast-Damaged Zone Hydraulic Conductivity (m/s)	Hydraulic Conductivity Ratio - Blast Zone to Intact Rock
1	6E-04	15,000
2	1E-04	2,500
3	5E-05	1,250
4	1E-05	250
5	8E-06	200
6	1E-06	25

NOTES:
1) Primary liner elevations based on 100% design drawing B1550-106120-102-01-GA-D (provided by AECOM).

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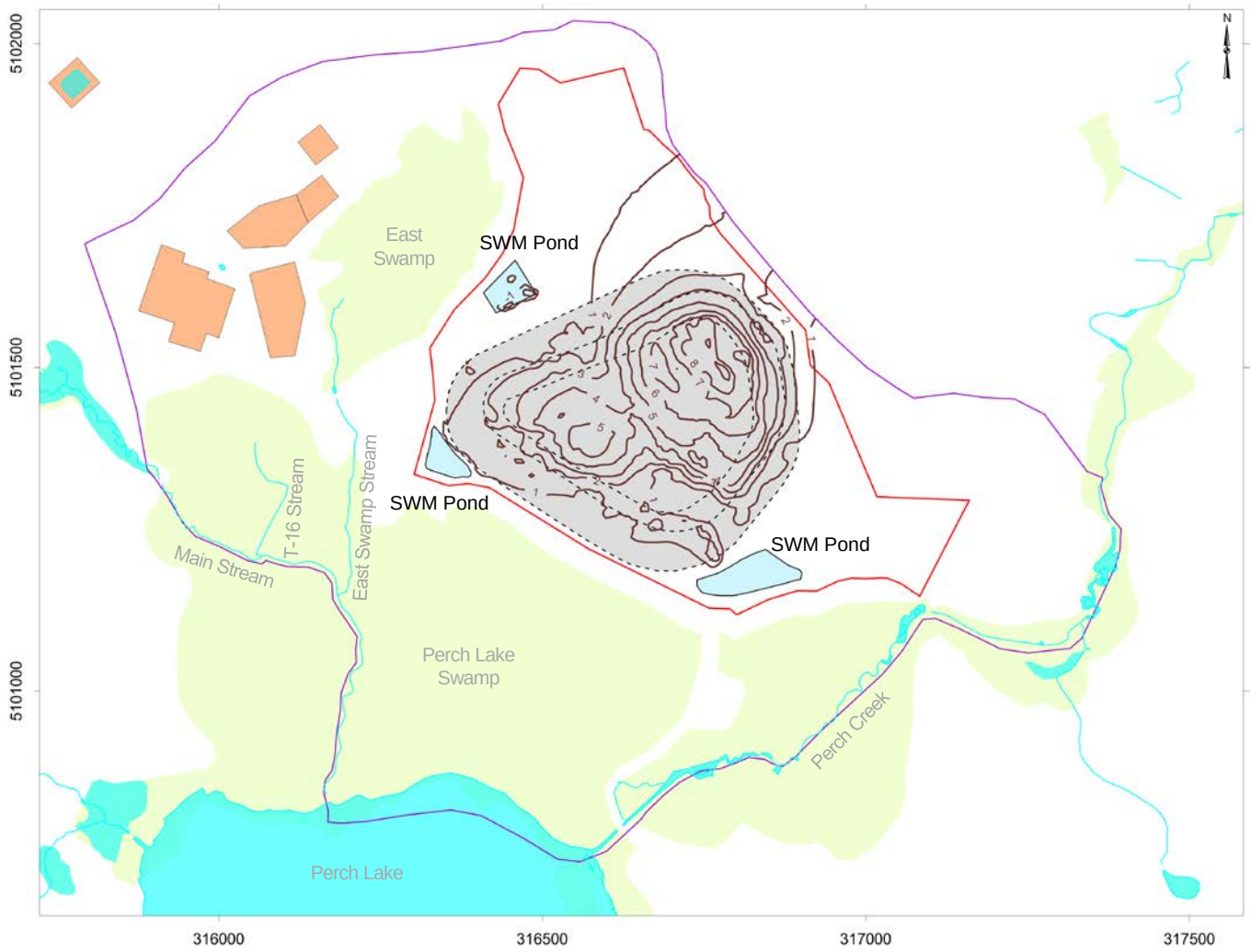
PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
GROUNDWATER FLOW MODEL RESULTS – SR7 (BLAST DAMAGED ZONE HYDRAULIC CONDUCTIVITY)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	4.17



Simulated Groundwater Discharge to Surface Water Features

	Calibrated Groundwater Flow Model (High Water Table)	Post-Closure Cover Intact, no ET	Post-Closure Cover Intact, with ET	Percent Change Following Application of ET
East Swamp (upstream of weir)	101	168	114	-32%
East Swamp (downstream of weir)	-91	-63	-83	-31%
T-16 Stream	-137	-137	-137	0%
Main Stream	-53	-50	-53	-5%
Perch Lake Swamp	318	367	248	-32%
Perch Lake	335	335	331	-1%
Perch Creek	271	272	270	0%
Sum:	*743*	*892*	*691*	-22%

LEGEND

- Model Boundary
- Simulated Change in Water Table Elevation – Calibration minus Forecast (m)
- Stream
- ECM Outline
- Waste Management Area
- Swamp

NOTES:
1) Negative values in the table indicate a net infiltration to groundwater

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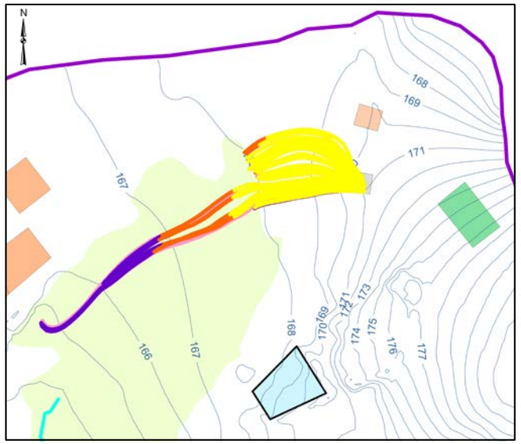
PREPARED	CWT
DESIGN	NFB
REVIEW	SD
APPROVED	SD

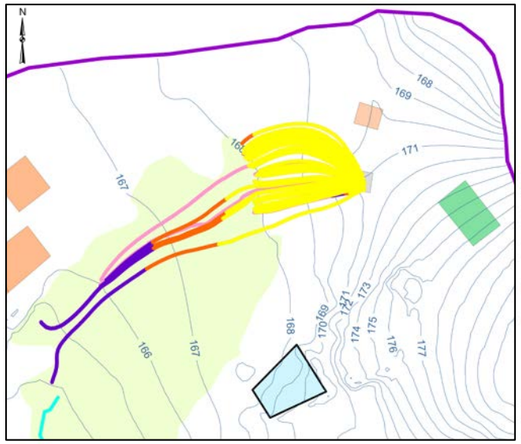
TITLE
Groundwater Flow Model Results – SR8 (Evapotranspiration Applied to Pond Infiltration)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	**4300**	**2**	**4.18**

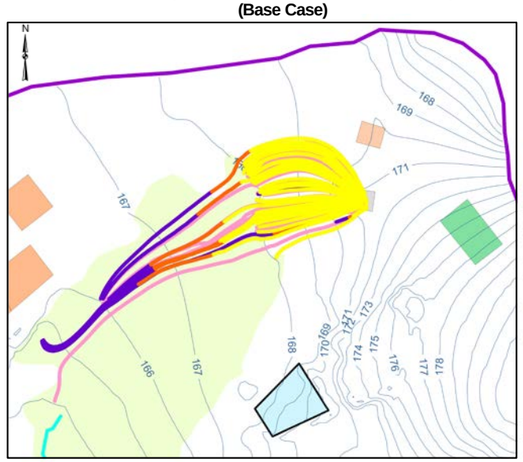
10 m³/day discharged to the Exfiltration Gallery



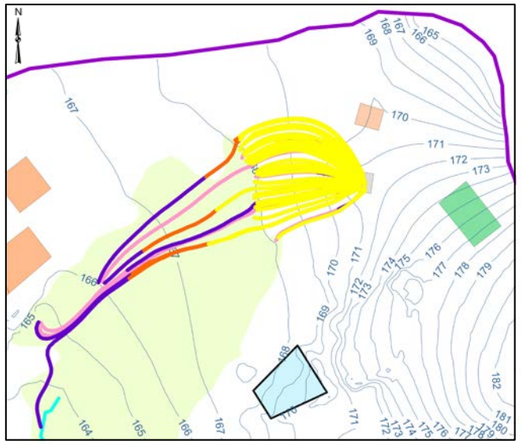
20 m³/day discharged to the Exfiltration Gallery



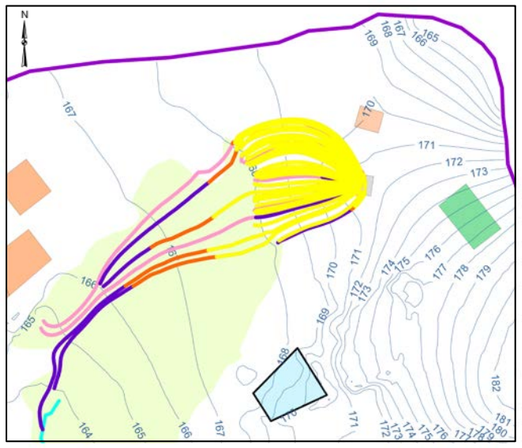
30 m³/day discharged to the Exfiltration Gallery
(Base Case)



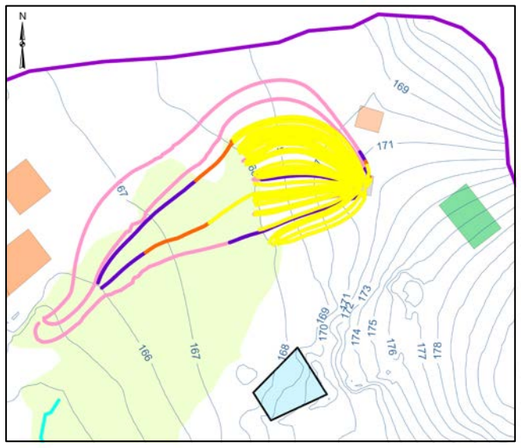
40 m³/day discharged to the Exfiltration Gallery



50 m³/day discharged to the Exfiltration Gallery



60 m³/day discharged to the Exfiltration Gallery



70 m³/day discharged to the Exfiltration Gallery

LEGEND

- Model Boundary
- Simulated Water Table Elevation (masl)

Groundwater Particle Traces
- 0 to 1-year
- 1 to 2-year
- 2 to 5-year
- 5 to 25-year

- Stream
- ECM Outline
- Waste Management Area
- Swamp

Notes:
1. Groundwater elevations and particle tracking based on High Water Table recharge conditions.

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APPROVED	SD

PROJECT
NEAR SURFACE DISPOSAL FACILITY
CHALK RIVER, ONTARIO

TITLE
GROUNDWATER FLOW MODEL RESULTS – SR9
(EXFILTRATION GALLERY DISCHARGE RATE)

PROJECT No.	PHASE	Rev.	FIGURE
1547525	4300	2	4.19

APPENDIX A

Borehole Logs

PROJECT: 1546969

RECORD OF BOREHOLE: 15-2

SHEET 1 OF 2

LOCATION: N 5101773.0 ;E 316630.0

BORING DATE: February 3-4, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		185.80							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; dark brown to black		0.00	1	SS	4				
		(SM) SILTY SAND; brown; non-cohesive, moist, loose		185.34 0.15							
		(SM) SILTY SAND, trace to some gravel; brown to grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		0.46	2	SS	34				
1					3	SS	62				
2					4	SS	>50				
3					5	SS	100				
4					6	SS	90				
					7	SS	>50				
5					8	SS	>50				
6					9	SS	>50				
		(SM) SILTY SAND, trace to some gravel; grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist, very dense		178.94 6.86	10	SS	>50				
7					11	SS	>50				
8					12	SS	>50				
9					13	SS	>50				
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-2

SHEET 2 OF 2

LOCATION: N 5101773.0 ;E 316630.0

BORING DATE: February 3-4, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Power Auger 200 mm Diam. (Hollow Stem)	(SM) SILTY SAND, trace to some gravel; grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist, very dense									
11					14	SS	>50		○		
				174.39							
		End of Borehole Auger Refusal		11.41							Open borehole dry upon completion of drilling
12											
13											
14											
15											
16											
17											
18											
19											
20											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: RI
CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-3

SHEET 1 OF 1

LOCATION: N 5101600.0 ;E 316652.0

BORING DATE: February 5, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		186.30							
0	Power Auger 200 mm Diam. (Hollow Stem)	(SM) SILTY SAND; brown to dark brown, contains organic matter, rootlets and ash; non-cohesive, moist, very loose		0.00							
				185.97	1	SS	1				
		(SM) SILTY SAND, trace to some gravel; brown to grey brown; non-cohesive, moist to wet, compact to very dense		0.33							
1					2	SS	17				
				184.78							
		(SM) SILTY SAND, trace to some gravel; brown to grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist, dense to very dense		1.52	3	SS	82				
2					4	SS	55				
3					5	SS	33				
4					6	SS	53				
				181.73	7	SS	>50				
		End of Borehole Auger Refusal		4.57							Open borehole dry upon completion of drilling
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-4

SHEET 1 OF 1

LOCATION: N 5101456.0 ;E 316482.0

BORING DATE: February 8, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) WATER CONTENT PERCENT Wp W Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		171.70							
0	Power Auger 200 mm Dia.	TOPSOIL - (SM) SILTY SAND; black		0.05							
		(SM) SILTY SAND, trace gravel; dark brown, contains rootlets (GLACIAL TILL); non-cohesive, moist, very dense		171.19	1	SS	51				
		End of Borehole Auger Refusal		0.51							
1											Open borehole dry upon completion of drilling
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: RI
CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-5

SHEET 1 OF 1

LOCATION: N 5101316.0 ;E 316568.0

BORING DATE: February 9, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		160.90							
0	Power Auger 200 mm Diam. (H.S.)	TOPSOIL - (SM) SILTY SAND, trace gravel; black, with cobbles; non-cohesive, wet, very loose		0.00 160.67							
0	Power Auger 200 mm Diam. (H.S.)	(SM) SILTY SAND, trace to some gravel; grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, wet, very dense		0.23	1	SS	3		W ○		Bentonite Seal Silica Sand 32 mm Diam. PVC #10 Slot Screen
1					2	SS	>50				
1		End of Borehole Auger Refusal		159.83 1.07							WL in open borehole at 0.20 m depth below ground surface upon completion of drilling

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-6

SHEET 1 OF 1

LOCATION: N 5101486.0 ;E 316599.0

BORING DATE: February 9, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; 20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		174.80							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (ML) sandy SILT; black		0.00							
		(SM) SILTY SAND, trace gravel; brown to grey brown; non-cohesive, moist to wet, compact		0.15	1	SS	11			326	Bentonite Seal
1					2	SS	14				Silica Sand
		(SM) SILTY SAND, trace to some gravel; grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist to wet, compact		173.58 1.22	3	SS	>50				32 mm Diam. PVC #10 Slot Screen
		End of Borehole Auger Refusal		173.07 1.73							WL in Screen at 0.96 m depth below ground surface on Feb. 10, 2016
2											
3											
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

LOGGED: RI

CHECKED: AM

Golder Associates

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-7

SHEET 1 OF 1

LOCATION: N 5101595.0 ;E 316510.0

BORING DATE: February 9, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		174.50							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown to black		0.05	1	SS	7		○		Native Backfill
		(SM) SILTY SAND; dark brown; non-cohesive, moist, loose		174.09 0.41							Bentonite Seal
		(SP) SAND; brown to grey brown, stratified; non-cohesive, moist, loose			2	SS	6		○		
1				172.98					○		
		(SM) SILTY SAND, trace to some gravel; brown to grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist, compact to dense		1.52	3	SS	10		○		Native Backfill
2					4	SS	27		○		
3					5	SS	30		○		Bentonite Seal
											Silica Sand
4				170.08							
		(SW) SAND, fine to coarse; brown; non-cohesive, wet, very loose		4.42	6	SS	36		○		32 mm Diam. PVC #10 Slot Screen
		(SM) SILTY SAND, trace to some gravel; grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, wet, dense		4.57							
5				169.01							Cave
		End of Borehole Auger Refusal		5.49							
6											WL in Screen at 3.21 m depth below ground surface on Feb. 10, 2016
7											
8											
9											
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

PROJECT: 1546969

RECORD OF BOREHOLE: 15-8

SHEET 1 OF 1

LOCATION: N 5101512.0 ;E 316360.0

BORING DATE: February 8, 2016

DATUM:

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.30m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		174.30							
0	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL - (SM) SILTY SAND; dark brown to black		0.05							Native Backfill
		(SM) SILTY SAND; dark brown, contains rootlets; non-cohesive, moist, very loose		173.61	1	SS	3				Bentonite Seal
1		(SP) SAND; brown to grey brown, contains silty sand seams; non-cohesive, moist, loose to compact		0.69	2	SS	5				
					3	SS	9				
2					4	SS	11				
3					5	SS	8				Native Backfill
4					6	SS	21				
5					7	SS	13				
				168.66	8	SS	23				
6		(SM) SILTY SAND, some gravel; grey brown, contains cobbles and/or boulders (GLACIAL TILL); non-cohesive, moist to wet, compact to very dense		5.64	9	SS	22				
7					10	SS	50				Bentonite Seal / Silica Sand
8					11	SS	73				32 mm Diam. PVC #10 Slot Screen
				165.46							
9		End of Borehole Auger Refusal		8.84							WL in Screen at 7.24 m depth below ground surface on Feb. 10, 2016
10											

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: RI

CHECKED: AM

MIS-BHS 001 1546969.GPJ GAL-MIS.GDT 04/11/16 JM

RECORD OF BOREHOLE No. BH2-1 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: ECM (N5101509, E316361)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 14 Oct 16 Date Completed: 14 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 174.5 m

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	light brown **(Disturbed) SILTY SAND** trace gravel moist	SS	1	63	2	0	174		9					
		SS	2	67	6	1			5					
	173.1 / 1.4						173							
	light brown to brown **SAND / SILTY SAND** trace gravel compact to very dense moist	SS	3	71	11	2			3					
		SS	4	75	10	3	172		6		-	91	(9)	
		SS	5	75	14				6					
		SS	6	75	32	4	171		7					
		SS	7	75	18	5	170		10					
	------ grey sand seam	SS	8	67	17		169		6					
		SS	9	88	40	6	168		9		3	62	32	3
						7	167							
		SS	10	75	70	8			12					
							166							
						9								
		SS	11	63	96/28		165	96/28	13					
						10								

Note: Where N-value is in format, e.g., 96/28, N-value is 96 blows for 28 cm penetration.

Continued on Next Page

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Environment & Infrastructure
104 Crockford Boulevard
Scarborough, Ontario, M1R 3C3
Canada
Tel. No.: (416) 751-6565
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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-1 - Overburden

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

amec foster wheeler

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_p W W_l Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	164.3	SS	12	67	50/10			50 / 10	15		
	End of Overburden Drilling Due to Auger Refusal 10.2										
	Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH2-1 - Rock")										
	End of Rock Coring at 20.7 m depth										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-2 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: ECM (N5101360, E316468)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 11 Oct 16 Date Completed: 11 Oct 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 163.6 m

Lithology Plot	DESCRIPTION		Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)
	About 80 mm TOPSOIL	163.6 / 0.1						
	brown (Disturbed) SILTY SAND trace gravel moist		SS	1	75	8		
		163.0 / 0.7						163
	brown SILTY SAND trace to some gravel moist		SS	2	90	50/3	1	
		162.6 / 1.0						
	End of Overburden Drilling Due to Auger Refusal							
	Rock Coring Started							
	BEDROCK							
	For rock core details, see "RECORD OF BOREHOLE No.: BH2-2 - Rock"							
	End of Rock Coring at 10.2 m depth							

FIELD TESTING: Penetration Testing (○ SPT □ PPT ● DCPT); MTO Vane* (△ Intact ▲ Remould); Nilcon Vane* (◇ Intact ◆ Remould); * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading (□ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400); W_P W W_L; Plastic Liquid; 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Note: Where N-value is in format, e.g., 50/3, N-value is 50 blows for 3 cm penetration.

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Environment & Infrastructure
104 Crockford Boulevard
Scarborough, Ontario, M1R 3C3
Canada
Tel. No.: (416) 751-6565
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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-3 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: ECM (N5101213, E316595)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 7 Oct 16 Date Completed: 7 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 157.5 m

Lithology Plot	DESCRIPTION	Elevation (m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)
	brown to grey (Disturbed) SAND / SILTY SAND some gravel, some clay moist	157.3					
		0.2	SS	1	75	7	
	brown to SILTY SAND trace gravel moist	157					
			SS	2	38	11	1
		156.1	SS	3	100	50/10	
	End of Overburden Drilling Due to Auger Refusal	1.4					
	Rock Coring Started						
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH BH2-3 - Rock")						
	End of Rock Coring at 12.2 m depth						

FIELD TESTING: Penetration Testing — ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80

SPT 'N' values: 20, 29, 50/10, 43

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.

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Environment & Infrastructure
104 Crockford Boulevard
Scarborough, Ontario, M1R 3C3
Canada
Tel. No.: (416) 751-6565
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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-4 - Overburrden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: ECM (N5101195, E316711)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 12 Oct 16 Date Completed: 12 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 157.7 m)	Elev.	Depth	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	Field Testing	Lab Testing	Instrumentation	GR	SA	SI	CL
	TOPSOIL (100 mm thick)	157.6	0.1											
	grey/ brown **(Disturbed) SAND / SILTY SAND** trace gravel moist	157.1	0.7	SS	1	67	6		30					
	grey/brown **SAND / SILTY SAND** trace gravel loose to very dense moist to wet			SS	2	63	12		29					
				SS	3	50	9		23					
	some gravel			SS	4	38	24		11		22	59	18	1
				SS	5	29	30		9					
	inferred cobbles/boulders			SS	6	0	50/15	50/15						
		152.5		SS	7	31	50/10	50/10	10		29	39	29	3
	End of Overburden Drilling Due to Auger Refusal		5.2											
	Rock Coring Started													
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH2-4 - Rock")													
	End of Rock Coring at 16.0 m depth													

Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.

Amec Foster Wheeler
Environment & Infrastructure
104 Crockford Boulevard
Scarborough, Ontario, M1R 3C3
Canada
Tel. No.: (416) 751-6565
amecfw.com

Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-5 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: ECM (N5101478, E316940)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 27 Sep 16 Date Completed: 28 Sep 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 193.1 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	brown/light brown **(Disturbed) SILTY SAND** trace gravel, with wood pieces and organics	SS	1	42	9		193		18		Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.
	192.4										
	grey 0.7 **SILTY SAND** trace to some gravel, rock fragments very dense mosit 191.9 1.2	SS	2	44	50/10	1	192	50/10	2		
	End of Overburden Drilling Due to Auger Refusal										
	Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH2-5 - Rock")										
	End of Rock Coring at 12.2 m depth										

PenetrationTesting: ○ SPT □ PPT ● DCPT
MTO Vane*: △ Intact ▲ Remould
Nilcon Vane*: ◇ Intact ◆ Remould
* Undrained Shear Strength (kPa) 20 40 60 80

Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8
△ COV (ppm) ▲ TOV (ppm) 100 200 300 400
W_P W W_L Plastic Liquid 20 40 60 80

COMMENTS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-6D - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: ECM (N5101456, E316895)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 27 Sep 16 Date Completed: 27 Sep 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION Geodetic Ground Surface Elevation: 191.6 m	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	brown **(Disturbed) SILTY SAND** trace gravel, with organics moist	SS	1	29	3		191		9		
	inferred cobbles/boulders with rock fragments 190.7										
	End of Overburden Drilling Due to Auger Refusal 0.9 Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH2-6 - Rock")										
	End of Rock Coring at 11.9 m depth										

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Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-6S - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: ECM (N5101456, E316895)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 27 Sep 16 Date Completed: 27 Sep 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

LITHOLOGY PROFILE			SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION Geodetic Ground Surface Elevation: 191.6 m		Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	PenetrationTesting ○ SPT □ PPT ● DCPT MTO Vane* △ Intact ▲ Remould Nilcon Vane* ◇ Intact ◆ Remould * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading □ COV (LEL) ■ TOV (LEL) 2 4 6 8 △ COV (ppm) ▲ TOV (ppm) 100 200 300 400 W_P W W_L Plastic Liquid 20 40 60 80		INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	brown **(Disturbed) SILTY SAND** trace gravel, with organics moist	191.4 0.2	SS	1	81	3			○	○ 12						
	End of Overburden Drilling Due to Auger Refusal Rock Coring Started															
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH2-6B - Rock")															
	End of Rock Coring at 10.7 m depth															

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▽ No freestanding groundwater measured in open borehole on completion of drilling.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-7 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: ECM (N5101650, E316753)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Track Mounted Drill
Date Started: 6 Oct 16 Date Completed: 6 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

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Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 191.8 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT), MTO Vane* (Intact / Remould), Nilcon Vane* (Intact / Remould), * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL), COV (ppm) / TOV (ppm), W_P Plastic, W, W_L Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	light brown **(Disturbed) SILTY SAND** trace gravel moist	SS	1	63	21				10		Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.
	191.1 light grey 0.7 **SILTY SAND / SAND AND SILT** trace gravel very dense moist rock fragments at tip of spoon	SS	2	21	50/13	1	191	50/13	5		
		SS	3	17	50/10	2	190	50/10	5		Auger sample collected GR 8 SA 50 SI 38 CL 4
		SS	4	0							Hard augering / grinding
	inferred cobbles/boulders	SS	5	38	50/14	3	189	50/14	8		GR 31 SA 55 SI 13 CL 1
	187.3	SS	6	0	50/8	4	188	50/8			
	End of Overburden Drilling Due to Auger Refusal 4.5 Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH2-7 - Rock")										
	End of Rock Coring at 14.8 m depth										

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RECORD OF BOREHOLE No. BH2-8 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: ECM (N5101556, E316528)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (NQ)
Drilling Machine: Truck Mounted Drill
Date Started: 27 Sep 16 Date Completed: 27 Sep 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
Geodetic Ground Surface Elevation: 174.5 m											
	brown (Disturbed) SILTY SAND some gravel moist 174.2 0.2	SS	1	100	50/3	0	174	50/3	28		Note: Where N-value is in format, e.g., 50/3, N-value is 50 blows for 3 cm penetration.
	End of Overburden Drilling Due to Auger Refusal					1	173				
	Rock Coring Started					2	172				
						3	171				
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH SH-2 - Rock")					4	170				
						5	169				
						6	168				
						7	167				
						8	166				
						9	165				
	End of Rock Coring at 10.2 m depth					10					

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Scale: 1 : 53

RECORD OF BOREHOLE No. GH1-1 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: Geophysical (N5101369, E316355)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (NQ)
Drilling Machine: Truck Mounted Drill
Date Started: 12 Oct 16 Date Completed: 13 Oct 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 161.5 m

Lithology Plot	DESCRIPTION		Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	About 150 mm TOPSOIL	161.3										Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.
	dark brown	0.2										
	(Disturbed) SILTY SAND trace gravel, with organics moist		SS	1	63	6						
		160.8										
	grey/brown	0.7										
	SILTY SAND trace gravel, trace clay, inferred cobbles/boulders dense to very dense moist		SS	2	92	46	1	161				
								160				
			SS	3	100	90	2					
			~~SS~~	~~4~~	~~100~~	~~50/3~~						
		158.9						159				
	End of Overburden Drilling Due to Auger Refusal Rock Coring Started	2.6										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: GH1-1 - Rock")											
	End of Rock Coring at 32.9 m depth											

FIELD TESTING: Penetration Testing — SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading — COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80

SOIL SAMPLING: 1 SS 63 6; 2 SS 92 46; 3 SS 100 90; ~~4 SS 100 50/3~~

FIELD TESTING: 50/3; LAB TESTING: 13, 2, 10

Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

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Scale: 1 : 53

RECORD OF BOREHOLE No. GH1-2 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: Geophysical (N5101373, E316380)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (NQ)
Drilling Machine: Truck Mounted Drill
Date Started: 13 Oct 16 Date Completed: 14 Oct 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 164.1 m

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	About 220 mm TOPSOIL 163.9						164				
	brown 0.2 (Disturbed) SILTY SAND trace gravel, with organics moist 163.4	SS	1	63	7				22		
	0.7 grey/brown SILTY SAND trace gravel firm to dense moist	SS	2	92	34	1	163		10		
	inferred cobbles/boulders	SS	3	200	14				5		
	------ rock fragments 161.9					2	162				
	End of Overburden Drilling 2.2 Due to Auger Refusal Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: GH1-2 - Rock")										
	End of Rock Coring at 32.7 m depth										

Penetration Testing: SPT, PPT, DCPT
MTO Vane*: Intact, Remould
Nilcon Vane*: Intact, Remould
* Undrained Shear Strength (kPa) 20 40 60 80

Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400
W_P W W_L Plastic Liquid 20 40 60 80

GR SA SI CL

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Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. GH1-4 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Geophysical (N5101496, E316738)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 6 Oct 16 Date Completed: 6 Oct 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

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Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 189.1 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	brown **(Disturbed) SILTY SAND** trace gravel, with wood pieces wet	SS	1	29	2				19		Note: Where N-value is in format, e.g., 50/8, N-value is 50 blows for 8 cm penetration.
	188.4 reddish brown 0.7 **SILTY SAND / SAND AND SILT** trace gravel, trace clay, cobbles	SS	2	63	57	1	188		9		
		SS	3	54	46	2	187		10		1 52 43 4
		SS	4	67	50/8			50/8	6		
	185.9 **End of Overburden Drilling Due to Auger Refusal** 3.2					3	186				
	Rock Coring Started **BEDROCK** (for rock core details, see "RECORD OF BOREHOLE No.: GH1-4 - Rock")										
	End of Rock Coring at 30.0 m depth										

PenetrationTesting: ○ SPT □ PPT ● DCPT
MTO Vane*: △ Intact ▲ Remould
Nilcon Vane*: ◇ Intact ◆ Remould
* Undrained Shear Strength (kPa) 20 40 60 80

Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8
△ COV (ppm) ▲ TOV (ppm) 100 200 300 400
W_P W W_L Plastic Liquid 20 40 60 80

GR SA SI CL

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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. GH1-5 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON
Drilling Location: Geophysical (N5101498, E316774)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 29 Sep 16 Date Completed: 29 Sep 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 188.5 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT), MTO Vane* (Intact / Remould), Nilcon Vane* (Intact / Remould), * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL), COV (ppm) / TOV (ppm), W_P W W_L Plastic Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	dark brown **(Disturbed) SILTY SAND** trace gravel, with organics moist	SS	1	42	13		188		25		Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.
	187.8 grey/brown **SILTY SAND** very dense moist 187.5 1.0	SS	2	100	50/10	1		50/10	3		
	End of Overburden Drilling Due to Auger Refusal Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: GH1-5 - Rock")										
	End of Rock Coring at 31.3 m depth										

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Scale: 1 : 53

RECORD OF BOREHOLE No. SH-1 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Supporting Structure (N5101743, E316671)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 18 Oct 16 Date Completed: 18 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 188.8 m

Depth (m)	Elevation (m)	Description	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	Field Testing	Lab Testing	Instrumentation Installation
0	188.8	light brown **(Disturbed) SAND / SILTY SAND** trace gravel, with organics moist	SS	1	67	9		13	
0.7	188.1	grey / light grey **SAND / SILTY SAND** trace gravel, cobbles / boulders compact to very dense moist to wet	SS	2	25	50/10	50/10	2	
1	188		SS	3	83	69		5	
2	187		SS	4	33	54		5	
3	186		SS	5	42	50/13	50/13	6	
4	185		SS	6	50	50/15	50/15	5	
5	184	wet	SS	7	58	88/28	88/28	7	
6	183		SS	8	42	50/10	50/10	9	
7	182		SS	9	25	50/15	50/15	9	
8	181		SS	10	21	50/13	50/13	8	
9	180		SS	11	25	50/15	50/15	13	
10	179								

Penetration Testing: ○ SPT □ PPT ● DCPT
MTO Vane*: △ Intact ▲ Remould
Nilcon Vane*: ◇ Intact ◆ Remould
* Undrained Shear Strength (kPa) 20 40 60 80

Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8
△ COV (ppm) ▲ TOV (ppm) 100 200 300 400
W_P W W_L Plastic Liquid 20 40 60 80

COMMENTS & GRAIN SIZE DISTRIBUTION (%)

Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.

GR	SA	SI	CL
6	67	25	2

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Scale: 1 : 53

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RECORD OF BOREHOLE No. SH-1 - Overburden

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_p W W_l Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	grey / light grey **SAND / SILTY SAND** trace gravel, cobbles / boulders compact to very dense moist to wet													
		SS	12	13	50/8	11	178	50/8	11		4	65	29	2
						12	177							
	------ some gravel	SS	13	13	50/8			50/8	7					
						13	176							
		SS	14	13	50/8			50/8	10					
	175.1													
	INFERRED COBBLES/BOULDERS OR POSSIBLE SHATTER POOR BEDROCK 13.7					14	175							
						15	174							
						16	173							
						17	172							
	171.5													
	End of Overburden Drilling Due to Auger Refusal 17.3 Rock Coring Started **BEDROCK** (for rock core details, see "RECORD OF BOREHOLE No.: SH-1 - Rock")													
	End of Rock Coring at 28.0 m depth													

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. SH-2 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Supporting Structure (N5101790, E316646)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 29 Sep 16 Date Completed: 30 Sep 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 186.6 m

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading / Plastic & Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	light brown (Disturbed) SILTY SAND trace gravel moist	SS	1	75	3				8		Note: Where N-value is in format, e.g., 74/25, N-value is 74 blows for 25 cm penetration.
	185.9 light brown to brown 0.7 SAND / SILTY SAND / SAND AND SILT trace gravel, trace clay very dense moist to wet	SS	2	88	56	1	186		5		
	cobbles --- grey/brown	SS	3	67	74/25	2	185	74/25	5		
		SS	4	100	59		184		6		
		SS	5	92	34	3			8		GR 5 SA 56 SI 35 CL 3
		SS	6	58	54/23	4	183	54/23	5		
		SS	7	50	50/13	5	182	50/13	6		GR 8 SA 50 SI 38 CL 4 Auger sample collected
		SS	8	42	50/10	6	181	50/10	6		
	--- some gravel	SS	9	13	50/13		180	50/13	5		
		SS	10	58	94/23	7 8	179	94/23	7		GWL inferred at 8.5 m depth during driling on 29 Sep 2016.
	--- grey/brown	SS	11	58	50/13	9	178	50/13	10		GR 28 SA 41 SI 29 CL 2
						10	177				

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▽ Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. SH-2 - Overburden

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT), MTO Vane* Intact/Remould, Nilcon Vane* Intact/Remould, * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL), COV (ppm) / TOV (ppm), W_p W W_l Plastic Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	light brown to brown **SAND / SILTY SAND / SAND AND SILT** trace gravel, trace clay very dense moist to wet					11	176				
	------ inferred cobbles/boulders	SS	12	25	50/13			50 / 13	8		
						12	175				
		SS	13	0			174				
						13					
		SS	14	25	50/10		173	50 / 10	13		
						14					
							172				
	trace to some clay	SS	15	21	50/13	15		50 / 13	15		
	170.9						171				
	grey/brown 15.7 **GRAVELLY SAND / SAND AND GRAVEL** some silt to silty, trace clay very dense moist to wet					16					
		SS	16	21	50/3		170	50 / 3	10		
						17					
							169				
		SS	17	13	50/5	18		50 / 5	12		
							168				
						19					
		SS	18	13	50/8		167	50 / 8	19		
						20					
							166				
		SS	19	25	50/13	21		50 / 13	11		39 36 23 2

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. SH-2 - Overburden

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	grey/brown **GRAVELLY SAND / SAND AND GRAVEL** some silt to silty, trace clay very dense moist to wet with rock fragments					22	165				
		SS	20	50	50/5	23	164	50 5	11		
	163.5 **End of Overburden Drilling Due to Auger Refusal** 23.2										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: BH SH-2 - Rock")										
	End of Rock Coring at 30.1 m depth										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. SH-3

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Supporting Structure (N5101828, E316631)
Drilling Method: 200 mm Hollow Stem Augering
Drilling Machine: Truck Mounted Drill
Date Started: 16 Oct 16 Date Completed: 17 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

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Lithology Plot	DESCRIPTION (Geodetic Ground Surface Elevation: 184.8 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT), MTO Vane* (Intact / Remould), Nilcon Vane* (Intact / Remould), * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL), COV (ppm) / TOV (ppm), W_P / W / W_L, Plastic / Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	light brown **(Disturbed) SAND / SILTY SAND** trace gravel, with organics moist	SS	1	54	6	0	184		19		
	184.1 light grey / grey 0.7 **SAND / SILTY SAND** trace gravel compact to very dense moist	SS	2	54	79	1			4		
		SS	3	67	91/28	2	183	91/28	4		Note: Where N-value is in format, e.g., 91/28, N-value is 91 blows for 28 cm penetration.
	------ some gravel	SS	4	38	50/5		182	50/5	3		1 64 30 5
		SS	5	8	50/13	3		50/13	1		
		SS	6	21	50/13	4	181	50/13	5		
		SS	7	21	50/8	5	180	50/8	5		6 60 30 4
		SS	8	13	50/8	6	179	50/8	14		Hard augering and below
	178.2 **INFERRED COBBLES/BOULDERS OR POSSIBLE SHATTER POOR BEDROCK** 6.6 some gravel, some sand moist	SS	9	13	50/5	7	178	50/5			
		SS	10	6	50/13	8	177				
						9	176	50/13			
						10	175				

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▽ No freestanding groundwater measured in open borehole on completion of drilling.

Scale: 1 : 53

RECORD OF BOREHOLE No. SH-3

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT); MTO Vane* Intact / Remould; Nilcon Vane* Intact / Remould; * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL); COV (ppm) / TOV (ppm); W_p Plastic; W; W_l Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	INFERRED COBBLES/BOULDERS OR POSSIBLE SHATTER POOR BEDROCK some gravel, some sand moist	SS	11	0	50/10	10	174	50/10						
						11								
	trace clay	SS	12	21	50/5	12	173	50/5	16		11	64	(25)	
						13	172							
		SS	13	17	50/15	14	171	50/15	2					
						15	170							
		SS	14	8	50/5	16	169	50/5	3					
		SS	15	4	50/15	17	168	50/15	3					
						18	167							
		SS	16	8	50/15	19	166	50/15	6					
						20	165							
		SS	17	8	50/8	21	164	50/8						
		SS	18	8	50/15			50/15	2					

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. SH-3

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_p W W_l Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	INFERRED COBBLES/BOULDERS OR POSSIBLE SHATTER POOR BEDROCK some gravel, some sand moist					22	163				
						23	162				
		SS	19	8	50/5	24	161	50 ○ 5			
						25	160				
						26	159				
						27	158				
		SS	20	0		28	157				
	154.9					29	156				
	End of Borehole 29.9						155				

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. SH-4 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Supporting Structure (N5101135, E316806)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 11 Oct 16 Date Completed: 11 Oct 16

Logged by: KT Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION Geodetic Ground Surface Elevation: 156.6 m	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	light brown **(Disturbed) SAND / SILTY SAND** trace gravel, with organics moist	SS	1	58	6			65						
	155.9 light grey / grey 0.7 **SAND / SILTY SAND** trace gravel compact wet	SS	2	50	29	1	156	8						
		SS	3	48	16	2	155	11			20	66		(14)
	------ some gravel 153.9	SS	4	93	27		154	14						
	End of Overburden Drilling Due to Auger Refusal 2.6 Rock Coring Started													
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: SH-4 - Rock")													
	End of Rock Coring at 13.5 m depth													

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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. SH-5 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Supporting Structure (N5101337, E316316)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 12 Oct 16 Date Completed: 12 Oct 16

Logged by: BC Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

Geodetic Ground Surface Elevation: 161.1 m

Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT), MTO Vane* (Intact / Remould), Nilcon Vane* (Intact / Remould), * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL), COV (ppm) / TOV (ppm), W_P / W / W_L (Plastic / Liquid)	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	About 100 mm TOPSOIL 161.0 / 0.1 brown (Disturbed) SILTY SAND trace gravel moist 160.4 / 0.7	SS	1	63	4	0	161		5		
	grey/brown SAND / SILTY SAND / SANDY SILT trace to some gravel firm to very dense moist	SS	2	75	8	1	160		5		
		SS	3	67	8	2	159		6		
		SS	4	75	5				5		- 98 (2)
	------ wet	SS	5	83	19	3	158		19		Wet spoon
		SS	6	83	7	4	157		30		- 95 (5)
		SS	7	100	16	5	156		16		13 36 49 2
	inferred cobbles/boulders 155.7	SS	8	100	50/10			50/10	19		
	End of Overburden Drilling Due to Auger Refusal Rock Coring Started 5.4										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: SH-5 - Rock")										
	End of Rock Coring at 15.5 m depth										

Note: Where N-value is in format, e.g., 50/10, N-value is 50 blows for 10 cm penetration.

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Groundwater was inferred at 3.4 m on 12 Oct 2016 during drilling. Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

RECORD OF BOREHOLE No. SH-6 - Overburden

Project Number: TZ16018
Project Client: Canadian Nuclear Laboratories Ltd.
Project Name: Multidisciplinary Subsurface Investigation for NSDF
Project Location: Chalk River, ON

Drilling Location: Supporting Structure (N5101611, E316429)
Drilling Method: 200 mm Hollow Stem Augering / Rock Coring (HQ)
Drilling Machine: Truck Mounted Drill
Date Started: 12 Oct 16 Date Completed: 13 Oct 16

Logged by: MA Compiled by: SC Reviewed by: SC/NR Revision No.: 0, 31/10/16

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION Geodetic Ground Surface Elevation: 174.9 m	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	reddish brown **(Disturbed) SAND / SILTY SAND** trace gravel moist	SS	1	79	5				10					
	174.3 grey / light grey 0.7 **SAND / SILTY SAND** trace gravel, cobbles / boulders compact to very dense moist to wet ------ brown ------ grey	SS	2	79	14	1	174		3					
		SS	3	58	36	2	173		4					
		SS	4	96	32				9					
		SS	5	42	20	3	172		4					
		SS	6	63	32	4	171		7					
		SS	7	13	25	5	170		18		-	69	(31)	
		SS	8	79	31	6	169		14		Hard augering			
		SS	9	79	73	7	168		9					
		SS	10	58	82	8	167		14		Wet spoon			
		SS	11	96	46	9	166		10					
						10	165							

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Groundwater at completion of borehole could not be measured due to drilling fluid used in rock coring.

Scale: 1 : 53

RECORD OF BOREHOLE No. SH-6 - Overburden

Project Number: TZ16018 Project Name: Multidisciplinary Subsurface Investigation for NSDF

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	grey / light grey **SAND / SILTY SAND** trace gravel, cobbles / boulders compact to very dense moist to wet										
		SS	12	42	50/25	11	164	50/25	17		Note: Where N-value is in format, e.g., 50/25, N-value is 50 blows for 25 cm penetration.
						12	163				
		SS	13	25	50/15			50/15	11		Hard augering 21 60 17 (2)
						13	162				
	inferred cobbles/boulders 161.2	SS	14	25	50/15			50/15	15		
	End of Overburden Drilling Due to Auger Refusal 13.7 Rock Coring Started										
	BEDROCK (for rock core details, see "RECORD OF BOREHOLE No.: SH-6 - Rock")										
	End of Rock Coring at 26.9 m depth										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. BH2-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101509, E316361)
DRILLING DATE : 14 Oct 16 - 14 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-1 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-1" Rock Coring Started on 14 October 2016																
10				164.30														
	14/10/2016 HQ	**DIORITE BEDROCK**		10.21									JN, PL, SR, Ch		1			
		RC 13: Classification based on RQD: Excellent			RC 13								JN, PL, SR, Ch		1			
													JN, PL, RO, Ch		1			
12													JN, PL, RO, Ch		1			
		RC 14: Classification based on RQD: Excellent			RC 14								JN, PL, SR, Ch		1			
													JN, UN, RO, Ch		0.75			
													JN, PL, SM, Ch		0.75			
													JN, PL, SR, Ch		1			
14		RC 15: Classification based on RQD: Excellent			RC 15								JN, PL, SR, Ch		0.75			
													JN, PL, SR, Ch		1			
													JN, PL, RO, Ch		1.5			
													JN, PL, SR, Ch		0.75			
													JN, PL, SR, Ch		1			
													JN, UN, SR, Ch		1.5			
		RC 16: Classification based on RQD: Excellent			RC 16								JN, PL, SR, Ch		1			
													JN, PL, SR, Ch		1			
16													JN, UN, SR, Ch		1			
													JN, PL, SR, Ch		1			
													JN, UN, SR, Ch		1			
													JN, PL, SR, Ch		0.75			
		RC 17: Classification based on RQD: Poor			RC 17										1			
18																		
		RC 18: Classification based on RQD: Poor			RC 18													

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : MA
CHECKED : SC/NR

RECORD OF BOREHOLE No. BH2-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101509, E316361)
DRILLING DATE : 14 Oct 16 - 14 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
20	14/10/2016 HQ	**DIORITE BEDROCK**			RC 18									JN, PL, K, Ch		1.5			
														JN, PL, SM, Ch		1.5			
														JN, PL, SR, Ch		1.5			
		RC 19: Classification based on RQD: Fair			RC 19									JN, PL, SR, Ch		1.5			
														JN, PL, SM, Ch		1.5			
				153.79															
		End of Rock Coring		20.72															
22																			
24																			
26																			
28																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101360, E316468)
DRILLING DATE : 11 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-2 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-2" Rock Coring Started on 11 October 2016																	
				162.64															
		QUARTZFELDSPATHIC GNEISS BEDROCK		1.01															
		RC 3: Classification based on RQD: Excellent			RC 3					>>				JN, CU, RO, Ca JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io	0.75 0.75 0.75 0.75			
2		RC 4: Classification based on RQD: Good			RC 4									JN, PL, SR, Ch/Ca JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Ca/Io JN, PL, RO, Io JN, PL, RO, Ch/Io	1 0.75 0.75 0.75 0.75 0.75			
4		RC 5: Classification based on RQD: Good			RC 5					>>				JN, PL, RO, Sa/Ch JN, PL, RO, Ch/Io JN, UN, RO, Io/Sa JN, PL, RO, Io JN, PL, SR, Ch/Sa JN, PL, RO, Ch/Io JN, PL, RO, Ca/Io	2 0.75 0.75 0.75 1 1 1			
	11/10/2016 HQ	RC 6: Classification based on RQD: Excellent			RC 6					>>				JN, PL, RO, Ch/Ca JN, PL, RO, Ch/Ca	1 1			
6		RC 7: Classification based on RQD: Excellent			RC 7														
8		RC 8: Classification based on RQD: Excellent			RC 8														
		RC 9: Classification based on RQD: Excellent			RC 9														

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101360, E316468)
DRILLING DATE : 11 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	HQ	Continued from non-cored borehole See Overburden log report.																	
		End of Rock Coring		10.16															
12																			
14																			
16																			
18																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. BH2-3 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101213, E316595)
DRILLING DATE : 7 Oct 16 - 7 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-3 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-3" Rock Coring Started on 7 October 2016		156.05														
2	07/10/2016 HQ	**GNEISS BEDROCK** RC 4: Classification based on RQD: Good		1.45	RC 4							• JN, PL, RO, Ch • JN, PL, RO, Ch			0.75 1.5			
4		RC 5: Classification based on RQD: Fair			RC 5							• JN, PL, RO, Io			1			
												• JN, PL, RO, Io			1			
6		RC 6: Classification based on RQD: Very Poor			RC 6													
		RC 7: Classification based on RQD: Very Poor			RC 7													
8		RC 8: Classification based on RQD: Very Poor			RC 8													
					RC 9							• JN, PL, SR, Ca/Ch/Io			1			
		RC 9: Classification based on RQD: Excellent										• JN, PL, RO, Ca			1			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 1 of 2

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-3 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101213, E316595)
DRILLING DATE : 7 Oct 16 - 7 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		GNEISS BEDROCK			RC 9									JN, PL, RO, Ca/Ch/Io		1.5			
														JN, PL, RO, Ch/Ca		1.5			
	07/10/2016 HQ	RC 10: Classification based on RQD: Good			RC 10									JN, PL, RO, Ch/Ca		1.5			
														JN, PL, RO, Ch/Ca		1.5			
														JN, PL, RO, Ch		1			
														JN, PL, RO, Ch		1			
12														JN, PL, RO, Ch		1			
				145.30															
		End of Rock Coring		12.20															
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101195, E316711)
DRILLING DATE : 12 Oct 16 - 12 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-4 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-4" Rock Coring Started on 12 October 2016		152.53															
	12/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 8: Classification based on RQD: Fair		5.21	RC 8									JN, PL, RO, Ch JN, UN, SR, Ch JN, PL, RO, Ch		1.5 1.5 1			
6		RC 9: Classification based on RQD: Excellent			RC 9									JN, PL, RO, Ch JN, PL, RO, Ch		1 1			
8		RC 10: Classification based on RQD: Excellent			RC 10									JN, PL, RO, Ca/Ch/Su JN, PL, RO, Su/Ca JN, PL, RO, Ch JN, PL, SR, Su/Ch		1 0.75 1 1			
10		RC 11: Classification based on RQD: Good			RC 11									JN, PL, SR, Ch/Ca JN, PL, RO, Ca/Ch/Su JN, PL, RO, Ca/Ch/Su JN, PL, RO, Ca/Ch/Su JN, ST, RO, Su/Ch JN, PL, RO, Su/Ch		1 1 1 0.75 1			
12		RC 12: Classification based on RQD: Excellent			RC 12									JN, PL, RO, Ca/Ch/Su		1			
		RC 13: Classification based on RQD: Excellent			RC 13									JN, PL, SR, Ca/Ch/Su JN, PL, RO, Ca/Ch		1 1.5			
					RC 14									JN, PL, RO, Ca/Ch/Su JN, PL, RO, Ca/Ch JN, PL, RO, Su/Ch JN, PL, RO, Ca		1 1.5 1 1.5			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : MA
CHECKED : SC/NR

RECORD OF BOREHOLE No. BH2-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101195, E316711)
DRILLING DATE : 12 Oct 16 - 12 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	12/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 14: Classification based on RQD: Excellent			RC 14									JN, PL, RO, Su/Ch		0.75			
														JN, PL, RO, Ca/Ch		1			
														JN, PL, SR, Su/Ch		1.5			
														JN, IR, RO, Su/Ca		1.5			
														JN, PL, RO, Ca/Ch		1			
		RC 15: Classification based on RQD: Fair			RC 15									JN, PL, SM, Ch		1.5			
														JN, PL, SR, Ch		1			
														JN, PL, SR, Su/Ch		1.5			
														JN, PL, RO, Ca		1.5			
														JN, PL, RO, Ch/Ca		1			
														JN, PL, RO, Ca/Ch		1.5			
				141.74										JN, PL, SM, Ch		1.5			
16		**End of Rock Coring**		16.00															

18

20

22

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : MA

CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101478, E316940)
DRILLING DATE : 27 Sep 16 - 28 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-5 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-5" Rock Coring Started on 27 September 2016																	
				191.90										JN, UN, RO, Si		0.75			
		QUARTZFELDSPATHIC GNEISS BEDROCK		1.22										JN, UN, SR, Si		0.75			
														JN, PL, RO, Si		0.75			
														JN, UN, RO, Si		1			
														JN, UN, RO, Si		0.75			
														JN, PL, SR, Si		1			
														JN, UN, RO, Si		0.75			
														JN, UN, VR, Si		0			
2		RC 3: Classification based on RQD: Fair			RC 3									JN, UN, RO, Si		1			
														JN, UN, VR, Si		1			
														JN, ST, VR, Si		1			
														JN, UN, VR, Si		1			
														CON, UN, RO, Si		1			
		SCHIST BEDROCK			RC 4									JN, UN, RO, Bi		1			
		RC 4: Classification based on RQD: Very Poor												JN, UN, RO, Bi		1			
														JN, UN, RO, Bi/Mu		1.5			
														JN, UN, RO, Bi/Si		1			
														JN, UN, RO, Bi/Si		1.5			
														JN, UN, RO, Bi/Mu		1.5			
		RC 5: Classification based on RQD: Good			RC 5									JN, UN, RO, Bi/Mu		1.5			
4														JN, ST, RO, Si		1			
														JN, PL, SR, Io		1			
				188.85										CON, UN, SR, Bi/Mu		1.5			
		SCHIST BEDROCK		4.27										JN, UN, RO, Bi/Mu		1.5			
					RC 6									JN, UN, SR, Bi/Io		1.5			
				188.33										JN, UN, RO, Bi/Io		1.5			
		QUARTZFELDSPATHIC GNEISS BEDROCK		4.79										CON, UN, RO, Bi/Mu		1.5			
		RC 6: Classification based on RQD: Good												JN, UN, SR, Io		1			
														JN, CU, SR, Io		1			
														JN, PL, SR, Io		1.5			
		RC 7: Classification based on RQD: Very Poor			RC 7									JN, UN, RO, Io		2			
														CON, UN, SR, Bi/Mu		2			
														CON, UN, SR, Bi/Mu		2			
														CON, UN, SR, Bi/Si		2			
														CON, PL, SR, Bi/Mu		2			
6														CON, PL, SR, Bi/Mu		2			
														CON, PL, SR, Bi/Mu		2			
														JN, UN, SR, -		2			
														CON, UN, SR, Bi/Mu		2			
		RC 8: Classification based on RQD: Good			RC 8									CON, UN, SR, Bi/Mu		2			
														JN, UN, VR, Ca		0.75			
														JN, UN, RO, Si/Bi		1.5			
														JN, CU, SR, Si/Bi		1			
														JN, UN, SR, Io/Ca		1.5			
														JN, UN, RO, Ca		1			
8		RC 9: Classification based on RQD: Good			RC 9									JN, PL, SR, Ca/Io		1			
														JN, PL, RO, Ca/Io		0.75			
														-, PL, RO , Io/Ch/Ca		1			
														-, PL, RO, Io		1			
														-, PL, SR, Io		1			
														-, PL, RO, Io		0.75			
														-, PL, RO, Io		1			
					RC 10									-, PL, RO, Io		1			
		RC 10: Classification based on RQD: Fair												-, PL, RO, Io		0.75			
														-, PL, RO, Io		1			
														-, PL, RO, Io		1.5			
														-, PL, SR, Io/Bi		1.5			
														-, PL, RO, Io		1			

27/09/2016 HQ

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 1 of 2

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101478, E316940)
DRILLING DATE : 27 Sep 16 - 28 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		QUARTZFELDSPATHIC GNEISS BEDROCK			RC 10									-, PL, RO, Io -, PL, RO, Ca/Io		1			
					RC 11									-, PL, RO, Io -, PL, RO, Ca -, PL, RO, Io -, PL, SR, Io/Ch -, PL, RO, Io		1 1 1 1 0.75			
	27/09/2016 HQ	**MAFIC INTRUSIVE BEDROCK** RC 11: Classification based on RQD: Very Poor RC 12: Classification based on RQD: Very Poor			RC 12									-, PL, RO, Io/Ch -, PL, SR, Ch -, PL, SM, Ch -, UN, RO, Ch -, PL, SR, Io/Ch -, PL, SR, Ch		1 1 1 1 1 11.5			
12		RC 13: Classification based on RQD: Excellent		180.88	RC 13									-, PL, SR, Ch -, PL, SR, Ch		1 1			
		End of Rock Coring		12.24															

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : BC

CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-6D - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101456, E316895)
DRILLING DATE : 29 Sep 16 - 29 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-6D- Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-6D" Rock Coring Started on 29 September 2016		190.66															
	29/09/2016 HQ	**DIORITE BEDROCK**		0.94	RC 2								>>						
2					RC 3									JN, UN, RO, Sa/Io JN, UN, RO, Sa/Io JN, UN, RO, Sa/Io JN, UN, RO, Sa/Io JN, UN, RO, Sa/Io		1.5 1.5 1.5 1.5 1.5			
4														JN, UN, VR, Sa/Io		1.5			
					RC 4									JN, UN, VR, Sa/Io JN, PL, VR, Sa/Io		1 1			
														JN, UN, RO, Io JN, IR, RO, Io		1 1			
6														JN, PL, RO, IO		1.5			
		RC 5: Classification based on RQD: Good			RC 5									JN, PL, SR, Io/Ca JN, PL, SR, Io/Ch/Ca JN, PL, SR, Io/Ch/Ca JN, PL, SR, Ch JN, PL, RO, Ch/Ca JN, PL, SR, Ch/IO JN, PL, VR, Io/Ch JN, PL, VR, Ch JN, PL, RO, Io/Ch		1.5 1.5 1.5 1.5 1 1 1 1			
8		RC 6: Classification based on RQD: Excellent			RC 6									JN, PL, VR, Io/Ch/Ca JN, PL, VR, Io/Ch/Ca JN, PL, RO, Io/Ch		1 1 1.5			
														JN, PL, RO, Io		1			
		RC 7: Classification based on RQD: Good			RC 7									JN, PL, VR, Io/Ch JN, PL, VR, Io/Ch/Ca JN, PL, RO, Io/Ch/Ca JN, PL, SR, Io/Ch/Ca		1.5 1 1.5 1			
														JN, PL, VR, Io/Ch/Ca		1.5			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. BH2-6D - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101456, E316895)
DRILLING DATE : 29 Sep 16 - 29 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		DIORITE BEDROCK			RC 7									JN, PL, RO, Io/Ch/Ca		1			
														JN, PL, RO, Io/Ch/Ca		1			
														JN, PL, RO, Io/Ch/Ca		1			
	29/09/2016 HQ				RC 8									JN, PL, SR, Io/Ch/Ca		1			
														JN, PL, VR, Io/Ch/Ca		1			
														JN, PL, RO, Io/Ch/Ca		1.5			
														JN, PL, RO, Io/Ch/Ca		1.5			
														JN, PL, SR, Io/Ch/Ca		1			
		RC 8: Classification based on RQD: Excellent												JN, PL, RO, Io/Ch/Ca		1			
														JN, PL, RO, Io/Ch/Ca		1			
														JN, PL, RO, Io/Ch/Ca		1.5			
				179.69										JN, PL, RO, Io/Ch/Ca		1			
12		**End of Rock Coring**		11.91															
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : BC

CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-6S - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101456, E316895)
DRILLING DATE : 6 Oct 16 - 6 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-6S - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-6S" Rock Coring Started on 6 October 2016																	
0				191.38															
	11/10/2016 HQ	**DIORITE BEDROCK**		0.22															
		RC 3: Classification based on RQD: Fair			RC 3									JN, PL, RO, Io		1			
2														JN, UN, RO, Io JN, PL, RO, Io JN, UN, RO, Io JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io		1 1 1 1 1 1.5			
		RC 4: Classification based on RQD: Fair			RC 4									JN, PL, RO, Io JN, PL, RO, Io		1.5 1			
														JN, PL, RO, Io JN, PL, RO, Io		1 1			
4		RC 5: Classification based on RQD: Very Poor			RC 5								>>	JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io JN, PL, RO, Io		1 1 1.5 1 1 1.5 1			
		RC 6: Classification based on RQD: Very Poor			RC 6								>>	JN, PL, RO, Io		1			
6														JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, SR, Ch		1.5 1.5 1 1.5			
		RC 7: Classification based on RQD: Fair			RC 7									JN, PL, SR, Ch JN, PL, SR, Ch JN, PL, SR, Ch JN, PL, RO, Ch JN, PL, RO, Ch		1 1.5 1.5 1.5 1			
														JN, PL, RO, Ch		1.5			
8														JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch		1.5 1 1 1.5			
		RC 8: Classification based on RQD: Fair			RC 8									JN, PL, SR, Ch JN, PL, RO, Ch		1 1.5			
														JN, IR, RO, Ch		1			
														JN, PL, RO, Ch JN, PL, RO, Ch		1.5 1.5			
														JN, IR, RO, Ch					

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. BH2-6S - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101456, E316895)
DRILLING DATE : 6 Oct 16 - 6 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH / COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																
		DIORITE BEDROCK											JN, PL, RO, Ch		1.5 1.5			
													JN, IR, RO, Ch		1			
													JN, PL, RO, Ch		1			
	11/10/2016 HQ												JN, PL, SR, Ch		1.5			
10		RC 9: Classification based on RQD: Fair			RC 9								JN, UN, SR, Ch		1			
				180.93									JN, PL, RO, Ch		1.5			
		End of Rock Coring		10.67														
12																		
14																		
16																		
18																		

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-7 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101650, E316753)
DRILLING DATE : 6 Oct 16 - 6 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-7 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-7" Rock Coring Started on 6 October 2016																	
4				187.29															
	06/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK**		4.50	RC 7									JN, PL, RO, Sa/Io		1.5			
		RC 7: Classification based on RQD: Excellent												JN, PL, RO, Ch		0.75			
6					RC 8									JN, PL, RO, Sa/Io		1.5			
														JN, PL, RO, Sa		1			
														JN, PL, RO, Sa		1			
		RC 8: Classification based on RQD: Good												JN, PL, RO, Sa/Io		1			
														JN, PL, RO, Io/Ch/Sa		1			
														JN, PL, RO, Sa/Io		1			
														JN, PL, RO, Sa/Io		1			
8					RC 9									JN, UN, RO, Ch/Io		1			
														JN, PL, RO, Io		0.75			
		RC 9: Classification based on RQD: Fair																	
					RC 10									JN, PL, RO, Ch/Io		1			
10		RC 10: Classification based on RQD: Excellent												JN, PL, RO, Io/Ch/Sa		1.5			
					RC 11														
		RC 11: Classification based on RQD: Excellent																	
12					RC 12									JN, UN, RO, Io		0.75			
		RC 12: Classification based on RQD:																	

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 1 of 2

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-7 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101650, E316753)
DRILLING DATE : 6 Oct 16 - 6 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
14	06/10/2016 HQ	Excellent **QUARTZFELDSPATHIC GNEISS BEDROCK**			RC 12									JN, PL, RO, Io/Ch/Sa		1.5			
		RC 13: Classification based on RQD: Excellent		177.03	RC 13									JN, PL, RO, Ca/Ch		1			
		End of Rock Coring		14.76															
16																			
18																			
20																			
22																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : MA

CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-8 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101556, E316528)
DRILLING DATE : 27 Sep 16 - 27 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-8 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH2-8" Rock Coring Started on 27 September 2016		174.23															
0	27/09/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK**		0.23															
		RC 2: Classification based on RQD: Poor			RC 2									JN, PL, RO, Io JN, PL, RO, Io JN, UN, RO, Io JN, PL, RO, Io JN, PL, RO, Io		1 1 1 1 0.75			
2		RC 3: Classification based on RQD: Fair			RC 3									JN, PL, RO, Io JN, UN, RO, Io JN, PL, RO, Io JN, IR, RO, Io JN, PL, RO, Io JN, PL, RO, Io		1 1 1.5 1 1 0.75			
4		RC 4: Classification based on RQD: Good			RC 4									JN, PL, RO, Io JN, PL, RO, Io JN, IR, RO, Io JN, PL, RO, Io JN, PL, RO, Io		1 1.5 1 1.5 1			
		RC 5: Classification based on RQD: Fair			RC 5									JN, UN, RO, Io JN, UN, RO, Ch JN, PL, RO, Ch JN, PL, RO, Io/Ca/Ch		0.75 1 1 1			
6		RC 6: Classification based on RQD: Excelletn			RC 6									JN, IR, RO, Ch/Ca JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, RO, Io/Ca/Ch		1.5 1 1.5 1			
		RC 7: Classification based on RQD: Good			RC 7									JN, PL, SR, Ca/IO JN, IR, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, SR, Ch		1.5 1 1 1.5 1.5			
8					RC 8									JN, PL, SR, Ch/Io		1.5			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-8 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101556, E316528)
DRILLING DATE : 27 Sep 16 - 27 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
10	27/09/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 8: Classification based on RQD: Excelletn		164.23	RC 8									JN, UN, RO, Ch JN, PL, RO, Ch JN, PL, SR, Ch		1 1 1.5			
														JN, PL, RO, Io/Ca/Ch		1			
		End of Rock Coring		10.23															
12																			
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : MA

CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101369, E316355)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE GH1-1 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - GH1-1" Rock Coring Started on 12 October 2016																	
2				158.89															
	12/10/2016 HQ	**GNEISS BEDROCK**		2.59															
		RC 5: Classification based on RQD: Excellent			RC 5				>>				90	JN, PL, VR, Io		1			
													90	JN, PL, RO, Bi		0.75			
		RC 6: Classification based on RQD: Excellent			RC 6														
4																			
		RC 7: Classification based on RQD: Good			RC 7														
		RC 8: Classification based on RQD: Excellent			RC 8								90	JN, PL, RO, Ch/Ca		1			
6													90	JN, PL, SR, Ch/Ca		1.5			
													90	JN, PL, RO, Ch		1			
		RC 9: Classification based on RQD: Excellent			RC 9														
													90	JN, PL, RO, Ca/Ch JN, PL, RO, Ca/Ch		1 0.75			
8		RC 10: Classification based on RQD: Excellent			RC 10								90	JN, PL, RO, Ca/Ch		1			
													90	JN, PL, SR, Ch/Ca		0.75			
		RC 11: Classification based on RQD: Fair			RC 11								90	JN, PL, RO, Ch/Ca		1			
10													90	JN, PL, RO, Ch JN, PL, RO, Ch		0.75 0.75			
					RC 12								90	JN, PL, RO, Io		0.75			

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101369, E316355)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		GNEISS BEDROCK RC 12: Classification based on RQD: Good			RC 12									JN, PL, RO, Ca/Ch		0.75			
														JN, PL, RO, Ca/Ch		0.75			
														JN, UN, RO, Ca/Ch		0.75			
12														JN, PL, RO, Ch		0.75			
														JN, PL, SR, Ch/Ca		1.5			
														JN, PL, RO, Ch/Ca		1			
														JN, PL, RO, Ch		1			
														JN, PL, SR, Ch		1			
		RC 13: Classification based on RQD: Excellent			RC 13														
14														JN, PL, RO, Ch		0.75			
		RC 14: Classification based on RQD: Excellent			RC 14									JN, PL, RO, Ca/Ch		1.5			
														JN, PL, RO, Ch		1			
		RC 15: Classification based on RQD: Excellent			RC 15														
16	12/10/2016 HQ													JN, PL, RO, Ch		0.75			
														JN, PL, RO, Ch		0.75			
		RC 16: Classification based on RQD: Excellent			RC 16									JN, PL, RO, Bi		0.75			
18																			
		RC 17: Classification based on RQD: Excellent			RC 17									JN, PL, SR, Ch		1			
				142.06															
		MAFIC INTRUSIVE BEDROCK		19.42										CON, PL, SR, Ch		1.5			
														JN, PL, SR, Ca/Ch		1.5			
20														JN, UN, RO, Ca/Ch		1			
		RC 18: Classification based on RQD: Excellent			RC 18									JN, UN, RO, Ca/Ch		1			
														JN, PL, RO, Ca/Ch		1			
					RC														

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101369, E316355)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		MAFIC INTRUSIVE BEDROCK			19														
		RC 19: Classification based on RQD: Excellent			RC 19									JN, UN, RO, Ca/Ch		1.5			
22														JN, PL, RO, Ch		1			
														JN, PL, RO, Ch/Ca		2			
		RC 20: Classification based on RQD: Excellent			RC 20									JN, UN, RO, Ch JN, PL, SR, Ch		0.75 1			
24														JN, PL, RO, Ch		1.5			
														JN, UN, RO, Ch		1			
		RC 21: Classification based on RQD: Excellent			RC 21									JN, PL, RO, Ch		1			
														JN, PL, SR, Ch		1.5			
														JN, PL, SR, Ch		1.5			
26	12/10/2016 HQ													JN, PL, RO, Ch		1			
		RC 22: Classification based on RQD: Good			RC 22									JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, SR, Ch		1.5 2 1.5			
														JN, PL, SM, Ch		0.75			
		RC 23: Classification based on RQD: Excellent			RC 23									JN, PL, SR, Ch JN, PL, SR, Ch		0.75 1			
28														JN, IR, SR, Ch/Ca		1			
														JN, PL, SR, Ca/Ch		1			
		RC 24: Classification based on RQD: Excellent			RC 24									JN, UN, SR, Ca/Ch JN, IR, RO, Ch		1 1			
30														JN, PL, SR, Ca/Ch		1			
					RC 25									JN, UN, RO, Ch/Bi		1			
		RC 25: Classification based on RQD: Excellent												JN, CU, SR, Ch JN, PL, RO, Ch/Ca		1 1			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101369, E316355)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.							NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY										
32	12/10/2016 HQ	**MAFIC INTRUSIVE BEDROCK**			RC 25														
		RC 26: Classification based on RQD: Excellent			RC 26								•	JN, PL, RO, SR, Ch/Ca		0.5			
				128.56															
		End of Rock Coring		32.92															
34																			
36																			
38																			
40																			

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 4 of 4

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101373, E316380)
DRILLING DATE : 13 Oct 16 - 14 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE GH1-2 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - GH1-2" Rock Coring Started on 13 October 2016																	
2				161.94															
	13/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 4: Classification based on RQD: Fair		2.16	RC 4														
4		RC 5: Classification based on RQD: Excellent			RC 5														
		RC 6: Classification based on RQD: Excellent			RC 6									JN, UN, SR, Ch JN, PL, RO, Bi JN, PL, RO, Ch/Bi	0.75 0.75 0.75				
6		RC 7: Classification based on RQD: Excellent			RC 7									JN, PL, SR, Ch JN, UN, SR, Io/Ch JN, , , JN, PL, RO, Ca/Ch	0.75 1 1.5				
8		RC 8: Classification based on RQD: Excellent			RC 8														
		RC 9: Classification based on RQD: Excellent			RC 9									JN, PL, RO, Ca	0.75				
10					RC 10									JN, PL, SR, Ch	1				

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101373, E316380)
DRILLING DATE : 13 Oct 16 - 14 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		QUARTZFELDSPATHIC GNEISS BEDROCK																	
		RC 10: Classification based on RQD: Excellent			RC 10								0	JN, PL, RO, Ch/Ca		1			
													0	JN, PL, RO, Ch		1			
12													0	JN, PL, RO, Ch/Ca		1.5			
													0	JN, PL, RO, Ca/Ch		1			
		RC 11: Classification based on RQD: Excellent			RC 11								0	JN, PL, RO, Ca/Ch		0.75			
													0	JN, PL, RO, Ch		1			
													0	JN, PL, RO, Ch		1.5			
14													0	JN, PL, SM, Ch		1.5			
		RC 12: Classification based on RQD: Excellent			RC 12														
													0	JN, PL, SR, Ch/Ca		1			
	13/10/2016 HQ	RC 13: Classification based on RQD: Excellent			RC 13								0	JN, PL, SM, Ch		1.5			
16													0	JN, PL, RO, Ca		0.75			
		RC 14: Classification based on RQD: Excellent			RC 14								0	JN, PL, SR, Ch/Ca		1.5			
18													0	JN, PL, SR, Ca		0.75			
		RC 15: Classification based on RQD: Excellent			RC 15								0	JN, PL, RO, Ca		0.75			
													0	JN, PL, SR, Ch		1			
20													0	JN, PL, SR, Ch/Ca		1			
		RC 16: Classification based on RQD: Excellent			RC 16														

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101373, E316380)
DRILLING DATE : 13 Oct 16 - 14 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		QUARTZFELDSPATHIC GNEISS BEDROCK												JN, PL, RO, Ch		0.75			
														JN, PL, SR, Ch		1			
22		RC 17: Classification based on RQD: Excellent			RC 17									JN, PL, SR, Ca/Su		0.75			
														JN, PL, SR, Ch/Bi		1.5			
														JN, PL, SM, Ch/Ca/Su		1.5			
		RC 18: Classification based on RQD: Excellent			RC 18									JN, UN, SM, Ca/Ch		1			
														JN, PL, SM, Ca/Ch		1.5			
24																			
		RC 19: Classification based on RQD: Good			RC 19									JN, PL, SM, Ch		1.5			
														JN, PL, RO, Ch		1.5			
														JN, PL, RO, Ch/Ca		1.5			
														JN, PL, RO, Ca		0.75			
														JN, PL, SM, Ca		0.75			
														JN, UN, SR, Ca		0.75			
														JN, PL, SR, Ca		0.75			
														JN, PL, SR, Ch		1.5			
26	13/10/2016 HQ	RC 20: Classification based on RQD: Good			RC 20									JN, PL, RO, Ch		1			
														JN, PL, SR, Ch		1			
		RC 21: Classification based on RQD: Excellent			RC 21									JN, PL, SR, Ch/Ca		1			
28																			
		RC 22: Classification based on RQD: Excellent			RC 22									JN, PL, RO, Ca		0.75			
														JN, PL, RO, Ch/Su		0.75			
30																			
		RC 23: Classification based on RQD: Excellent			RC 23									JN, PL, RO, Ch/Ca		1.5			
														JN, PL, RO, Ch/Ca		0.75			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101373, E316380)
DRILLING DATE : 13 Oct 16 - 14 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
32	13/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK**			RC 23														
		RC 24: Classification based on RQD: Excellent			RC 24								•	JN, PL, RO, Ca/Ch		1			
				131.41															
		End of Rock Coring		32.69															
34																			
36																			
38																			
40																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 4 of 4

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101496, E316738)
DRILLING DATE : 4 Oct 16 - 4 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE GH1-4 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - GH1-4" Rock Coring Started on 4 October 2016																	
				185.87															
		DIORITE BEDROCK		3.20										JN, PL, RO, Sa/Io		1			
														JN, PL, RO, Sa/Io		1			
		RC 5: Classification based on RQD: Poor			RC 5									JN, PL, VR, Sa/Io JN, PL, RO, Io/Ch JN, UN, RO, Sa/Io JN, PL, RO, Sa/Io JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch/Sa		1 1 1 1 1 1 1 1.5 1 1			
4																			
					RC 6									JN, PL, RO, Io JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, UN, RO, Io JN, PL, RO, Io/Ch JN, UN, RO, Io JN, PL, RO, Io/Sa		1.5 1 1.5 1 1 1 1			
6														JN, UN, RO, Io/Ch JN, UN, RO, Io/Ch		1 1.5			
		RC 7: Classification based on RQD: Poor			RC 7									JN, PL, SR, Io/Ch SH, IR, RO, Io/Ch JN, IR, RO, Io/Ch JN, PL, RO, Io/Ch		1 1.5 1 1.5			
														JN, PL, SR, Ch/Ca		1			
8	04/10/2016 HQ	RC 8: Classification based on RQD: Fair			RC 8									JN, PL, RO, Ch		1			
														JN, PL, SR, Ch		1.5			
		RC 9: Classification based on RQD: Fair			RC 9									JN, IR, SR, Ch/Su JN, PL, SR, Ch/Su		1 1			
10														JN, PL, SR, Ch JN, PL, RO, Ch		1 1			
		RC 10: Classification based on RQD: Poor			RC 10									JN, PL, SR, Ch JN, UN, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch JN, UN, RO, Ch		1.5 1.5 1.5 1.5 1			
														JN, PL, RO, Ch		1			

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101496, E316738)
DRILLING DATE : 4 Oct 16 - 4 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		DIORITE BEDROCK																	
		RC 11: Classification based on RQD: Fair			RC 11									JN, PL, K, Ch/Ca JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, IR, RO, Ch JN, PL, RO, Io/Ch		1.5 1 1.5 1 1			
14		RC 12: Classification based on RQD: Good			RC 12									JN, PL, RO, Ca/Io/Ch JN, PL, RO, Ca/Io/Ch JN, PL, SR, Ch JN, IR, SR, Ch		1.5 1.5 1 1.5			
16	04/10/2016 HQ	RC 13: Classification based on RQD: Excellent			RC 13									JN, PL, SR, Ch JN, PL, RO, Ch/Ca JN, PL, RO, Ch		1.5 1.5 1			
		RC 14: Classification based on RQD: Good			RC 14									JN, PL, RO, Ch/Ca JN, PL, K, Ch/IO JN, ST, SM, Ch/Ca JN, PL, SR, Ca/Io/Ch JN, PL, SR, Ch JN, PL, RO, Ch		1.5 1.5 1.5 1.5 1 1			
18		RC 15: Classification based on RQD: Good			RC 15									JN, PL, RO, Ch/IO SH, PL, RO, Ca/Io/Ch		1.5			
20		RC 16: Classification based on RQD: Excellent			RC 16									JN, PL, RO, Ch/Ca JN, PL, RO, Ca/Io/Ch JN, PL, RO, Io/Ch JN, PL, RO, Ch JN, UN, RO, Ch/Ca		1.5 1 1 1.5 1.5			
		RC 17: Classification based on RQD: Good			RC 17									JN, UN, RO, Ch JN, PL, RO, Ch		1 1			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101496, E316738)
DRILLING DATE : 4 Oct 16 - 4 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		DIORITE BEDROCK			RC 17									JN, PL, RO, Ch		1.5			
														JN, PL, RO, Ch		1.5			
					RC 18									JN, UN, RO, Ch JN, PL, RO, Ch		1.5 1.5			
		RC 18: Classification based on RQD: Excellent																	
24														JN, PL, RO, Ch, SR, K		1.5			
		RC 19: Classification based on RQD: Excellent			RC 19														
														JN, PL, RO, Ch, SR		1.0			
26	04/10/2016 HQ	RC 20: Classification based on RQD: Excellent			RC 20														
														JN, PL, RO, Ch		0.75			
		RC 21: Classification based on RQD: Excellent			RC 21														
28														JN, PL, RO, Ch, SR		1			
		RC 22: Classification based on RQD: Excellent			RC 22														
30		**End of Rock Coring**		159.10 29.97															

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 3 of 3

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101498, E316774)
DRILLING DATE : 30 Sep 16 - 30 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE GH1-5 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - GH1-5" Rock Coring Started on 30 September 2016												JN, PL, ST, SM, Ch/Ca, RO		1.0			
				187.51															
		QUARTZFELDSPATHIC GNEISS BEDROCK		1.01										JN, UN, RO, Bi		0.75			
														JN, PL, RO, Io		0.75			
					RC 3									JN, PL, SR, Io/Su		0.75			
2		RC 3: Classification based on RQD: Excellent												JN, UN, RO, Bi		1			
														JN, UN, RO, Bi/Mu		1			
														JN, UN, SR, Bi/Io		1			
					RC 4									JN, UN, SR, Io		1			
		RC 4: Classification based on RQD: Excellent												JN, PL, SR, Bi		1			
														JN, PL, SR, Io		0.75			
4														JN, UN, RO, Io		0.75			
														JN, PL, SR, Io		0.75			
														JN, UN, SR, Io		1			
					RC 5									JN, UN, SR, Io		0.75			
		RC 5: Classification based on RQD: Excellent												JN, UN, SR, Io		1			
														JN, UN, SR, Io		1			
														JN, UN, RO, Ca		1.5			
6														JN, UN, SR, Io/Su		1.5			
					RC 6									JN, UN, RO, Io/Su		1.5			
		RC 6: Classification based on RQD: Excellent												JN, PL, PL, Io		0.75			
														JN, UN, RO, Ca/Ch		0.75			
														JN, PL, SR, Bi		1.5			
					RC 7									JN, UN, SR, Io		0.75			
8		RC 7: Classification based on RQD: Excellent												JN, UN, SR, Bi		1			
														JN, UN, SR, Bi		1			
														JN, PL, SR, Mu/Io		1			
					RC 8									JN, PL, SR, Io		1			
		RC 8: Classification based on RQD: Excellent												JN, Cu, SR, Ch/Ca		1.5			

30/09/2016 HQ

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101498, E316774)
DRILLING DATE : 30 Sep 16 - 30 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	30/09/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK**		176.49	RC 8														
		RC 9: Classification based on RQD: Good			RC 9									JN, PL, SR, Io JN, PL, RO, io JN, PL, SR, Io JN, PL, SR, Ch/Ca JN, UN, SR, Io/Sa JN, UN, RO, Io/Sa JN, UN, SR, Io JN, PL, SR, Io		1 0.75 1 1 1 0.75 1 1			
		MAFIC INTRUSIVE BEDROCK		12.03										CON, PL, SR, Io JN, UN, SM, Ch JN, PL, SR, Ch/Ca/Io JN, PL, SM, Ch/Io JN, PL, SR, Ch/Io		1 1 1 1 1			
		RC 10: Classification based on RQD: Poor			RC 10									JN, PL, SM, Ch/Io JN, PL, SM, Ch/Io		1 1.5			
14		RC 11: Classification based on RQD: Fair			RC 11									JN, PL, SR, Ch/Io JN, PL, SR, Ch/Io		1.5 1			
		RC 12: Classification based on RQD: Good			RC 12									JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch/Ca/Io JN, PL, RO, Ch JN, PL, SR, Ch/Io JN, PL, RO, Ch/Ca JN, PL, RO, Ch JN, UN, RO, Ch		1 1 1.5 1.5 1 1 1 1.5			
16		RC 13: Classification based on RQD: Fair			RC 13									JN, PL, RO, Ch JN, UN, RO, Ch JN, PL, RO, Ch JN, PL, SR, Ch JN, UN, SR, Ch JN, PL, SR, Ch/Ca JN, CU, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch JN, PL, SM, Ch		1.5 1.5 1.5 1 1 1.5 1 1 1 1.5			
18		RC 14: Classification based on RQD: Fair			RC 14									JN, PL, SR, Ch JN, UN, RO, Ch JN, ST, RO, Ch JN, PL, SR, Ch JN, PL, SR, Ch JN, PL, SR, Ch JN, PL, SR, Ch JN, PL, RO, Ch		1 1.5 1.5 1.5 1 1 1 1.5			
		RC 15: Classification based on RQD: Excellent			RC 15									JN, PL, K, Ch		1.5			

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 4

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. GH1-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101498, E316774)
DRILLING DATE : 30 Sep 16 - 30 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		MAFIC INTRUSIVE BEDROCK			RC 15									JN, PL, SR, Ch JN, PL, SR, Ch		1 1.5			
		RC 16: Classification based on RQD: Fair			RC 16									JN, PL, RO, Ch		1			
22		RC 17: Classification based on RQD: Good			RC 17									JN, PL, UN, SR, Ch, RO		1			
24		RC 18: Classification based on RQD: Fair			RC 18									JN, PL, UN, SR, Ch/Io, RO		1			
26	30/09/2016 HQ	RC 19: Classification based on RQD: Excellent			RC 19									JN, PL, VR, SR, RO		1			
		RC 20: Classification based on RQD: Excellent			RC 20									JN, PL, SR, K, Ch/Io, RO		1.5			
28		RC 21: Classification based on RQD: Excellent			RC 21									JN, PL, SM, Ch/Io, RO		1.0			
					RC 22														

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

RECORD OF BOREHOLE No. GH1-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Geophysical (N5101498, E316774)
DRILLING DATE : 30 Sep 16 - 30 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	30/09/2016 HQ	**MAFIC INTRUSIVE BEDROCK** RC 22: Classification based on RQD: Fair		157.22	RC 22									JN, PL, UN, SR, VR, Ch/Io, RO		1.5			
		End of Rock Coring		31.30															
32																			
34																			
36																			
38																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS
▽ IN OPEN BOREHOLE ON COMPLETION
WATER LEVEL (date)

SHEET 4 of 4

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101743, E3106711)
DRILLING DATE : 18 Oct 16 - 18 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-2 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH 2-2" Rock Coring Started on 17 October 2016		171.52															
	18/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK**		17.31															
18		RC 15: Classification based on RQD: Excellent			RC 15								•	JN, PL, RO, Sa		0.75			
													•	JN, PL, RO, Sa		0.75			
		RC 16: Classification based on RQD: Excellent			RC 16								•	JN, PL, RO, Sa		0.75			
20													•	JN, PL, RO, Ca		1.5			
		RC 17: Classification based on RQD: Excellent			RC 17														
22		RC 18: Classification based on RQD: Excellent			RC 18								•	JN, UN, RO, Ca/Io		0.75			
													•	JN, PL, SR, Ch/Ca		1			
24		RC 19: Classification based on RQD: Excellent			RC 19								•	JN, PL, RO, Ch/Ca		0.75			
					RC 20														
		RC 20: Classification based on RQD:																	

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-1 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101743, E3106711)
DRILLING DATE : 13 Oct 16 - 18 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
	18/10/2016 HQ	Excellent **QUARTZFELDSPATHIC GNEISS BEDROCK**			RC 20									JN, PL, RO, Ch/Ca		1			
		RC 21: Classification based on RQD: Excellent			RC 21														
28		**End of Rock Coring**		160.79 28.04															
30																			
32																			
34																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-2 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101790, E2366466)
DRILLING DATE : 29 Sep 16 - 30 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH / COLOUR / % RETURN	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA: Alpha angle (deg.)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES / WATER LEVELS / INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE BH2-2 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - BH 2-2" Rock Coring Started on 29 October 2016																
				163.46														
		GNEISS BEDROCK		23.16														
		RC 21: Classification based on RQD: Poor			RC 21													
24		RC 22: Classification based on RQD: Poor			RC 22								JN, PL, RO, Ca JN, PL, RO, Ca JN, PL, RO, Ca		1.5 0.75 0.75			
		RC 23: Classification based on RQD: Fair			RC 23								JN, PL, RO, Sa JN, PL, RO, Ca JN, PL, RO, Ca		0.75 0.75 0.75			
26	29/09/2016 HQ	RC 24: Classification based on RQD: Fair			RC 24								JN, PL, RO, Sa/Ca JN, PL, RO, Sa		0.75 0.75			
		RC 25: Classification based on RQD: Fair			RC 25								JN, PL, RO, Ca JN, PL, RO, Ca JN, PL, RO, Di JN, PL, RO, Ca/Sa JN, UN, RO, Ca JN, PL, RO, Br		0.75 0.75 1 1.5 1 0.75			
28													JN, UN, RO, Ca JN, PL, SR, Ca		1.5 1			
		RC 26: Classification based on RQD: Fair			RC 26								JN, PL, RO, Ca		1			
30				156.52														
		End of Rock Coring		30.10														

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION
WATER LEVEL (date)

SHEET 1 of 1

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101135, E1068066)
DRILLING DATE : 5 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
2		- For overburden details, see "RECORD OF BOREHOLE SH-4 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - SH-4" Rock Coring Started																	
				153.94															
		QUARTZFELDSPATHIC GNEISS BEDROCK RC 5: Classification based on RQD: Fair		2.64	RC 5									JN, UN, RO, Ch JN, PL, SR, Ch JN, PL, RO, Ch		1 1 1			
4		RC 6: Classification based on RQD: Excellent			RC 6									JN, PL, RO, Ch JN, PL, SR, Ch		1.5 1			
		RC 7: Classification based on RQD: Excellent			RC 7									JN, PL, SR, Ch JN, PL, SR, Ch/Ca		1.5 1.5			
6														JN, PL, SR, Ch JN, IR, SR, Ch JN, PL, SR, Ch JN, PL, SM, Ch JN, PL, SM, Ch JN, PL, SR, Ch		1.5 1.5 1.5 1.5 1.5 1.5			
	HQ	RC 8: Classification based on RQD: Fair			RC 8														
				149.64															
		MAFIC INTRUSIVE BEDROCK		6.94										JN, PL, SM, Ch/Io JN, PL, RO, Ch/Io JN, PL, SR, Ch		1.5 2 1.5			
8														JN, UN, RO, Ch		1			
		RC 10: Classification based on RQD: Fair			RC 9									JN, PL, RO, Ca/Ch JN, UN, RO, Ca/Ch JN, PL, RO, Ch/Io JN, PL, RO, Ch JN, PL, RO, Ca/Ch/Io JN, PL, SM, Ch/Io		1.5 1 1 1 1 1			
				147.54										JN, PL, SR, Ch JN, ST, SR, Ch		1.5 1			
		SCHIST BEDROCK		9.04										CON, PL, RO, Ch JN, UN, RO, Ch		1 1.5			
10		RC 11: Classification based on RQD: Excellent			RC 10									JN, PL, RO, Ch JN, PL, RO, Ch		1.5 1.5			
		End of Rock Coring												JN, PL, SR, Ch JN, PL, RO, Ch		1.5 1			
				146.02															
		GNEISS BEDROCK		10.56	RC 11									JN, PL, RO, Ch/Ca JN, PL, RO, Ch		1 1.5			

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : KT/MA
CHECKED : SC/NR

RECORD OF BOREHOLE No. SH-4 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101135, E31[illegible]6)
DRILLING DATE : 3 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		GNEISS BEDROCK																	
		RC 12: Classification based on RQD: Excellent			RC 11								90	JN, PL, SR, Ch/Ca		1.5			
													90	JN, PL, RO, Su/Ch		1			
12	HQ																		
		RC 13: Classification based on RQD: Excellent			RC 12								90	JN, PL, SR, Ch/Ca		1			
													90	JN, PL, SR, Ch/Ca		1			
													90	JN, PL, RO, Ch/Ca		1			
				143.13															
		End of Rock Coring		13.45															
14																			
16																			
18																			
20																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : KT/MA

CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101337, E2106316)
DRILLING DATE : 11 Oct 16 - 12 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE SH-5 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - SH-5" Rock Coring Started on 11 October 2016		155.61															
6	12/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 9: Classification based on RQD: Fair		5.49	RC 9				>>					JN, PL, RO, Io		0.75			
		RC 10: Classification based on RQD: Fair			RC 10									JN, PL, RO, Ca/Ch JN, PL, RO, Ca/Ch		1.5 1.5			
8		RC 11: Classification based on RQD: good		152.49	RC 11									JN, PL, RO, Io JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, PL, RO, Io JN, PL, RO, Ch/Ca JN, PL, VR, Io		1 1 1 1 1.5 1			
		SCHIST BEDROCK RC 12: Classification based on RQD: Very Poor		8.61	RC 12									JN, IR, RO, Sa/Ch JN, PL, RO, Sa/Ch JN, PL, VR, Sa/Ch JN, IR, RO, Ch		1 1.5 1.5 1			
				151.34										JN, PL, RO, Ch JN, UN, RO, Sa/Ch JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch JN, UN, RO, Io/Ch/Sa JN, PL, RO, Io/Ch CON, PL, RO, Io/Ch/Ca		1 1 1 1.5 1.5 1 1			
10		**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 13: Classification based on RQD: good RC 14: Classification based on RQD: Very Poor		9.76	RC 14 RC 13									JN, PL, SR, Ch JN, PL, RO, Ch JN, PL, RO, Ch		1 1 1.5			
		RC 15: Classification based on RQD: Excellent			RC 15									JN, PL, RO, Io/Ch JN, PL, RO, Io/Ch		1.5 1			
12														JN, PL, RO, Io/Ch/Ca		1			
		RC 16: Classification based on RQD: Excellent			RC 16									JN, UN, RO, Io/Ch JN, PL, RO, Io/Ch/Ca JN, IR, RO, Ch JN, PL, RO, Ch JN, PL, RO, Ch/Ca		1 1 0.75 0.75 0.5			
					RC 17														

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS
▽ IN OPEN BOREHOLE ON COMPLETION
WATER LEVEL (date)

SHEET 1 of 2

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-5 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101337, E2106316)
DRILLING DATE : 11 Oct 16 - 12 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		QUARTZFELDSPATHIC GNEISS BEDROCK																	
	12/10/2016 HQ	RC 17: Classification based on RQD: Excellent			RC 17														
		RC 18: Classification based on RQD: Excellent			RC 18								•	JN, UN, RO, Ch		0.75			
													•	JN, PL, RO, Ch		1.5			
														JN, PL, SR, Ch		1			
		End of Rock Coring		145.56 15.54															
16																			
18																			
20																			
22																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

LOGGED : BC
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-6 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101611, E2301429)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		- For overburden details, see "RECORD OF BOREHOLE SH-6 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - SH-6"																	
		Rock Coring Started on 12 October 2016		161.23															
		QUARTZFELDSPATHIC GNEISS BEDROCK		13.72															
14		RC 15: Classification based on RQD: Poor			RC 15														
16		RC 16: Classification based on RQD: Poor			RC 16								>>						
		RC 17: Classification based on RQD: Excellent			RC 17														
18	12/10/2016 HQ	RC 18: Classification based on RQD: Excellent			RC 18									JN, PL, RO, Ca/Ch		0.75			
20		RC 19: Classification based on RQD: Excellent			RC 19									JN, PL, SR, Ch		1			
														JN, ST, RO, Ch		0.75			
														JN, PL, RO, Ca		1			
		RC 20: Classification based on RQD: Excellent			RC 20									JN, PL, RO, Su/Ca/Ch		1			
				153.15										JN, PL, SR, Su/Ch		1			
22		**SCHIST BEDROCK**		21.80										JN, PL, RO, Ch JN, UN, RO, Ch JN, UN, RO, Ch		1.5 1.5 1.5			
					RC 21									JN, PL, RO, Ch		1			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS
▽ IN OPEN BOREHOLE ON COMPLETION
WATER LEVEL (date)

SHEET 1 of 2

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-6 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101611, E2101429)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.							NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY										
		SCHIST BEDROCK RC 21: Classification based on RQD: Excellent			RC 21								90	JN, PL, RO, Ch		1.5			
24																			
	12/10/2016 HQ	RC 22: Classification based on RQD: Excellent		150.10 24.85	RC 22								90	JN, PL, RO, Ch		1			
		QUARTZFELDSPATHIC GNEISS BEDROCK																	
26		RC 23: Classification based on RQD: Excellent			RC 23														
				148.05															
		End of Rock Coring		26.90															
28																			
30																			
32																			

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date)

SHEET 2 of 2

LOGGED : MA
CHECKED : SC/NR

AMECFW ROCK TZ16018_NSDF_BEDROCK_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. AW15-6 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : (N5101482, E316599)
DRILLING DATE : -
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																
		- For overburden details, see "RECORD OF BOREHOLE G-BH15-6"																
2																		
4																		
6				168.10														
		End of Well		6.50														
8																		

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

SHEET 1 of 1

LOGGED :
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-2 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101360, E316468)
DRILLING DATE : 11 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		About 80 mm TOPSOIL													
		brown **(Disturbed) SILTY SAND** trace gravel moist	162.96												
		brown **SILTY SAND** trace to some gravel moist	0.69 162.64												
		End of Overburden Drilling Due to Auger Refusal	1.01	RC 3		>>									
		Rock Coring Started on 11 October 2016 **QUARTZOFELDSPATHICGNEISS BEDROCK** RC 3: Classification based on RQD: Excellent													
2		RC 4: Classification based on RQD: Fair		RC 4											
4		RC 5: Classification based on RQD: Good		RC 5		>>									
	11/10/2016 HQ	RC 6: Classification based on RQD: Excellent		RC 6		>>									
6		RC 7: Classification based on RQD: Excellent		RC 7											
8		RC 8: Classification based on RQD: Excellent		RC 8											
		RC 9: Classification based on RQD: Excellent		RC 9											

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 20/10/2016

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : BC
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-2 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101360, E316468)
DRILLING DATE : 11 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	HQ	Continued from non-cored borehole See Overburden log report.																
		End of Rock Coring		10.16														
12																		
14																		
16																		
18																		

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 20/10/2016

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : BC
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-3 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101213, E316595)
DRILLING DATE : 7 Oct 16 - 7 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
		brown to grey **(Disturbed) SAND /SILTY SAND** some gravel, some clay moist																	
		brown to **SILTY SAND** trace gravel moist																	
		End of Overburden Drilling Due to Auger Refusal		156.05															
		Rock Coring Started on 11 October 2016 **GNEISS BEDROCK**		1.45															
2		RC 4: Classification based on RQD: Fair			RC 4														
		RC 5: Classification based on RQD: Poor			RC 5														
4																			
	07/10/2016 HQ	RC 6: Classification based on RQD: Very Poor			RC 6														
6		RC 7: Classification based on RQD: Very Poor			RC 7														
		RC 8: Classification based on RQD: Very Poor			RC 8														
8		RC 9: Classification based on RQD: Excellent			RC 9														

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-3 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101213, E316595)
DRILLING DATE : 7 Oct 16 - 7 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	07/10/2016 HQ	**GNEISS BEDROCK** RC 10: Classification based on RQD: Fair		145.30	RC 9 RC 10														
		End of Rock Coring		12.20															
14																			
16																			
18																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-6 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101456, E316895)
DRILLING DATE : 29 Sep 16 - 29 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		brown **(Disturbed) SILTY SAND** trace gravel, with organics moist	190.91												
		brown **COBBLES/BOULDERS** with rock fragments	190.66 0.69												
		End of Overburden Drilling Due to Auger Refusal Rock Coring Started on 29 September 2016 **DIORITE BEDROCK**	190.25 0.94	RC 2											
2				RC 3											
4				RC 4											
6	29/09/2016 HQ	RC 5: Classification based on RQD: Fair		RC 5											
8		RC 6: Classification based on RQD: Good		RC 6											
		RC 7: Classification based on RQD: Fair		RC 7											

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : BC
CHECKED : KG/NR

RECORD OF BOREHOLE No. BH2-6 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101456, E316895)
DRILLING DATE : 29 Sep 16 - 29 Sep 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
	29/09/2016 HQ	**DIORITE BEDROCK**			RC 7														
		RC 8: Classification based on RQD: Good			RC 8														
				179.69															
12		**End of Rock Coring**		11.91															
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

SHEET 2 of 2

LOGGED : BC
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-7 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101650, E316753)
DRILLING DATE : 6 Oct 16 - 6 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		light brown **(Disturbed) SILTY SAND** trace gravel moist	191.10												
		light grey **SILTY SAND** trace gravel very dense moist rock fragments at tip of spoon	0.69												
2		cobbles/boulders													
4		**End of Overburden Drilling Due to Auger Refusal** Rock Coring Started on 6 October 2016	187.29												
	06/10/2016 HQ	**QUARTZOFELDSPATHICGNEISS BEDROCK**	4.50												
		RC 7: Classification based on RQD: Excellent		RC 7											
6		RC 8: Classification based on RQD: Fair		RC 8											
8		RC 9: Classification based on RQD: Poor		RC 9											
		RC 10: Classification based on RQD: Good		RC 10											

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. BH2-7 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : ECM (N5101650, E316753)
DRILLING DATE : 6 Oct 16 - 6 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		QUARTZOFELDSPATHICGNEISS BEDROCK			RC 10													
		RC 11: Classification based on RQD: Excellent			RC 11													
12	06/10/2016 HQ																	
		RC 12: Classification based on RQD: Excellent			RC 12													
14		RC 13: Classification based on RQD: Good			RC 13													
				177.03														
		End of Rock Coring		14.76														
16																		
18																		

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-4 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101135, E1068016)
DRILLING DATE : 31 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH / COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																
		light brown **(Disturbed) SILTY SAND** trace gravel, with organics moist		155.89														
		light grey / grey **SAND / SILTY SAND** trace gravel compact wet		0.69														
2		**End of Overburden Drilling Due to Auger Refusal** Rock Coring Started ------ some gravel		153.94														
		QUARTZOFELDSPATHICGNEISS BEDROCK RC5 : Classification based on RQD: Poor		2.64	RC 5													
4		RC6 : Classification based on RQD: Good			RC 6													
		RC7 : Classification based on RQD: Excellent			RC 7													
6	HQ	RC8 : Classification based on RQD: Poor		149.64	RC 8													
		MAFIC INTRUSIVE BEDROCK		6.94														
8		RC9 : Classification based on RQD: Poor			RC 9													
		SCHIST BEDROCK		147.54 9.04														
		RC10 : Classification based on RQD: Excellent			RC 10													

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : KT/MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-4 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101135, E1068016)
DRILLING DATE : 5 Oct 16 - 11 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		SCHIST BEDROCK			RC 10														
		End of Rock Coring		146.02															
		GNEISS BEDROCK		10.56															
12	HQ	RC11 : Classification based on RQD: Good			RC 11														
		RC12 : Classification based on RQD: Excellent			RC 12														
				143.13															
		End of Rock Coring		13.45															
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : KT/MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-5 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101337, E2106316)
DRILLING DATE : 12 Oct 16 - 12 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																
		About 100 mm TOPSOIL																
		brown **(Disturbed) SILTY SAND** trace gravel moist		160.41														
		grey/brown **SILTY SAND** trace gravel firm to very dense moist		0.69														
2		------ wet																
4		**End of Overburden Drilling Due to Auger Refusal**																
		Rock Coring Started on 12 October 2016 cobbles/boulders		155.61														
	12/10/2016 HQ	**QUARTZFELDSPATHIC GNEISS BEDROCK** RC 9: Classification based on RQD: Poor		5.49	RC 9			>>										
6		RC 10: Classification based on RQD: Poor			RC 10													
8		RC 11: Classification based on RQD: Fair		152.49	RC 11													
		SCHIST BEDROCK		8.61	RC 12													
				151.34	RC 13													
		QUARTZFELDSPATHIC GNEISS BEDROCK		9.76														

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : BC
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-5 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101337, E2106316)
DRILLING DATE : 11 Oct 16 - 12 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
		RC 13: Classification based on RQD: Fair **QUARTZFELDSPATHIC GNEISS BEDROCK**			RC 13 RC 14 RC 14														
		RC 15: Classification based on RQD: Excellent			RC 15														
12	12/10/2016 HQ	RC 16: Classification based on RQD: Good			RC 16														
14		RC 17: Classification based on RQD: Excellent			RC 17														
		RC 18: Classification based on RQD: Excellent		145.56	RC 18														
		End of Rock Coring		15.54															
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : BC
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-6 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101611, E2106429)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
		reddish brown **(Disturbed) SILTY SAND** trace gravel moist																	
				174.26															
		grey / light grey **SAND / SILTY SAND** trace gravel, cobbles / boulders compact to very dense moist to wet		0.69															
		------ grey																	
2																			
4																			
6																			
8																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-6 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101611, E2106429)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

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DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
12		grey / light grey **SAND / SILTY SAND** trace gravel, cobbles / boulders compact to very dense moist to wet																	
		End of Overburden Drilling Due to Auger Refusal Rock Coring Started on 12 October 2016		161.23															
14	12/10/2016 HQ	**QUARTZOFELDSPATHICGNEISS BEDROCK** RC15 : Classification based on RQD: Very Poor		13.72	RC 15														
16		RC16 : Classification based on RQD: Very Poor			RC 16														
		RC17 : Classification based on RQD: Excellent			RC 17														
18		RC18 : Classification based on RQD: Good			RC 18														
					RC 19														

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. SH-6 - Monitoring Well

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multicidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : Supporting Structure (N5101611, E2106429)
DRILLING DATE : 12 Oct 16 - 13 Oct 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical
DATUM: Geodetic

amec foster wheeler

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Continued from non-cored borehole See Overburden log report.																	
		RC19 : Classification based on RQD: Excellent **QUARTZOFELDSPATHICGNEISS BEDROCK**			RC 19														
		RC20 : Classification based on RQD: Excellent		153.15	RC 20														
22		**SCHIST BEDROCK**		21.80															
	12/10/2016 HQ	RC21 : Classification based on RQD: Excellent			RC 21														
24																			
		RC22 : Classification based on RQD: Excellent		150.10	RC 22														
		QUARTZOFELDSPATHICGNEISS BEDROCK		24.85															
26		RC23 : Classification based on RQD: Excellent			RC 23														
		End of Rock Coring		148.05 26.90															
28																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date)

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 20/10/2016

LOGGED : MA
CHECKED : KG/NR

AMECFW ROCK TZ16018_NSDF_WELL_24OCT2016.GPJ AMECFW ROCK 2016.GDT 31/10/16

RECORD OF BOREHOLE No. W-1A - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316738.3, N5101496.32
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 188.86																	
	NW Casing	Augering to 31.2 m Without Sampling (former GH1-4)																	
2																			
4																			▽
6																			
8																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

SHEET 1 of 4

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1A - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316738.3, N5101496.32
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	NW Casing	Augering to 31.2 m Without Sampling (former GH1-4)																	
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1A - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316738.3, N5101496.32
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
22	NW Casing	Augering to 31.2 m Without Sampling (former GH1-4)																	
24																			
26																			
28																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

SHEET 3 of 4

LOGGED : BC

CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1A - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316738.3, N5101496.32
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	NW Casing	Augering to 31.2 m Without Sampling (former GH1-4)		157.67															
		End of Augering		31.19															
32		Well Installation Details: 0 - 6.1 m Bentonite 6.1 - 6.9 m Sand 6.9 - 9.9 m Screen 9.9 - 10.4 m Sand 10.4 - 31.2 m Grout																	
34																			
36																			
38																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

SHEET 4 of 4

LOGGED : BC

CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1B - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316773.6, N5101498.13
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 188.28																	
	NW Casing	Augering to 31.1 m Without Sampling (former GH1-4)																	▽
2																			
4																			
6																			
8																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

SHEET 1 of 4

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1B - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316773.6, N5101498.13
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	NW Casing	Augering to 31.1 m Without Sampling (former GH1-4)																	
12																			
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1B - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316773.6, N5101498.13
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	NW Casing	Augering to 31.1 m Without Sampling (former GH1-4)																	
22																			
24																			
26																			
28																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-1B - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316773.6, N5101498.13
DRILLING DATE : Dec 1, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	NW Casing	Augering to 31.1 m Without Sampling (former GH1-4)		157.19															
		End of Augering		31.09															
		Well Installation Details: 0 - 27.4 m Bentonite 27.4 - 28.1 m Sand 28.1 - 31.1 m Screen																	
32																			
34																			
36																			
38																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 12/01/2016

SHEET 4 of 4

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-2D - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316670.78, N5101743.21
DRILLING DATE : Nov 25, 16 - Nov 26, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 188.60																	
	NW Casing	Augering to 30.0 m Without Sampling (former SH-1)																	
2																			
4																			
6																			
8																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/26/2016

SHEET 1 of 4

LOGGED : MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-2D - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316670.78, N5101743.21
DRILLING DATE : Nov 25, 16 - Nov 26, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	NW Casing	Augering to 30.0 m Without Sampling (former SH-1)																	
14																			
16																			
18																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/26/2016

LOGGED : MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-2D - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316670.78, N5101743.21
DRILLING DATE : Nov 25, 16 - Nov 26, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
	NW Casing	Augering to 30.0 m Without Sampling (former SH-1)		158.60															
22																			
24																			
26																			
28																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/26/2016

SHEET 3 of 4

LOGGED : MA

CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-2D - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316670.78, N5101743.21
DRILLING DATE : Nov 25, 16 - Nov 26, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		End of Augering Well Installation Details: 0 - 0.3 Concrete 0.3 - 7.6 m Bentonite 7.6 - 16.6 m Grout 16.6 - 17.5 Bentonite 17.5 - 18.0 Sand 18.0 - 21.0 Screen 21.0 - 21.3 Sand 21.3 - 23.3 Bentonite 23.3 - 30.0 Grout		30.00															
32																			
34																			
36																			
38																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/26/2016

SHEET 4 of 4

LOGGED : MA

CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-2S - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316670.78, N5101743.21
DRILLING DATE : Nov 24, 16 - Nov 25, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 188.60																	
	HW Casing	Augering to 14.1 m Without Sampling (beside former SH-1) **SILTY SAND** cobbles/boulders																	
2																			
4																			
6																			
8																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/25/2016

LOGGED : MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-2S - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316670.78, N5101743.21
DRILLING DATE : Nov 24, 16 - Nov 25, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)
12	HW Casing	Augering to 14.1 m Without Sampling (beside former SH-1) **SILTY SAND** cobbles/boulders	
14			174.53
		End of Augering 14.07 Well Installation Details: 0 - 0.6 Concrete 0.3 - 9.6 m Bentonite 9.6 - 11.0 Sand 11.0 - 14.1 Screen	
16			
18			

SYMBOLIC LOG | SAMPLE No. | PENETRATION RATE (m/min) | FLUSH | COLOUR / % RETURN

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

RECOVERY: TOTAL CORE % (20 40 60 80) | SOLID CORE % (20 40 60 80)
R.Q.D. % (20 40 60 80)
FRACTURE INDEX PER 1 m (5 10 15 20)
DISCONTINUITY DATA: Alpha angle (deg.) (0 30 60 90) | TYPE AND SURFACE DESCRIPTION | Jr | Ja
ROCK STRENGTH INDEX (R0 R1 R2 R3 R4 R5 R6)
WEATHERING INDEX (W1 W2 W3 W4 W5 W6)

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/25/2016

SHEET 2 of 2

LOGGED : MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-3 - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316514.12, N5101765.64
DRILLING DATE : Nov 27, 16 - Nov 28, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 171.99																	
	HW Casing	Augering to 12.04 m (former SR-2) **SILTY SAND** some gravel, cobbles/boulders																	
2																			
4																			
6																			
8																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/28/2016

SHEET 1 of 2

LOGGED : MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-3 - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316514.12, N5101765.64
DRILLING DATE : Nov 27, 16 - Nov 28, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	HW Casing	Augering to 12.04 m (former SR-2) **SILTY SAND** some gravel, cobbles/boulders		159.95														
		End of Augering Well Installation Details: 0 - 0.6 Concrete 0.6 - 8.6 m Bentonite 8.6 - 9.0 m Sand 9.0 - 12.0 m Screen		12.04														
14																		
16																		
18																		

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/28/2016

SHEET 2 of 2

LOGGED : MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-4

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316658.15, N5101405.58
DRILLING DATE : Nov 29, 16 - Nov 30, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 171.51																
		Augering to Bedrock Without Soil Sampling **SAND** some gravel, cobbles																
				169.69														
2		pink/white/black **GNEISS EDROCK**		1.82									JN, UN, RO, Sa / Ch JN, UN, RO, Io / Ca JN, UN, RO, Ch / Ca	2.5 2.5 2.5	0.75 0.75 0.75			
		RC 1: Classification based on RQD: Good			RC 1								JN, PL, RO, Ch / Ca JN, PL, RO, Io / Ca	1.5 1.5	1.5 1.5			
4	Rook Coring (HQ)	RC 2: Classification based on RQD: Excellent			RC 2								JN, UN, RO, Ca / Ch	2.5	2			
		RC 3: Classification based on RQD: Excellent			RC 3								JN, ST, RO, Ca JN, UN, RO, Ca	3.5 2.5	2 2			
													JN, IR, VR, Ca	4	1			
													JN, UN, RO, Ca / Io	2.5	2			
6				165.35									JN, UN, RO, Ca / Io	2.5	2			
		End of Rock Coring		6.16														
		Well Installation Details: 0 - 2.7 m Bentonite 2.7 - 3.0 m Sand 3.0 - 6.1 m Screen																
8																		

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/30/2016

LOGGED : BC
CHECKED : NR/KG

RECORD OF BOREHOLE No. W-5

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316796.73, N5101249.93
DRILLING DATE : Nov 29, 16 - Nov 30, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja
		Ground Surface Elev: 165.06										
		Augering to Bedrock Without Soil Sampling										
		black **PEAT**								BC		
		pink/white/black **GNEISS BEDROCK**								JN, UN, RO, Sa	2.5	0.75
		RC 1: Classification based on RQD: Fair		RC 1						JN, UN, RO, Sa	2.5	0.75
										JN, UN, RO, Sa BC, , ,	2.5	0.75
2										JN, UN, VR, Io	3	0.75
		RC 2: Classification based on RQD: Fair		RC 2								
										JN, UN, RO, Io	2.5	0.75
4	Rcok Coring (HQ)	RC 3: Classification based on RQD: Excellent		RC 3								
										BC		
		RC 4: Classification based on RQD: Excellent		RC 4						JN, UN, RO, Ca	2.5	10
6												
		RC 5: Classification based on RQD: Excellent		RC 5						JN, UN, RO, Si	2.5	0.75
			157.52									
		End of Rock Coring	7.54									
		Well Installation Details:										
8		0 - 1.6 m Bentonite 1.6 - 2.0 m Sand 2.0 - 5.0 m Screen 5.0 - 5.1 m Sand 5.1 - 7.5 m Bentonite										

NOTE: For abbreviations, symbols and descriptions refer to **LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY**

ROCK STRENGTH INDEX: R0 R1 R2 R3 R4 R5

WEATHERING INDEX: W1 W2 W3 W4 W5

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/29/2016

LOGGED : BC
CHECKED : NR/KG

RECORD OF BOREHOLE No. W-6 - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316619.44, N5101664.15
DRILLING DATE : Nov 26, 16 - Nov 27, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
		Ground Surface Elev: 184.78																	
		Augering to 12.2 m Without Sampling **SILTY SAND** trace gravel																	
2																			
4																			
6																			
		inferred cobbles/boulders																	
8																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/27/2016

SHEET 1 of 2

LOGGED : BC
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. W-6 - Monitoring Well

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316619.44, N5101664.15
DRILLING DATE : Nov 26, 16 - Nov 27, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

amec foster wheeler

DATUM: masl

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12		Augering to 12.2 m Without Sampling **SILTY SAND** trace gravel --- inferred boulders		172.59															
		End of Augering 12.19 Well Installation Details: 0 - 0.6 m Concrete 0.6 - 3.4 m Bentonite 3.4 - 7.8 m Bentonite 7.8 - 8.5 m Bentonite 8.5 - 9.1 m Sand 9.1 - 12.2 m Screen																
14																			
16																			
18																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/27/2016

LOGGED : BC
CHECKED : NR/KG

RECORD OF BOREHOLE No. W-7

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316672.93, N5101490.64
DRILLING DATE : Nov 30, 16 - Dec 1, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: masl

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX
		Ground Surface Elev: 180.56												
		Augering to Bedrock Without Soil Sampling **SAND and GRAVEL** cobbles	179.54											
	Rcok Coring (HQ)	pink/white/black **GABBRO / DIORITE BEDROCK** RC 1: Classification based on RQD: Excellent	1.02	RC 1						JN, UN, SR, Io	2	2		
2										JN, UN, SR, Io JN, UN, RO, Io	2 2.5	2 2		
		RC 2: Classification based on RQD: Excellent		RC 2						JN, ST, RO, Io JN, UN, RO, Io	3.5 2.5	2 2		
4		RC 3: Classification based on RQD:		RC 3						JN, UN, RO, Io JN, PL, RO, Io	2.5 1.5	2 2		
		RC 4: Classification based on RQD: Good		RC 4						JN, PL, SR, Io / Ca	1.25	2		
6		RC 5: Classification based on RQD: Excellent	173.19	RC 5						JN, UN, SR, Ch / Ca JN, UN, SR, Ch / Ca JN, UN, SR, Ch / Ca JN, UN, SR, Ch / Ca JN, UN, SR, Ch / Ca JN, ST, SR, Ch / Ca	2 2 2 2 2 3	1 1 1.5 1 1.5 1		
		End of Rock Coring Well Installation Details: 0 - 2.5 m Bentonite 2.5 - 2.8 m Sand 2.8 - 5.8 m Screen 5.8 - 6.1 m Sand 6.1 - 7.4 m Bentonite	7.37											
8														

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/30/2016

LOGGED : MA
CHECKED : NR/KG

RECORD OF BOREHOLE No. W-8

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316936.88, N5101478.32
DRILLING DATE : Nov 30, 16 - Dec 2, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: masl

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX
		Ground Surface Elev: 193.16												
		Augering to Bedrock Without Soil Sampling (former BH2-5)	191.79											
		pink/white/black **GNEISS BEDROCK** RC 1: Classification based on RQD: Poor	1.37 / 191.53	RC 1						JN, PL, SR, Si / Ca BC JN, IR, VR, Si JN, UN, RO, Ca	1.25 4 2.5	0.75 4 1		
		pink/white/black **GNEISS, PEGMATITE and SCHIST BEDROCK** RC 2: Classification based on RQD: Good	1.63 / 190.09	RC 2						JN, PL, RO, Mu JN, PL, RO, Mu JN, PL, SR, Mu / Si JN, UN, RO, Mu / Si JN, UN, SR, Mu JN, UN, RO, Bi / Ca	1.5 1.5 1.25 2.5 2 2.5	4 4 2 2 2 1		
2														
	Rook Coring (HQ)	**GABBRO, PEGMATITE AND SCHIST BEDROCK** RC 3: Classification based on RQD: Very Poor	3.07	RC 3						JN, UN, VR, Ca BC JN, UN, VR, Ca / Si JN, UN, VR, Si JN, UN, VR, Si JN, UN, RO, Si JN, ST, VR, Si / Io JN, UN, RO, Si / Io JN, UN, RO, Mu / I0 JN, UN, RO, Mu / I0	3 3 3 3 2.5 4 2.5 2.5 2.5	0.75 1.5 1 0.75 1 1 1 2 2		
4														
		RC 4: Classification based on RQD: Fair		RC 4		>>				BC JN, UN, SR, Si / Io JN, IR, SR, Si / Io JN, IR, SR, Io JN, UN, RO, Mu / Io JN, UN, SR, Ca / Io JN, PL, RO, Ca / Sa JN, UN, VR, Ca JN, UN, SR, Ca JN, UN, SR, Ca / Ch JN, UN, SR, Si / Mu JN, UN , SR, Ca / Ch BC JN, UN, SR, Ca / Ch JN, UN, RO, Ca / Ch BC JN, UN, RO, Ca / Io JN, Si, SR, Ca / Io	 2 3 3 2.5 2 1.5 3 2 2 2 2 2 2.5 2.5 3.5	 1 1 1 1 2 2 1 1 1 1 2 2 1 1 0.75		
6		pink/white/black **MONZONITE BEDROCK** with gravel, some gneiss	186.86 6.30											
		RC 5: Classification based on RQD: Fair		RC 5		>>				JN, UN, SR, Ca / Io BC, , ,	2	2		
		RC 6: Classification based on RQD: Excellent		RC 6		>>				JN, UN, RO, Ca JN, UN, RO, Ca / Io JN, PL, SR, Ca / Io JN, UN, RO, Ca / Io / Si JN, PL, SR, Ca / Io JN, UN, SR, Ca / Io	2.5 2.5 1.25 2.5 1.25 2	1 0.75 1.5 2 0.75 1		
8														
		dark grey/black **GABBRO / DIORITE BEDROCK**	183.94 9.22											
				RC 7		>>				JN, PL, RO, Mu / Si JN, PL, SR, Si JN, IR, RO, Bi / Si JN, UN, RO, Si / Io JN, UN, RO, Ca / Io	1.5 1.25 3.5 2.5	2 2 1 0.75		

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/30/2016

LOGGED : BC/MA
CHECKED : NR/KG

RECORD OF BOREHOLE No. W-8

PROJECT No. : TZ16018- Phase II
CLIENT : Canadian Nuclear Laboratories Ltd.
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF - Chalk River, ON

DRILLING LOCATION : E316936.88, N5101478.32
DRILLING DATE : Nov 30, 16 - Dec 2, 16
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: masl

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja
	RC 7: Classification based on RQD: Good dark grey/black **GABBRO / DIORITE BEDROCK**		RC 7						JN / CON, UN, RO, Ca / Ch	2.5	1
									JN / CON, UN, RO, Ca / Ch	2.5	2
									BC		
									JN, IR, RO, Ca / Ch	3.5	2
									JN, PL, SR, Ca / Ch	1.25	2
									JN, IR, VR, Ch	4	2
									JN, PL, RO, Ch	1.5	2
									JN, PL, SR, Ch / Ca	1.25	2
	RC 8: Classification based on RQD: Good		RC 8		>>				JN, IR, RO, Ch	3.5	2
									JN, PL, SR, Ch	1.25	2
									BC		
									JN, PL, SR, Ch	1.25	2
12									JN, UN, RO, Ch	2.5	2
									JN, UN, SR, Ch	2	2
									JN, PL, SR, Ch	1.25	2
									JN, PL, SR, Ch	1.25	2
									BC		
									JN, PL, SR, Ch	1.25	2
	RC 9: Classification based on RQD: Fair		RC 9		>>				JN, IR, SR, Ch	3	2
									JN, UN, SR, Ch	2	2
									JN, UN, SR, Ch	2	2
									JN, UN, SR, Ch	2	2
									JN, PL, RO, Ch	1.5	2
		179.25							JN, UN, SR, Ch	2.5	2
									JN, UN, VR, Ch	3	2
									BC, , ,		
14	**End of Rock Coring**	13.91							JN, UN, SR, Ch	2	2
									JN, UN, SR, Ch / Mu	2	2
	Well Installation Details: 0 - 10.1 m Bentonite 10.1 - 10.4 m Sand 10.4 - 13.4 m Screen 13.4 - 13.7 m Sand 13.7 - 14.0 m Bentonite										
16											
18											

ROCK STRENGTH INDEX: R0 R1 R2 R3 R4 R5 R6
WEATHERING INDEX: W1 W2 W3 W4 W5 W6

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ IN OPEN BOREHOLE ON COMPLETION

WATER LEVEL (date) 11/30/2016

LOGGED : BC/MA
CHECKED : NR/KG

AMECFW ROCK TZ16018_NSDF_ALLINONE_PHASE II_DEC2016.GPJ AMECFW ROCK 2016.GDT 16/01/17

RECORD OF BOREHOLE No. PH17-001 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316670.3 N: 5101860
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 18 Dec 17 Date Completed: 20 Dec 17

Logged by: KC/BC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION (Ground Surface Elevation: 186.4 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT / PPT / DCPT), MTO Vane* (Intact / Remould), Nilcon Vane* (Intact / Remould), * Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading COV (LEL) / TOV (LEL), COV (ppm) / TOV (ppm), W_P / W / W_L (Plastic / Liquid)	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	brown to light brown **WEATHERED fine SAND** some silt, trace gravel, cobbles, and organics, loose to very dense, moist	SS	1	68	6	0	186	50/5	22		Top 0.1 m of soil was frozen.
		SS	2	100	50/5cm	1					NOTE: When N-Value is in the format, e.g. 50/5 cm, N-Value is 50 blows for 5 cm penetration. Switched to casing and washboring.
	185.2 — dark brown to dark grey **SILTY fine SAND** some gravel, very dense, moist 1.2	SS	3	91	50/13cm	2	185	50/13	9		
	...below 6.1 m, soil contains trace of cobbles	SS	4	83	50/15cm	3	184	50/15	11		
		SS	5	82	50/13cm	4	183	50/13	10		
		SS	6	0	50/3cm	5		50/3			
		SS	7	90	50/10cm	6	182	50/10	10		4 63 (33)
	... GRAVEL, some silt	SS	8	33	50/15cm	7	181	50/15			
	...at 6.1 m, a 0.15 m thick pocket of GRAVELLY SAND, some silt	SS	9	50	50/15cm	8	180	50/15	10		0.46 m of recovery (gravel and cobbles) from coring between 6.1 m to 7.6 m.
		SS	10	100	50/8cm	9	179	50/8	13		
	...at 9.1 m, a 0.15 m thick pocket of medium SAND, some gravel	SS	11	73	82	10	178		15		0.18 m of recovery (silt, sand, gravel, and cobbles) from coring between 7.6 m to 9.1 m.
							177				

Continued on Next Page

Amec Foster Wheeler
Environment & Infrastructure
300-210 Colonnade Road South
Ottawa, Ontario, K2E 7L5
Canada
Tel. No.: (613) 727-0658
amecfw.com

Groundwater depth during drilling on 22/12/2017 at a depth of: 15.6 m.
Groundwater depth observed on 2/1/2018 at a depth of: 15.5 m.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-001 - Overburden

Project Number: **TZ16108** Project Name: **Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4**

Project Location: **Chalk River, ON**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	dark brown to dark grey **SILTY fine SAND** some gravel, very dense, moist					0	176				0.00 m of recovery from coring between 9.1 m to 10.7 m.
		SS	12	50	50 / 15cm	1	175	50 / 15	13		0.20 m of recovery (gravel and cobbles) from coring between 10.7 m to 12.2 m.
		SS	13	0	50 / 15cm	2	174	50 / 15			0.00 m of recovery from coring between 12.2 m to 13.7m.
		SS	14	100	50 / 15cm	3	173	50 / 15	15		0.00 m of recovery from coring between 13.7 m to 15.2 m.
		SS	15	100	50 / 8cm	4	172	50 / 8			0.00 m of recovery from coring between 15.2 m to 16.8 m.
		SS	16	100	50 / 3cm	5	171	50 / 3			0.08 m of recovery (cobbles) from coring between 16.8 m to 18.3 m.
		SS	17	100	50 / 5cm	6	170	50 / 5	14		0.00 m of recovery from coring between 18.3 m to 19.8 m.
						7	169				0.00 m of recovery from coring between 19.8 m to 21.3 m.
						8	168				
						9	167				
						10	166				
						11					
						12					
						13					
						14					
						15					
						16					
						17					
						18					
						19					
						20					
						21					

Scale: 1 : 53

Continued on Next Page

RECORD OF BOREHOLE No. PH17-001 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Penetration Testing (SPT ○ PPT □ DCPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80)	LAB TESTING: Soil Vapour Reading (□ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80)	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	dark brown to dark grey **SILTY fine SAND** some gravel, very dense, moist ... at 21.3 m, a 0.10 m thick pocket of SILT AND SAND	SS	18	100	50 / 8cm	22	164	50 / 8	11		0.18 m of recovery (silty sand, trace gravel and cobbles) from coring between 21.3 m to 22.9m.
		SS	19	67	50 / 8cm	23	163	50 / 8	13		Casing shoe broke. Driller had to remove casing and core barrel out and redrill.
						24					0.51 m of recovery (sand and gravel, some silt and cobbles) from coring between 22.9 m to 24.3 m.
		SS	20	0	50 / 3cm	25	162	50 / 3			0.13 m of recovery (gravel and cobbles) from coring between 24.3 m to 25.9 m.
		SS	21	0	50 / 3cm	26	161	50 / 3			0.15 m of recovery (gravel and cobbles) from coring between 25.9 m to 27.4 m.
	159.0 27.4 **End Of Borehole** **Well Installation Details** 0.0 - 23.8 m Bentonite 23.8 - 24.4 m Sand 24.4 - 27.4 m Screen					27	160 159				

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-002 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316630.2 N: 5101949
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 20 Dec 17 Date Completed: 21 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	Ground Surface Elevation: 182.0 m							Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80		GR SA SI CL
	brown to light brown **WEATHERED fine SAND** trace silt and organics, loose, moist	SS	1	63	7				9		Top 0.2 m of soil was frozen.
	181.3										
	light brown to light grey 0.7 **Fine SAND** trace silt, loose, moist	SS	2	50	6	1	181		10		
	180.5										
	brown to dark grey 1.4 **Fine SAND** trace silt and gravel, loose to dense, moist	SS	3	63	8	2	180		10		
	at 2.4 m, a 0.30 m thick pocket GRAVELLY SAND, trace silt	SS	4	71	35				8		
	179.0					3	179				
	dark grey to light brown 3.0 **SILTY fine SAND** some gravel, trace cobbles, very dense, moist	SS	5	58	34				5		
		SS	6	71	40	4	178		15		10 64 (26)
		SS	7	73	68 / 23cm			68 / 23	6		NOTE: When N-Value is in the format, e.g. 68/23 cm, N-Value is 68 blows for 23 cm penetration.
						5	177				
						6	176				encountered cobbles/boulders when augering from 4.6 m to 7.6 m.
						7	175				
		SS	8	92	50 / 15cm			50 / 15	5		
						8	174				
						9	173				encountered cobbles/boulders when augering from 7.6 m to 10.6 m.
						10	172				

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Groundwater depth during drilling on 21/12/2017 at a depth of: 11.5 m.
Groundwater depth observed on 2/1/2018 at a depth of: 13.1 m.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-002 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)			
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR	SA	SI	CL
	dark grey to light brown **SILTY fine SAND** some gravel, trace cobbles, very dense, moist													
		SS	9	94	89 / 28cm	11	171	89 / 28	8		7	65	(28)	
						12	170							
						13	169							
		SS	10	90	50 / 10cm	14	168	50 / 10	8					Difficult to auger. Switched to casing and washboring.
						15	167							
						16	166							
		SS	11	0	50 / 10cm	17	165	50 / 10						0.43 m of recovery (silty sand, trace gravel and cobbles) from coring between 16.8 m to 19.8 m.
						18	164							
						19	163							
		SS	12	100	50 / 10cm	20	162	50 / 10	12					
						21	161							

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-002 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	dark grey to light brown **SILTY fine SAND** some gravel, trace cobbles, very dense, moist					22	160				1.40 m of recovery (siilty sand, some grave, trace cobbles) from coring between 19.8 m to 22.9 m.
		SS	13		50 / 0cm	23	159	50 / 0	12		
						24	158				
	157.6 24.4 **End Of Borehole** **Well Installation Details** 0.0 - 20.7 m Bentonite 20.8 - 21.3 m Sand 21.3 - 24.4 m Screen										

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-003 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316484.3 N: 5101872
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 21 Dec 17 Date Completed: 21 Dec 17

Logged by: BC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P Plastic, W, W_L Liquid; 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	. Ground Surface Elevation: 170.3 m CORED WITHOUT SOIL SAMPLING					0 1 2 3 4 5 6 7 8 9 10	170 169 168 167 166 165 164 163 162 161				Lithology profile may be referred to BH-114, which it was drilled at E: 316491 N: 5101868, with a surface elevation 170.2 m.

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▽ Groundwater depth during drilling on 21/12/2017 at a depth of: 2.0 m.
▼ Groundwater depth observed on 2/1/2018 at a depth of: 1.3 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-003 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	CORED WITHOUT SOIL SAMPLING						160				
	159.6										
	10.7 **End Of Borehole**										
	Well Installation Details 0.0 - 7.0 m Bentonite 7.0 - 7.6 m Sand 7.6 - 10.7 m Screen										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-004 - Overburden

Project Number:	TZ16108	Drilling Location:	E: 316597.5 N: 5101894
Project Client:	Canadian Nuclear Laboratories	Drilling Method:	HQ Rock Coring
Project Name:	Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4	Drilling Machine:	Track Mounted Drill
Project Location:	Chalk River, ON	Date Started:	21 Dec 17
		Date Completed:	22 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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LITHOLOGY PROFILE | SOIL SAMPLING | FIELD TESTING | LAB TESTING | INSTRUMENTATION INSTALLATION | COMMENTS & GRAIN SIZE DISTRIBUTION (%)

Field Testing legend: PenetrationTesting ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80

Lab Testing legend: Soil Vapour Reading □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80

Ground Surface Elevation: 179.3 m

Elevation (m) / Depth (m)	Description
179.3 / 0.1	ICE / SNOW - about 5.0 cm thick
179.2 / 0.1	ORGANICS - about 7.5 cm thick
	brown **WEATHERED fine SAND** trace silt and organics, loose, moist
178.4 / 0.9	light brown **Fine SAND** trace silt and gravel, loose, moist
177.9 / 1.4	light brown to light grey **Fine SAND** some silt and gravel, dense, moist
177.0 / 2.3	light brown to light grey **SANDY GRAVEL** trace silt, very dense, moist
176.2 / 3.1	brown to grey **SILTY fine SAND** trace to some gravel, trace cobbles, very dense, moist

Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	Moisture (%)	GR	SA	SI	CL
SS	1	38	10	18				
SS	2	79	9	8				
SS	3	71	38	7				
SS	4	88	50 / 5cm	3				
SS	5	63	31	6	3	64	(33)	
SS	6	88	72 / 28cm	6				
SS	7	68	54	7	13	56	(31)	
~~SS~~	~~8~~	~~0~~	50 / 5cm					

Depth (m): 1 2 3 4 5 6 7 8 9 10

Elevation (m): 179 178 177 176 175 174 173 172 171 170

Comments:

NOTE: Where N-Value is in the format, e.g. 72/28 cm, N-Values is 72 blows for 28 cm penetration.

Auger hit refusal. Switched to casing and washboring.

0.00 m of recovery from coring between 6.1 m to 7.6 m.

0.30 m of recovery (gravel and cobbles) from coring between 7.6 m to 10.7 m.

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Canada
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▽ Groundwater depth during drilling on 22/12/147 at a depth of: 8.8 m.

▼ Groundwater depth observed on 2/1/2018 at a depth of: 9.5 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-004 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	brown to grey **SILTY fine SAND** trace to some gravel, trace cobbles, very dense, moist	SS	9	67	50 / 8cm	10	169	50 / 8			0.08 m of recovery (silty sand, some gravel) from coring between 10.7 m to 13.7 m.
						11	168				
						12	167				
						13	166				
		SS	10	0	50 / 8cm	14	165	50 / 8			0.45 m of recovery (gravel, trace cobbles/boulders) from coring between 13.7 m to 16.7 m.
						15	164				
						16	163				
						17	162				Did not performed a SPT as driller noted hard material.
						18	161				0.00 m of recovery from coring between 16.7 m to 20.7 m.
						19	160				
						20	159				
	158.6 20.7										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-004 - Overburden

Project Number: **TZ16108** Project Name: **Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4**

Project Location: **Chalk River, ON**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane*: △ Intact ▲ Remould; Nilcon Vane*: ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	End Of Borehole **Well Installation Details** 0.0 - 17.1 m Bentonite 17.1 - 17.7 m Sand 17.7 - 20.7 m Screen										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-005 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316787.5 N: 5101720
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 13 Dec 17 Date Completed: 15 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION (Ground Surface Elevation: 193.5 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING: Undrained Shear Strength (kPa)	LAB TESTING: Soil Vapour Reading / Plastic & Liquid	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	ORGANICS - about 7.5 cm thick (193.4 / 0.1)										
	brown to light brown WEATHERED fine SAND some silt, trace gravel and organics, very loose to compact, moist	SS	1	50	3						
	(192.5)										
	light grey GRAVELLY SAND trace silt, compact, moist (1.0 / 192.0)	SS	2	63	29	1	193				
	light brown to light grey SILTY fine SAND some gravel, trace cobbles and boulders, very dense, moist (1.4)	SS	3	78	50 / 8cm		192	50/8			
		SS	4	78	93 / 28cm	2	191	93/28			NOTE: Where N-Value is in the format, e.g. 50/8 cm, N-Value is 50 blows for 8 cm penetration Switched to casing and washboring.
		SS	5	73	50 / 13cm	3	190	50/13			14 59 (27)
		SS	6	79	83 / 20cm	4	189	83/20			
		SS	7	67	50 / 8cm	5	188	50/8			2 63 (35) 0.40 m of recovery (boulders) from coring between 5.3 m to 6.1 m.
		SS	8	100	50 / 8cm	6	187	50/15			
		SS	9	100	50 / 15cm	7	186				0.50 m of recovery (cobbles / boulders) from coring between 6.1 m to 8.2 m.
		SS	10	100	50 / 15cm	8	185	50/15			
		SS	11	100	50 / 8cm	9	184	50/8			0.20 m of recovery (gravel and cobles) from coring between 8.2 m to 9.1 m.
						10					

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Canada
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Groundwater depth during drilling on 15/12/2017 at a depth of: 9.3 m.
Groundwater depth observed on 2/1/2018 at a depth of: 10.6 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-005 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	light brown to light grey **SILTY fine SAND** some gravel, trace cobbles and boulders, very dense, moist	SS	12	100	50 / 5cm	11	183	50 / 5	13		0.40 m of recovery (cobbles) from coring between 9.1 m to 10.7 m.
		SS	13	67	50 / 8cm	12	182	50 / 8	13		0.00 m of recovery from coring between 10.7 m to 12.2 m.
	178.6					13	181				0.40 m of recovery (gravel and cobbles) from coring between 12.2 m to 13.7 m.
	black 14.9 **GNEISS TO SCHIST BEDROCK** slightly to highly weathered	RC	14	100	0	14	180				Did not perform SPT as driller noticed hard material
	(for rock core details, see "RECORD OF BOREHOLE No. PH17-005 - ROCK")	RC	15	88	66	15	179				
		RC	16	63	30	16	178				
		RC	17	79	74	17	177				Driller noticed a weak layer
		RC	18	100	100	18	176				
	172.5 21.0					19	175				
						20	174				
						21	173				

Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80

Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80

GR SA SI CL

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RECORD OF BOREHOLE No. PH17-005 - Overburden

Project Number: **TZ16108** Project Name: **Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4**

Project Location: **Chalk River, ON**

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	End of Borehole **Well Installation Details** 0.0 - 17.7 m Bentonite 17.7 - 18.0 m Sand 18.0 - 21.0 m Screen										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

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RECORD OF BOREHOLE No. PH17-005 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316787.5 N: 5101720
DRILLING DATE : 13 Dec 17 - 15 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
14		- For overburden details, see "RECORD OF BOREHOLE PH17-005 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - PH17-005" Rock Coring Started on 14 Dec 2017		178.55															
		black **GNEISS to SCHIST BEDROCK**		14.94	RC 14									BC from 14.94 m to 15.39 m					
														BC from 15.39 m to 15.51 m					
16		RC 15: Classification based on RQD: Fair			RC 15									JN, PL, SR, Si, Sa JN, PL, SR, Si, Sa JN, PL, SR VN, Si, Sa BC from 16.26 m to 13.61 m	1.25 1.25 1.25	1 1 1			
														JN, PL, SR	1.25	1			
		RC 16: Classification based on RQD: Poor			RC 16									JN, PL, SR	1.25	0.75			
18	15/12/2017 Rock Coring (HQ)													JN, PL, SR JN, PL, SR	1.25 3	0.75 0.75			
		RC 17: Classification based on RQD: Fair			RC 17									JN, PL, SR	3	1			
														JN, PL, SR	1.25	1			
20		RC 18: Classification based on RQD: Excellent			RC 18									JN, PL, SR, Sa	1	0.75			
				172.49															
		End of Rock Coring		21.00															
22																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 15/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-006 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316749.9 N: 5101578
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 12 Dec 17 Date Completed: 12 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION (Ground Surface Elevation: 190.1 m)	Elev.	Depth	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)
	ICE / SNOW - about 5 cm thick	190.1	0.0				
	ORGANICS - about 7.5 cm thick	190.0	0.1				
	brown to light brown **WEATHERED - fine SAND** trace to some gravel, trace silt and cobbles, very loose to very dense, moist			SS	1	42	3
				SS	2	78	57 / 30cm
		188.7	1.4	RC	3	100	
	black, green, white **GNEISS TO SCHIST BEDROCK** fresh to moderately weathered (for rock core details, see "RECORD OF BOREHOLE No. PH17-006 - ROCK")			RC	4	100	40
				RC	5	100	75
				RC	6	100	79
				RC	7	100	81
				RC	8	100	85
				RC	9	100	100

FIELD TESTING: Penetration Testing — SPT, PPT, DCPT; MTO Vane* (Intact, Remould); Nilcon Vane* (Intact, Remould); * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading — COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE: Where N-Value is in the format, e.g. 57/30 cm, N-Value is 57 blows for 30 cm penetration Switched to casing and washboring.

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300-210 Colonnade Road South
Ottawa, Ontario, K2E 7L5
Canada
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Groundwater depth during drilling on 12/12/2017 at a depth of: 2.5 m.
Groundwater depth observed on 2/1/2018 at a depth of: 3.2 m.

Scale: 1 : 53

Continued on Next Page

RECORD OF BOREHOLE No. PH17-006 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	black, green, white **GNEISS TO SCHIST BEDROCK** fresh to moderately weathered						180				
		RC	10	100	100	11	179				
	178.2 11.9 **End Of Borehole** **Well Installation Details** 0.0 - 8.1 m Bentonite 8.1 - 8.8 m Sand 8.8 - 11.9 m Screen										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-006 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316749.9 N: 5101578
DRILLING DATE : 12 Dec 17 - 12 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA: Alpha angle (deg.)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja
		- For overburden details, see "RECORD OF BOREHOLE PH17-006 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - PH17-006" Rock Coring Started on 12 Dec 2017	188.73									
2	12/12/2017 Rock Coring (HQ)	black, white, pink, white **SCHIST to GNEISS BEDROCK**	1.37	RC 4						BC from 1.94 m to 2.24 m		
		RC 4: Classification based on RQD: Poor								JN, PL, RO	1.5	1
										JN, IR, RO	3.5	1
				RC 5						BC from 2.84 m to 2.91 m BC from 3.03 m to 5.09 m		
		RC 5: Classification based on RQD: Poor								JN, PL, SR, Cl	20	1.25
										JN, PL, RO, Cl	20	1.25
4										JN, PL, RO, Cl	20	1.25
				RC 6						JN, PL, SR	1.25	1.0
										JN, PL, SR, Cl	20	1.25
		RC 6: Classification based on RQD: Good								JN, IR, SM	1.25	1
										JN, IR, SM, Io BC from 5.39 m to 5.59 m	10	2.5
6										JN, IR, SR, Cl	2	1
										JN, IR, SR	20	2
										BC from 6.30 m to 6.8 m		
		RC 7: Classification based on RQD: Good		RC 7						JN, IR, SR	20	2
										JN, IR, SR	3	1
										JN, IR, SR	3	1
		RC 8: Classification based on RQD: Excellent								BC from 8.03 m to 8.11 m		
8				RC 8						JN, PL, SM	1	1
										BC from 8.53 m to 8.67 m		
		RC 9: Classification based on RQD: Excellent								JN, PL, SM	1	1
				RC 9						JN, IR, SR	3	0.75
10										JN, IR, SM	1	1.5

ROCK STRENGTH INDEX: R0 R1 R2 R3 R4 R5
WEATHERING INDEX: W1 W2 W3 W4 W5

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 12/12/2017

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-006 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316749.9 N: 5101578
DRILLING DATE : 12 Dec 17 - 12 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	DISCONTINUITY DATA Jr	DISCONTINUITY DATA Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	12/12/2017 Rock Coring (HQ)	black, white, pink, white **SCHIST to GNEISS BEDROCK** RC 10: Classification based on RQD: Excellent		178.21	RC 10								•	JN, IR, SR	3	1			
													•	JN, IR, SR	3	1			
													•	JN, IR, SR	3	1			
		End of Rock Coring		11.89															
14																			
16																			
18																			
20																			

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 12/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-007 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316828.1 N: 5101498
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 11 Dec 17 Date Completed: 11 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	Ground Surface Elevation: 189.3 m							Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80		GR SA SI CL
	ICE / SNOW - about 3 cm thick 189.6										
	ORGANICS - about 5.0 cm thick 189.3										
	brown to light brown **WEATHERED fine SAND** trace silt, gravel, and organics, loose, moist	SS	1	54	4		189		23		
	188.4										
	grey to brown 0.9 **Fine to medium SAND** trace silt and gravel, compact, moist	SS	2	60	30	1			9		
	187.7	RC	3	100	0		188				Switched to casing and washboring.
	white, black, pink 1.6 **GNEISS BEDROCK** fresh to slightly weathered (for rock core details, see "RECORD OF BOREHOLE No. PH17-007 - ROCK")	RC	4	98	76	2	187				
		RC	5	80	65	3 ▽	186			▼	
		RC	6	100	100	4	185				
		RC	7	100	100	5	184				
		RC	8	100	90	6	183				
		RC	9	100	100	7	182				
						8	181				
						9	180				
						10					

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▽ Groundwater depth during drilling on 12/12/2017 at a depth of: 3.0 m.
▼ Groundwater depth observed on 2/1/2018 at a depth of: 3.3 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

Continued on Next Page

RECORD OF BOREHOLE No. PH17-007 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	white, black, pink **GNEISS BEDROCK** fresh to slightly weathered						179				
		RC	10	100	100	11	178				
		RC	11	100	100	12	177				
	176.4 13.0 **End Of Borehole** **Well Installation Details** 0.0 - 9.0 m Bentonite 9.0 - 9.9 m Sand 9.9 - 13.0 m Screen										

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-007 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316828.1 N: 5101498
DRILLING DATE : 11 Dec 17 - 11 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja
		- For overburden details, see "RECORD OF BOREHOLE PH17-007 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - PH17-007" Rock Coring Started on 11 Dec 2017	187.71									
		White, black, pink **GNEISS BEDROCK**	1.60							JN, PL, SR, Sa, Si	1.25	0.75
2		RC 3: Classification based on RQD: Poor		RC 4						JN, IR, VR, JN, IR, VR, JN, IR, VR, JN, IR, VR, JN, IR, Sr, Si JN, IR, VR,	4 4 4 3 3 1	1 0.75 0.75 0.75 0.75
										BC from 2.60 m to 3.08 m		
		RC 4: Classification based on RQD: Fair		RC 5						JN, PL, SR,	1.25	0.75
4										JN, IR, SR, Si	3	0.75
		RC 5: Classification based on RQD: Excellent		RC 6						JN, IR, SR, JN, PL, SR, Si JN, PL, Sr, Si	0.75 1.25 1.25	0.75 0.75
6	11/12/2017 Rock Coring (HQ)	RC 6: Classification based on RQD: Excellent		RC 7						JN, PL, SR, JN, PL, SR JN, PL, SR, JN, PL, SR, Si JN, PL, SR, Si	1.25 1.25 1.25 1.25 1.25	1 0.75 0.75 1 1
										JN, PL, SR, Si	1.25	0.75
8		RC 7: Classification based on RQD: Excellent		RC 8						JN, PL, SR, JN, PL, SR, JN, IR, SR, JN, PL, SM,	1.25 3.5 1	1 1 1
										JN, PL, SR, Cl	1.25	0.75
10		RC 8: Classification based on RQD: Excellent		RC 9						JN, IR, SR, Cl JN, PL, SR, Cl	3 3	0.75 1
				RC 10						JN, IR, SR,	3	0.75

ROCK STRENGTH INDEX: R0 R1 R2 R3 R4 R5 R6
WEATHERING INDEX: W1 W2 W3 W4 W5 W6

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 12/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-007 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316828.1 N: 5101498
DRILLING DATE : 11 Dec 17 - 11 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: mAMSL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	11/12/2017 Rock Coring (HQ)	White, black, pink **GNEISS BEDROCK**												JN, PL, SR, Cl	1.25	1			
														JN, PL, SR, Cl	0.25	1			
		RC 9: Classification based on RQD: Excellent			RC 10									JN, IR, SR, Cl	3	1			
														JN, IR, SR, Cl	3	0.75			
														JN, PL, SR,	1.25	1			
														JN, PL, SR,	1.25	1			
		RC 10: Classification based on RQD: Excellent			RC 11									JN, IR, SR,	3	1			
														JN, PL, SR,	1.25	1			
				176.36										JN, IR, SR,	3	1			
				12.95															
		End of Rock Coring																	
14																			
16																			
18																			
20																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 12/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

RECORD OF BOREHOLE No. PH17-008 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316858.1 N: 5101575
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 6 Dec 17 Date Completed: 6 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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LITHOLOGY PROFILE			SOIL SAMPLING						FIELD TESTING	LAB TESTING		
Lithology Plot	DESCRIPTION Ground Surface Elevation: 195.5 m		Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	ORGANICS - about 7.5 cm thick	195.4 0.1										
	light brown to brown **WEATHERED fine SAND** trace silt, gravel, boulders, and organics, very dense, moist		SS	1	52	53 / 23cm	1	195	53 23			NOTE: Where N-Value is in the format, e.g. 53/23 cm, N-Value is 53 blows for 23 cm penetration Switched to casing and washboring.
		194.0 1.5						194				
	End of Borehole Abandon hole as casing and core barrel got stuck inside of a boulder.											

Amec Foster Wheeler
Environment & Infrastructure
300-210 Colonnade Road South
Ottawa, Ontario, K2E 7L5
Canada
Tel. No.: (613) 727-0658
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▽ No freestanding groundwater measured in open borehole on completion of drilling.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-008A - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316856.6 N: 5101575
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 7 Dec 17 Date Completed: 8 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION (Ground Surface Elevation: 195.5 m)	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	FIELD TESTING	LAB TESTING	INSTRUMENTATION INSTALLATION	COMMENTS & GRAIN SIZE DISTRIBUTION (%)
	ORGANICS - about 2.5 cm thick 195.5										Borehole was drilled approximately 1.5 m West of PH17-008A
	brown to light brown WEATHERED fine SAND some silt, trace gravel and organics, very loose, moist 194.7	SS	1	50	3						
	grey to light grey Fine SAND trace silt, gravel, and cobbles, very dense, moist 193.3	SS	2	75	30	1	195		22		
		SS	3	0	78	2	194		7		Switched to casing and washboring.
	black, pink, white GNEISS TO SCHIST BEDROCK slightly weathered 2.2	RC	4	100	41	3	193		24		
		RC	5	100	50	4	192				
		RC	6	100	88	5	191				
		RC	7	100	100	6	190				
		RC	8	100	100	7	189				
		RC	9	100	100	8	188				
						9	187				
						10	186				

PenetrationTesting: SPT, PPT, DCPT
MTO Vane* Intact, Remould; Nilcon Vane* Intact, Remould
* Undrained Shear Strength (kPa) 20 40 60 80
Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400
W_P W W_L Plastic Liquid 20 40 60 80

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Amec Foster Wheeler
Environment & Infrastructure
300-210 Colonnade Road South
Ottawa, Ontario, K2E 7L5
Canada
Tel. No.: (613) 727-0658
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Groundwater depth during drilling on 08/12/2017 at a depth of: 5.3 m.
Groundwater depth observed on 2/1/2018 at a depth of: 6.9 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

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RECORD OF BOREHOLE No. PH17-008A - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

amec foster wheeler

LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	black, pink, white **GNEISS TO SCHIST BEDROCK** slightly weathered										
		RC	10	100	100	11	185				
						12	184				
		RC	11	95	65	13	183				
	between 13.5 m and 16.5 m, bedrock contains pyrite					14	182				
		RC	12	100	100	15	181				
		RC	13	97	86	16	180				
						17	179				
		RC	14	100	74		178				
	177.6 17.9										
	End Of Borehole **Well Installation Details** 0.0 - 13.7 m Bentonite 13.7 - 14.0 m Sand 14.0 - 17.1 m Screen 17.1 - 17.9 m Sand										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-008A - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316856.6 N: 5101575
DRILLING DATE : 7 Dec 17 - 8 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	TOTAL CORE %	SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	Alpha angle (deg.)	TYPE AND SURFACE DESCRIPTION	Jr	Ja
		- For overburden details, see "RECORD OF BOREHOLE PH17-008A - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - PH17-008A" Rock Coring Started on 07 Dec 2017	193.29									
2		black, pink, white **GNEISS TO SCHIST BEDROCK**	2.21							JN, ST, SR, Sa	3	0.75
		RC 4: Classification based on RQD: Poor		RC 4						JN, IR, SR, JN, IR, RO, Sa	3 3	0.75 0.75
										JN, IR, SR, BC from 3.14 m to 3.26 m	3	.75
		RC 5: Classification based on RQD: Poor		RC 5						JN, IR, SR, JN, IR, SR, Sa BC from 3.53 to 3.58 m JN, IR, SR, Sa JN, PL, SR, Sa	3 3 3 1.25	.75 .75 0.75 0.75
4										JN, IR, SR, Sa BC from 4.27 m to 4.35 m	3	0.75
		RC 6: Classification based on RQD: Good		RC 6						JN, IR, SR, Sa JN, PL, SR, JN, IR, SM, Si	3 1.25 2.5	0.75 0.75 0.75
										JN, PL, SR,	1.25	1
6	07/12/2017 Rock Coring (HQ)	RC 7: Classification based on RQD: Excellent		RC 7						JN, PL, SM,	1	0.75
										JN, IR, RO,	3.5	0.75
										JN, IR, RO,	3.5	0.75
8		RC 8: Classification based on RQD: Excellent		RC 8						JN, IR, RO,	3.5	0.75
		RC 9: Classification based on RQD: Excellent		RC 9						JN, IR, SR,	3.	.75
10										JN, IR, SR,	1.25	0.75
		RC 10: Classification based on RQD:		RC 10						JN, IR, SR, JN, IR, SR,	1.25 1.25	0.75 0.75

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

ROCK STRENGTH INDEX: R0 R1 R2 R3 R4 R5
WEATHERING INDEX: W1 W2 W3 W4 W5

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

▽ SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 08/12/2017

▼ DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-008A - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316856.6 N: 5101575
DRILLING DATE : 7 Dec 17 - 8 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX
12	07/12/2017 Rock Coring (HQ)	Excellent black, pink, white **GNEISS TO SCHIST BEDROCK**		RC 10										
										JN, PL, SR,	1.25	0.75		
		RC 11: Classification based on RQD: Fair		RC 11						JN, PL, SR,	1.25	0.75		
										JN, PL, SR,	1.25	0.75		
										BC from 13.05 m to 13.54 m				
14		RC 12: Classification based on RQD: Excellent		RC 12						JN, IR, RO,	3.5	.75		
										JN, PL, SR,	1.25	1		
		RC 13: Classification based on RQD: Good		RC 13										
16														
		RC 14: Classification based on RQD: Fair		RC 14										
			177.59											
18		**End of Rock Coring**	17.91											
20														

NOTE: For abbreviations, symbols and descriptions refer to **LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY**

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 08/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-009 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E: 316954.9 N: 5101534
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 5 Dec 17 Date Completed: 6 Dec 17

Logged by: KC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)
	Ground Surface Elevation: 191.3 m						
	ORGANICS - about 5.0 cm thick 191.2 / 0.1						
	light brown WEATHERED fine SAND trace silt, gravel, and organic, very loose to very dense, moist	SS	1	38	3		
		SS	2	91	50 / 13cm	1	190
	190.2						
	black, pink, white 1.1 GNEISS TO SCHIST BEDROCK fresh to slightly weathered	RC	3	98	69	2	189
		RC	4	100	85		
		RC	5	100	100	3	188
						4	187
		RC	6	100	100	5	186
		RC	7	100	100	6	185
						7	184
		RC	8	98	95	8	183
						9	182
		RC	9	100	100	10	

FIELD TESTING: Penetration Testing — SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80

LAB TESTING: Soil Vapour Reading — COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P W W_L Plastic Liquid 20 40 60 80

INSTRUMENTATION INSTALLATION

COMMENTS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

NOTE: Where N-Value is in the format, e.g. 50/13 cm, N-Value is 50 blows for 13 cm penetration
Switched to casing and washboring.

Amec Foster Wheeler
Environment & Infrastructure
300-210 Colonnade Road South
Ottawa, Ontario, K2E 7L5
Canada
Tel. No.: (613) 727-0658
amecfw.com

Groundwater depth during drilling on 06/12/2017 at a depth of: 0.4 m.
Groundwater depth observed on 2/1/2018 at a depth of: 2.0 m.

Scale: 1 : 53

Continued on Next Page

RECORD OF BOREHOLE No. PH17-009 - Overburden

Project Number: TZ16108 Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4

Project Location: Chalk River, ON

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	Penetration Testing: ○ SPT □ PPT ● DCPT; MTO Vane* △ Intact ▲ Remould; Nilcon Vane* ◇ Intact ◆ Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: □ COV (LEL) ■ TOV (LEL) 2 4 6 8; △ COV (ppm) ▲ TOV (ppm) 100 200 300 400; W_P W W_L; Plastic Liquid 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	black, pink, white **GNEISS TO SCHIST BEDROCK** fresh to slightly weathered						181				
		RC	10	96	93	11	180				
		RC	11	100	100	12	179				
	178.4	RC	12	100	100						
	12.9 **End Of Borehole** **Well Installation Details** 0.0 - 9.2 m Bentonite 9.2 - 9.8 m Sand 9.8 - 12.9 m Screen										

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying 'Explanation of Borehole Log'.

Scale: 1 : 53

RECORD OF BOREHOLE No. PH17-009 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316954.9 N: 5101534
DRILLING DATE : 5 Dec 17 - 6 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

DATUM: mAMSL

NOTE: For abbreviations, symbols and descriptions refer to LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	ELEV. DEPTH (m)	SAMPLE No.	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA: Alpha angle (deg.)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	Jr	Ja
		- For overburden details, see "RECORD OF BOREHOLE PH17-009 - Overburden" - For core details, see "TABLE FOR ROCK CORE LOG - PH17-009"										
		Rock Coring Started on 05 Dec 2017										
			190.17									
		Black, pink, white **GNEISS to SCHIST**	1.12									
		RC 3: Classification based on RQD: Fair		RC 3						JN, PL, RO,	1.5	1
										JN, PL, SR,	1.25	1
2										JN, PL, SR, Sa	1.25	1
		RC 4: Classification based on RQD: Good		RC 4						JN, PL, RO,	1.5	1
		RC 5: Classification based on RQD: Excellent		RC 5						JN, PL, SR,	1.25	1
										JN, PL, SR,	1.25	0.75
4										JN, PL, RO,	1.5	0.75
		RC 6: Classification based on RQD: Excellent		RC 6						JN, PL, SR, JN, IR, SR,	1.25 3	0.75 1
										JN, PL, RO,	1.5	1
6		RC 7: Classification based on RQD: Excellent		RC 7								
		RC 8: Classification based on RQD: Excellent		RC 8						JN, PL, SM,	1	1
										JN, PL, SR, JN, PL, SR,	1.25 1.25	0.75 1
8										JN, PL, SR,	1.75	0.75
		RC 9: Classification based on RQD: Excellent		RC 9								
10												

05/12/2017 Rock Coring (HQ)

ROCK STRENGTH INDEX: R0 R1 R2 R3 R4 R5 R6
WEATHERING INDEX: W1 W2 W3 W4 W5 W6

NOTES
WATER LEVELS
INSTRUMENTATION

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 06/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-009 - Rock

PROJECT No. : TZ16018
CLIENT : Canadian Nuclear Laboratories
NAME / LOCATION : Multidisciplinary Subsurface Investigation for NSDF Project - Phase 4 - Chalk River, ON

DRILLING LOCATION : E: 316954.9 N: 5101534
DRILLING DATE : 5 Dec 17 - 6 Dec 17
INCLINATION (Deg.) : Vertical
AZIMUTH (Deg.) : Vertical

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DATUM: mAMSL

DEPTH SCALE (metres)	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	SAMPLE No.	PENETRATION RATE (m/min)	FLUSH	COLOUR / % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACTURE INDEX PER 1 m	DISCONTINUITY DATA Alpha angle (deg.)	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	Jr	Ja	ROCK STRENGTH INDEX	WEATHERING INDEX	NOTES WATER LEVELS INSTRUMENTATION
12	05/12/2017 Rock Coring (HQ)	Black, pink, white **GNEISS to SCHIST**												JN, PL, SR,	1.25	0.75	R2 R2 R2 R4 R2 R2	W1 W2 W4 W3 W4 W1	
		RC 10: Classification based on RQD: Excellent			RC 10														
		RC 11: Classification based on RQD: Excellent			RC 11									JN, IR, SR,	1.25	0.75			
		RC 12: Classification based on RQD: Excellent		178.44	RC 12									JN, IR, SR, Sa	1.25	0.75			
		End of Rock Coring		12.85															
14																			
16																			
18																			
20																			

NOTE:
For abbreviations, symbols and descriptions refer to
LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

GROUNDWATER ELEVATIONS

SHALLOW/SINGLE INSTALLATION
WATER LEVEL (date) 06/12/2017

DEEP/DUAL INSTALLATION
WATER LEVEL (date) 2/1/2018

LOGGED : KC
CHECKED : NR

AMECFW ROCK TZ16018_NSDF_PHASE4_BEDROCK.GPJ AMECFW ROCK 2016.GDT 13/02/18

RECORD OF BOREHOLE No. PH17-010 - Overburden

Project Number: TZ16108
Project Client: Canadian Nuclear Laboratories
Project Name: Multidisciplinary Subsurface Investigation for the NSDF Project - Phase 4
Project Location: Chalk River, ON
Drilling Location: E:316534.8 N: 5101992
Drilling Method: HQ Rock Coring
Drilling Machine: Track Mounted Drill
Date Started: 20 Dec 17 Date Completed: 21 Dec 17

Logged by: BC Compiled by: KC Reviewed by: NR Revision No.: 0, 13/2/18

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LITHOLOGY PROFILE		SOIL SAMPLING						FIELD TESTING	LAB TESTING		COMMENTS & GRAIN SIZE DISTRIBUTION (%)
Lithology Plot	DESCRIPTION Ground Surface Elevation: 171.3 m	Sample Type	Sample Number	Recovery (%)	SPT 'N' / RQD (%)	DEPTH (m)	ELEVATION (m)	PenetrationTesting: SPT, PPT, DCPT; MTO Vane* Intact/Remould; Nilcon Vane* Intact/Remould; * Undrained Shear Strength (kPa) 20 40 60 80	Soil Vapour Reading: COV (LEL), TOV (LEL) 2 4 6 8; COV (ppm), TOV (ppm) 100 200 300 400; W_P Plastic, W, W_L Liquid; 20 40 60 80	INSTRUMENTATION INSTALLATION	GR SA SI CL
	CORED WITHOUT SOIL SAMPLING					0	171				Lithology profile may be referred to BH-110, which it was drilled at E: 316535 N: 5101992, with a surface elevation of 171.3 m.
						1	170				
						2	169				
						3	168				
						4	167				
						5	166				
						6	165				
	164.3					7					
	7.0 End Of Borehole Well Installation Details 0.0 - 3.4 m Bentonite 3.4 - 4.0 m Sand 4.0 - 7.0 m Screen										

Amec Foster Wheeler
Environment & Infrastructure
300-210 Colonnade Road South
Ottawa, Ontario, K2E 7L5
Canada
Tel. No.: (613) 727-0658
amecfw.com

▽ Groundwater depth during drilling on 22/12/2017 at a depth of: 3.1 m.
▼ Groundwater depth observed on 2/1/2018 at a depth of: 3.1 m.

Borehole details as presented, do not constitute a thorough understanding of all potential conditions present and require interpretative assistance from a qualified Geotechnical Engineer. Also, borehole information should be read in conjunction with the geotechnical report for which it was commissioned and the accompanying'Explanation of Borehole Log'.

Scale: 1 : 53

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa + 27 11 254 4800
Asia + 86 21 6258 5522
Australasia + 61 3 8862 3500
Europe + 44 1628 851851
North America + 1 800 275 3281
South America + 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1931 Robertson Road
Ottawa, Ontario, K2H 5B7
Canada
T: +1 (613) 592 9600

Golder Associates