



REPORT

Groundwater Existing Conditions and Impact Assessment

W12A Landfill Expansion EA, City of London, Ontario

Submitted to:

City of London
300 Dufferin Avenue
London, Ontario
PO BOX 5035
N6A 4L9

Attention: Mike Losee, Division Manager, Solid Waste Management

Submitted by:

Golder Associates Ltd.
1931 Robertson Road
Ottawa, Ontario, K2H 5B7 Canada

+1 613 592 9600

1648176

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Distribution List

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Existing Groundwater Conditions – Dillon Consulting Limited

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Acronyms and Glossary of Terms

Term / Acronym	Definition
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
EPA	<i>Environmental Protection Act</i>
HELP	Hydrologic Evaluation of Landfill Performance
m	metres
m ³	cubic metres
masl	Metres Above Sea Level
MECP	Ministry of Environment, Conservation and Parks
MRF	Material Recovery Facility
POLLUTE	contaminant transport model
ToR	Terms of Reference

1.0 INTRODUCTION

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London Ontario.

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the details of the existing conditions and impact assessment related to groundwater for the Environment Assessment (EA) of the proposed W12A Landfill expansion. This work has been completed in two parts; Dillon Consulting Limited (Dillon) completed the existing conditions in Attachment A and Golder Associates Ltd. (Golder) completed the impact assessment in Attachment B.

All work was conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR) dated February 2019 and the Work Plan dated November 2019 that was developed with input from First Nation Communities (Aamjiwnaang First Nation, Chippewas of the Thames First Nation, Munsee-Delaware First Nation, Oneida First Nation) and their consultant (Dragun Corporation) and circulated to the Ministry of the Environment, Conservation and Parks (MECP). In addition, the work also included additional contaminant transport modelling as a result of feedback from a First Nation Communities workshop held in August 2020.

This report is a supporting document to the Environmental Assessment Study Report (EASR).

2.0 PROJECT DESCRIPTION

The following describes the Project components considered relevant for the purposes of this groundwater assessment.

The landfill expansion consists of a vertical expansion over the existing landfill footprint to provide 13.8 million cubic metres (m³) of airspace for waste and daily cover. To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be adjacent to Scotland Drive and a 100 metre (m) buffer width will be provided on the east side of the landfill footprint and some additional area in the southeast corner to tie into the adjacent Material Recovery Facility (MRF) property line. This results in a 106.3 hectare (ha) landfill footprint within a 192.4 ha landfill property, with a highest ridge elevation of waste of 318.43 metres above sea level (masl).

Additional details of the project pertinent to the groundwater impact assessment are described in Attachment B, Section 2.

3.0 EXISTING CONDITIONS

The details and discussion of existing conditions is provided in Attachment A by Dillon. Dillon first reviewed previous hydrogeological investigations of the landfill and then completed supplementary hydrogeological investigations in 2019 and 2020 to provide additional information on previously less investigated parts of the Site Study Area including information required to assess impacts associated with landfill expansion. The supplementary hydrogeological investigations included evaluating hydrogeological conditions to the north of

the existing landfill, hydrogeological conditions to the east of the existing landfill, and supplementary subsurface investigations including test pitting and borehole drilling with monitoring well installations. Upon completion of these investigations, Dillon prepared a summary of the existing hydrogeological conditions.

4.0 IMPACT ASSESSMENT

The completion of the impact assessment is provided in Attachment B by Golder. Golder prepared an assessment of long-term groundwater quality impacts by using the HELP model to estimate leachate generation rates and the POLLUTE model to assess possible impacts from the expanded landfill on the groundwater quality off-Site. The parameters evaluated included those required by the Landfill Standards and Ontario Regulation 232/98. The results identified that additional mitigation beyond the original project description would be required for long term protection of off-Site groundwater and compliance with Ontario Regulation 232/98.

Within the impact assessment the potential effects of the expansion on groundwater quantity was also evaluated. The analysis indicates the expansion is not expected to affect: the groundwater supply available to water supply wells in the area; groundwater baseflow to off-Site watercourses or other natural environment features in the area of the landfill; or, off-Site groundwater levels that support vegetation.

5.0 MITIGATION

Additional mitigation is required to meet groundwater quality objectives at the landfill site property boundary. It is proposed to incorporate leachate collection into the design of a first tier of horizontal landfill gas collector trenches to be installed in the older part of the landfill known as Phase 1 (see Attachment B, Appendix A). This will control the height of the leachate mound. With this additional mitigation, all groundwater quality requirements for the landfill expansion are predicted to be met.

6.0 GROUNDWATER AND LEACHATE MONITORING PROGRAM

The City of London has an existing comprehensive groundwater monitoring program for the existing landfill that has been updated to reflect current existing conditions and the proposed landfill expansion. A summary of the proposed groundwater monitoring program for the landfill expansion, leachate and neighbouring water wells is provided in Attachment B Table 12, Table 13 and Table 14, respectively. Attachment B Section 6 also provides details regarding a leachate mound monitoring component for the Phase 1 area of the landfill.

7.0 OTHER APPROVALS

The groundwater component of this EA will also require approval under the *Environmental Protection Act* (EPA) as part of an amended Environmental Compliance Approval (ECA) for waste disposal.

ATTACHMENT A

**Existing Groundwater Conditions –
Dillon Consulting Limited**



City of London

Existing Groundwater Conditions

**Environmental Assessment of the Proposed W12A Landfill
Expansion**

July 2020 - 19-1230

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1.0 Introduction

This document presents the existing hydrogeological conditions as part of the groundwater component of the Environmental Assessment (EA) of the proposed W12A Landfill expansion (project). The Existing Groundwater Conditions documentation forms part of the overall groundwater assessment developed for the Environmental Assessment and documented in the report, titled “Groundwater Work Plan”, dated August 2019.

1.1 Overall Assessment Framework

The Environmental Assessment is completed in a series of nine steps as follows:

- Step 1 – Characterize existing environmental conditions
- Step 2 – Identify the ‘Alternative Methods’ of landfill expansion
- Step 3 – Qualitative evaluation of ‘Alternative Methods’
- Step 4 – Compare the ‘Alternative Methods’ for landfill expansion and identify the preferred alternative
- Step 5 – Refine the mitigation measures and determine the net effects of the preferred alternative
- Step 6 – Describe the preferred ‘Alternative Method’
- Step 7 – Consideration of climate change
- Step 8 – Cumulative impact assessment
- Step 9 – Preparation of the EA Study Report

The report documents Step 1 for the Groundwater Discipline.

1.2 Report Format

This report presents an overview of existing environmental conditions for the groundwater component on and in the area of the W12A Landfill. The existing conditions described in this report are based on existing documentation which consist of numerous previous hydrogeological investigations completed for the W12A Landfill area and a supplemental investigation completed in 2019 and 2020 that focused on obtaining additional hydrogeological information related to the expansion alternatives for the W12A landfill. The work plan for the supplemental investigations is detailed in the Groundwater Work Plan, dated August 2019.

2.0

Overview of Hydrogeological Conditions

Previous investigations over the last 40 years have resulted in a thorough understanding of the hydrogeological setting of the existing landfill. In terms of geological setting, the landfill is located on part of the Westminster moraine, which consists of low permeability till soils identified as the Port Stanley Till. Immediately north of the landfill site, gravel and gravelly sand were formed from the older Catfish Creek drift (located under the Port Stanley Till) or were deposited underneath the Port Stanley Till by subglacial streams.

Major hydrostratigraphic units are divided into aquitards and aquifers. An aquitard consists of low permeability soils that inhibit groundwater flow. An aquifer consists of permeable soils that can transmit large enough quantities of water such that when water wells are installed they produce usable quantities of water.

In terms of the hydrogeological setting, the site is underlain by low permeability Port Stanley Till, which comprises most of the Westminster Moraine. The next major regional hydrogeological feature is an aquifer found beneath the Port Stanley Till, consisting of stratified sand and gravel soils, most likely part of the Catfish Creek Drift. These soil deposits comprise the White Oak Aquifer. The White Oak Aquifer extends as far north as Lambeth and extends southeast to Kettle Creek. The aquifer has an irregular vertical distribution with a maximum thickness of approximately 45 m just north of the landfill along Scotland Drive. Groundwater flow in the White Oak Aquifer in the area of the landfill is in a general north to south/southeast direction.

Some local aquifers consisting of sand and gravel soil layers occur in the Port Stanley Till and were probably formed by subglacial processes at the time that the till soils were deposited. These local aquifers are not regionally extensive and generally thinner than the White Oak Aquifer. One such local aquifer is present underneath the landfill (referred to as the Upper Aquifer) and separates the Port Stanley Till into the Surficial Aquitard and a Lower Aquitard, both of which are above the White Oak Aquifer. The Upper Aquifer has not been identified north of Scotland Drive, but extends south of Manning Drive; groundwater flow in the Upper Aquifer is towards the southwest.

The thickness of the Surficial Aquitard varies from as much as 20 m at the northwest corner of the existing W12A Landfill site, to 15 m or greater below much of the existing landfill, and to about 8 m at the southeast corner of the site along Manning Drive. Groundwater moves downward at an estimated velocity of 1 to 2 centimetres (cm) per year in the Surficial Aquitard. The upper portion of the Surficial Aquitard is weathered and fractured. The degree of significant fracturing decreases with depth such that the

shallower fractured till zone is more hydraulically active than the lower less fractured till soil. Generally, regional studies have indicated that the tills are highly fractured to a depth of 3-4 m, a transitional zone occurs beneath the highly weathered and fractured soil with isolated vertical fractures occurring to depths of approximately 6 m. Studies completed by the University of Western Ontario and Dillon in 2000 on Phase 1 of the landfill (where excavation depths of landfill cells were less than those in Phase 2) indicated that the depth of active fractures beneath the waste fill is less than 2 m and that desiccation fractures in till soils occurring during landfill cell construction are “self-healing” (this study is subsequently described in more detail in this report)

Limestone bedrock is found approximately 80 to 90 m below the landfill and slopes downwards from north-northeast.

Municipal water is available to residences near the landfill on Manning Drive, White Oak Road, Scotland Drive and Wellington Road South; however, some of the homeowners have not connected to the available municipal services. These residences, as well as residences and farms further away from the landfill area, rely on individual water supply wells, installed in either the Upper Aquifer or the White Oak Aquifer for their water supply. Individual water supply wells in the vicinity of the landfill are monitored annually.

Source water protection studies were carried out for the watersheds in which the City of London is located. The resulting Source Water Protection Plans delineate source protection areas with respect to municipal drinking water supplies (Wellhead Protection Areas – WHPAs and Intake Protection Zones – IPZs) as well as groundwater recharge areas, assign vulnerability to these source protection areas and describe appropriate land use planning for their protection. There are two Source Protection Regions in the area of and surrounding the W12A Landfill; the Thames-Sydenham & Region (the Upper Thames River Source Protection Area) and the Lake Erie Region Drinking Water Source Protection Region (Kettle Creek Source Protection Area). The primary source of drinking water for the City is surface water from Lake Huron and Lake Erie, with a stand-by backup supply from groundwater from the Hyde Park and Fanshawe well fields located in the northeast and west parts of the City.

All of these sources are distant from the W12A Landfill. The closest municipal well field to the W12A Landfill is the Belmont well field (Kettle Creek Source Protection Area) located 10 km east of the landfill. The capture area for the Belmont well field extends to the north of Belmont and not in the direction of the landfill. There are no source water protection areas identified on or in the area of the W12A Landfill. As such, neither the existing landfill nor the proposed expansion are influenced by planning considerations or requirements related to source water protection.

3.0 Previous Hydrogeological Assessments

There have been numerous hydrogeological investigations completed at the landfill over the past 40 years. A listing of these reports are contained in the References section of this report. Numerous boreholes have been drilled and monitoring wells installed. Two hydrogeological assessments were completed that have particular relevance to this assessment and are discussed in detail below.

3.1 2000 W12A Hydrogeological Investigation, University of Western Ontario and Dillon

The objective of this hydrogeological investigation was to determine if the leachate collection system used in Phase 1 of the existing landfill provided sufficient protection to groundwater resources and to make recommendations for potential modifications to the leachate collection system design for Phase 2 of the landfill (Dillon, 2000). The Phase 1 leachate collection system is a perimeter collection system and leachate will mound between the perimeter drains. The 2000 hydrogeological investigation was targeted on defining the hydraulic characteristics of the Surficial Aquitard and using contaminant transport modelling to predict potential impacts to groundwater resources and consisted of the following tasks:

1. Borehole drilling, soil sampling and monitoring well installation below and beside Phase 1 of the landfill.
2. Contaminant profiling underneath the Phase 1 fill area by extracting porewater from discrete sections of soil cores taken beneath the waste, analyzing for chloride concentrations and then using computer models to back-calculate contaminant transport parameters.
3. Laboratory testing of soil samples to estimate properties such as vertical hydraulic conductivity, the fraction of organic carbon and cation exchange capacity.
4. Leachate sampling to determine leachate quality.
5. Contaminant transport modelling to predict groundwater impacts from Phase 1 of the landfill and the new landfill area (Phase 2).

Tasks 3 and 4 were completed by the Geotechnical Research Centre of the University of Western Ontario and the results are summarized below:

- The hydraulic conductivity as determined by flexible wall hydraulic conductivity testing on two soil cores were 1.3×10^{-10} m/s and 1.4×10^{-10} m/s.

- The chloride diffusion coefficient obtained by a diffusion test was estimated to be $6.5 \times 10^{-10} \text{ m}^2/\text{s}$ (0.02 m/a) which is typical for chloride diffusion rates measured in clayey soils.
- The cation exchange capacity from two soil cores was 15.2 meq/100 g and 14.2 meq/ 100 g. Cation exchange capacities of this amount indicates significant adsorption potential for heavy metals.

The fraction of organic carbon was 0.4% of one soil core. The greater the fraction of organic carbon the more adsorption potential there is for organic parameters.

Computer modelling was completed to simulate the migration of chloride due to advection and diffusion and estimated the advective flux at 0.005-0.010 m/year. For the measured porosity of 0.35, this flux would result in a downward groundwater velocity of 0.014 to 0.028 m/year. For a Surficial Till thickness of 14 m, this would translate to a travel time of about 700 years. This is consistent with a hydraulic conductivity of the Surficial Aquitard of $1 \times 10^{-10} \text{ m/s}$.

Contaminant transport modelling was completed for a number of different scenarios of leachate collection systems design configurations. Modelled parameters consisted of those listed in Schedule 4 of O.Reg. 232/98: namely, chloride, dichloromethane, benzene, vinyl chloride, cadmium and lead. Of these parameters, chloride is an aesthetic related parameter and the other parameters are health-related parameters. For the health related parameters, modelling results for Phase 1 of the landfill indicated that concentrations decrease to negligible values within 2 metres of the base of the landfill though a combination of adsorption and biodegradation. The heavy metals were significantly adsorbed onto the soil resulting in extremely long travel times in the Surficial Aquitard. Chloride concentrations were predicted to increase to maximum concentrations in the Upper Aquifer at about the advective travel time of 700 years. The modelling indicated that a full leachate underdrain resulted in less predicted chloride concentration increases and a full underdrain leachate collection system design was adopted for Phase 2 of the landfill.

3.2 **W12A Landfill Area Plan Study, Hydrogeological Background Study (2005)**

The Hydrogeological Background Study, was one of six background studies prepared in support of the W12A Landfill Area Plan Study as part of the City of London Official Plan Secondary Planning process (Dillon, 2005). The purpose of the assessment was to assemble and analyze the hydrogeological conditions within the Study Area (defined as an area of 1.5 km buffer around the Core Area). The Core Area was defined as the area of land confined by White Oak Road to the west, Manning Drive to the south, Wellington

Road to the east and Scotland Drive to the north. The study assessed the continuity of the major hydrostratigraphic units beneath and adjacent to the landfill site. A Surficial Aquitard Thickness Map was produced that illustrated the thickness of the Surficial Aquitard and areas where the aquitard does not exist.

The study concluded that generally, the White Oak Aquifer Complex is protected by the overlying Surficial Aquitard and Lower Aquitard hydrostratigraphic units south of Scotland Drive. The amount of recharge through the overlying aquitard units is limited by the low permeability of the aquitards. The White Oak Aquifer occurs at surface at the gravel pits north of Scotland Drive and the ponds located along Highway 401, west of White Oak Road. It was concluded that this area is a significant recharge area for the White Oak Aquifer. The groundwater flow direction in the White Oak Aquifer Complex is to the south / southeast.

The study also concluded that significant groundwater protection is provided by the Surficial Aquitard to the underlying aquifers. The Surficial Aquitard is thickest (15 to 20 m thick) in the western part of the Core Area. In the southeastern portion of the Core Area the Surficial Aquitard varies in thickness from 6 m to 15 m. Groundwater movement is extremely slow (a few centimetres per year) in the Surficial Aquitard and it was concluded that the aquitard provides groundwater protection for most potential land uses within the Core Area. The study also recommended that the integrity of the Surficial Aquitard be retained. Any penetration of the Surficial Aquitard should be completed with this in mind (e.g., all wells should be fully grouted, and if not used, decommissioned, and any foundation piles or deep excavations should be completed using methods ensuring that the natural protection provided by the aquitard is retained).

4.0 Supplemental Hydrogeologic Investigation 2019-2020

In addition to reviewing the data sources described in **Section 3** and despite the thorough understanding of the hydrogeology setting of the existing landfill, there remains some potential areas for further field investigations to the north and east of the existing landfill, related to existing conditions but also landfill expansion

4.1 Hydrogeologic Issues North of Existing Landfill

The main issue at this location is the nature of the hydrogeological connection between the local Upper Aquifer and the regional White Oak Aquifer especially to the north of the existing landfill. Integral to the connection is the presence and hydraulic conductivity of the till layer (aquitard) separating the aquifer hydrostratigraphic units.

An evaluation of this issue consisted of using a “multiple lines of evidence” approach where borehole data was used to develop physical localized hydrostratigraphic limits coupled with groundwater level data and hydrogeochemistry data. In addition, hydrogeological data that has been obtained over the operating period of the landfill obtained from hydrogeological studies completed on aggregate pits north of the landfill site (north of Scotland Drive) has been used to supplement the hydrogeological understanding of this area. Overall, these sources of information were used to further define aquifer units and identify data gaps that could be addressed by additional investigation. The need for additional hydrostratigraphic information in the area immediately south of Scotland Drive was identified. New boreholes / monitoring wells in this area would further define lithology and groundwater levels and enable a better understanding of existing conditions and aid in the evaluation of proposed expansion alternatives (i.e., lateral landfill expansion to the north of the existing landfill).

4.2 Hydrogeologic Issues East of Existing Landfill

One of the proposed landfill development alternatives is possible expansion to the east of the present fill site. The hydrogeology east of the landfill is well understood but additional information in this area would allow better evaluation of expansion alternatives in this area.

4.3 Supplemental Subsurface Investigation Methodology

To address the issues requiring additional hydrogeological information identified above, a subsurface investigation was completed in the fall of 2019. This investigation consisted of the following components:

- Borehole drilling / monitoring well installations at seven locations: three east of the existing landfill and four north of the existing landfill. Monitoring wells were installed in different hydrostratigraphic units (“nested” monitoring wells) mainly in the Upper Aquifer and the White Oak Aquifer
- Testing of soil cores obtained in the drilling program
- Groundwater sampling and analysis from the new monitoring wells
- Groundwater level monitoring including the installation of dataloggers in select monitoring wells (completed in January/February 2020)
- The completion of a large test pit immediately east of the landfill to assess the degree of weathering and fracturing of the upper portion of the Surficial Aquitard

4.3.1 Borehole Drilling

The drilling locations are shown on **Figure 1**. The deepest borehole (White Oak Aquifer) at each location was drilled using a PQ coring using drilling mud as the drilling fluid by Aardvark Drilling. This system provided relatively good quality continuous soil cores. The soil cores were logged for soil type, structure, colour, and moisture using ASTM Standard D2488 for Visual-Manual Description and Identification of Soils. Borehole logs are contained in **Appendix A** and include soil descriptions, soil core retrieval information (intervals and recovery). If a monitoring well was required in the Upper Aquifer (no Upper Aquifer monitoring wells were installed at locations BH19-1 and BH19-3 since Upper Aquifer monitoring wells already existed near these locations), soil sampling was completed at select intervals using standard splitspoons to obtain standard penetration test data (“blow counts”) and to obtain Shelby tubes for subsequent soil testing.

4.3.2 Monitoring Well Installation

Monitoring wells were installed in each borehole. The monitoring well constructions details are shown on the borehole logs (**Appendix A**) and generally consisted of nominal 50 mm diameter PVC monitoring pipe connected to a 1.5 m long PVC No. 10 slot screen. Silica sand was placed around the screen annulus and extended at least 0.5 m above the top of screen, bentonite chips were then placed above the silica sand and the remaining borehole annulus was filled with bentonite grout to ground surface. The monitoring wells were developed by removing a relatively large quantity of water using a submersible pump.

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The nomenclature used to name boreholes and monitoring wells is summarized in **Table 1**, which also contains the hydrostratigraphic units in which the wells were installed.

Figure 1: Site Plan



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SITE PLAN
Figure 1

- LEGEND**
- 2019 Drilling Location
 - Historical Borehole Location
 - ▣ Test Pit Location

Note: See Figure 8 for
Geologic Sections



MAP CREATED BY : LOM
MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO

Table 1: Borehole and Monitoring Well Designations

Borehole Number	Monitoring Well Designation	Hydrostratigraphic Unit
BH19-1	19-1	White Oak Aquifer
BH19-2	19-2	Upper Aquifer
BH19-2-2	92-7a	Upper Aquifer (a replacement monitoring well for existing monitoring well 92-7, which was decommissioned in 2019 due to integrity concerns)
BH19-3	19-3	White Oak Aquifer
BH19-4	19-4a	White Oak Aquifer
BH19-4-2	19-4b	Upper Aquifer
BH19-5	19-5a	White Oak Aquifer
BH19-5-2	19-5b	Upper Aquifer
BH19-6	19-6a	White Oak Aquifer
BH19-6-2	19-6b	Upper Aquifer
BH19-7	19-7a	Lower White Oak Aquifer
BH19-7-2	19-7b	Upper White Oak Aquifer
BH19-7-3	19-7c	Surficial Aquitard
BH19-9	92-10a	White Oak Aquifer (a replacement monitoring well for existing monitoring well 92A 10a which was decommissioned in 2019 due to integrity concerns)

4.3.3**Soil and Hydrogeological Testing**

Soil samples from the Surficial Aquitard, Upper Aquifer, Lower Aquitard and White Oak Aquifer were collected and tested for various parameters as listed in **Table 2**. In addition, groundwater samples were taken from the new monitoring wells and analyzed for conventional water quality analysis.

Table 2: Number and Type of Soil and Hydrogeological Tests

Test	Hydrostratigraphic Unit - Surficial Aquitard	Hydrostratigraphic Unit - Upper Aquifer	Hydrostratigraphic Unit - Lower Aquitard	Hydrostratigraphic Unit - White Oak Aquifer
Grain Size Analysis, Moisture Content	13	4	4	4
Fraction of Organic Carbon, Cation Exchange Capacity	6	1		
Flexible Wall Permeability Tests	6			
Conventional Water Quality Analysis		5		4
Isotope Analysis (porewater extracted from aquitard soil cores)	8			

4.3.4 Water Level Monitoring

Water levels in the new monitoring wells were taken using a manual water level tape several times in 2019 and 2020. In addition, dataloggers were installed in select monitoring wells to continuously record water levels with time. The dataloggers were installed in early January 2020 and were downloaded in late February 2020. The dataloggers remain in the monitoring wells and continue to continuously record water levels. The “top of pipe” elevation of the monitoring wells were surveyed by the City of London and this data was used to convert water level depth measurements to geodetic elevations (i.e., metres above sea level – masl).

4.3.5 Test Pit Excavation - Surficial Aquitard Fracture Assessment

The presence of fractures within the upper portion of the Surficial Aquitard is a well-known phenomenon. To evaluate the nature of the fractures and their potential to create a preferred pathway for leachate migration from the landfill expansion, a benched test pit measuring approximately 12 m x 12 m in plan and 5.4 m in depth was completed. The test pit was located between the landfill and the Material Recovery Facility (shown on **Figure 1**). The test pit allowed the fracture characteristics and fracture frequency to be assessed with depth.

The fracture network was logged and photographs taken. **Appendix B** contains a summary of the observations from the test pit as well as photographs.

4.4 Results of Laboratory Analysis of Soil Samples

The results of the grain size analysis is presented as a ternary diagram (see **Figure 2**). The results of the soil tests are summarized in Table 3 and Table 4. Detailed test results are in **Appendix C**.

Table 3: Summary of Grain Size Analysis

Borehole No.	Sample No.	Depth (mbgs)	Depth (masl)	Layer	Grain Size Analysis (%) Clay	Grain Size Analysis (%) Silt	Grain Size Analysis (%) Sand	Grain Size Analysis (%) Gravel	Water Content %
BH19-1	2	3	270.7	SA	46	44	7	3	15.2
BH19-1	4	10.3	263.4	UA	5	9	86	0	20.4
BH19-1	5	13.1	260.6	UA	5	23	72	0	20.3
BH19-1	9	24.2	249.5	LA	48	43	9	0	18.3
BH19-1	12	40.6	233.1	WOA	26	24	47	3	13.1
BH19-2	1	3.6	269.4	SA	42	52	6	0	18.6
BH19-2	2	9.3	263.7	SA	39	41	10	10	20
BH19-2	3	13.2	259.8	UA	5	25	70	0	18.4
BH19-2	4	24.9	248.1	LA	41	44	14	1	16.4
BH19-2	5	30.6	242.4	LA	22	60	18	0	11
BH19-2	6	46.9	226.1	WOA	10	36	53	1	9
BH19-3	2	4.7	270.5	SA	46	46	8	0	23.5
BH19-3	5	9.2	266	SA	45	49	6	0	20.2
BH19-3	8	14.4	260.8	UA	1	97	2	0	19.1
BH19-4	1	4.4	276.7	SA	42	48	9	1	20.5
BH19-4	2	9.2	271.9	SA	43	48	9	0	21.2

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Borehole No.	Sample No.	Depth (mbgs)	Depth (masl)	Layer	Grain Size Analysis (%) Clay	Grain Size Analysis (%) Silt	Grain Size Analysis (%) Sand	Grain Size Analysis (%) Gravel	Water Content %
BH19-5	1	4.4	278.3	SA	41	49	10	0	20.9
BH19-5	4	9.2	273.5	SA	43	47	9	1	20.1
BH19-5	7	13.7	269	SA	44	46	10	0	20.4
BH19-5	10	17	265.7	SA	48	45	7	0	20.3
BH19-5	13	24.5	258.2	LA	44	43	12	1	16.9
BH19-5	14	31.2	251.5	WOA	7	21	72	0	18.4
BH19-6	1	4.6	276.3	SA	49	43	8	0	21.1
BH19-6	2	9.3	271.6	SA	45	43	9	3	20.1
BH19-6	8	26.1	254.8	WOA	16	30	54	0	16.7

SA = Surficial Aquitard; UA= Upper Aquifer; LA = Lower Aquitard; WOA = White Oak Aquifer

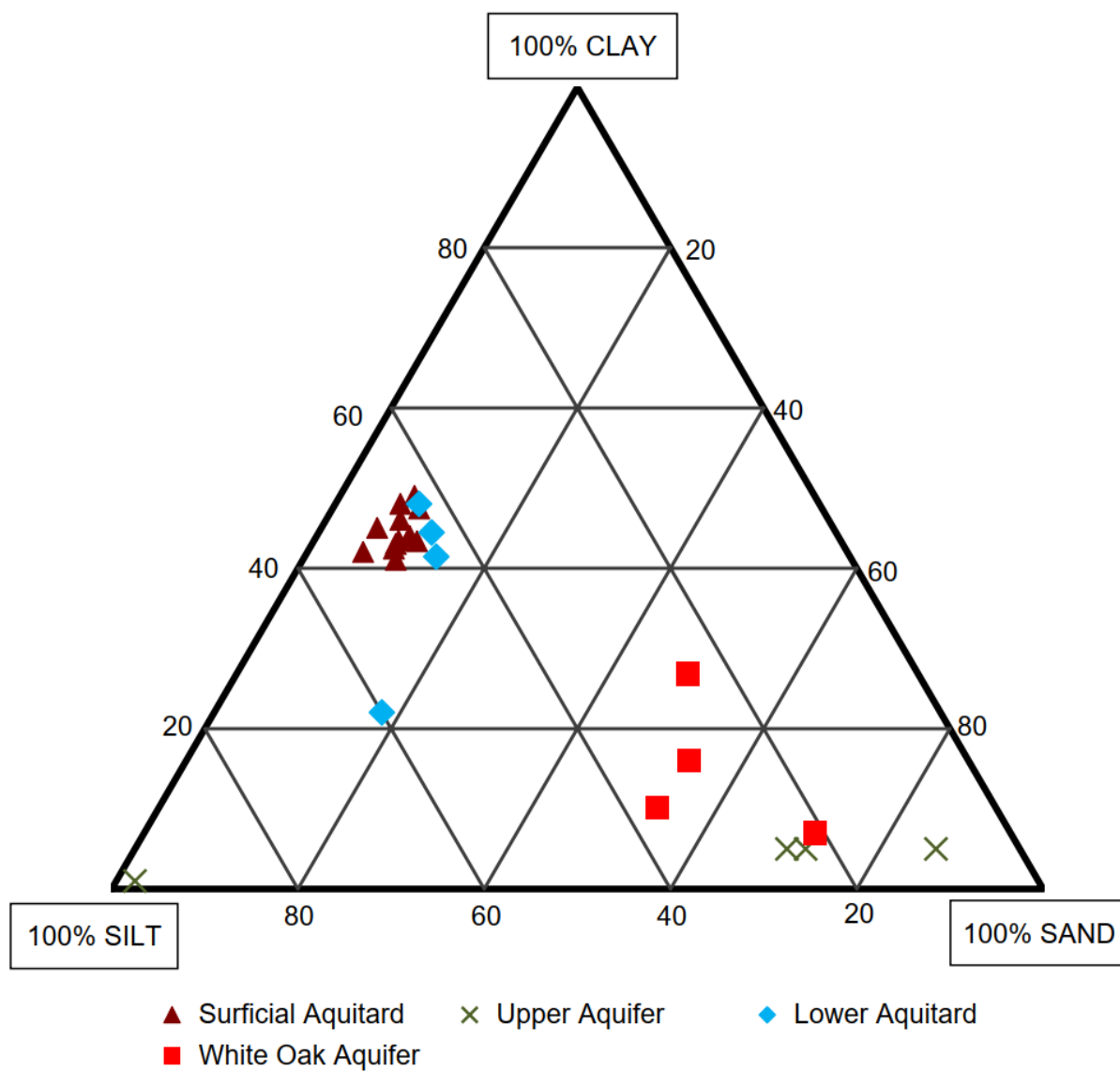
Table 4: Summary of Fraction of Organic Carbon and Cation Exchange Capacity Tests

Borehole No.	Sample No.	Depth (mbgs)	Depth (masl)	Layer	Cation Exchange Capacity (meq/100 g)	Total Organic Carbon (%) <0.6mm	Total Organic Carbon (%) Whole Soil
BH19-3	2	4.7	270.5	SA	118.3	0.28	0.27
BH19-3	5	9.2	266.0	SA	112.4	0.19	0.18
BH19-3	8	14.4	260.8	UA	16.5	0.08	0.08
BH19-5	1	4.4	278.3	SA	112.8	0.16	0.15
BH19-5	4	9.2	273.5	SA	100.8	0.19	0.19
BH19-5	7	13.7	269.0	SA	108.0	0.23	0.21
BH19-5	10	17.0	265.7	SA	107.2	0.23	0.22

SA = Surficial Aquitard; UA= Upper Aquifer

As **Figure 2** illustrates, soil samples from the different hydrostratigraphic units plot in similar areas on the Ternary Diagram. In particular, soil samples taken from the Surficial Aquitard all plot very closely together on the diagram which is consistent with the field observations that the composition of the Surficial Aquitard is very consistent both by depth and location.

Figure 2: Grain Size Data



4.5 Hydraulic Conductivity Tests

Hydraulic conductivity testing was completed on soil cores taken at three drilling locations: BH19-2, BH19-5 and BH19-6. The purpose of these tests was to take soil cores at approximately the same depth those taken in 2000 and tested by the University of Western Ontario in 2000. At the new locations, flexible wall permeameter tests (ASTM D5084 – Method A; Constant Head) were completed on soil core obtained by taking Shelby tubes (thin walled steel sample tubes that minimize the disturbance of the soil structure) at a depth equivalent to being below the landfill base. The test results are found in **Appendix D** and are summarized in **Table 5**. The intent was to also complete in situ hydraulic conductivity tests in Upper Aquifer wells. There was insufficient water in these monitoring wells to complete these tests (water levels are documented in Section 4.6)

Table 5: Summary of Hydraulic Conductivity Test Results

Borehole No.	Sample No.	Depth (mbgs)	Depth (masl)	Layer	Hydraulic Conductivity (m/s)
BH19-2-2	SS1	5	268	SA	1.0×10^{-10}
BH19-2-2	SS2	6.4	266.6	SA	1.0×10^{-10}
BH19-5-2	SS1	4.8	277.9	SA	9.0×10^{-11}
BH19-5-2	SS2	6.4	276.3	SA	1.0×10^{-10}
BH19-6-2	SS1	4.8	276.1	SA	1.0×10^{-10}
BH19-6-2	SS2	6.2	274.7	SA	1.0×10^{-10}
BH00-5a*	1	1.9**	267.2	SA	1.3×10^{-10}

Notes - *sample tested by UWO in 2000; **depth below waste interface (Phase 1)

SA – Surficial Aquitard

4.6 Groundwater Level Monitoring

Water levels from monitoring wells were used to identify groundwater flow directions and to calculate hydraulic gradients. Hydrographs are found in **Appendix E**.

4.6.1 Groundwater Flow Directions

4.6.1.1 Surficial Aquitard

Groundwater flow in the Surficial Aquitard is principally vertical under a high vertical hydraulic gradient. The water level in the underlying Upper Aquifer is below the surface of the aquifer which results in the high vertical gradient. The significantly weathered and fractured clay that occurs at surface and extends within the first 5 m will have a horizontal component of groundwater flow. However most of the active highly fractured zone will be removed by horizontal expansion landfill cell construction and the remaining fractures are spaced sufficiently far apart to significantly reduce the horizontal groundwater flow component. In addition, the self-healing properties of the clay as documented in the University of Western Ontario study indicate that the effect of these fractures will be reduced with the addition of effective stress (weight) induced by the overlying waste fill.

4.6.1.2 Upper Aquifer

Groundwater flow in the Upper Aquifer is shown on **Figure 3**. As indicated on the figure, groundwater flows from the northeast to the southwest. The groundwater elevation in the new monitoring well 19-6b was installed in an aquifer encountered at a higher elevation than the Upper Aquifer at nearby monitoring wells 19-4b and 19-5b. This aquifer is probably related to a localized sand layer located within the Surficial Aquitard and is not hydraulically related to the Upper Aquifer system.

4.6.1.3 White Oak Aquifer

Figure 4 illustrates the water level in the White Oak Aquifer. Groundwater elevations are highest in the northwest near Scotland Drive and White Oak Road and decrease to the southeast. Based on previous assessments (Dillon, 2015), the ponds in the gravel pits north of Scotland Drive are directly hydraulically connected to the White Oak Aquifer and cause an elevated groundwater elevation in this area. Groundwater elevations decrease to the southeast. Three new monitoring wells were installed in the White Oak Aquifer (19-1, 19-2a and 19-3) and groundwater elevations at 19-2a, 19-1 and historic monitoring well 92-8 are very similar in elevation (~253.5 masl). The reason for the lack of hydraulic gradient in this area is not known but may be related to a decrease in recharge from surface and /or less influence from the recharge zone north of Scotland Drive (the gravel pit ponds) due to a greater distance from the recharge zone.

Figure 3: Groundwater Elevation in Upper Aquifer



Existing Groundwater Conditions

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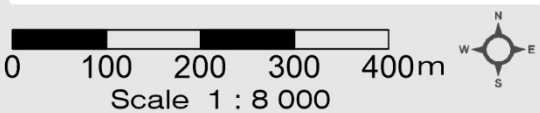
**GROUNDWATER ELEVATION
IN UPPER AQUIFER**

Figure 3

LEGEND

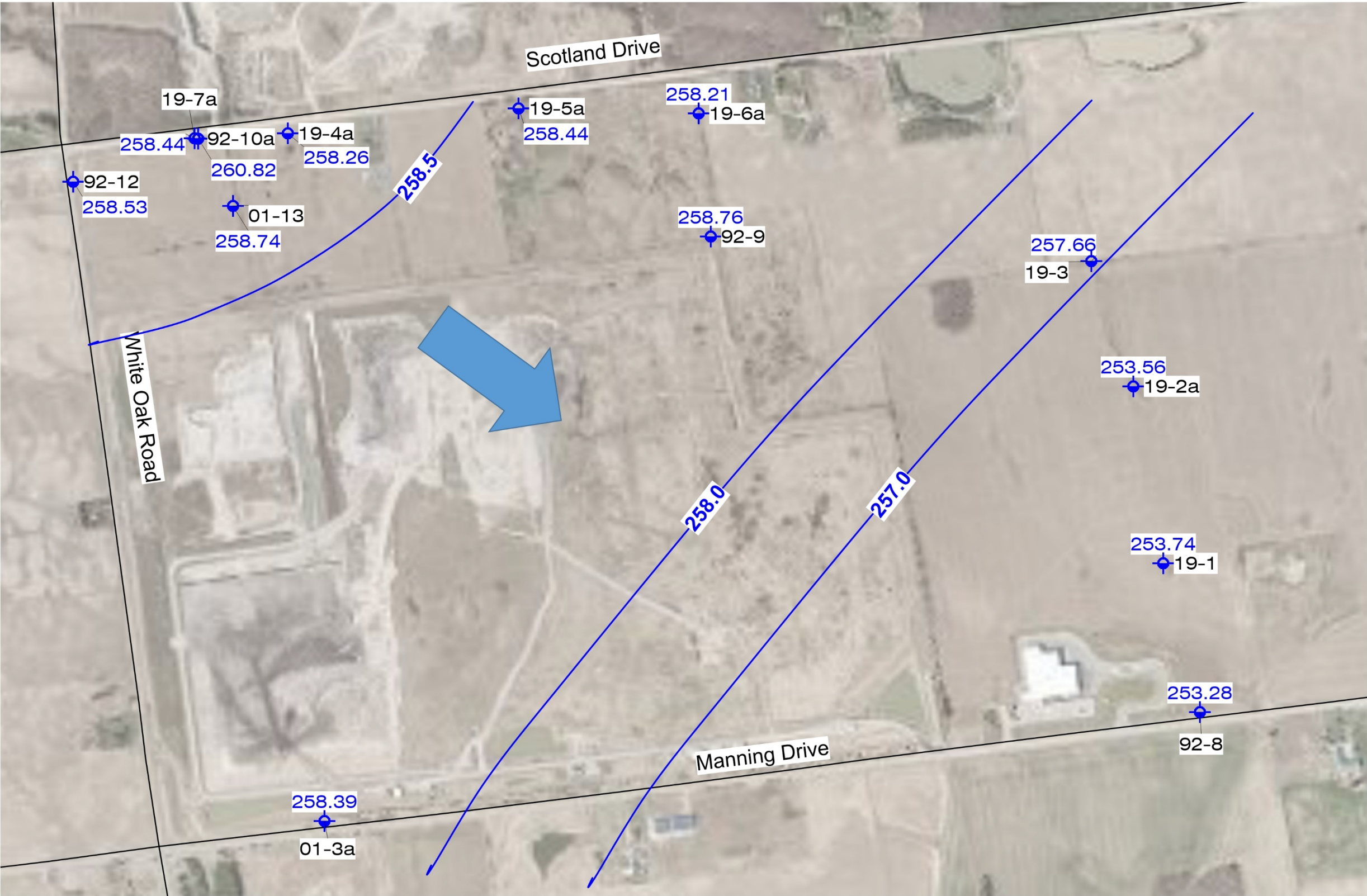
259.46
Fall 2019 Upper Aquifer
Groundwater Elevation (masl)

Groundwater
Flow Direction



MAP CREATED BY : LOM
MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO

Figure 4: Groundwater Elevation in White Oak Aquifer



Existing Groundwater Conditions

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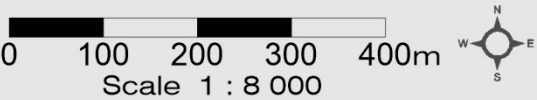
**GROUNDWATER ELEVATION
IN WHITE OAK AQUIFER**

Figure 4

LEGEND

257.66
Groundwater Elevation (masl)

Groundwater
Flow Direction



MAP CREATED BY : LOM
MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO

4.7

Groundwater Chemistry

Groundwater samples were collected from the new monitoring wells installed in the proposed expansion areas. The target parameter list was similar to the current groundwater monitoring program. A summary of the laboratory results is found in **Appendix F** which also contains the laboratory Certificates of Analysis. Samples were not obtained in the newly installed Upper Aquifer wells since these wells had insufficient water column in the well to be sampled. The exception to this was monitoring well 19 to 6b.

In addition, the isotopes of oxygen and hydrogen were quantified in porewater extracted from soil cores. Water samples from Upper Aquifer monitoring wells were also planned to be submitted for isotopic analysis but could not, since these wells could not be sampled.

The chemistry of groundwater changes as it moves through soils and rock and can be used to assess the relative residence time in the subsurface. From this perspective, groundwater chemistry “ages” in the subsurface. For instance, relatively fresh groundwater recently recharged from surface infiltration is dominated by a calcium/magnesium cation and bicarbonate (alkalinity) as the dominant anion. As the residence time in the subsurface increases, groundwater chemistry slowly changes so that sodium is the dominant cation and chloride is the dominant anion.

Major ion data from the laboratory analysis of groundwater samples were used to generate Durov diagrams that utilize trilinear diagrams to differentiate groundwater chemical characteristics for different hydrostratigraphic units and locations within the groundwater environment. A Durov diagram plots major cations and anions in trilinear plots and then transfers their location in a general rectangular plot. **Figure 5a** has an explanatory Durov diagram and illustrates the various “types” of groundwater and the general evolution of groundwater quality from “fresh” calcium bicarbonate type water to “old” sodium chloride type water.

Figure 5b includes the data collected for the monitoring wells previously installed in the area of the landfill as well as the samples taken from the new monitoring wells. Data from the historic monitoring wells is from 2010 to 2019. As shown on the figure, the dominant water type is a calcium-bicarbonate water type with the Upper Aquifer exhibiting both calcium-bicarbonate and sodium bicarbonate type waters. Overall, it can be concluded that the new wells are consistent with the laboratory analytical data from the existing wells included in the monitoring program.

Figure 5a: Explanatory Durov Diagram

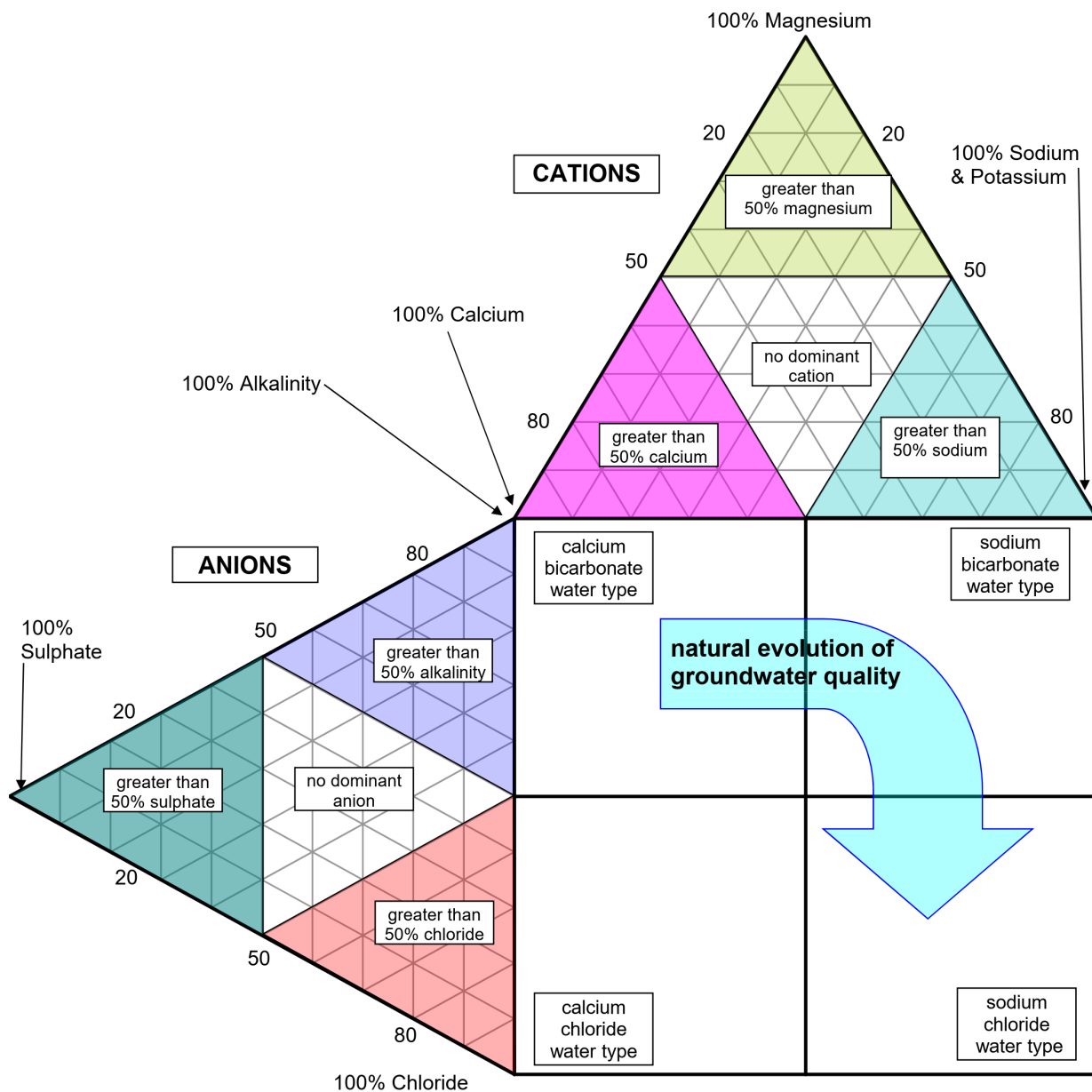
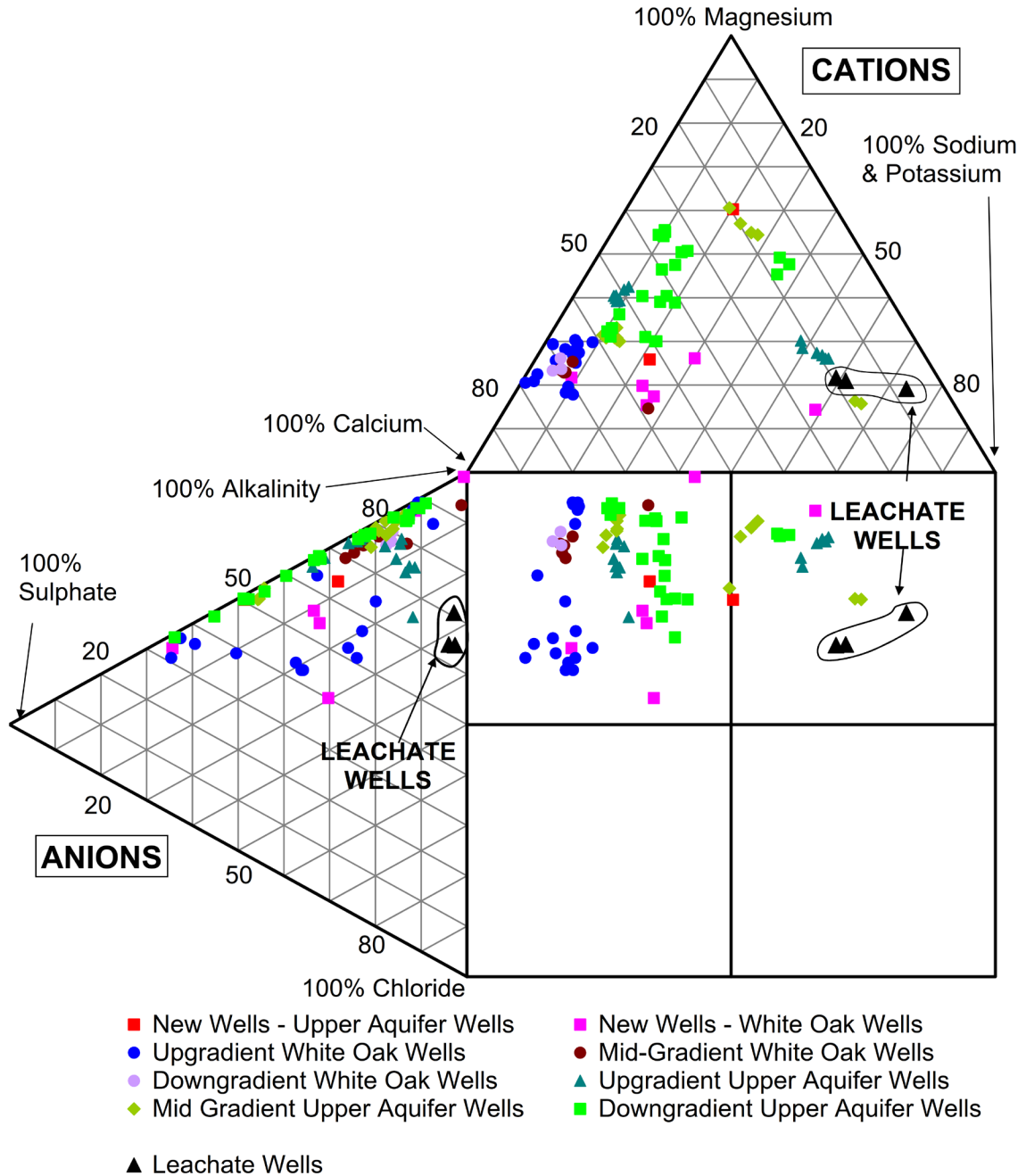


Figure 5b: Durov Diagram



4.8 Isotope Chemistry

Stable isotopes of oxygen and hydrogen are other indicators of groundwater movement. They are particularly useful because they are part of the ions that constitute water and are not subject to attenuation processes that can change concentrations of dissolved constituents and have been used to date the age of groundwater.

The depletion of oxygen-18 ($\delta^{18}\text{O}$) and deuterium ($\delta^2\text{H}$) with respect to Vienna Mean Standard Ocean Water (VMSOW) is an age indicator when data are compared to similar data in areas where the relationship between oxygen-18 depletion and groundwater age has been established. Desaulniers, et al, 1981 established that greater depletion indicates greater age. However, Edwards and Fritz, 1987 describes a possible exception to this where groundwater recharged during the Hypsithermal era (between approximately 4,000 and 7,000 years ago) could be less depleted than modern recharge waters. Cross-plots of depletion of Oxygen-18 against deuterium (hydrogen-2) can provide insight into groundwater movement and age. Isotopic data is reported as a difference between the sampled water and VMSOW and is reported in per thousand (‰). For instance, a value of Oxygen-18 of -10‰ means that the water sample has 10‰ less (i.e., is depleted) Oxygen-18 than the standard. Interpretation of stable isotope data is commonly referenced to the Meteoric Water Line (MWL), representative of these isotopes in global precipitation (Dansgaard, 1964). A more local meteoric water line has been established and is referred to as the Great Lakes Meteoric Water line and it is shown on **Figure 6**.

The results of the laboratory analysis of porewater extracted from soil cores is found in **Appendix G. Figure 6** cross-plots the results of the analysis of oxygen-18 and deuterium in porewater from soil core samples collected during the drilling of BH19-3 and BH19-5. This figure shows that Oxygen-18 and deuterium plot consistently with the Great Lakes Meteoric Water line and other studies in southern Ontario. Isotope data from porewater is plotted with depth on **Figure 7** for both Oxygen-18 and deuterium. The amount of depletion is consistent and does not significantly change with depth.

The estimated travel time through the Surficial Aquitard has been estimated to be in the order of 700 years (Dillon, 2000). Therefore the lack of change in isotope depletion with depth is expected and does not indicate older groundwater age.

Figure 6: Porewater Isotope Chemistry

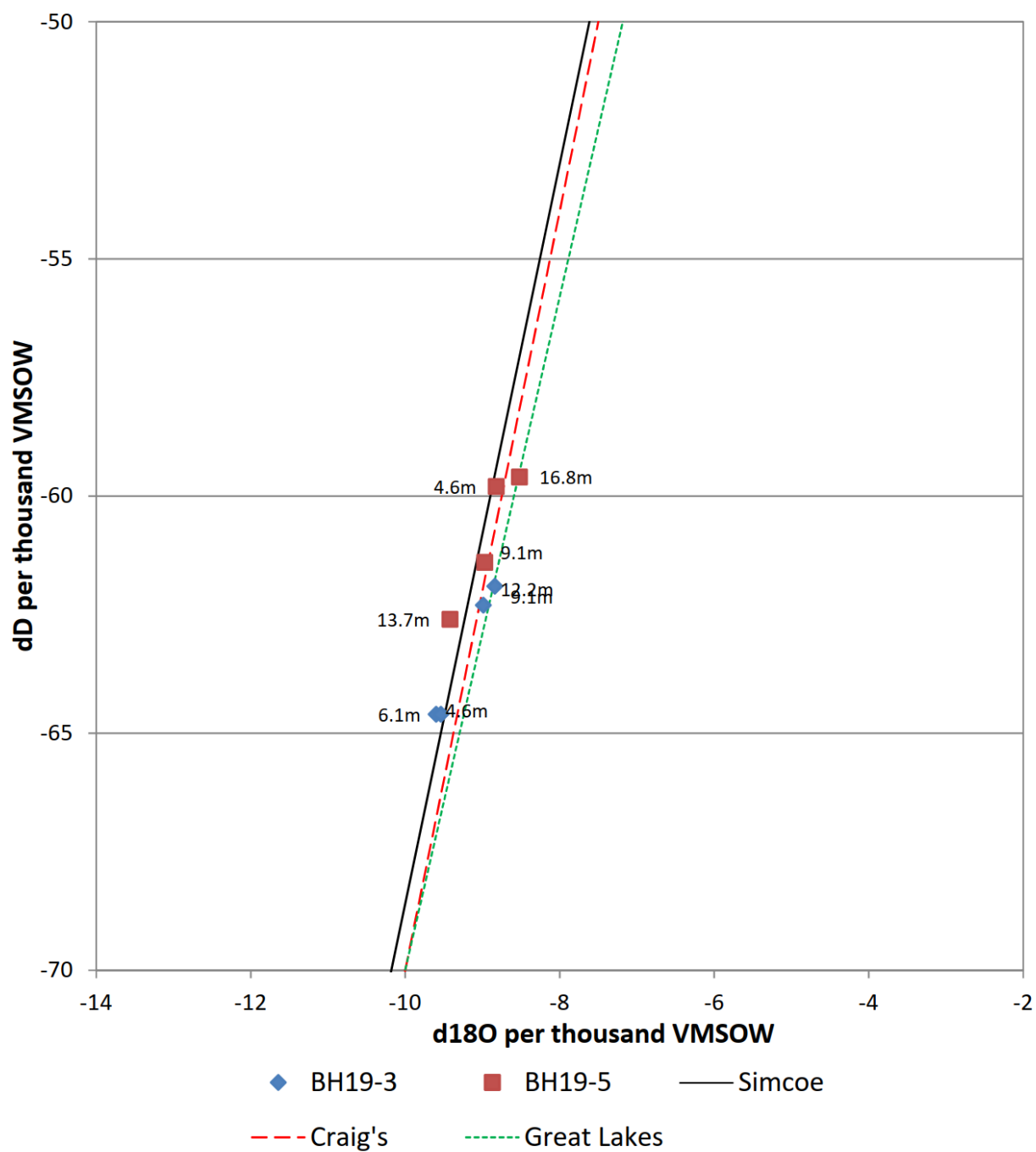
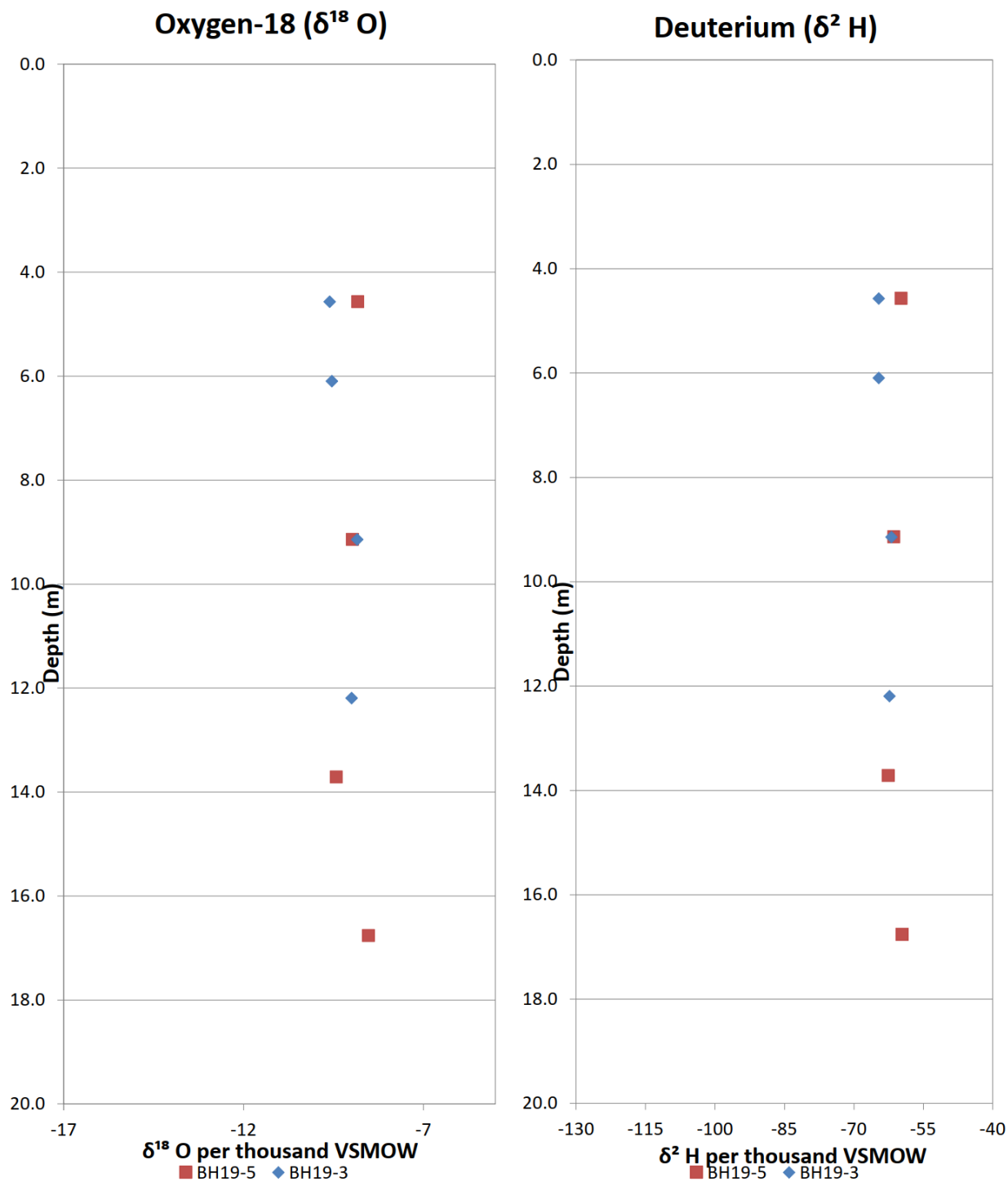


Figure 7: Isotopes in Porewater with Depth



Tritium concentrations in porewater also serve as an indicator of groundwater age. Tritium levels in global precipitation increased significantly between the years 1952 and 1963 as a result of atmospheric thermonuclear bomb testing. Given that tritium has a half life of 12.3 years, tritium concentrations in groundwater recharged prior to bomb testing should be generally less than 1 tritium unit (TU). The enriched tritium results are summarized in **Table 6** for soil core samples taken at various depths at BH19-3 and BH19-5. Overall, tritium concentrations are quite low, which makes definitive conclusions regarding groundwater age difficult. The highest tritium concentration was in the shallow soil core sample at each borehole location: 3.7 TU for BH19-3 and 4.1 TU at BH19-5 at 4.6 m depth. Enriched tritium concentrations were less than 1 TU in three deeper soil cores and less than 2.3 TU in the other 3 deeper soil cores. Overall, the tritium results, while inconclusive, are consistent with a low vertical groundwater velocity.

Table 6: Summary of Enriched Tritium Results

Borehole	Sample Depth (m)	Enriched Tritium (TU)	Standard Deviation
BH19-3	4.6	3.7	1
BH19-3	6.1	<0.8	0.7
BH19-3	9.1	2	0.8
BH19-3	12.2	<0.8	0.7
BH19-5	4.6	4.1	0.8
BH19-5	9.1	1.4	0.7
BH19-5	13.7	0.9	0.6
BH19-5	16.8	2.3	0.9

5.0 Summary of Existing Conditions

This section provides a summary of the existing hydrogeological conditions at, and in close vicinity, to the landfill. It is based on the previous hydrogeological investigations and the supplemental investigation described in Section 3 and Section 4, respectively.

5.1 Hydrostratigraphic Unit Description

The hydrostratigraphic units described are shown graphically on cross-sections shown on **Figure 8**. The cross-sections show the stratigraphy west – east along the Scotland Drive Wells (Section A-A') and in a north - south direction for the drilling locations east of the existing landfill (Section B-B'). The thickness of the Surficial Aquitard is shown on the sections. In addition to the cross-sections, maps were prepared that illustrate either the surface of various geological and hydrostratigraphic layers using contour lines or the thickness of the layers (referred to as isopachs) using information from new boreholes installed in the expansion area and historical boreholes installed at, and in the vicinity, of the landfill. To provide context beyond the immediate vicinity of the landfill, the Area Study completed in 2005 that relied on water well record information was also used in the interpretation.

The following figures were prepared:

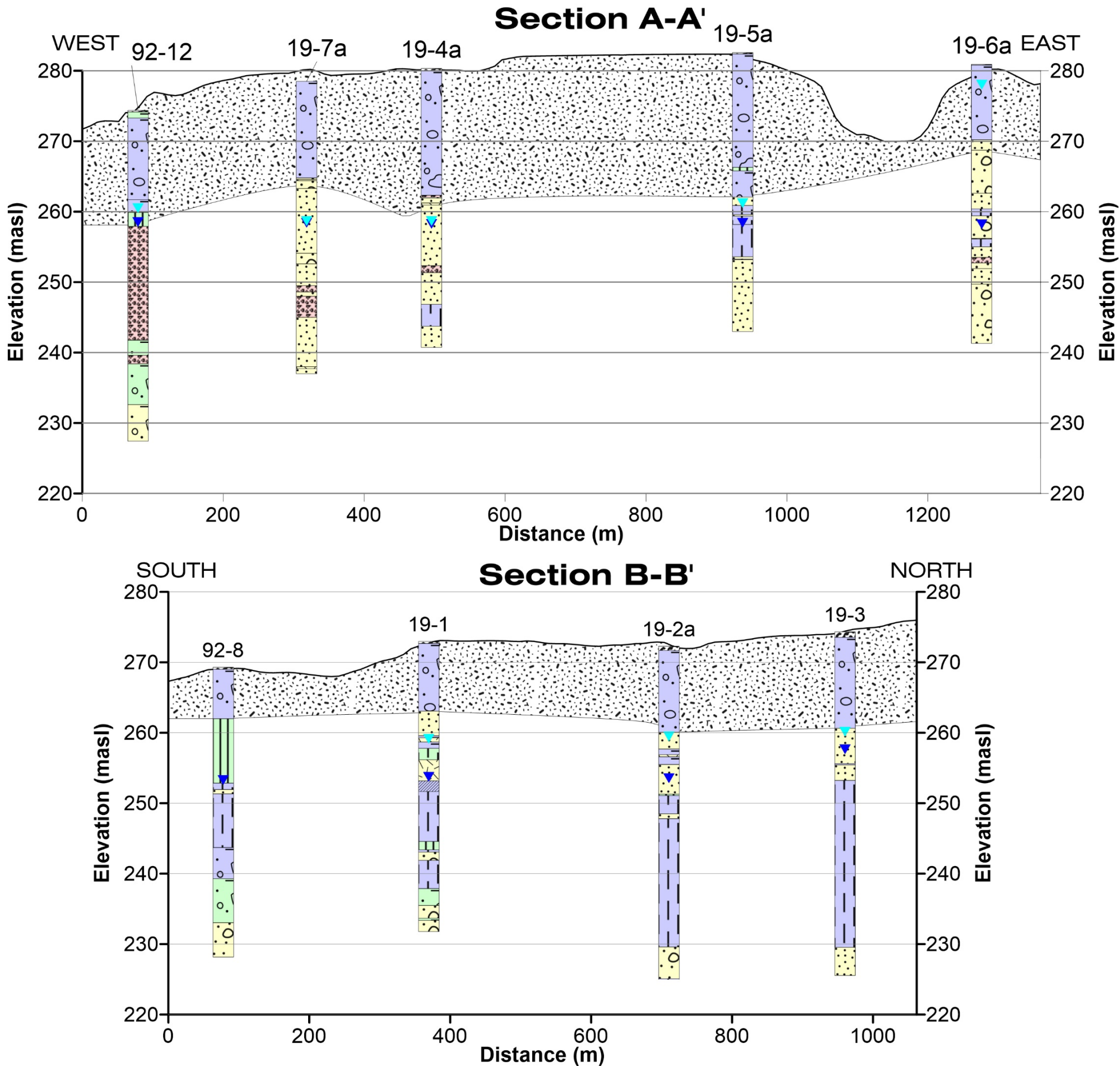
Figure 9 shows the interpreted surface of the Upper Aquifer

Figure 10 illustrates the thickness of the Surficial Aquitard. It is important to note that the original ground surface elevation was used to produce this figure (does not include the elevation of the fill areas of the existing landfill).

5.1.1 Surficial Aquitard

As shown on **Figure 10**, the thickness of the Surficial Aquitard varies from as much as 20 m in the northwest corner of the existing W12A Landfill site, to 15 m or greater below much of the existing landfill, and to about 8 m at the southeast corner of the site along Manning Drive. The new boreholes drilled east of the landfill (19-1, 19-2, and 19-3) confirmed the identified thickness of the Upper Aquitard at previously installed monitoring wells (19-3, 92-7 and 92-4, respectively).

Figure 8 Geologic Cross Sections



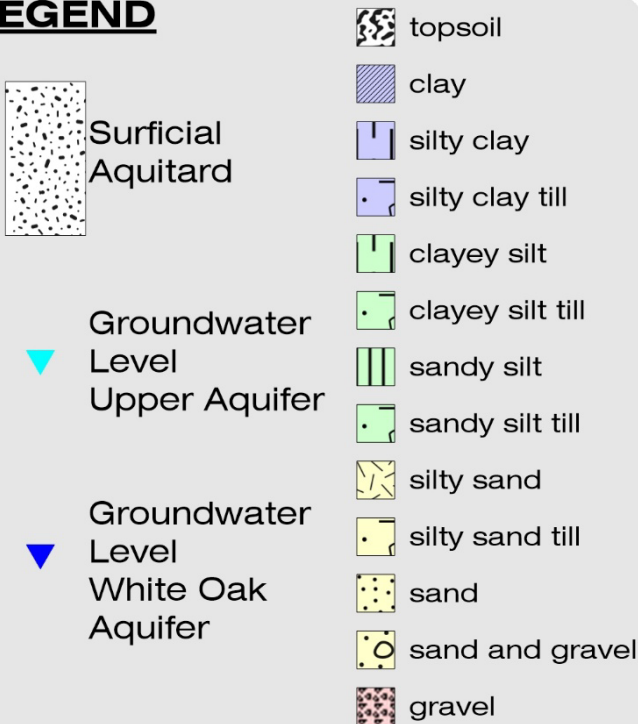
Existing Groundwater Conditions

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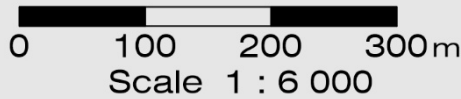
GEOLOGIC CROSS SECTIONS

Figure 8

LEGEND



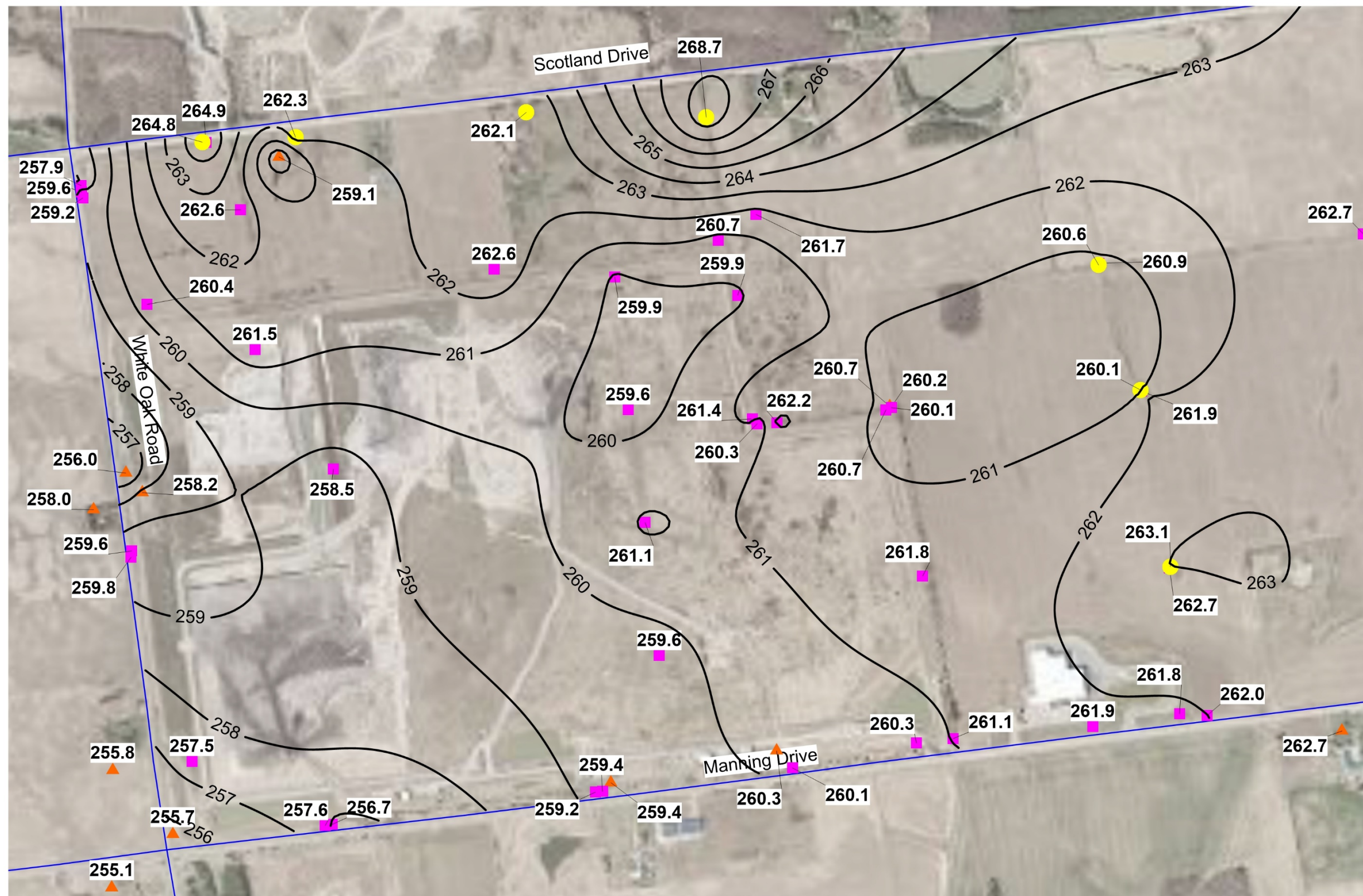
Note: See Figure 1 for
Geologic Section Locations



NOTE: VERTICAL SCALE
EXAGGERATED 10x

MAP CREATED BY : LOM
MAP CHECKED BY: RFK

Figure 9: Upper Aquifer Surface Elevation



Existing Groundwater Conditions

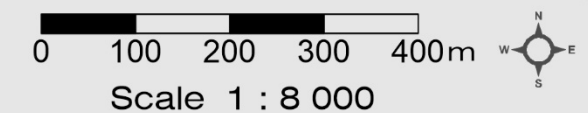
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UPPER AQUIFER SURFACE ELEVATION

Figure 9

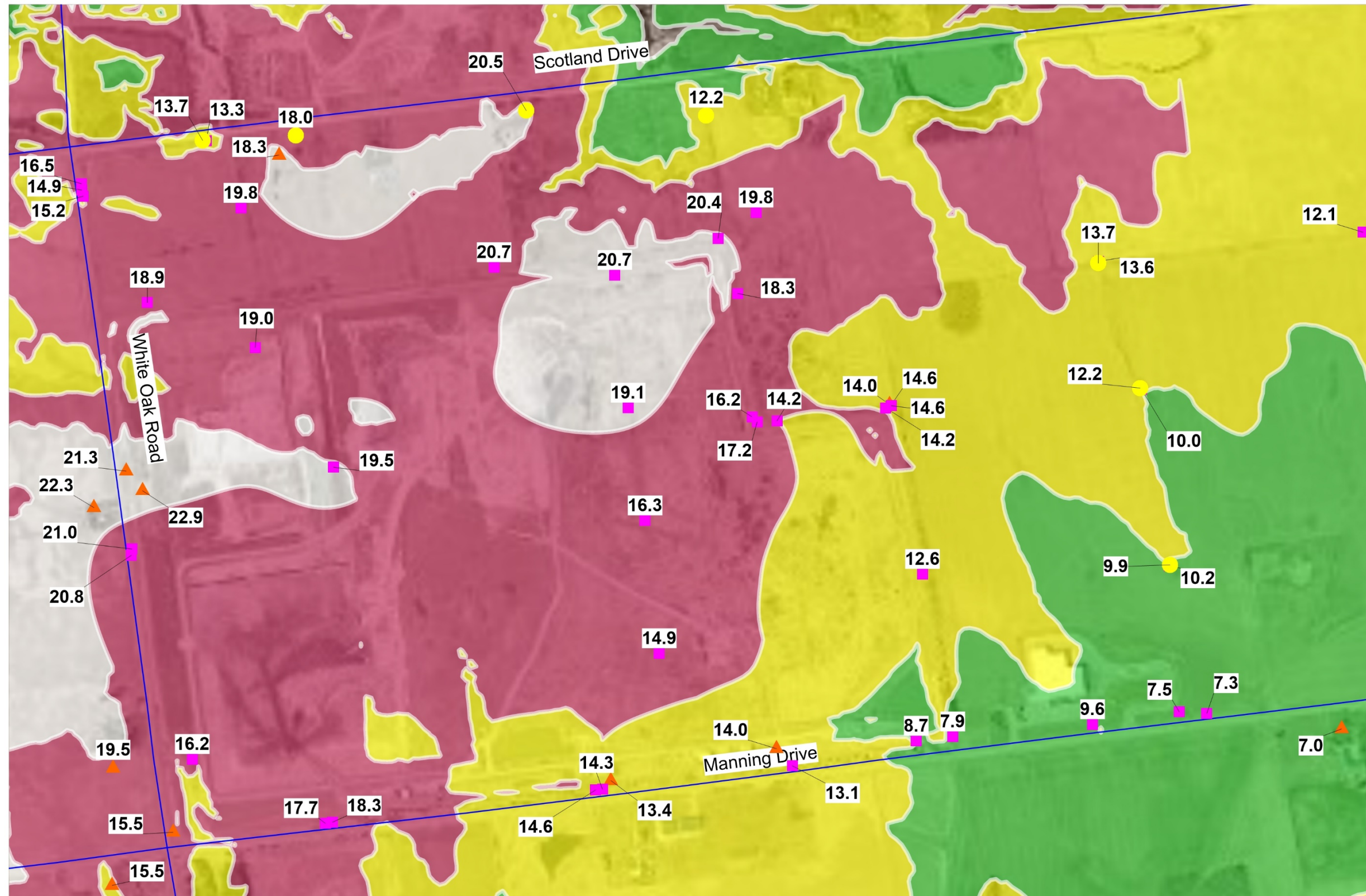
LEGEND

- 2019 Drilling Location
- Historical Borehole Data
- ▲ Water Well Record Data
- 260.1 Elevation of Upper Aquifer (masl)
- 260 Upper Aquifer Surface Contour (masl)



MAP CREATED BY : LOM
MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO

Figure 10: Surficial Aquitard Thickness



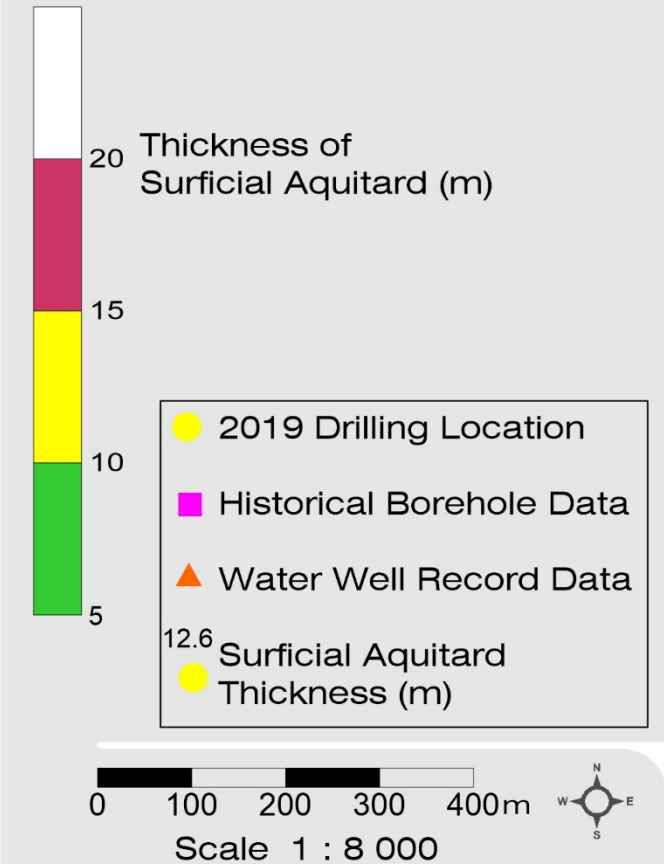
Existing Groundwater Conditions

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SURFICIAL AQUITARD THICKNESS

Figure 10

LEGEND



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MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO

North of the landfill, the boreholes drilled just south of Scotland Drive indicated a consistent Surficial Aquitard thickness of 18 m to 20 m with the exception of BH19-6, the eastern-most borehole location, where a permeable layer of gravelly sand was encountered at a depth of 12.2 m and extended to a depth of 18.3 m (based on groundwater levels, the upper sand layers are probably hydraulically isolated from the Upper Aquifer - see Section 6.1.2).

Figure 9, which shows the interpreted surface elevation of the Upper Aquifer, indicate a relatively even surface (with the exception at BH19-6 noted above) that slopes from the northeast at an elevation of 263 masl to the southwest where it was encountered at an elevation of 256 masl (a slope of less than 0.5 %). From this figure it is concluded that the variations in the Surficial Aquitard thickness are more related to surface topography changes than variations in the elevation of the base of the aquitard unit. This is evident in the topographic low east of the Material Recovery Facility where the thickness of the Surficial Aquitard is consistently less than 10 m thick.

The results of the test pit excavation indicated a pattern of significant weathering and fracturing within the upper approximately 3 m from surface. The fracture spacing was generally less than 0.3 m. The colour of the till changed from mostly brown at ground surface to a mottled grey and brown appearance from about 1 m transitioning to mostly grey at a depth of 4 m. At depths below 4 m, the fracture frequency noticeably decreased to a separation distance greater than 0.5 m. Although, at the bottom of the test pit, one distinctive fracture was noted but did not extend below the base of the test pit.

Significant fracturing was noted in the soil cores taken below the Phase 1 landfill waste and subsequently tested at the University of Western Ontario in 2000. The effect of fracturing was most evident at one testing location where the upper 0.6 m of the core had significant chloride penetration in one core sample. However, beneath this depth, the chloride concentration profile with depth became diffusion dominated consistent with the other testing location. A flexible wall hydraulic conductivity test where a discoloured fracture was noted in the core sample had a hydraulic conductivity of 1.4×10^{-10} m/s, consistent with the unfractured core samples. It was concluded in that study that, even though the clay was observed to be fractured in the core samples, that consolidation due to the effective stress applied by the weight of the overlying waste effectively closed the fracture and did not cause preferential flow in the fracture (UWO, 2000).

Grain size testing of soil samples from soil cores taken in 2019 confirm visual observations that the till soils do not vary by location and are uniformly consistent. Overall, the Surficial Aquitard was encountered at all 2019 drilling locations and

consistent with previous hydrogeological investigations completed in and in the vicinity of the landfill.

5.1.2 Upper Aquifer

The Upper Aquifer consists of layered sand and gravel soils found beneath the Surficial Aquitard. The layered nature of these soils indicates that they were deposited not directly by glaciers as were the till soils but are water-lain sediments. Like most local aquifers, there is considerable variability in the composition of the aquifer material but mainly the aquifer can be characterized as a sand aquifer with gravelly sand at some locations. The thickness of the Upper Aquifer is likewise variable ranging from less than 2 m to more than 8 m thick. The soil cores taken in 2019 also indicated some layers of silt and clay soil within the aquifer which is consistent with water-laid sediment. The Upper Aquifer is not present north of Scotland Drive, but extends south of Manning Drive.

5.1.3 Lower Aquitard

The Lower Aquitard occurs beneath the Upper Aquifer and separates the Upper Aquifer from the lower White Oak Aquifer. The Lower Aquitard consists mainly of silty clay soils. Unlike the Surficial Aquitard, there is considerable variation in the composition of the aquitard with silt water-laid sediments encountered immediately beneath the Upper Aquifer and clayey silt till soil generally found beneath the silt soils. Overall, the logging of continuous soil cores taken from the 2019 boreholes indicates more variability in the composition (in particular less till soils and more water-laid silt and clay soils) of the Lower Aquitard than previous investigations. Previous investigations did not continuously core through the Lower Aquitard and overburden conditions were inferred from the drilling process and discontinuous soil sampling. The Lower Aquitard was not encountered at BH19-7 where the Upper Aquifer occurs immediately above the White Oak Aquifer and the two aquifer systems are not distinguishable.

5.1.4 White Oak Aquifer

The White Oak Aquifer occurs beneath the Lower Aquitard and consist of stratified sand and gravel deposits most likely part of the Catfish Creek Drift. Regionally extensive, the White Oak Aquifer has been estimated to be 100 km² in area and extends from south of Lambeth (north of the Landfill) to approximately Glanworth Drive (south of the landfill). Groundwater flow in the White Oak Aquifer is from the northwest, where groundwater elevations are elevated due to a recharge zone north of Scotland Drive (gravel pit area) where ponds are directly hydraulically connected to the aquifer. Groundwater elevations decrease to the southeast. New monitoring wells installed in 2019 in the White Oak Aquifer (19-1, 19-2a and 19-3) indicate an area of low hydraulic gradient. The reason for

the lack of hydraulic gradient in this area is not known but may be related to a decrease in recharge from surface and /or less influence from the recharge zone north of Scotland Drive (the gravel pit ponds) due to a greater distance from the recharge zone.

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The following items are scanned documents and materials that were made publicly available during the study. We have endeavored to make this document as accessible as possible but realize that there may be limitations in this area. We are happy to provide you with detailed information and description about any of the letters, articles, and other materials in this section of the document. For a description of these materials for accessibility purposes, please contact Wesley Abbott, wabbott@london.ca, 226-376-2311 who will help provide you with the details you require.

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- City of London, Landfill Site W-12, Site Plan and Sections Showing Soil Conditions Figure 1, (James F. MacLaren Limited, September 1972)
- City of London, Landfill Site W-12A, Sections Showing Soil Conditions Figure 2, (James F. MacLaren Limited, September 1972)
- James F. MacLaren Limited Subsurface Investigation Proposed White Oak Landfill Site London Ontario (Report #72483), (Golder Associates, November 1972)
- James F. MacLaren Limited Additional Subsurface Investigation Proposed White Oak Landfill Site London Ontario (Report #72483-1), (Golder Associates, December 1972)
- James F. MacLaren Limited Additional Subsurface Investigation Proposed White Oak Landfill Site London Ontario (Report #72483-2), (Golder Associates, June 1973)

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Report on Preliminary Hydrogeological Investigation Part 1, Lot 20, Concession VI, Township of Westminster Ontario (Report #921-3115), (Golder Associates, May 1992)

Report on Monitoring Well Installation W12A Landfill Township of Westminster Ontario (Report #921-3115-1), (Golder Associates, July 1992)

Report on Monitoring Well Installation W12A Landfill London Ontario (Report #941-3210), (Golder Associates, November 1994)

Report on Monitoring Well Installation W12A Landfill London Ontario (Report #941-3210), (Golder Associates, November 1994)

Untitled Borehole Logs, (Agra Earth and Environmental, 1997)

Report On Geotechnical Investigation for Proposed Garbage Storage Area W12A Landfill Site, (Atkinson Davies Inc., December 1999)

Report On Geotechnical Investigation for Proposed New Scales and Scalehouse for W12A Landfill Site, (Atkinson Davies Inc., June 2000)

City of London W12A Landfill Investigation, (Geotechnical Research Centre University of Western Ontario, September 2000)

City of London Hydrogeological Investigation for the W12A Landfill, (Dillon Consulting Ltd., December 2000)

Report to the City of London Groundwater Monitoring Well Installations W12A Landfill (Report # 011-3240), (Golder Associates, January 2002)

Phase One- Groundwater Impact Assessment (Appendix R, W12A Landfill 2004 Annual Status Report), (Dillon Consulting Ltd., March 2004)

Groundwater Monitoring Wells (Letter Report # 041-130234), (Golder Associates, December 2004)

W12A Landfill Site Assessment of Water Well Monitoring Program (Letter Report # 04-3935), (Dillon Consulting Ltd., February 2005)

Groundwater Monitoring Wells, Vicinity of W12A Landfill (Letter Report #05-1135-089), (Golder Associates, December 2005)

- City of London W12A Landfill Area Plan Study Hydrology/Hydrogeological Background Study, (Dillon Consulting Limited, December 2005)
- Report on Abandonment of Inactive Private Water Wells, Wells 7 and 50 (Report # 05-1135107), (Golder Associates, February 2006)
- Water Well Records, Groundwater Monitoring Wells, Vicinity of W12A Landfill (Report # 051135-089), (Golder Associates, March 2006)
- Installation of Groundwater Monitoring Wells, Vicinity of W12A Landfill (Report # 06-1135-070), (Golder Associates, January 2007)
- Abandonment of Inactive Wells, Vicinity of W12A Landfill Site (Report # 06-1135-070), (Golder Associates, February 2007)
- W12A Landfill Assessment of Nearby Private Wells On-Site Treatment Options (Report # 13601), (Urban & Environmental Management Inc., June 2013)
- Well Abandonment, Installation and Repair Program W12A Landfill (Report # 13-1134-0115R01), (Golder Associates, January 2014)
- Review of Groundwater Quality Upgradient (North) of W12A Landfill (Letter Report Dated February 6, 2015), (Dillon Consulting Ltd., February 2015)
- Proposed Greenhouse Development G.I. Farms, Wellington Road South and Manning Drive London, Ontario (Report #1526180-R01), (Golder Associates, June 2015)
- Report on Geophysical Surveys at the Abandoned Well Sites near W12A City of London – July, August, & December 2019, (Clearview Geophysics Inc., 2019)

Appendix A

Borehole Logs

Borehole ID: BH19-1
Monitoring Well ID: 19-1

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/04/2019 Date Completed: 09/09/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	TOPSOIL Brown, moist, soft, lots of organics		0.3				Cement seal with protective casing	
1	SILTY CLAY TILL Brown silty clay with trace medium gravel, mottled, increasing clay content and stiffer with depth			BH19-1-SS1		ST		272
2	Trace fine to medium gravel and increased mottling with depth, stiff to very stiff							271
3	Trace fine sand			BH19-1-SS2	A	ST		270
4								269
5	Transition to grey silty clay, no mottling							268
6	Some fine sand							267
7				BH19-1-SS3		ST		266
8							PVC riser with grout to surface	265
9	Trace medium to fine angular to subrounded gravel							264
10	SAND Brown, fine sand, loose, moist		9.9	BH19-1-SS4	A	ST		263
11								262
12								261
13				BH19-1-SS5	A	ST		260
14	SILTY CLAY TILL Grey silty clay, stiff, moist		13.4					259
	SILTY SAND Grey silty sand with trace clay, moist, stiff		14.3					

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

	Organics		Sand		Clay
	Silt / Clay		Silty Sand		Sandy Clay

Northing (m) : 482562
Easting (m) : 4747433

Casing: 2"
Grade Elevation (m asl) : 272.97
Top of Casing Elevation (m asl) : 273.74
ST - Split Tube

Borehole ID: BH19-1
Monitoring Well ID: 19-1

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/04/2019 Date Completed: 09/09/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
16	SILTY CLAY Grey silty clay, stiff, moist(<i>continued</i>) CLAYEY SILT Grey clayey silt, stiff, moist		15.2					257
				BH19-1-SS6		ST		
17	SILTY SAND Grey silty sand with some fine sand, stiff, moist		16.8					256
18								255
19				BH19-1-SS7		ST		254
20	CLAY Grey clay, stiff, moist		19.8					253
21								252
22	SILTY CLAY TILL Grey silty clay with trace fine to medium gravel, very stiff, moist		21.3					251
23				BH19-1-SS8		ST		250
24								249
25	Trace fine sand and fine gravel			BH19-1-SS9	A	ST		248
26								247
27								246
28	Some fine to medium gravel							245
29	SANDY CLAY Brown sandy clay with trace fine gravel, stiff, moist		28.4					244
	SILTY CLAY		29.6					

PVC riser with grout to surface

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Sand
 Clay
 Silt / Clay
 Silty Sand
 Sandy Clay

Northing (m) : 482562
 Easting (m) : 4747433

Casing: 2"
 Grade Elevation (m asl) : 272.97
 Top of Casing Elevation (m asl) : 273.74
 ST - Split Tube

Borehole ID: BH19-1
Monitoring Well ID: 19-1

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/04/2019 Date Completed: 09/09/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
31	Grey silty clay with trace medium to fine gravel, stiff, moist GRAVELLY SAND Brown medium to fine gravelly sand, loose, moist(continued) Transition to grey medium to fine gravelly sand with clay, stiff		29.9					242
32	SILTY CLAY Grey silty clay with trace fine gravel, stiff, moist Very stiff		31.1					241
33								240
34	Trace fine sand						PVC riser with grout to surface	239
35								238
36	GRAVELLY CLAY Grey coarse to fine gravelly clay with silt and trace fine sand, stiff, moist		35.1	BH19-1-SS10		ST		237
37							PVC riser with bentonite	236
38	GRAVELLY SAND Grey to brown fine to medium gravelly sand with silt, firm, moist		37.5	BH19-1-SS11		ST	#1 silica sand pack	235
39								234
40	SANDY CLAY Grey fine sandy clay with silt and trace medium to fine gravel, stiff, moist		39.3					233
41	GRAVELLY SAND Grey fine to medium gravelly sand, stiff, moist		39.6	BH19-1-SS12	A	ST	PVC screen with #1 silica sand pack	232
	End of borehole at 41.2 m bgs		41.2				End cap	

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

LITHOLOGY SYMBOLS

	Organics		Sand		Clay
	Silt / Clay		Silty Sand		Sandy Clay

Northing (m) : 482562
Easting (m) : 4747433

Casing: 2"
Grade Elevation (m asl) : 272.97
Top of Casing Elevation (m asl) : 273.74
ST - Split Tube

Borehole ID: BH19-2
Monitoring Well ID: 19-2

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/10/2019 Date Completed: 09/12/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	TOPSOIL Brown topsoil with organics, soft, moist						Cement seal with protective casing	272
1	SILTY CLAY TILL Brown weathered silty clay with trace fine to medium gravel and grey mottling, soft to stiff		0.6					271
2	Loose							270
3	Stiff							269
4				BH19-2-SS1	B	ST		268
5	Slight grey mottling, moist							267
6	Transition to grey							266
7								265
8	Trace medium sand						PVC riser with grout to surface	264
9								263
10				BH19-2-SS2	B	ST		262
11								261
12								260
13	SAND Grey fine to medium sand sand, soft		12.2					259
14	Moist			BH19-2-SS3	A	ST		258
	Gray silty clay seam, stiff, moist		14.6					

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Sand
 Sandy Gravel
 Silt / Clay
 Clayey Sand

Northing (m) : 482505
Easting (m) : 4747770

Casing: 2"
Grade Elevation (m asl) : 272.29
Top of Casing Elevation (m asl) : 273.01
 ST - Split Tube

Borehole ID: BH19-2
Monitoring Well ID: 19-2

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/10/2019 Date Completed: 09/12/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	Gray silty clay seam, stiff, moist(<i>continued</i>)							
	CLAYEY SAND		15.4					257
16	grey clayey sand, stiff, moist		15.7					
	SILTY CLAY							
	Grey silty clay, stiff, moist							256
	Intermix of above silty clay and clayey sand							
17	SAND		16.8					255
	Grey fine to medium sand, stiff, moist							
	Grey silty clay seam with trace fine sand, stiff, moist							
18								254
	Trace silt							
19								253
20								252
21	Grey clayey sand seam, soft, wet,		21					251
	SILTY CLAY TILL		21.2					
	Grey silty clay, stiff, moist							
22								250
	Grey sandy clay seam, soft, wet							
23	Trace fine to medium gravel							249
24	SAND		23.6					248
	Fine to medium sand with trace medium gravel, stiff, moist							
	Transition to gravelly sand		24.5					
25	SILTY CLAY			BH19-2-SS4	A	ST		247
	Grey silty clay with trace fine to medium gravel, stiff, moist							
26	Trace coarse gravel							246
27								245
	Trace fine to medium sand							244
28								
29								243

PVC riser with
grout to surface

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

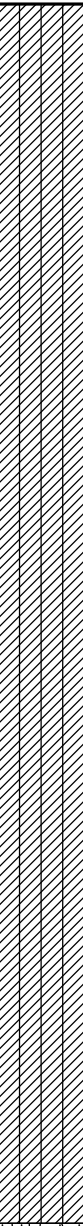
 Organics
 Sand
 Sandy Gravel
 Silt / Clay
 Clayey Sand

Northing (m) : 482505
 Easting (m) : 4747770

Casing: 2"
 Grade Elevation (m asl) : 272.29
 Top of Casing Elevation (m asl) : 273.01
 ST - Split Tube

Borehole ID: BH19-2
Monitoring Well ID: 19-2

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/10/2019 Date Completed: 09/12/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
31	SILTY CLAY TILL Grey silty clay with trace fine to medium gravel, stiff, moist(<i>continued</i>) Trace to fine to medium gravel and fine to medium sand			BH19-2-SS5	A	ST		242
								241
								240
								239
								238
								237
								236
								235
								234
								233
								232
								231
								230
								229
								228
32								
33								
34								
35	Trace coarse gravel and fine to medium sand							
36								
37								
38								
39								
40								
41	Trace fine to medium sand							
42								
43	GRAVELLY SAND Fine to medium gravelly sand with trace silt and clay, soft, moist		42.7					
44	Trace clay							
	Grey silty clay seam, soft, moist							

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

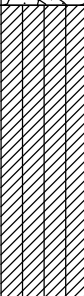
 Organics
  Sand
  Sandy Gravel
 Silt / Clay
  Clayey Sand

Northing (m) : 482505
 Easting (m) : 4747770

Casing: 2"
 Grade Elevation (m asl) : 272.29
 Top of Casing Elevation (m asl) : 273.01
 ST - Split Tube

Borehole ID: BH19-2
Monitoring Well ID: 19-2

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/10/2019 Date Completed: 09/12/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)				
				Soil Sample ID	Lab Analysis	Type						
46	GRAVELLY SAND Fine to medium gravelly sand with trace silt and clay, soft, moist(<i>continued</i>)		47.2	BH19-2-SS6	A	ST	 PVC screen with #1 silica sand pack End cap	227				
47									226			
48	SILTY CLAY TILL Silty clay with trace fine to medium gravel and fine to medium sand, stiff, moist		50.3					225				
49												224
50												
End of borehole at 50.3 m bgs			50.3					222				

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
  Sand
  Sandy Gravel
 Silt / Clay
  Clayey Sand

Northing (m) : 482505
 Easting (m) : 4747770

Casing: 2"

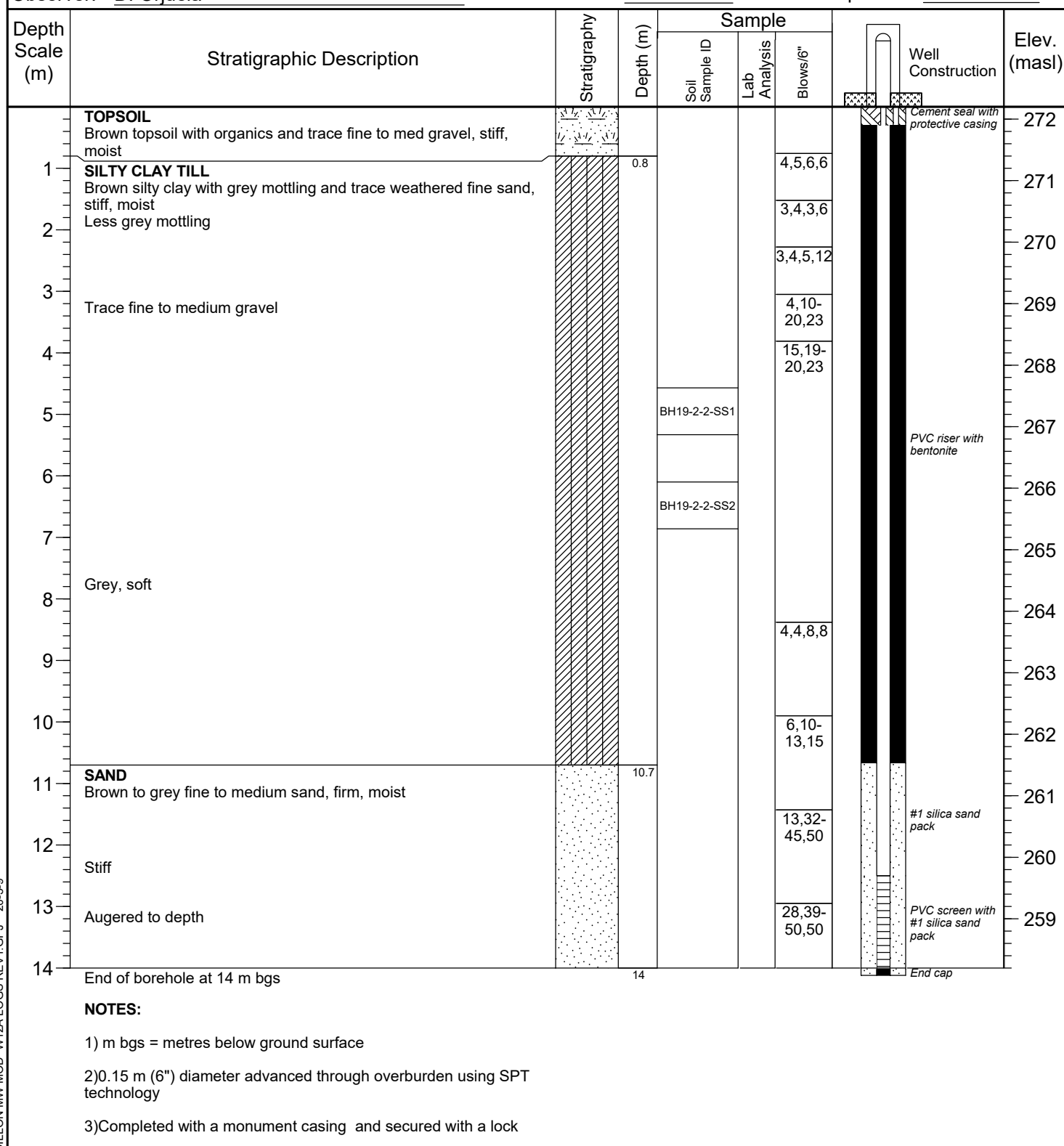
Grade Elevation (m asl) : 272.29

Top of Casing Elevation (m asl) : 273.01

ST - Split Tube

Borehole ID: BH19-2-2
Monitoring Well ID: 92-7a

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
Observer: D. Orjuela Date Started: 09/19/2019 Date Completed: 09/23/2019



DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

	Organics		Sand
	Silt / Clay		

Northing (m) : 482507
Easting (m) : 4747769

Casing: 2"
Grade Elevation (m asl) : 272.20
Top of Casing Elevation (m asl) : 272.99

Borehole ID: BH19-3
Monitoring Well ID: 19-3

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/24/2019 Date Completed: 09/25/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	TOPSOIL Brown topsoil with organics and trace fine to med gravel, stiff, moist						Cement seal with protective casing	274
1	SILTY CLAY TILL Brown weathered silty clay with trace fine gravel, stiff, moist		0.8					273
2								272
3	Grey with brown mottling			BH19-3-SS1		ST		271
4								270
5	Brown with trace fine to medium gravel, soft to stiff			BH19-3-SS2	B + X-Ray	ST		269
6	Trace fine gravel			BH19-3-SS3		ST		268
7								267
8	Brown to grey with trace fine gravel			BH19-3-SS4		ST	PVC riser with grout to surface	266
9	Grey			BH19-3-SS5	B	ST		265
10								264
11				BH19-3-SS6		ST		263
12				BH19-3-SS7		ST		262
13	Occasional sand pockets							261
14	SAND Fine brown sand with trace medium sand, firm, moist		13.7	BH19-3-SS8	B	ST		260

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Sand
 Silt / Clay

Northing (m) : 482425
 Easting (m) : 4748008

Casing: 2"
 Grade Elevation (m asl) : 274.34
 Top of Casing Elevation (m asl) : 275.15
 ST - Split Tube

Borehole ID: BH19-3
Monitoring Well ID: 19-3

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/24/2019 Date Completed: 09/25/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
16	SAND Fine brown sand with trace medium sand, firm, moist(continued) Silty clay pocket							259
17	Intermixed sand and silty clay							258
18	Brown to grey, moist Brown, moist, soft							257
19	SILTY CLAY Silty clay, soft, moist		18.7 18.9					256
20	SAND Brown to grey fine sand with trace medium sand, soft, moist							255
21	Intermixed sand and silty clay		21.1					254
22	SILTY CLAY Grey silty clay, stiff, moist Brown to grey with trace fine to medium sand, soft Some grey mottling, stiff, moist							253
23	No mottling with trace fine gravel							252
24								251
25				BH19-3-SS9		ST		250
26								249
27								248
28	Stiff to very stiff below 27.4 mbgs							247
29	Some fine to medium gravel							246
								245

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

Organics Sand
Silt / Clay

Northing (m) : 482425
Easting (m) : 4748008

Casing: 2"
Grade Elevation (m asl) : 274.34
Top of Casing Elevation (m asl) : 275.15
ST - Split Tube

Borehole ID: BH19-3
Monitoring Well ID: 19-3

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location: <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>PQ</u>
Observer: <u>D. Orjuela</u>	Date Started: <u>09/24/2019</u> Date Completed: <u>09/25/2019</u>

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
31	SILTY CLAY Grey silty clay, stiff, moist(<i>continued</i>)			BH19-3-SS10		ST		244
								243
32								242
								241
33								240
34								239
35								238
36								237
37								236
38								235
39								234
40								233
41								232
42								231
43								230
44	Pocket of brown to grey medium to fine sand, compact, moist		44.6					

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Sand
 Silt / Clay

Northing (m) : 482425
 Easting (m) : 4748008

Casing: 2"
 Grade Elevation (m asl) : 274.34
 Top of Casing Elevation (m asl) : 275.15
 ST - Split Tube

Borehole ID: BH19-3
Monitoring Well ID: 19-3

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location: <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>PQ</u>
Observer: <u>D. Orjuela</u>	Date Started: <u>09/24/2019</u> Date Completed: <u>09/25/2019</u>

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)		
				Soil Sample ID	Lab Analysis	Type				
46	SAND Grey to brown fine sand with trace medium gravel, moist, firm(<i>continued</i>) Trace fine to medium gravel and clay		48.8	BH19-3-SS11		ST		229		
47	Some fine to medium gravel with trace silty clay							228		
48										227

End of borehole at 48.8 m bgs

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Sand
 Silt / Clay

Northing (m) : 482425
Easting (m) : 4748008

Casing: 2"
Grade Elevation (m asl) : 274.34
Top of Casing Elevation (m asl) : 275.15
ST - Split Tube

Borehole ID: BH19-4
Monitoring Well ID: 19-4a

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/27/2019 Date Completed: 09/30/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	TOPSOIL Organics		0.3				Cement seal with protective casing	280
1	SILTY CLAY TILL Brown silty clay with trace fine to medium gravel and organics, weathered, stiff Grey mottling, moist							279
2								278
3	Some brown to light brown mottling							277
4								276
5	No mottling			BH19-4-SS1	A	ST		275
6	Less stiff							274
7								273
8	Grey						PVC riser with grout to surface	272
9	Trace fine sand			BH19-4-SS2	A	ST		271
10								270
11								269
12								268
13	Lens of fine, brown sand with trace medium sand, firm moist							267
14	Trace fine to medium gravel							266

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
  Gravel
  Sand
 Silt / Clay
  Sandy Gravel
  Silty Sand

Northing (m) : 480896
 Easting (m) : 4748251

Casing: 2"
 Grade Elevation (m asl) : 280.34
 Top of Casing Elevation (m asl) : 281.09
 ST - Split Tube

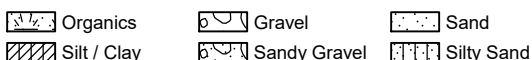
Borehole ID: **BH19-4**

Monitoring Well ID: **19-4a**

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location: <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>PQ</u>
Observer: <u>D. Orjuela</u>	Date Started: <u>09/27/2019</u> Date Completed: <u>09/30/2019</u>

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
16	SILTY CLAY TILL Brown silty clay with trace fine to medium gravel and organics, weathered, stiff(<i>continued</i>) Lens of fine to coarse sand, loose, moist Grey to brown with some fine sand and brown mottling, soft							265
17	Lens of brown fine to medium sand, loose, moist							264
18	Grey		18					263
18	GRAVEL Cobbles		18.3					262
19	GRAVELLY SAND Brown fine to medium gravelly sand, stiff, moist		18.4					262
19	SAND Brown fine to medium sand, firm, moist		19.1					261
20	SILTY SAND Grey silty sand, stiff, moist		19.4	BH19-4-SS3		ST		261
20	SAND Brown fine to medium sand, stiff, moist							260
21	Medium grained sand							259
22	Fine grained sand							258
23	Coarse grained with fine gravel, loose, moist							257
24	Trace fine gravel							256
25								255
26	Grey coarse to medium sand, firm, moist							254
27								253
28	GRAVEL Cobbles, loose		28					252
29	SAND Fine to medium grain sand, firm, moist		29					251

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS


Northing (m) : 480896
 Easting (m) : 4748251

Casing: 2"
 Grade Elevation (m asl) : 280.34
 Top of Casing Elevation (m asl) : 281.09
 ST - Split Tube

Borehole ID: BH19-4
Monitoring Well ID: 19-4a

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 09/27/2019 Date Completed: 09/30/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
31	SAND Fine to medium grain sand, firm, moist(<i>continued</i>) Trace fine to medium gravel							250
32	Little fine to medium gravel							249
33								248
34	SILTY CLAY Grey silty clay with coarse gravel, soft, moist		33.5					247
35								246
36								245
37	SAND Dark brown medium to coarse sand with trace fine gravel, firm, moist to wet		36.6					244
38	Wet							243
39								242
				BH19-4-SS4		ST		241
End of borehole at 39.6 m bgs			39.6					241

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

	Organics		Gravel		Sand
	Silt / Clay		Sandy Gravel		Silty Sand

Northing (m) : 480896
Easting (m) : 4748251

Casing: 2"
Grade Elevation (m asl) : 280.34
Top of Casing Elevation (m asl) : 281.09
ST - Split Tube

Borehole ID: BH19-4-2

Monitoring Well ID: 19-4b

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location : <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>Split Spoon</u>
Observer: <u>D. Orjuela</u>	Date Started: <u>10/02/2019</u> Date Completed: <u>10/02/2019</u>

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Blows/6"		
	TOPSOIL Organics		0.3				Cement seal with protective casing	280
1	SILTY CLAY TILL Brown silty clay with trace fine to medium gravel, stiff, brown							279
2								278
3								277
4						4,12-16,16		276
5	Grey			BH19-4-2-SS1		4,5,6,7		275
6				BH19-4-2-SS2				274
7								273
8						9,13		272
9	Trace fine gravel					9,12-15,20	PVC riser with grout to surface	271
10						1,6-11,16		270
11								269
12						3,6-7,11		268
13								267
14						5,9-15,18		266
15						7,9-14,12		265
16						6,10-16,30		264

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS
 Organics
 Silt / Clay

 Sand
 Sandy Gravel

 Gravel

Northing (m) : 480898

Easting (m) : 4748253

Casing: 2"

Grade Elevation (m asl) : 280.44

Top of Casing Elevation (m asl) : 281.12

Borehole ID: BH19-4-2

Monitoring Well ID: 19-4b

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
 Observer: D. Orjuela Date Started: 10/02/2019 Date Completed: 10/02/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Blows/6"		
18	Trace fine to medium sand SAND Brown fine to medium sand, firm, moist		17.6				PVC riser with grout to surface	263
19	GRAVELLY SAND Brown fine to medium gravelly sand, moist		18.9			7,11-34,31	PVC riser with bentonite	262
20						52,70	#1 silica sand pack	261
21						6,50,50		260
22	GRAVEL Fine to medium gravel		21.9				PVC screen with #1 silica sand pack	259
	SAND Brown fine to medium sand, firm, moist		22.1					258
	End of the borehole at 22.9 m bgs		22.9			20,45-53,53	End cap	

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using SPT technology
- 3) Completed with a monument casing and secured with a lock

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS
 Organics
 Silt / Clay

 Sand
 Sandy Gravel

 Gravel

Northing (m) : 480898

Easting (m) : 4748253

Casing: 2"

Grade Elevation (m asl) : 280.44

Top of Casing Elevation (m asl) : 281.12

Borehole ID: **BH19-5**

Monitoring Well ID: **19-5a**

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location : <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>PQ</u>
Observer: <u>D. Orjuela</u>	Date Started: <u>10/04/2019</u> Date Completed: <u>10/04/2019</u>

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	TOPSOIL Organics		0.2				Cement seal with protective casing	282
1	SILTY CLAY TILL Light brown silty clay with grey mottling and trace fine medium gravel, stiff, moist							281
2	Trace grey mottling							280
3	Grey							279
4	No mottling							278
5				BH19-5-SS1	B + X-Ray	ST		277
6				BH19-5-SS2		ST		276
7				BH19-5-SS3		ST		275
8				BH19-5-SS4	B	ST		274
9				BH19-5-SS5		ST		273
10	Some cobbles			BH19-5-SS6		ST		272
11				BH19-5-SS7	B	ST		271
12	Some cobbles							270
13								269
14								268

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics	 Sandy Clay
 Silt / Clay	 Sand

Northing (m) : 481335
 Easting (m) : 4748299

Casing: 2"
 Grade Elevation (m asl) : 282.58
 Top of Casing Elevation (m asl) : 283.28
 ST - Split Tube

Borehole ID: BH19-5

Monitoring Well ID: 19-5a

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: PQ
 Observer: D. Orjuela Date Started: 10/04/2019 Date Completed: 10/04/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
16	SILTY CLAY TILL Light brown silty clay with grey mottling and trace fine medium gravel, stiff, moist(<i>continued</i>) Occasional medium sand pockets			BH19-5-SS8		ST	PVC riser with grout to surface	267
				BH19-5-SS9		ST		266
17	SANDY CLAY Brown medium to coarse sandy clay with fine to medium gravel, stiff, moist		16.3					266
			16.8	BH19-5-SS10	B	ST		265
18	SILTY CLAY TILL Grey silty clay with trace fine sand and fine gravel, stiff							265
19								264
20				BH19-5-SS11		ST		263
21	SAND Brown fine to medium sand, firm, moist		20.5	BH19-5-SS12		ST		262
22	SILTY CLAY Grey silty clay with trace fine sand, stiff, moist		21.7					261
23	SAND Brown fine to medium sand, firm, moist		23					260
			23.2					259
24	SANDY CLAY Brown fine to medium sandy clay with fine gravel, firm, moist							259
25	SILTY CLAY TILL Grey silty clay with trace sand and fine to medium gravel, very stiff, moist		24.4	BH19-5-SS13	A	ST		258
26								257
27								256
28								255
29	SAND Fine to medium sand with trace fine gravel, firm, moist		29					254
			29.3					253
	SILTY CLAY Grey silty clay with sand and trace gravel, stiff		29.4					253

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Sandy Clay
 Silt / Clay
 Sand

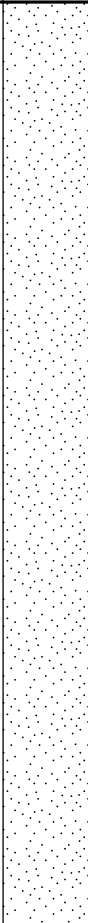
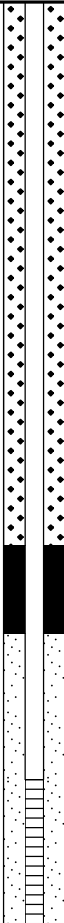
Northing (m) : 481335
 Easting (m) : 4748299

Casing: 2"
 Grade Elevation (m asl) : 282.58
 Top of Casing Elevation (m asl) : 283.28
 ST - Split Tube

Borehole ID: **BH19-5**

Monitoring Well ID: **19-5a**

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location : <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>PQ</u>
Observer: <u>D. Orjuela</u>	Date Started: <u>10/04/2019</u> Date Completed: <u>10/04/2019</u>

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	SAND Grey fine to medium sand, firm, moist <i>(continued)</i>						252	
31			BH19-5-SS14	A	ST		251	
32								250
33								249
34	Some coarse gravel						248	
35							247	
36							246	
37							245	
38							244	
39							243	
End of borehole at 39.6 m bgs			39.6				End cap	

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics	 Sandy Clay
 Silt / Clay	 Sand

Northing (m) : 481335
 Easting (m) : 4748299

Casing: 2"
 Grade Elevation (m asl) : 282.58
 Top of Casing Elevation (m asl) : 283.28
 ST - Split Tube

Borehole ID: BH19-5-2
Monitoring Well ID: 19-5b

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
Observer: D. Orjuela Date Started: 10/09/2019 Date Completed: 10/09/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Blows/6"		
	TOPSOIL Brown top soil with organics, moist, stiff		0.1				Cement seal with protective casing	
1	SILTY CLAY TILL Light brown weather silty clay with grey mottling, stiff, dry to moist Brown with trace fine sand					5,12-16,16		282
2						7,12-16,16		281
3						5,10-14,15		280
4						5,10-14,18		279
5				BH19-5-2-SS1				278
6	No mottling, trace fine sand							277
7				BH19-5-2-SS2		5,9-15,17		276
8	Trace fine to medium gravel						PVC riser with grout to surface	275
9						4,9-13,16		274
10	Grey					5,10-12,18		273
11						6,8-12,14		272
12						7,9-13,15		271
13						5,4-12,15		270
14								269
								268

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Silt / Clay

 Sand

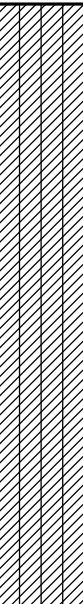
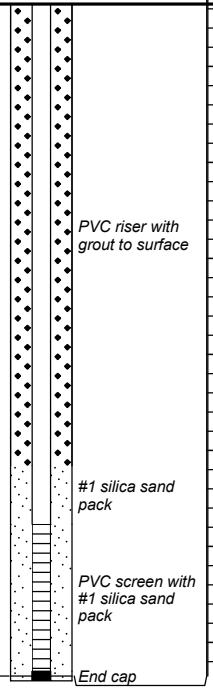
Northing (m) : 481336
Easting (m) : 4748300

Casing: 2"
Grade Elevation (m asl) : 282.65
Top of Casing Elevation (m asl) : 283.44

Borehole ID: BH19-5-2

Monitoring Well ID: 19-5b

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
 Observer: D. Orjuela Date Started: 10/09/2019 Date Completed: 10/09/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Blows/6"		
16	SILTY CLAY TILL Light brown weather silty clay with grey mottling, stiff, dry to moist(<i>continued</i>)					8,11-14,16		267
17								266
18						8,11-14,13		265
19						5,9-8,12		264
20						6,10-16,18		263
21	SAND Brown to grey fine to medium sand, firm, moist		21.3					262
22						20,24-44,28		261
	End of borehole at 22 m bgs		22					

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Silt / Clay

 Sand

Northing (m) : 481336
 Easting (m) : 4748300

Casing: 2"
 Grade Elevation (m asl) : 282.65
 Top of Casing Elevation (m asl) : 283.44

Borehole ID: BH19-6

Monitoring Well ID: 19-6a

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: PQ
 Observer: D. Orjuela Date Started: 10/11/2019 Date Completed: 10/11/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
	TOPSOIL Brown top soil with organics, stiff, moist		0.1				Cement seal with protective casing	
1	SILTY CLAY TILL Brown weathered silty clay with grey mottling and trace fine gravel, stiff, dry to moist							280
2								279
3	Trace fine to medium gravel							278
4								277
5	No mottling with trace to coarse gravel			BH19-6-SS1	A	ST		276
6								275
7	Grey with trace fine gravel							274
8								273
9								272
10								271
11	Little gravel							270
12	SAND Grey fine sand, firm, moist Grey sand intermixed with grey silty clay, trace fine to medium gravel, firm, moist		10.7					269
13	GRAVELLY SAND Fine to medium gravelly sand with trace clay, firm, moist		12.2	BH19-6-SS3		ST		268
14								267

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

	Organics		Sand		Sandy Clay
	Silt / Clay		Sandy Gravel		Silty Sand and Gravel

Northing (m) : 481678
 Easting (m) : 4748289

Casing: 2"
 Grade Elevation (m asl) : 280.91
 Top of Casing Elevation (m asl) : 281.65
 ST - Split Tube

Borehole ID: BH19-6

Monitoring Well ID: 19-6a

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: PQ
 Observer: D. Orjuela Date Started: 10/11/2019 Date Completed: 10/11/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
16	GRAVELLY SAND Fine to medium gravelly sand with trace clay, firm, moist(continued)							265
17								264
18								263
19	SAND Grey to brown fine to medium sand, firm, moist to wet		18.3	BH19-6-SS4		ST		262
20				BH19-6-SS5		ST		261
21	SANDY CLAY Grey fine sandy clay, stiff, moist		20.5					260
22	SANDY GRAVEL Brown coarse sandy gravel Brown sandy gravel intermixed with brown silty clay, stiff, moist		21.5 21.6					259
23				BH19-6-SS7		ST		258
24								257
25	GRAVEL Cobbles		24.7 24.8					256
26	SILTY CLAY Grey silty clay with trace fine to medium gravel, stiff, moist							255
27	SAND Grey sand with trace fine to medium gravel, firm, moist		25.9	BH19-6-SS8	A	ST		254
28	GRAVEL Coarse gravel with trace sand		27.4					253
29	GRAVELLY SAND Grey fine to medium gravelly sand, firm, moist		28.2					252
	SAND Grey sand with trace fine to medium gravel, firm moist to wet		29					

PVC riser with grout to surface

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

	Organics		Sand		Sandy Clay
	Silt / Clay		Sandy Gravel		Silty Sand and Gravel

Northing (m) : 481678

Easting (m) : 4748289

Casing: 2"

Grade Elevation (m asl) : 280.91

Top of Casing Elevation (m asl) : 281.65

ST - Split Tube

Borehole ID: **BH19-6**

Monitoring Well ID: **19-6a**

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: PQ
 Observer: D. Orjuela Date Started: 10/11/2019 Date Completed: 10/11/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
31	SAND Grey sand with trace fine to medium gravel, firm moist to wet(continued)							250
32	SANDY GRAVEL Fine to medium sandy gravel, loose, moist to wet		31.2					249
33	GRAVELLY SAND Grey fine to medium gravelly sand, firm, moist to wet		32					248
34								247
35								246
36								245
37	SANDY GRAVEL Fine to medium sandy gravel, moist to wet		36.6					244
38								243
39								242

End of borehole at 39.6 m bgs

39.6

End cap

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

LITHOLOGY SYMBOLS

	Organics		Sand		Sandy Clay
	Silt / Clay		Sandy Gravel		Silty Sand and Gravel

Northing (m) : 481678

Easting (m) : 4748289

Casing: 2"

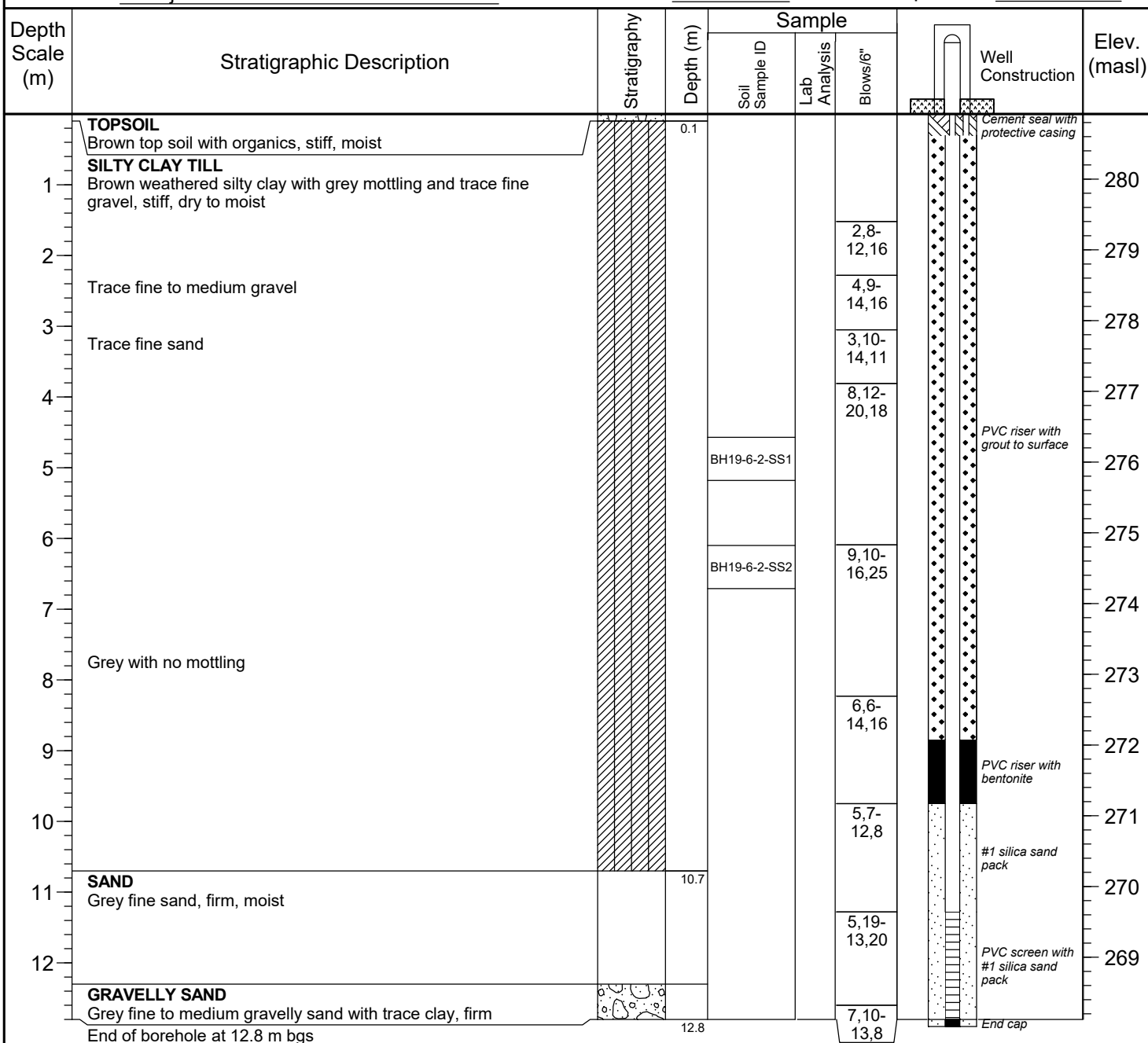
Grade Elevation (m asl) : 280.91

Top of Casing Elevation (m asl) : 281.65

ST - Split Tube

Borehole ID: BH19-6-2
Monitoring Well ID: 19-6b

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
Observer: D. Orjuela Date Started: 10/17/2019 Date Completed: 10/18/2019



NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using SPT technology
- 3) Completed with a monument casing and secured with a lock

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Silt / Clay

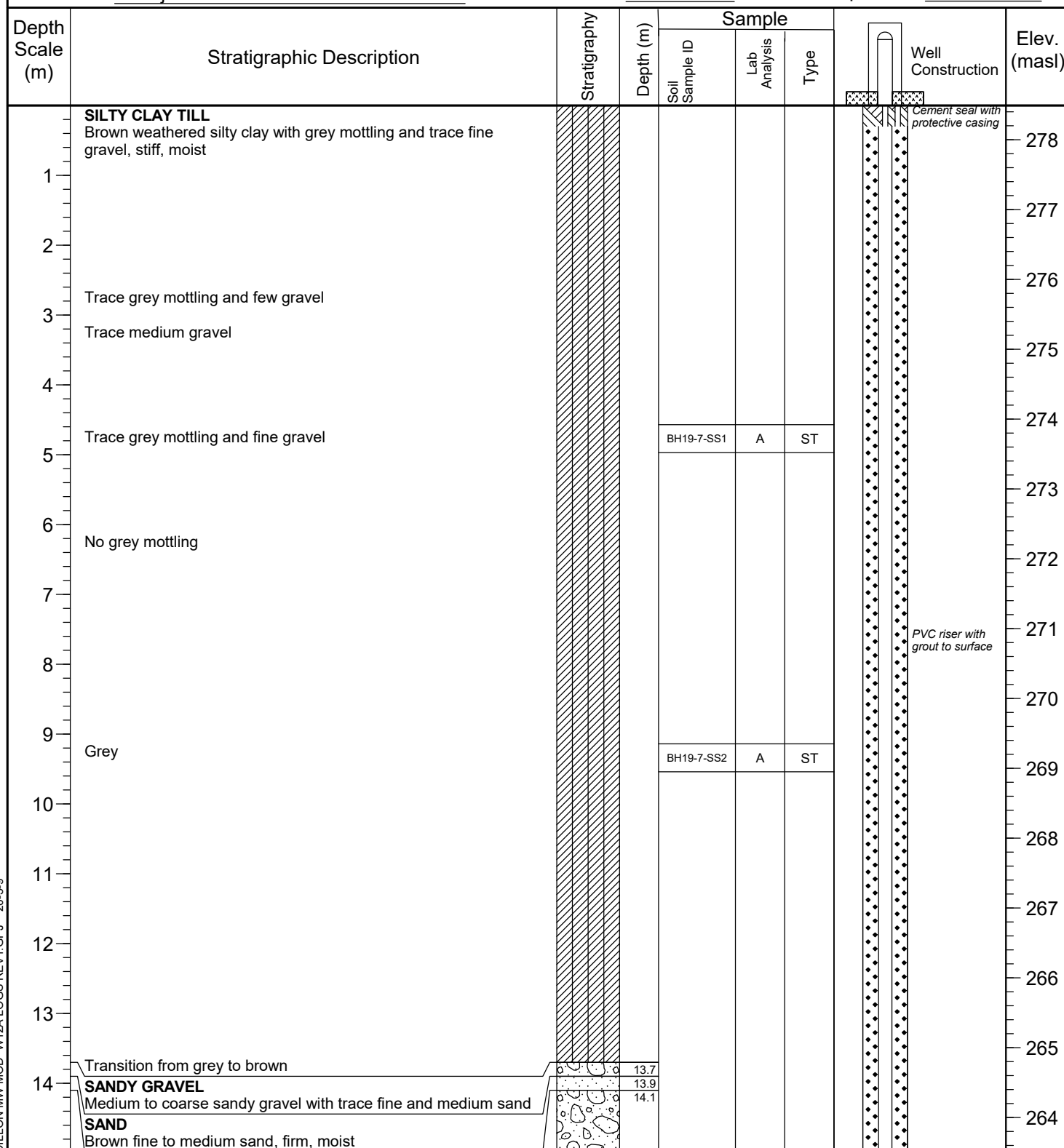
 Sandy Gravel

Northing (m) : 481679
Easting (m) : 4748289

Casing: 2"
Grade Elevation (m asl) : 280.92
Top of Casing Elevation (m asl) : 281.69

Borehole ID: BH19-7
Monitoring Well ID: 19-7a

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 10/23/2019 Date Completed: 10/29/2019



DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Silt / Clay
  Sand
  Sandy Silt
 Sandy Gravel
  Gravel

Northing (m) : 480718
 Easting (m) : 4748242

Casing: 2"
 Grade Elevation (m asl) : 278.49
 Top of Casing Elevation (m asl) : 279.29
 ST - Split Tube

Borehole ID: BH19-7

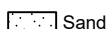
Monitoring Well ID: 19-7a

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: PQ
 Observer: D. Orjuela Date Started: 10/23/2019 Date Completed: 10/29/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
15.2	SANDY GRAVEL Brown fine to medium sandy gravel, loose, moist(continued)		15.2	BH19-7-SS3	A	ST		263
16	SAND Brown to light brown fine to medium sand, firm, moist							262
17								261
18	Light brown with trace fine gravel							260
19								259
20	Brown							258
21								257
22	Grey							256
23	Fine sand with no gravel							255
24								254
24.4	GRAVELLY SAND Medium to coarse gravelly sand, moist, loose		24.4					253
25								252
25.9	SAND Grey coarse sand with trace fine gravel, firm, moist		25.9					251
26								250
27	Some gravel							249
28								
29	GRAVEL Coarse gravel to cobbles with trace sand, moist		29					

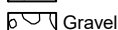
DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS
 Silt / Clay

 Sand

 Sandy Silt

 Sandy Gravel

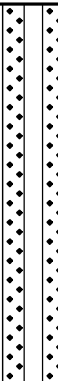
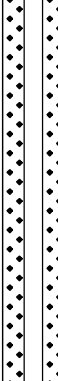
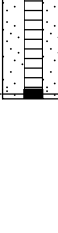
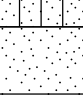
 Gravel

Northing (m) : 480718
 Easting (m) : 4748242

Casing: 2"
 Grade Elevation (m asl) : 278.49
 Top of Casing Elevation (m asl) : 279.29
 ST - Split Tube

Borehole ID: BH19-7
Monitoring Well ID: 19-7a

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: PQ
Observer: D. Orjuela Date Started: 10/23/2019 Date Completed: 10/29/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
31	GRAVELLY SAND Grey medium to coarse gravelly sand, firm, moist(continued)		29.9					248
	GRAVEL Coarse gravel with trace sand, loose		30.5					247
32								246
33								245
34	SAND Grey coarse sand with trace fine gravel, firm, moist		33.5					244
35	Some fine sand							243
36								242
37	Coarse sand							241
38								240
39								239
40								238
41	SILTY SAND Grey silty sand, firm, moist		40.5					237
	SAND Grey coarse sand, firm, moist		40.8					237
	End of borehole at 41.5 m bgs		41.5					

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using PQ technology
- 3) Completed with a monument casing and secured with a lock

Analysis A:

Grain Size and Moisture Content

Analysis B:

Grain Size, Moisture Content, Fraction of Organic Carbon, Cation Exchange Capacity

LITHOLOGY SYMBOLS



Northing (m) : 480718
Easting (m) : 4748242

Casing: 2"

Grade Elevation (m asl) : 278.49

Top of Casing Elevation (m asl) : 279.29

ST - Split Tube

Borehole ID: BH19-7-2

Monitoring Well ID: 19-7b

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
 Observer: D. Orjuela Date Started: 10/30/2019 Date Completed: 10/30/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Blows/6"		
1	TOPSOIL Top soil with organics					2,1,2,2	Cement seal with protective casing	278
2	SILTY CLAY TILL Brown weathered silty clay, stiff, moist		1.5			2,1,3,4		277
	Trace medium gravel		2.5			2,3,7,12		276
3	SILTY CLAY					3,4-14,14		275
4						7,12-14,11		274
5						4,6-10,11		273
6				BH19-7-2-SS1				272
7								271
8	Trace fine gravel					2,2,4,4	PVC riser with grout to surface	270
9						3,4,7,6		269
10						5,6,7,8		268
11						4,8-11,10		267
12						7,12-14,16		266
13								265
14	Brown							264

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS
 Organics
 Silt / Clay

 Sand

Northing (m) : 480721

Easting (m) : 4748242

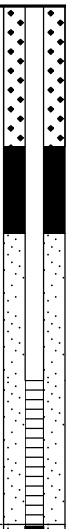
Casing: 2"

Grade Elevation (m asl) : 278.61

Top of Casing Elevation (m asl) : 279.37

Borehole ID: BH19-7-2
Monitoring Well ID: 19-7b

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: Split Spoon
Observer: D. Orjuela Date Started: 10/30/2019 Date Completed: 10/30/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Blows/6"		
16	SAND Brown to light brown fine to medium sand, firm, moist		15.2			5,43,50	 <i>PVC riser with grout to surface</i>	263
17						27,50	 <i>PVC riser with bentonite</i>	262
18	Light gravel with trace fine gravel					20,40-42,40	 <i>#1 silica sand pack</i>	261
19						20,40-42,40	 <i>PVC screen with #1 silica sand pack</i>	260
20	Few rounded gravel					18,32,50	 <i>End cap</i>	259
End of the borehole at 20.4 m bas			20.4					

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using SPT technology
- 3) Completed with a monument casing and secured with a lock

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

 Organics
 Silt / Clay

 Sand

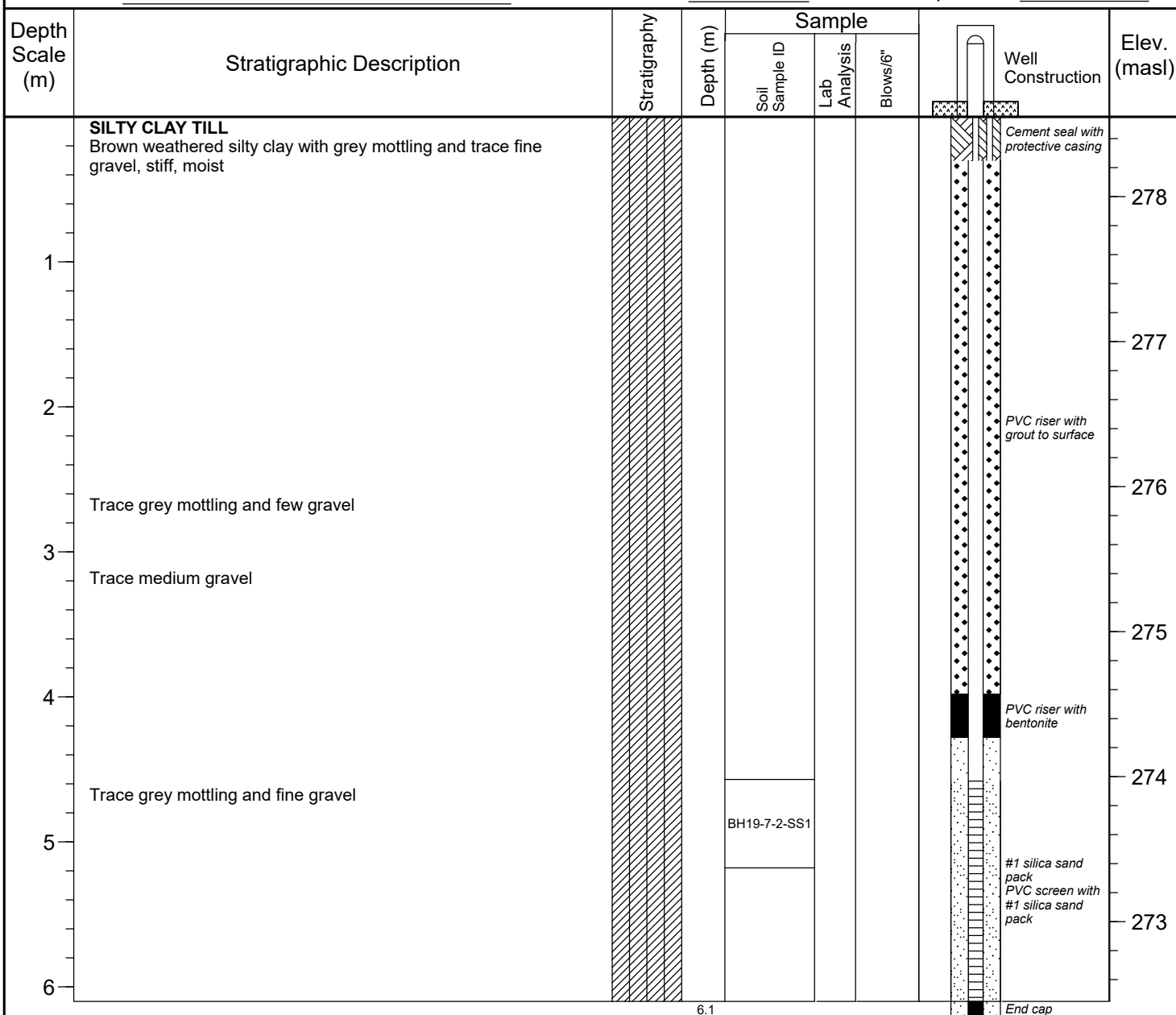
Northing (m) : 480721
Easting (m) : 4748242

Casing: 2"
Grade Elevation (m asl) : 278.61
Top of Casing Elevation (m asl) : 279.37

Borehole ID: **BH19-7-3**

Monitoring Well ID: **19-7c**

Client: <u>City of London</u>	Project: <u>W12A Landfill Site Drilling Program</u>
Project No.: <u>19-1230</u>	Location: <u>W12A Landfill, London, Ontario</u>
Drilling Co.: <u>Aardvark Drilling</u>	Drilling Method: <u>Solid Stem Auger</u>
Observer: <u>M. Al-Sheikh</u>	Date Started: <u>10/31/2019</u> Date Completed: <u>10/31/2019</u>



NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using solid stem auger technology, no samples recovered
- 3) Completed with a monument casing and secured with a lock

Lithology same as BH19-7

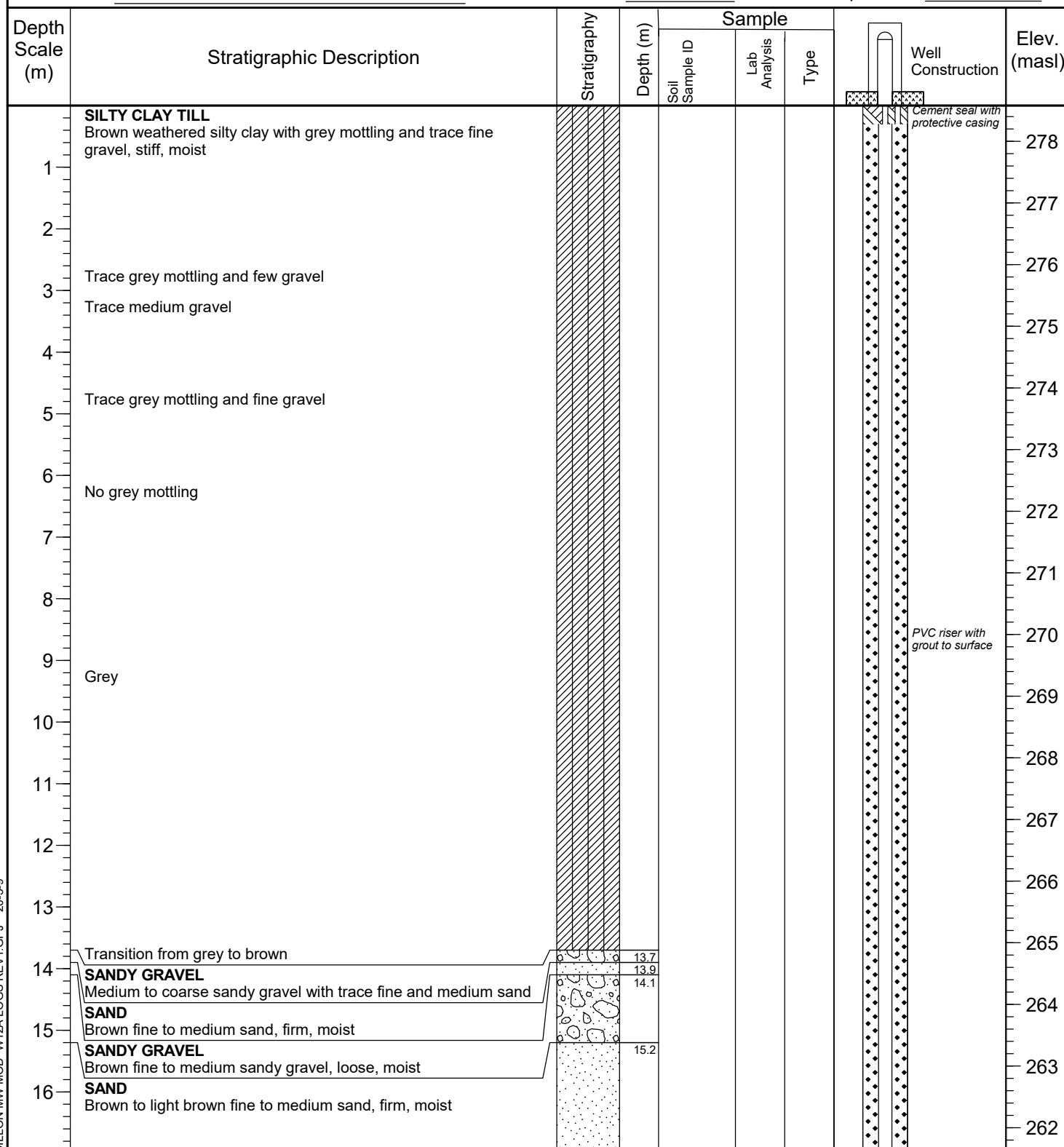
LITHOLOGY SYMBOLS
 Silty Clay

Northing (m) : 480715
Easting (m) : 4748242

Casing: 2"
Grade Elevation (m asl) : 278.55
Top of Casing Elevation (m asl) : 279.33

Borehole ID: BH19-8
Monitoring Well ID: 92-10a

Client: City of London Project: W12A Landfill Site Drilling Program
Project No.: 19-1230 Location: W12A Landfill, London, Ontario
Drilling Co.: Aardvark Drilling Drilling Method: Solid Stem Auger
Observer: M. Al-Sheikh Date Started: 10/21/2019 Date Completed: 10/22/2019



DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS

	Silt / Clay		Sand
	Sandy Gravel		

Northing (m) : 480712
Easting (m) : 4748241

Casing: 2"
Grade Elevation (m asl) : 278.58
Top of Casing Elevation (m asl) : 279.29
ST - Split Tube

Borehole ID: BH19-8

Monitoring Well ID: 92-10a

Client: City of London Project: W12A Landfill Site Drilling Program
 Project No.: 19-1230 Location: W12A Landfill, London, Ontario
 Drilling Co.: Aardvark Drilling Drilling Method: Solid Stem Auger
 Observer: M. Al-Sheikh Date Started: 10/21/2019 Date Completed: 10/22/2019

Depth Scale (m)	Stratigraphic Description	Stratigraphy	Depth (m)	Sample			Well Construction	Elev. (masl)
				Soil Sample ID	Lab Analysis	Type		
18	SAND Brown to light brown fine to medium sand, firm, moist(continued)							261
19	Light brown with trace fine gravel							260
20	Brown							259
21	Grey							258
22								257
23	Fine sand with no gravel							256
24								255
25	GRAVELLY SAND Medium to coarse gravelly sand, moist, loose		24.4				PVC riser with bentonite	254
26	SAND Grey coarse sand with trace fine gravel, firm, moist		25.9				#1 silica sand pack PVC screen with #1 silica sand pack End cap	253
			26.3					

NOTES:

- 1) m bgs = metres below ground surface
- 2) 0.15 m (6") diameter advanced through overburden using solid stem auger technology, no samples recovered
- 3) Completed with a monument casing and secured with a lock

Lithology same as BH19-7

DILLON MW MOD W12A LOGS REV1.GPJ 20-3-9

LITHOLOGY SYMBOLS



Northing (m) : 480712
Easting (m) : 4748241

Casing: 2"
Grade Elevation (m asl) : 278.58
Top of Casing Elevation (m asl) : 279.29
ST - Split Tube

Appendix B

Test Pit Summary



THE CORPORATION OF THE CITY OF LONDON

W12A London Landfill

Benched Test Pit Report





Introduction

The presence of fractures within the upper portion of the Surficial Aquitard is a well known phenomenon. To evaluate the nature of the fractures and their potential to create a preferred pathway for leachate migration from the landfill expansion, a benched test pit measuring approximately 12 m x 12 m in plan and 5.4 m in depth was completed. The location of the test pit was between the landfill and the Material Recovery Facility. The test pit allowed the fracture characteristics and fracture frequency to be assessed with depth. The fracture network was logged and photographs taken.

Benched Test Pit Program

Physical and chemical stress in the environment result in fracturing and weathering of the earth's surface. Although clay till is considered ductile, weathering and brittle deformation may still occur in clays. Fracturing and weathering of a geological unit may increase the potential to create a preferred pathway for leachate migration. As such, an evaluation of the fractures and weathering of the Surficial Aquitard was undertaken.

On November 6, 2019, a benched test pit measuring approximately 12 m x 12 m in plan was excavated to a depth of approximately 5.4 m below ground surface (mbgs) resulting in a total of four benches of approximately 1.4 m. Mechanical excavation was completed using a Cat 336D Excavator equipped with a 1.5 m Straight Edge Bucket for Benches 1 through 3 and a 1.1 m General Duty Bucket for Bench 4. A Dillon geologist and engineer were present to log the excavation. The benched test pit was completed to a depth of 5.4 mbgs and required the construction of a series of benches approximately 1.5 m wide and 1.4 m deep. The benched test pit was orientated to give west, north, and east faces with a sloped south ramp.

The overall slope of the test pit faces was approximately 1:1. Excavated soils from each bench were stockpiled separately and the test pit was backfilled using corresponding stockpiled soils. Excavation and backfill were completed on the same day.

Following each bench excavation, a relative survey of the depth was taken prior to the mapping exercise and a 1 m x 1 m section of each wall was cleaned with a trowel/shovel/pickaxe to expose fractures that may have been smeared by the excavation process.

The description of the fractures included notes of the following:

- Fracture Frequency (number of fractures per metre)
- Fracture Spacing (distance between fractures)
- Orientation (Strike/Dip)

- Aperture
- Degree of Weathering
- Colour
- Presence of iron oxidation
- Presence and nature of infilling
- Presence of groundwater
- Rate of groundwater flow (if measurable)
- Displacement (if identifiable)

The description of the soils included observations of the following:

- Lateral and vertical extent
- Depth
- Degree of weathering
- Presence of iron oxidation
- Presence of cementation
- Presence of groundwater
- Rate of groundwater flow (if measurable)

A Silva compass was used to measure the strike and dip of dominant fracture sets. Fractures from ground surface to a depth of approximately 3.0 mbgs (Benches 1 and 2, and part of 3) were described qualitatively. Fractures from 3.0 mbgs to 5.4 mbgs were mapped individually. Composite photographs of each bench wall are presented in Photographs.

2.1.1 Benched Test Pit Evaluation

Below the topsoil, fractures in the first 1.0 mbgs had sub-millimetre (mm) spacing (>100 fractures/m) and appeared vertical and ubiquitous with no defined orientation; fractures were stained grey. The soils consisted predominantly of brown weathered clay to clayey silt till with minor cobbles and sparse sand. Pervasive oxidation and high weathering of the soil were evident.

Between 1.0 mbgs and 3.2 mbgs the soil consisted predominantly of mottled brown clay with minor (<10%) round to sub-round pebbles and cobbles (5mm-80mm). The fracture spacing between 1.0 mbgs and 2.3 mbgs continued in the sub-mm range. Below approximately 2.3 mbgs, distinct fractures were observed with an orientation of 140/80 (strike/dip) and orthogonal 030/80 with aperture ranging from 1 mm - 4 mm with a grey staining/infill and with fracture spacing ranging from 60-80 mm.

A slow trickle of water was observed at the base of Bench 2 on the west wall (note: excavation stockpiles were placed to the west). The inflow was not significant to the test pitting operation.

Between 3.2 and 3.9 mbgs the soil transitioned from mottled brown to mostly grey clay. This oxidation horizon was slightly deeper in the east (approximately 3.2 mbgs), and shallower in the west

(approximately 3.0 mbgs). Fracture frequency below 3.2 m reduced to 1-2 joints per metre with orientations of 140/80 and 110/85. Aperture of the fractures was between 0 mm and 2mm; however, distinct back-wall-alteration causing a colour change of red at the surface of the fracture penetrating 2-5mm into the back-wall, transitioning to brown until faded to grey.

Soils below 3.9 m were solely clay that was grey in colour. A total of two fractures with similar orientations of 110/85 were identified beyond 3.8 mbgs with one fracture terminating at 4 mbgs and the other fracture terminating at 4.7 mbgs. Fractures were not observed at the base of the test pit (area of 1.2 m x 2.0 m).

3.0 Summary of Findings

In summary, the examination of the benched test pit showed the following:

- Distinct fractures with orientations of 140/80, 030/80 were orthogonal to each other;
- Fractures were almost all near vertical and fracture frequency dissipated with depth;
- The fracture frequency declined from >100 fractures per metre at approximately 1.0 mbgs to approximately 12 fractures per metre at approximately 2.1 mbgs to 1 to 2 fractures per metre at 3.2 mbgs;
- Fracture spacing increased with depth;
- Fractures were not observed below 4.7 mbgs;
- Oxidation and alteration decreased with depth;
- The till was oxidized to a depth of 3.2 mbgs where the colour of the clay till changed from brown to grey over a transition zone from 3.2 mbgs to 3.9 mbgs;
- Below 4.7 mbgs, the till was unweathered and contained no fractures.

Photos



Photograph 1

Bench 1, facing northwest



Photograph 2

Bench 1, facing southwest



Photograph 3

Bench 2, facing north



Photograph 4

Bench 2, facing north



Photograph 5

Bench 3, facing south



Photograph 7

Bench 4, facing northwest



Photograph 6

Bench 3, facing west



Photograph 8

Bench4, facing south



Photograph 9
Bench 1, facing west



Photograph 10
Bench 1, facing north



Photograph 11
Bench 1, facing east



Photograph 12

Bench 2, facing west



Photograph 13

Bench 2, facing north



Photograph 14

Bench 2, facing east



Photograph 15
Bench 3, facing west



Photograph 16
Bench 3, facing north



Photograph 17
Bench 3, facing east



Photograph 18

Bench 4, facing west



Photograph 19

Bench 1, facing east

Appendix C

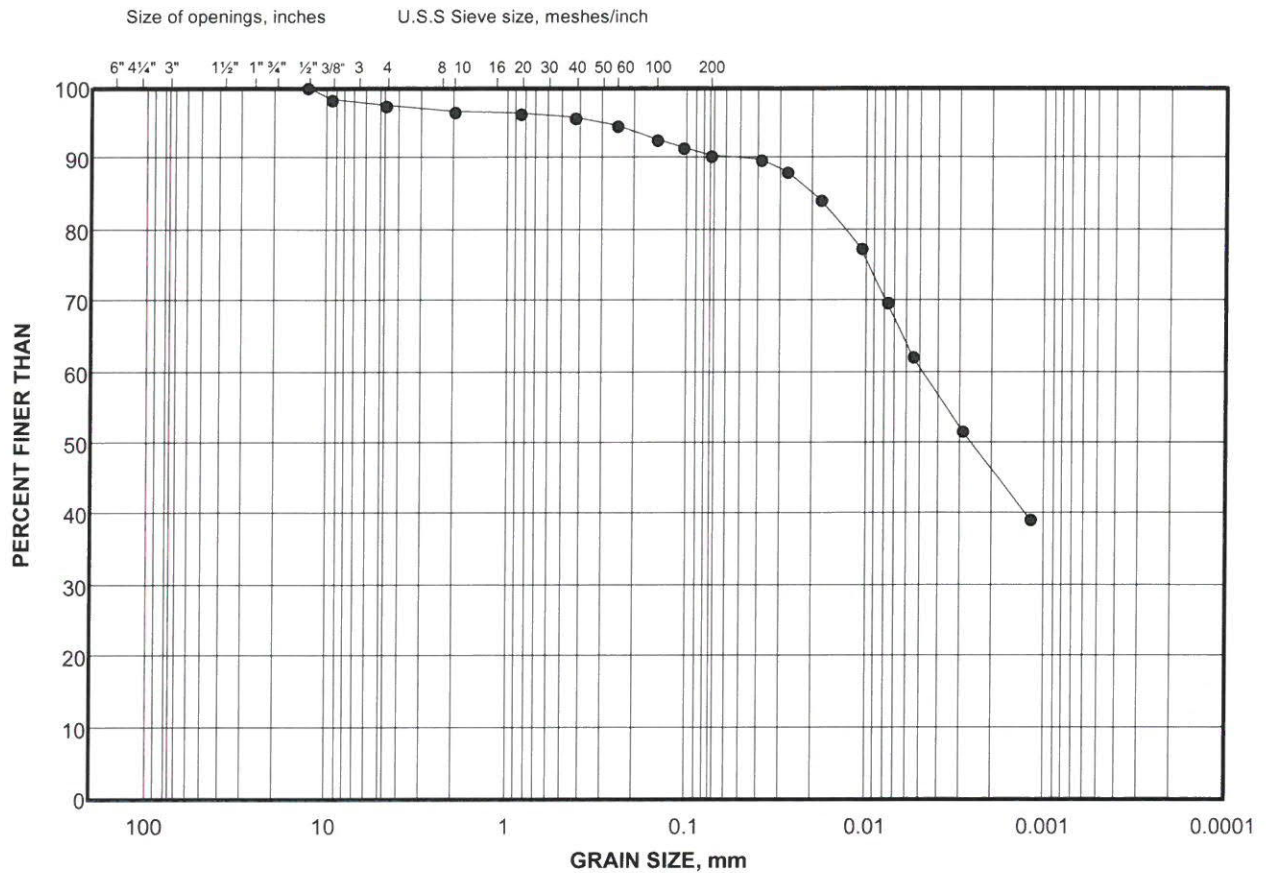
Soil Analysis Results

Summary of Soil Tests

Borehole No.	Sample No.	Depth		Layer	Grain Size Analysis (%)				Water Content %	Cation Exchange Capacity (meq/100 g)	Total Organic Carbon (%)	
		mbgs	masl		Clay	Silt	Sand	Gravel			<0.6mm	Whole Soil
BH19-1	2	3.0	270.7	SA	46	44	7	3	15.2			
	4	10.3	263.4	UA	5	9	86	0	20.4			
	5	13.1	260.6	UA	5	23	72	0	20.3			
	9	24.2	249.5	LA	48	43	9	0	18.3			
	12	40.6	233.1	WOA	26	24	47	3	13.1			
BH19-2	1	3.6	269.4	SA	42	52	6	0	18.6			
	2	9.3	263.7	SA	39	41	10	10	20.0			
	3	13.2	259.8	UA	5	25	70	0	18.4			
	4	24.9	248.1	LA	41	44	14	1	16.4			
	5	30.6	242.4	LA	22	60	18	0	11.0			
	6	46.9	226.1	WOA	10	36	53	1	9.0			
BH19-3	2	4.7	270.5	SA	46	46	8	0	23.5	118.3	0.28	0.27
	5	9.2	266.0	SA	45	49	6	0	20.2	112.4	0.19	0.18
	8	14.4	260.8	UA	1	97	2	0	19.1	16.5	0.08	0.08
BH19-4	1	4.4	276.7	SA	42	48	9	1	20.5			
	2	9.2	271.9	SA	43	48	9	0	21.2			
BH19-5	1	4.4	278.3	SA	41	49	10	0	20.9	112.8	0.16	0.15
	4	9.2	273.5	SA	43	47	9	1	20.1	100.8	0.19	0.19
	7	13.7	269.0	SA	44	46	10	0	20.4	108.0	0.23	0.21
	10	17.0	265.7	SA	48	45	7	0	20.3	107.2	0.23	0.22
	13	24.5	258.2	LA	44	43	12	1	16.9			
	14	31.2	251.5	WOA	7	21	72	0	18.4			
BH19-6	1	4.6	276.3	SA	49	43	8	0	21.1			
	2	9.3	271.6	SA	45	43	9	3	20.1			
	8	26.1	254.8	WOA	16	30	54	0	16.7			

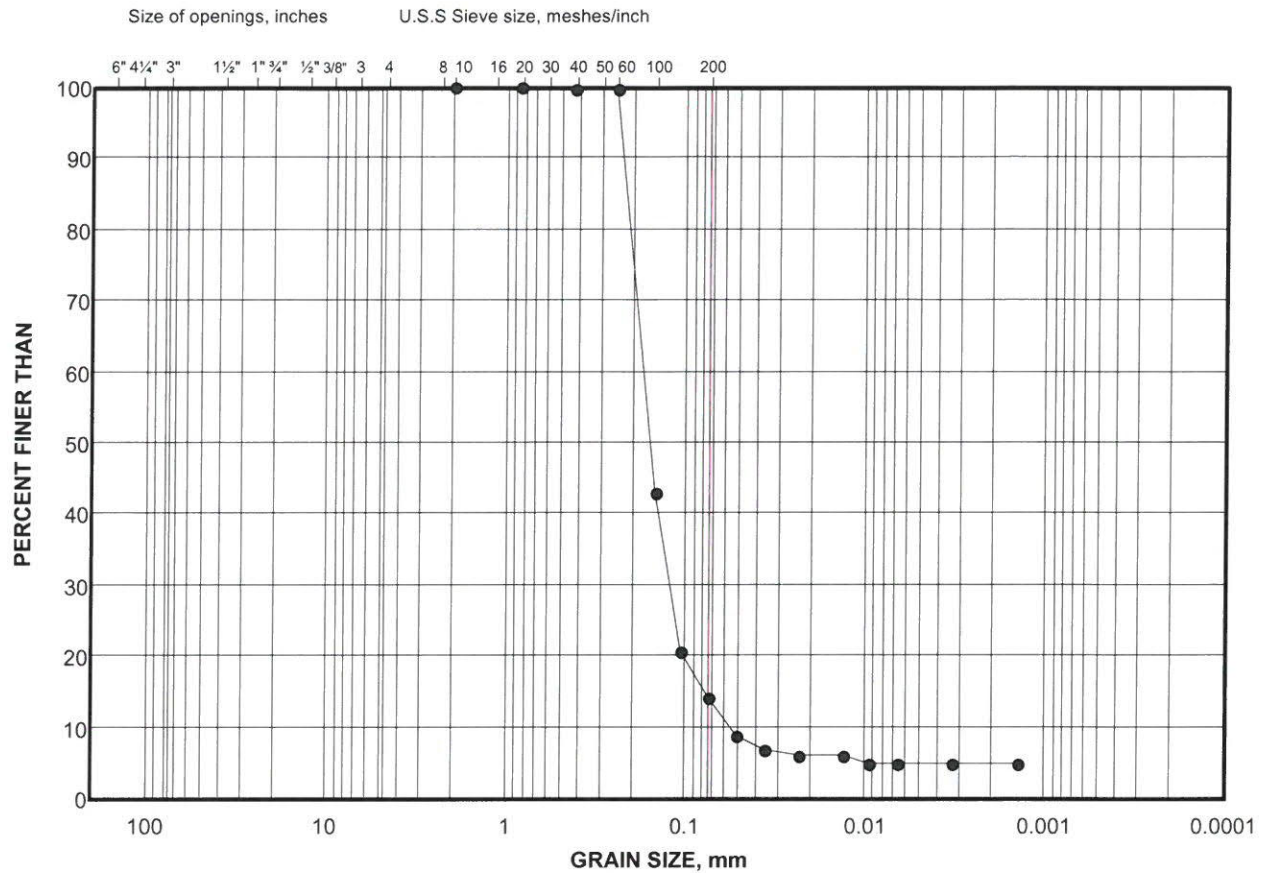
GRAIN SIZE DISTRIBUTION

FIGURE 1



GRAIN SIZE DISTRIBUTION

FIGURE 2



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-1	SS4	10.3 Upper Aquifer

REMARKS

Water Content (LS 701)- 20.4%

Project Number: 19131594

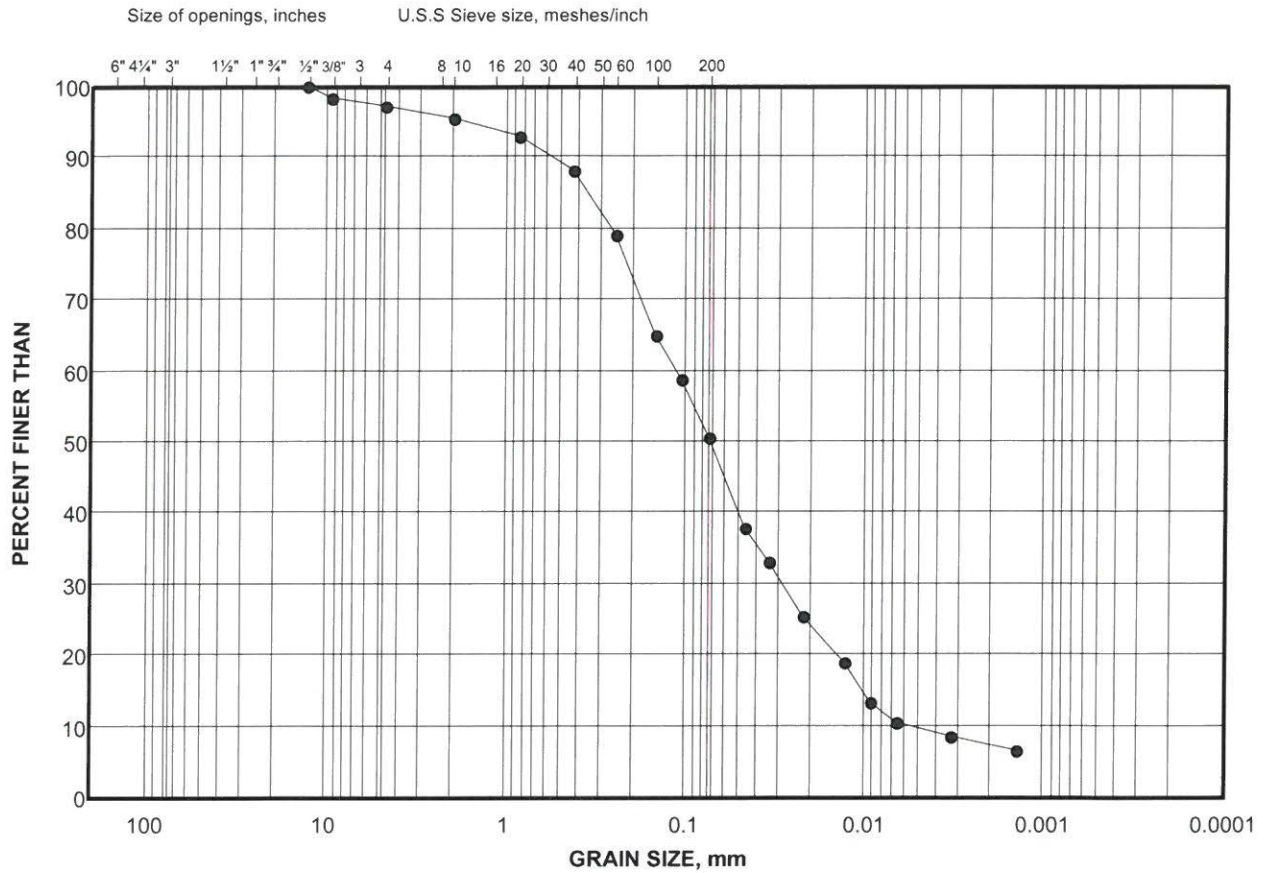
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Golder Associates

Date: 16-Oct-19

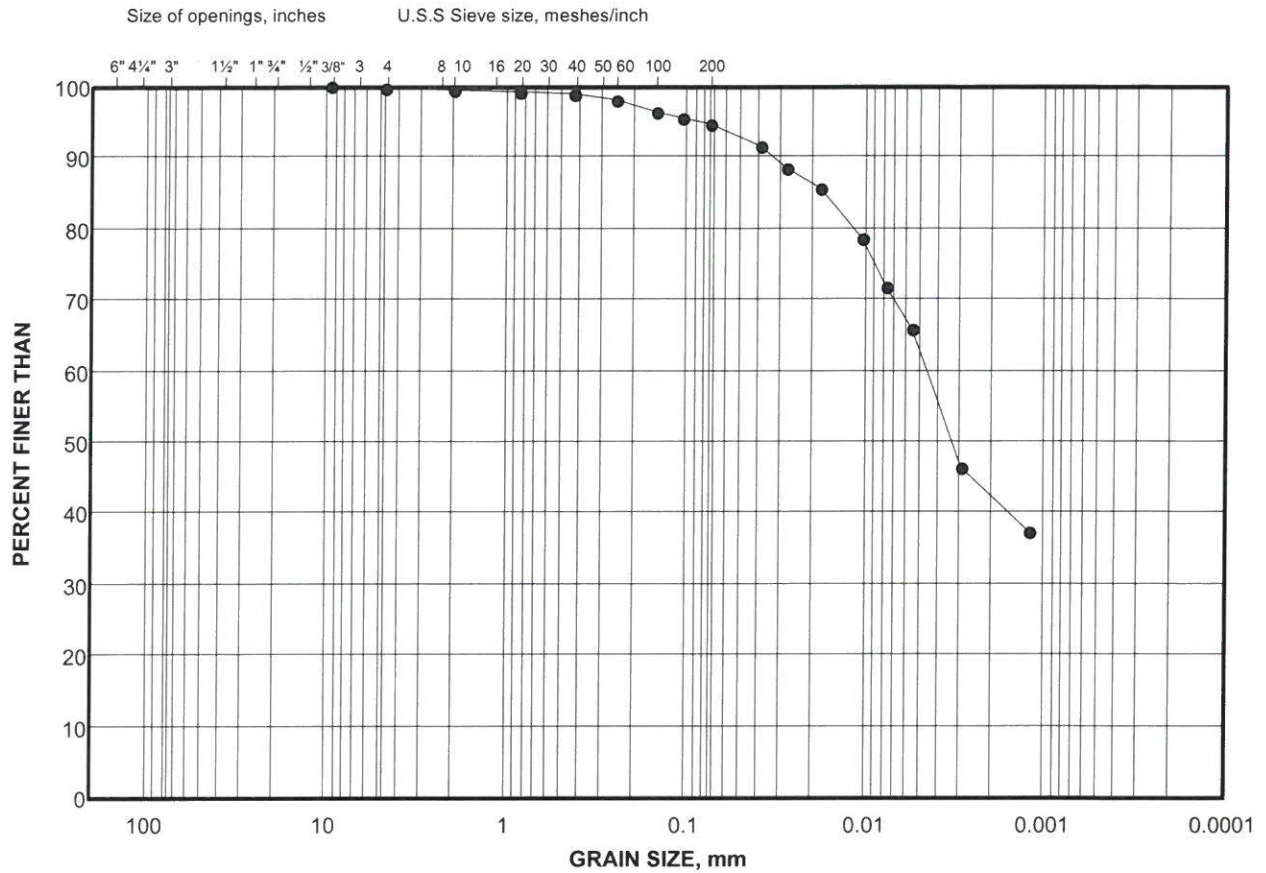
GRAIN SIZE DISTRIBUTION

FIGURE 5



GRAIN SIZE DISTRIBUTION

FIGURE 6



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-2	SS1	3.6 Surficial Aquitard

REMARKS

Water Content (LS 701)- 18.6%

Project Number: 19131594

Checked By: _____

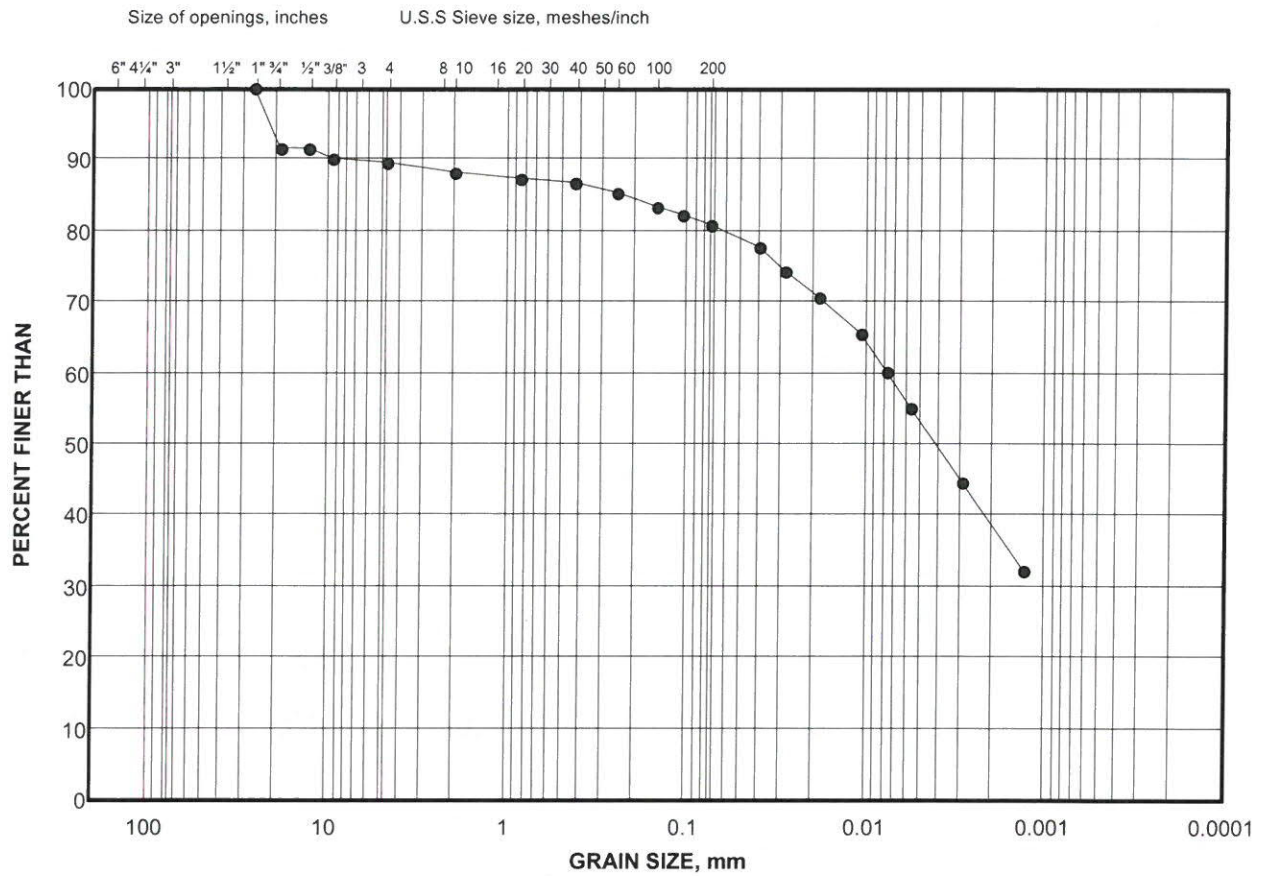
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Golder Associates

Date: 16-Oct-19

GRAIN SIZE DISTRIBUTION

FIGURE 7



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-2	SS2	9.3 Surficial Aquitard

REMARKS

Water Content (LS 701)- 20.0%

Project Number: 19131594

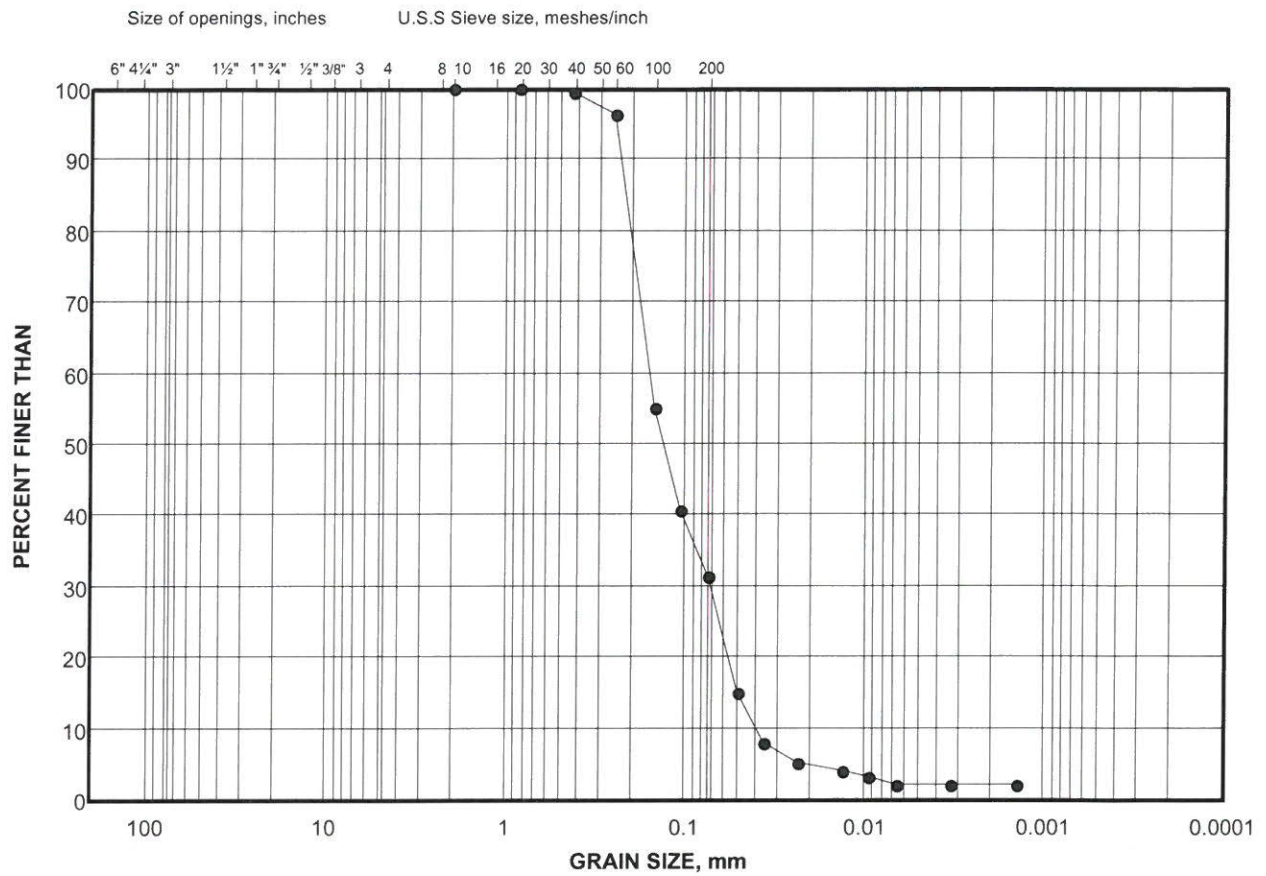
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Golder Associates

Date: 16-Oct-19

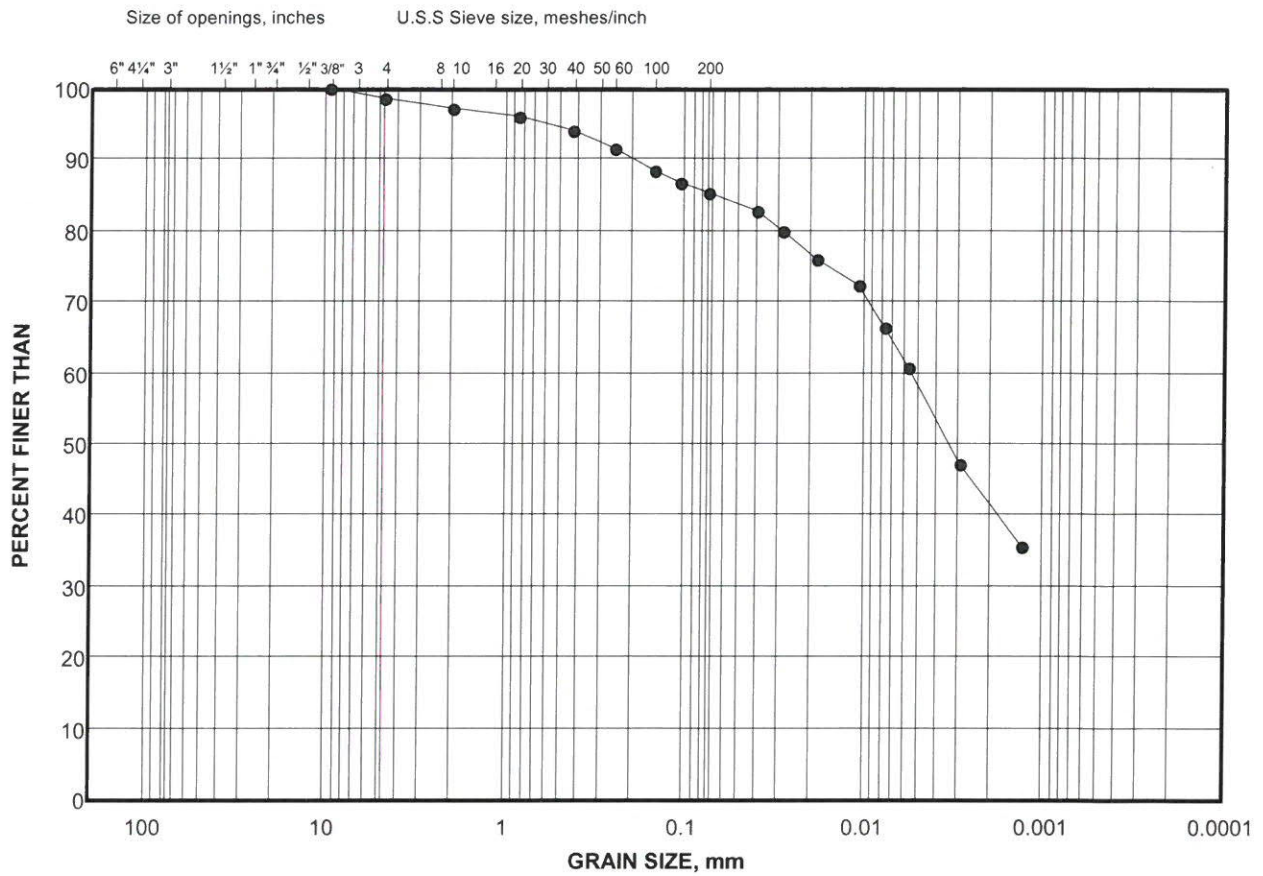
GRAIN SIZE DISTRIBUTION

FIGURE 8



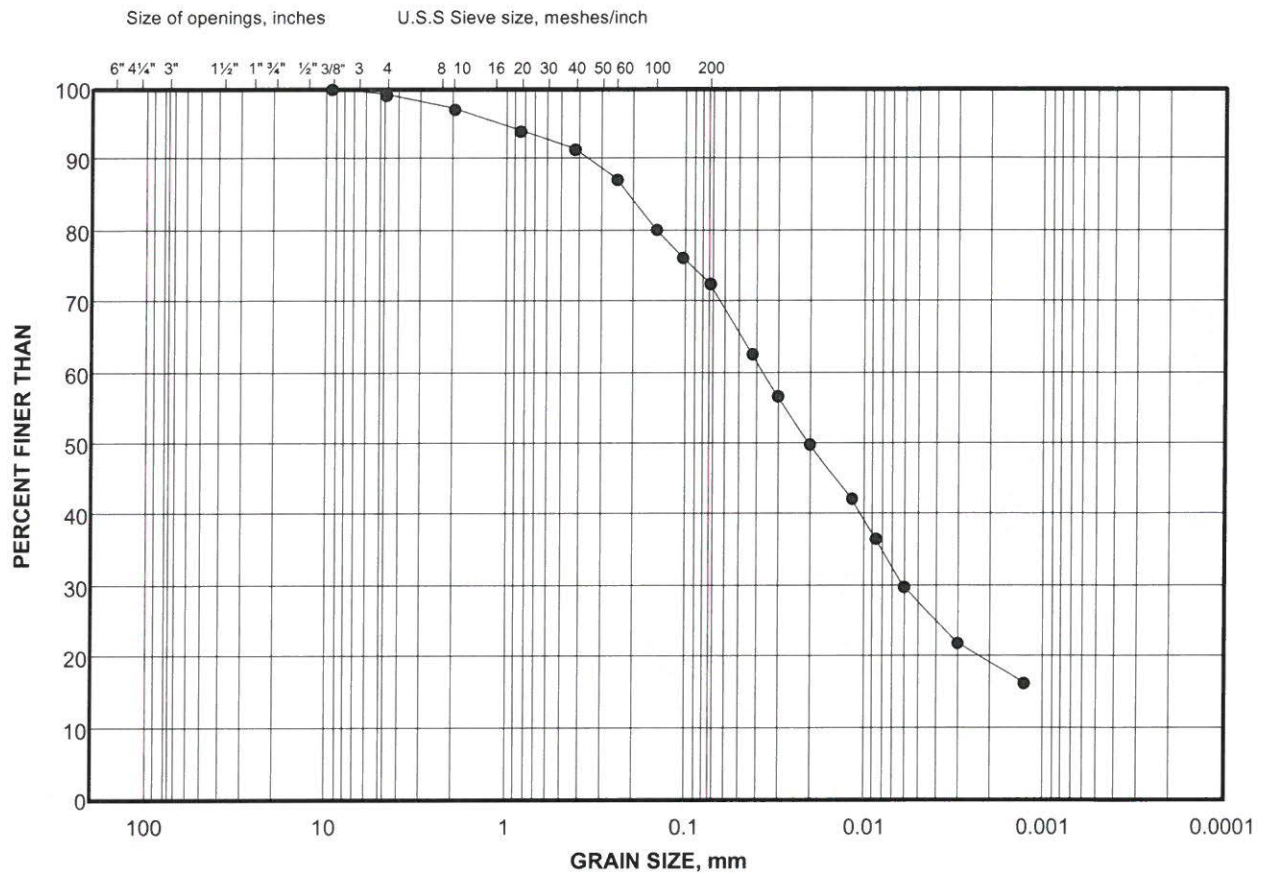
GRAIN SIZE DISTRIBUTION

FIGURE 9



GRAIN SIZE DISTRIBUTION

FIGURE 10



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-2	SS5	30.6 Lower Aquitard

REMARKS

Water Content (LS 701)- 11.0%

Project Number: 19131594

Checked By: _____

Golder Associates

Date: 16-Oct-19

FIGURE 11



SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
●	19-2	SS6	46.9 White Oaks Aquifer

Water Content (LS 701)- 9.0%

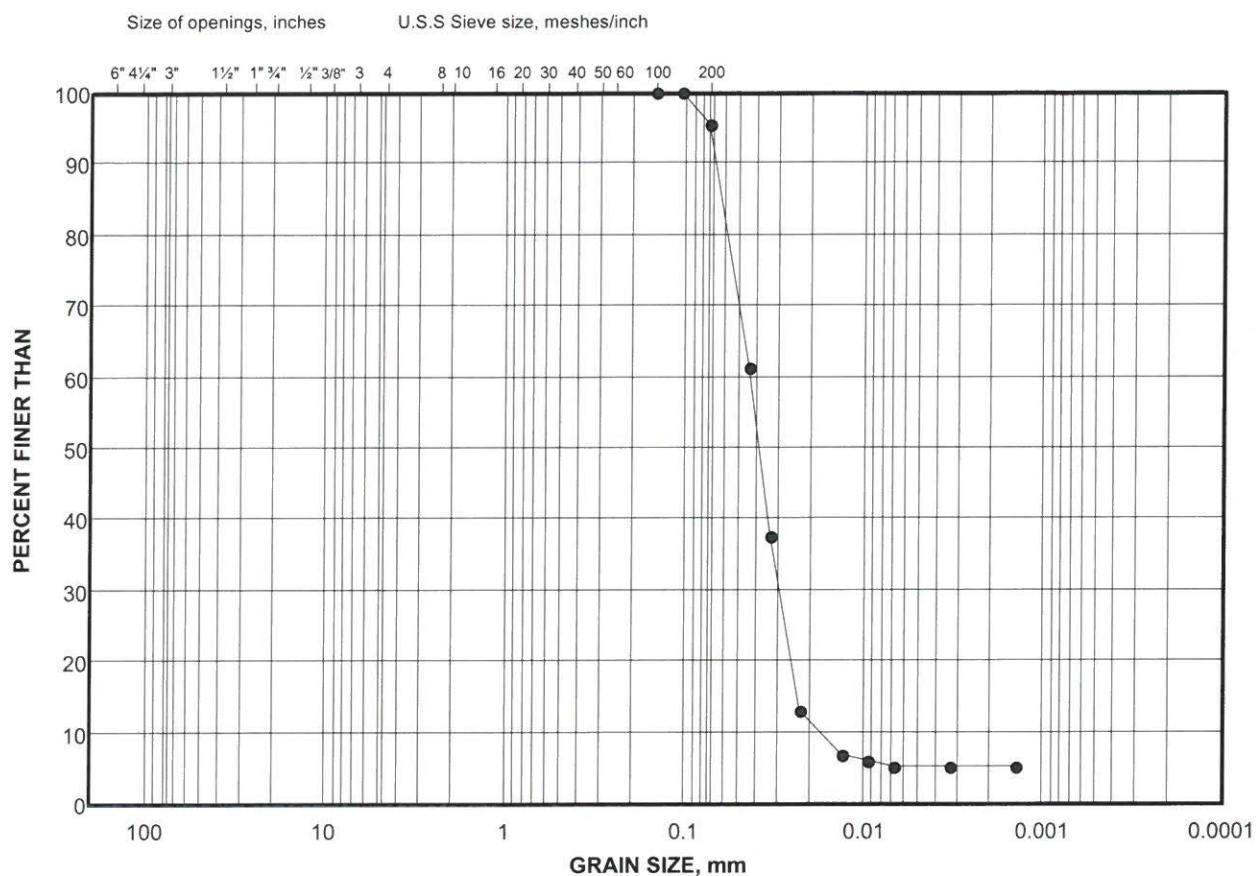
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Golder Associates

Date: 16-Oct-19

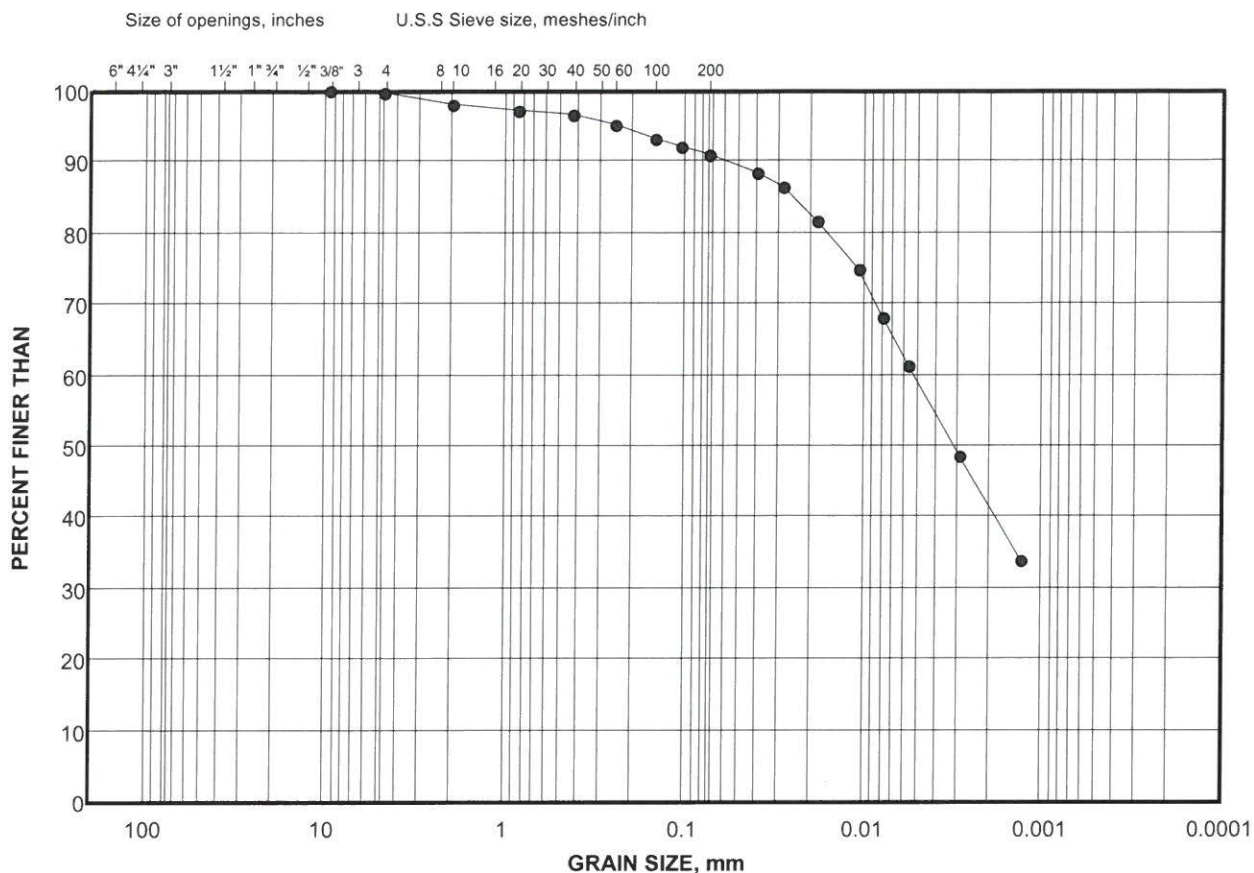
GRAIN SIZE DISTRIBUTION

FIGURE 14



GRAIN SIZE DISTRIBUTION

FIGURE 17



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-5	SS1	4.4 Surficial Aquitard

REMARKS

Water Content= 20.9%

Project Number: 19131594

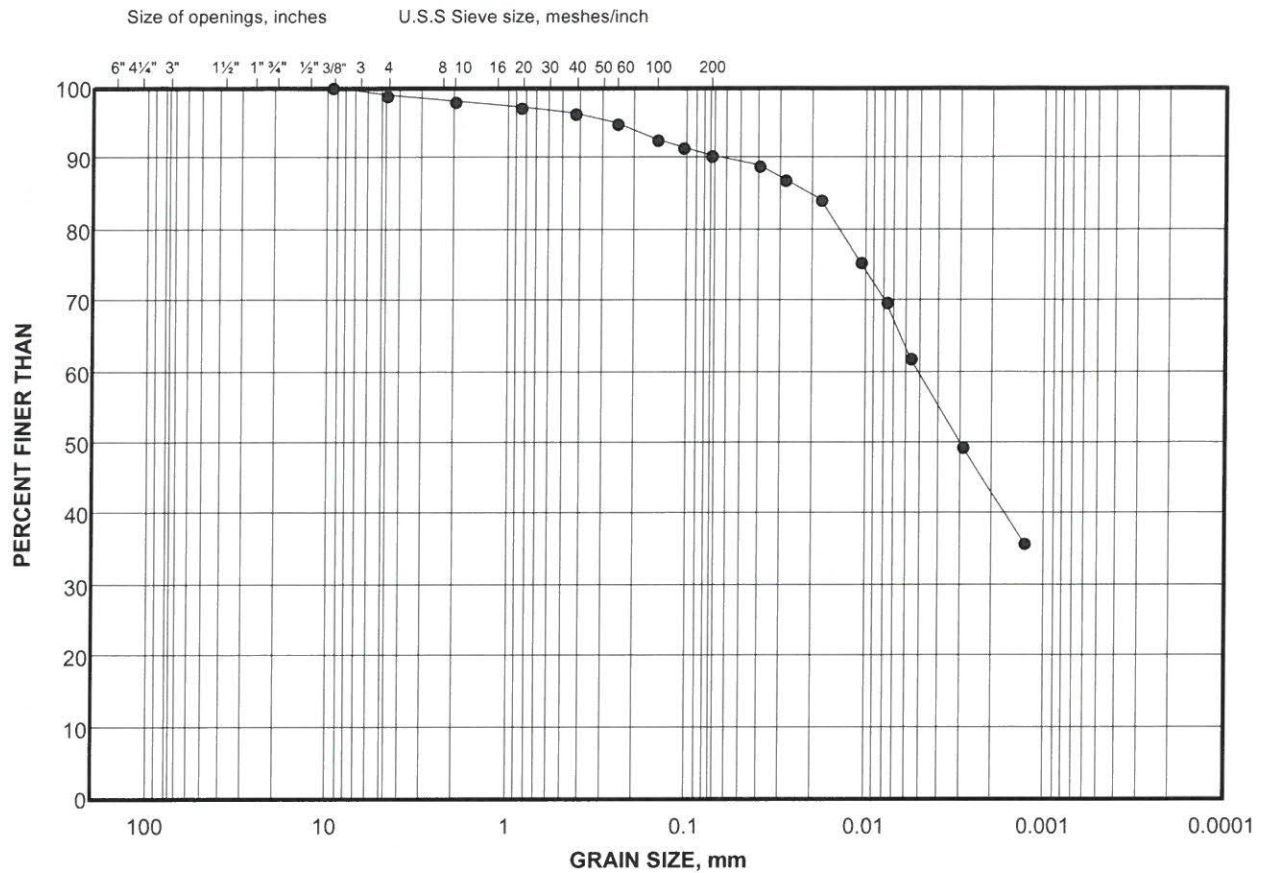
Checked By: *[Signature]*

Golder Associates

Date: 12-Nov-19

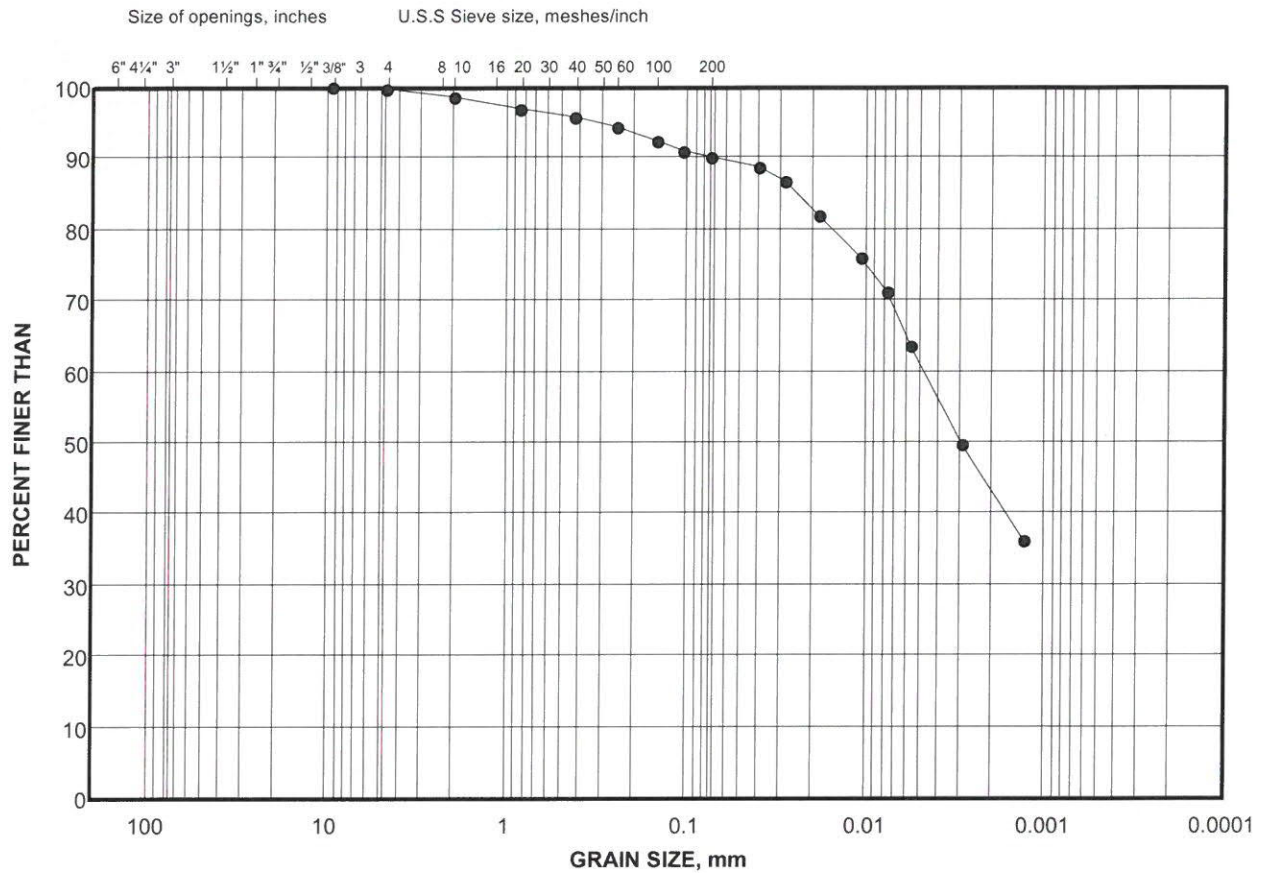
GRAIN SIZE DISTRIBUTION

FIGURE 18



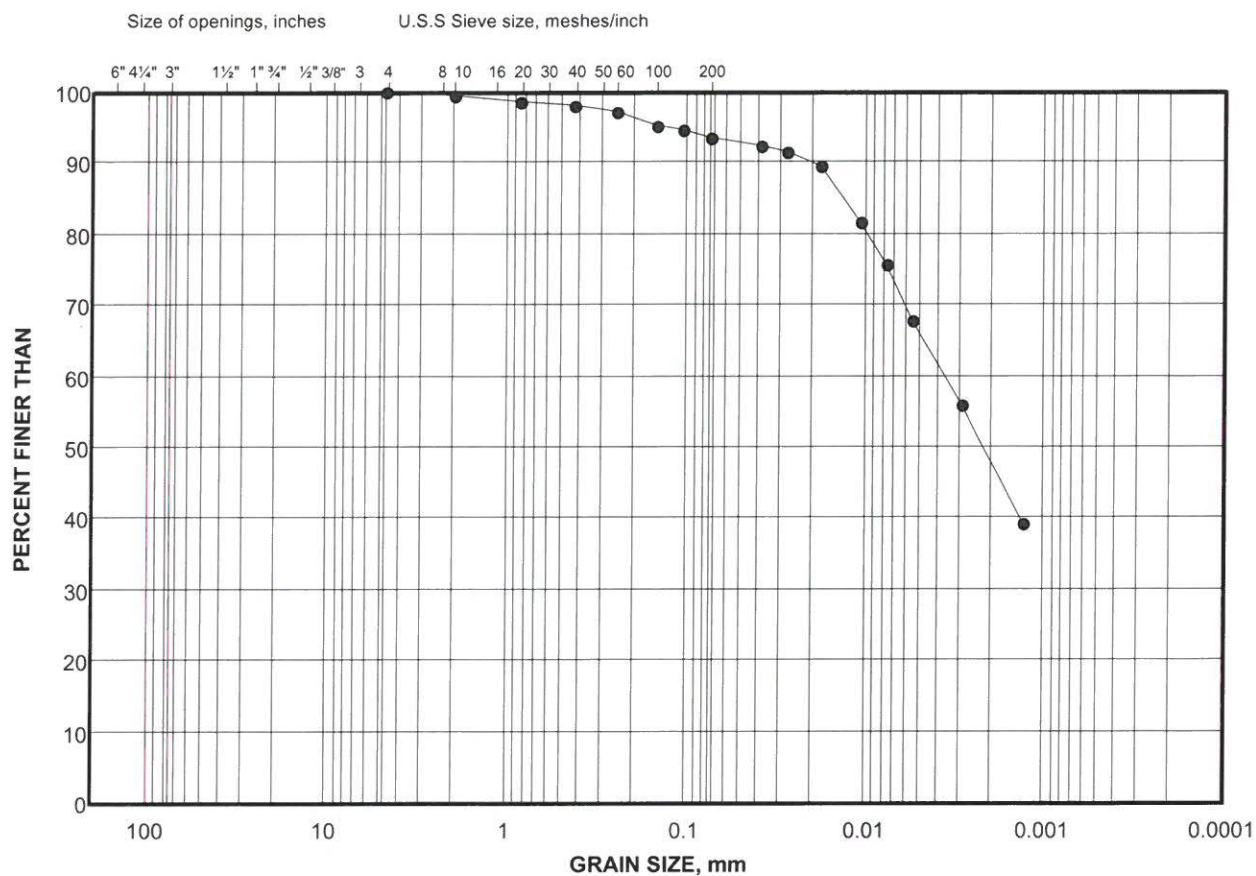
GRAIN SIZE DISTRIBUTION

FIGURE 19



GRAIN SIZE DISTRIBUTION

FIGURE 20



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-5	SS10	17.0 Surficial Aquitard

REMARKS

Water Content= 20.3%

Project Number: 19131594

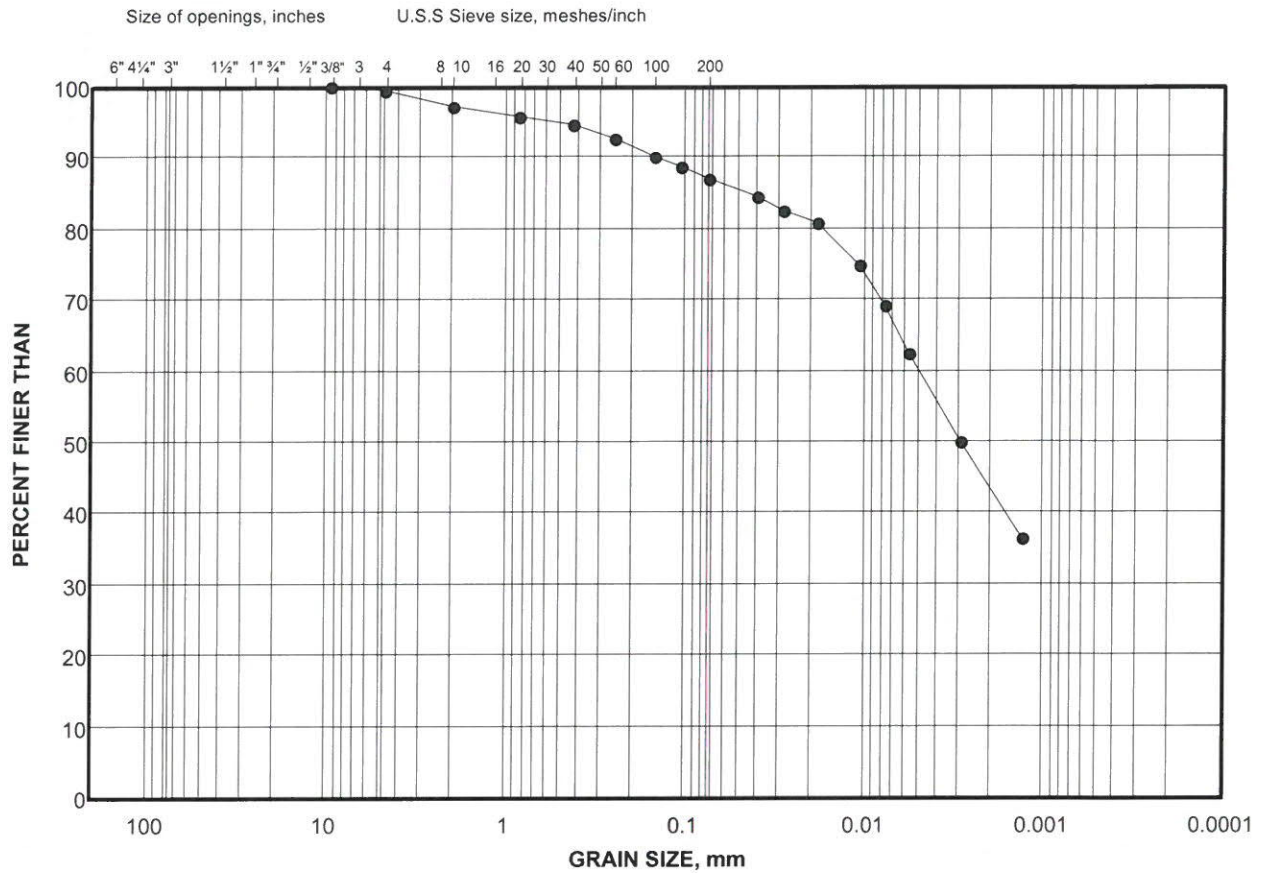
Checked By: *[Signature]*

Golder Associates

Date: 12-Nov-19

GRAIN SIZE DISTRIBUTION

FIGURE 21



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-5	SS13	24.5 Lower Aquitard

REMARKS

Water Content= 16.9

Project Number: 19131594

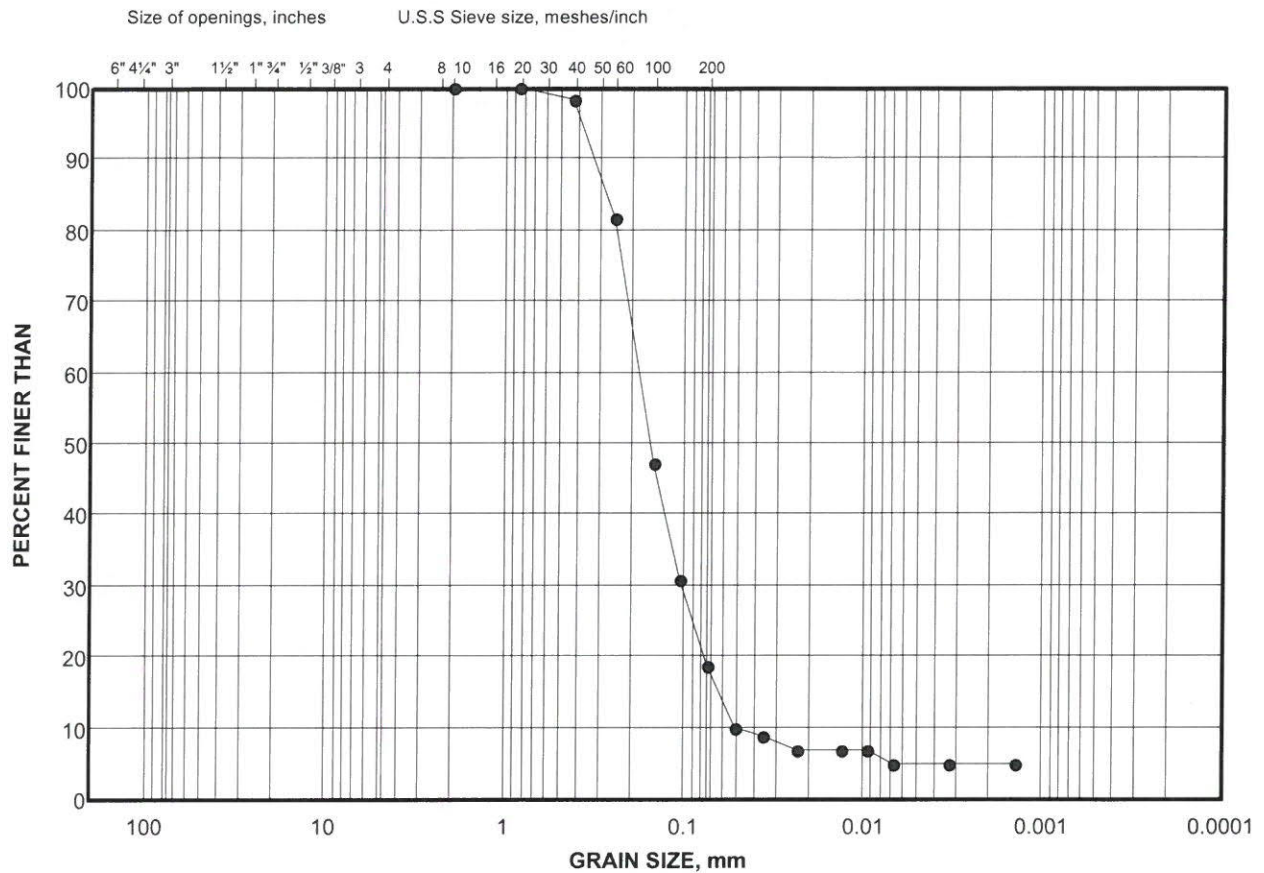
Checked By: *Chris Parker*

Golder Associates

Date: 12-Nov-19

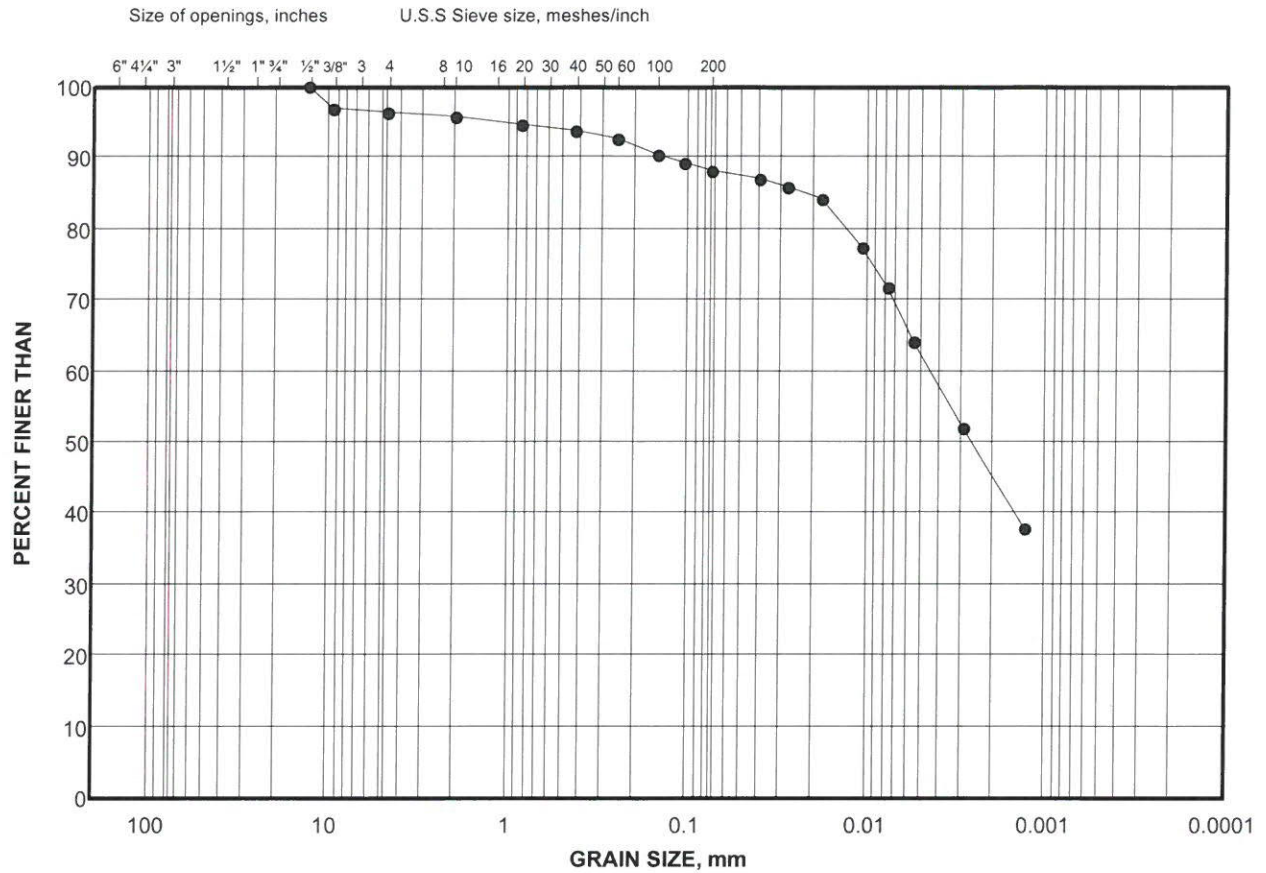
GRAIN SIZE DISTRIBUTION

FIGURE 22



GRAIN SIZE DISTRIBUTION

FIGURE 24



COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-6	SS2	9.3 Surficial Aquitard

REMARKS

Water Content= 20.1%

Project Number: 19131594

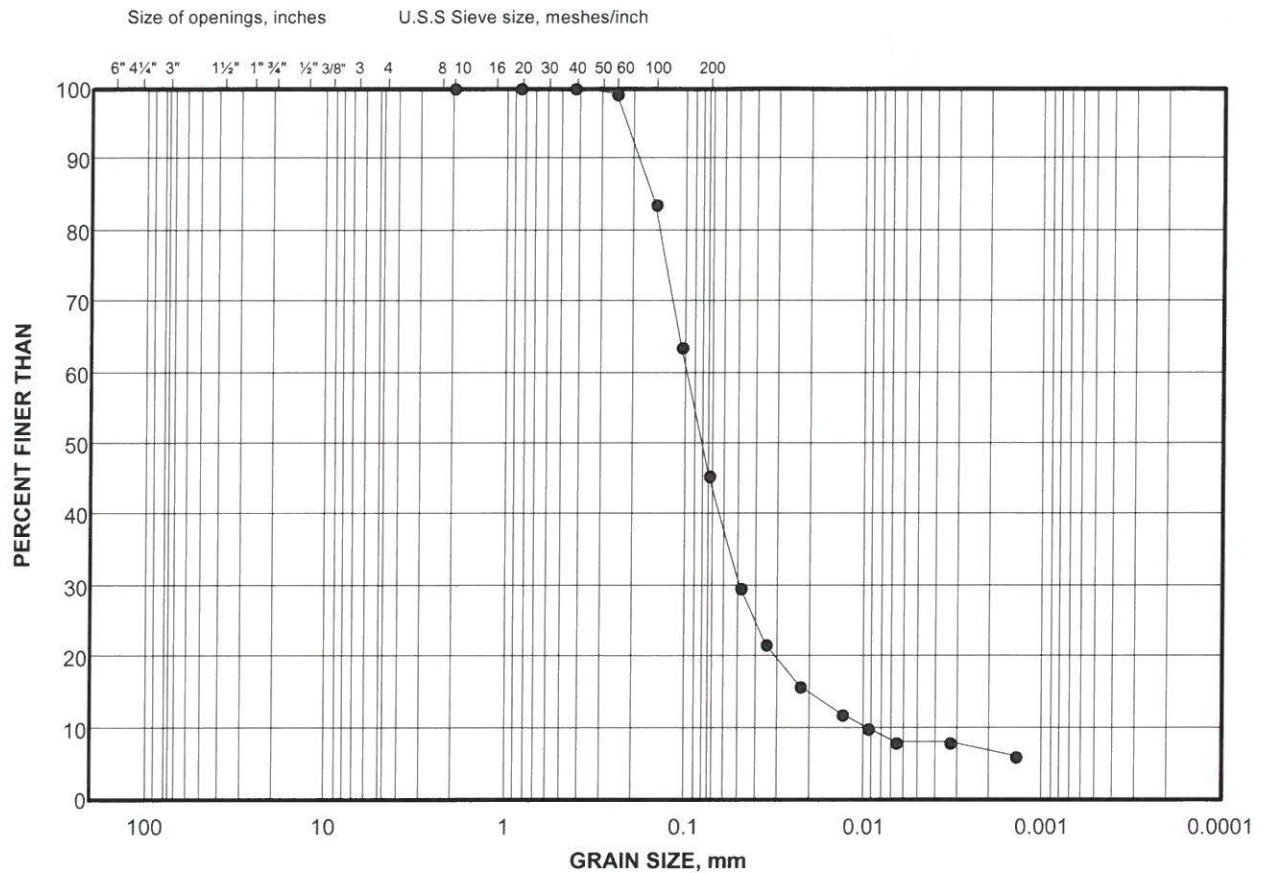
Checked By: *[Signature]*

Golder Associates

Date: 12-Nov-19

GRAIN SIZE DISTRIBUTION

FIGURE 25



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)
•	19-6	SS8	26.1 White Oaks Aquifer

REMARKS

Water Content= 16.8%

Project Number: 19131594

Checked By: *[Signature]*

Golder Associates

Date: 12-Nov-19

TOTAL ORGANIC CARBON CONTENT (TOC)

PROJECT NUMBER		1648176 (6000)						
PROJECT NAME		CityLondon/EOI LongTermSolidWaste						
DATE TESTED		November 15, 2019						
Borehole	Sample	Soil Grain Size Distribution					TOC	TOC*
		Passing 0.6mm (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	<0.6mm (%)	Whole Soil (%)
19-3	SS2	97.0	1.6	6.4	50.0	42.0	0.28	0.27
19-3	SS5	99.0	0.0	6.0	49.0	45.0	0.19	0.18
19-3	SS8	100.0	0.0	2.0	97.5	0.5	0.09	0.09
19-3	SS8	Repeat	100.0	0.0	2.0	97.5	0.07	0.07
19-5	SS1	94.0	1.6	10.4	52.0	36.0	0.16	0.15
19-5	SS4	97.0	1.1	6.8	51.0	41.1	0.17	0.17
19-5	SS4	Repeat	97.0	1.1	6.8	51.0	0.21	0.21
19-5	SS7	91.0	7.6	8.4	47.0	37.0	0.23	0.21
19-5	SS10	98.0	0.0	7.0	50.0	43.0	0.23	0.22

Notes:

1. Samples dried at 110 degree centigrade prior to testing.
2. Test performed on minus 600 micron soil fraction, using the method of Walkley and Black (Walkley, 1946)
3. Grain size distribution of sand, silt and clay based on Unified Soil Classification.

* Corrected TOC for whole (ie. unfractionated) soil assuming negligible organic carbon content associated with the plus 600 micron soil.



Report # 558561

Analytical Report

Page 1 of 2

Email

GOLDER ASSOCIATES - Marijana - BH193 SS2-
SS10 CEC
6925 Century Avenue
Suite 100
Mississauga, ON L5N 7K2

Fax: 905-567-6561

Email: mmanojlovic@golder.com

Date Received: Nov-13-2019

Date Reported: Nov-27-2019

Laboratory Number:	31930701	31930702	31930703	31930704
Sample ID:	BH19-3 SS2	BH19-3 SS5	BH19-3 SS8	BH19-5-SS1
Sample Description:	Clay		Silt	Clay
CEC - Actual (MEQ/100g)	118.30	112.40	16.50	112.80

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Authorized By: Jack Legg
CCA-ON, 4R NMS

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Report # 558561

Analytical Report

Page 2 of 2

Email

GOLDER ASSOCIATES - Marijana - BH193 SS2-
SS10 CEC
6925 Century Avenue
Suite 100
Mississauga, ON L5N 7K2

Fax: 905-567-6561

Email: mmanojlovic@golder.com

Date Received: Nov-13-2019

Date Reported: Nov-27-2019

Laboratory Number:	31930705	31930706	31930708
Sample ID:	BH19-5 SS4	BH19-5 SS7	BH19-5SS10
Sample Description:			

CEC - Actual (MEQ/100g)	100.60	108.00	107.20
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Authorized By: Jack Legg
CCA-ON, 4R NMS

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Appendix D

Hydraulic Conductivity Tests

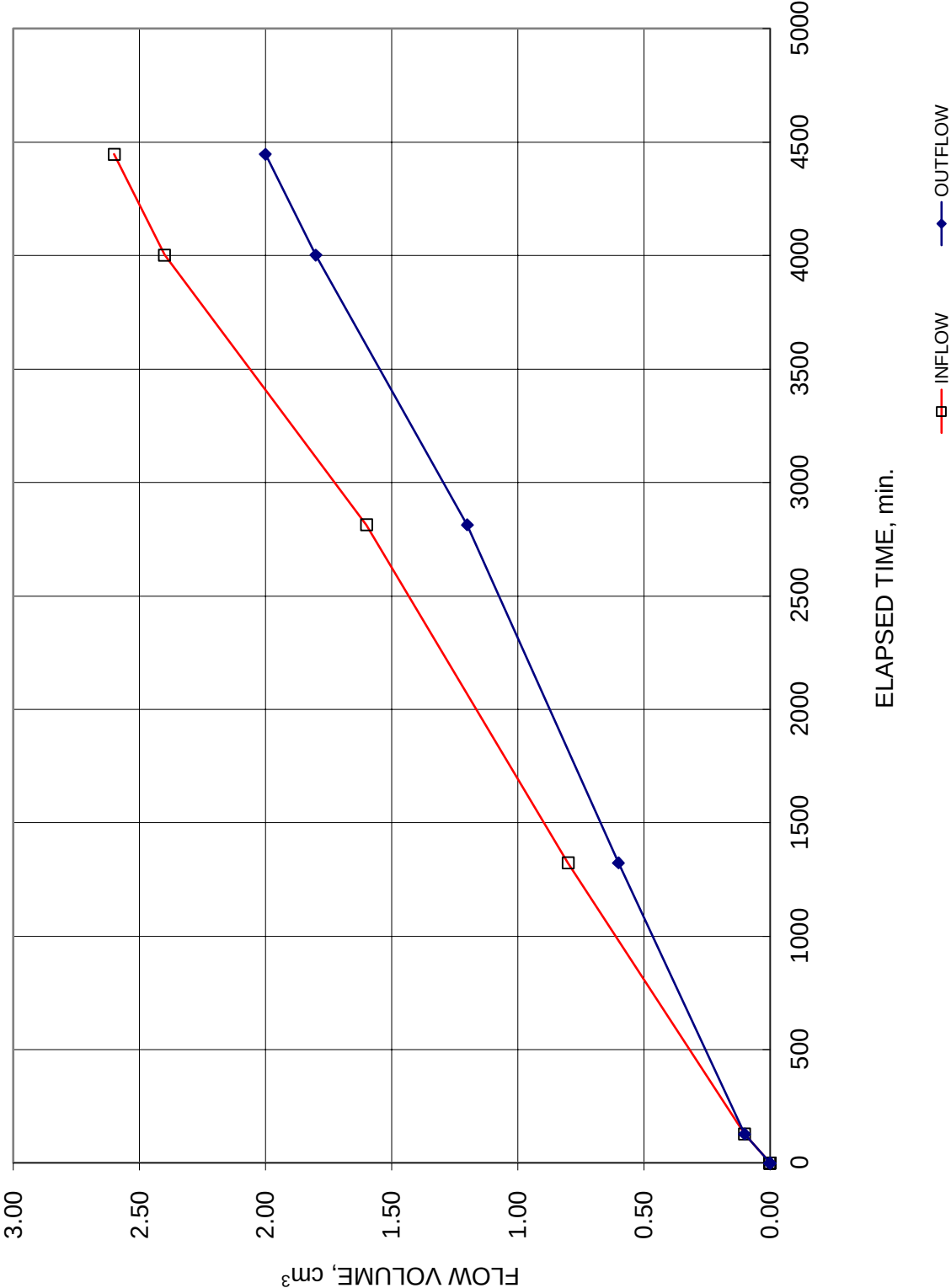
HYDRAULIC CONDUCTIVITY TEST
ASTM D 5084 (CONSTANT HEAD - Method A)

SAMPLE IDENTIFICATION			
PROJECT NUMBER	1648176(6000)	SAMPLE	SS1
PROJECT TITLE	CityLondon/EOI LongTermSolidWaste	SAMPLE DEPTH, m	-
BOREHOLE NUMBER	19-2-2	DATE	2/10/2020
SPECIMEN PROPERTIES AND DIMENSIONS (INITIAL)			
SAMPLE HEIGHT, cm	6.26	UNIT WEIGHT, kN/m ³	20.67
SAMPLE DIAMETER, cm	7.20	DRY UNIT WEIGHT, kN/m ³	17.20
SAMPLE AREA, cm ²	40.74	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	254.85	VOLUME OF SOLIDS, cm ³	165.51
TOTAL MASS, g	537.19	VOLUME OF VOIDS, cm ³	89.35
DRY MASS, g	446.88	VOID RATIO	0.54
WATER CONTENT, %	20.2		
SATURATION STAGE			
CELL PRESSURE, kPa	420.00	EFFECTIVE CONSOLIDATION STRESS, kPa	10
HEAD PRESSURE, kPa	410.00	DURATION, min	7,086
BACK PRESSURE, kPa	410.00	<i>B</i> COEFFICIENT	0.96
CONSOLIDATION STAGE			
CELL PRESSURE, kPa	460.00	EFFECTIVE CONSOLIDATION STRESS, kPa	50
HEAD PRESSURE, kPa	410.00	DURATION, min	1,209
BACK PRESSURE, kPa	410.00	VOLUME CHANGE, cm ³	2.30
		DRAINAGE	Top and Bottom
SPECIMEN PROPERTIES AND DIMENSIONS (AFTER CONSOLIDATION)			
SAMPLE HEIGHT, cm	6.24	SAMPLE AREA, cm ²	40.49
SAMPLE DIAMETER, cm	7.18	SAMPLE VOLUME, cm ³	252.56
HYDRAULIC CONDUCTIVITY STAGE			
CELL PRESSURE, kPa	472	EFFECTIVE CONSOLIDATION STRESS, kPa	50
HEAD PRESSURE, kPa	422	DURATION, min	4447
BACK PRESSURE, kPa	410	HYDRAULIC GRADIENT, i	20
SPECIMEN PROPERTIES AND DIMENSIONS (FINAL)			
SAMPLE HEIGHT, cm	6.24	UNIT WEIGHT, kN/m ³	20.92
SAMPLE DIAMETER, cm	7.18	DRY UNIT WEIGHT, kN/m ³	17.35
SAMPLE AREA, cm ²	40.49	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	252.56	VOLUME OF SOLIDS, cm ³	165.51
TOTAL MASS, g	538.87	VOLUME OF VOIDS, cm ³	87.05
DRY MASS, g	446.88	VOID RATIO	0.53
WATER CONTENT, %	20.6		
TEST RESULTS			
ELAPSED TIME TO STEADY STATE FLOW (min)			0.0
DURATION OF STEADY STATE FLOW (min)			4447
INFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)			2.6
OUTFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)			2.0
INFLOW TO OUTFLOW RATIO			1.3
HYDRAULIC CONDUCTIVITY (INFLOW) (m/s)			1.23E-10
HYDRAULIC CONDUCTIVITY (OUTFLOW) (m/s)			9.43E-11
HYDRAULIC CONDUCTIVITY, K, m/s			1.09E-10
HYDRAULIC CONDUCTIVITY AT STANDARD TEMPERATURE, K ₂₀ , m/s			1.01E-10
NOTES:			
Effective consolidation stress assigned, by client.			
PERMEANT FLUID	Deaired tap water		
AVERAGE TEST TEMPERATURE	23.0 °C		

HYDRAULIC CONDUCTIVITY TEST

Project title: CityLondon/EOI LongTermSolidWaste
Borehole number: 19-2-2
Sample depth: -

Flow volume vs. Time
BOREHOLE NUMBER - 19-2-2
SAMPLE - SS1



ASTM D 5084 (CONSTANT HEAD - Method A)

SAMPLE IDENTIFICATION

PROJECT NUMBER	1648176(6000)	SAMPLE	SS2
PROJECT TITLE	CityLondon/EOI LongTermSolidWaste	SAMPLE DEPTH, m	-
BOREHOLE NUMBER	19-2-2	DATE	2/18/2020

SPECIMEN PROPERTIES AND DIMENSIONS (INITIAL

SAMPLE HEIGHT, cm	6.70	UNIT WEIGHT, kN/m ³	21.14
SAMPLE DIAMETER, cm	7.20	DRY UNIT WEIGHT, kN/m ³	17.81
SAMPLE AREA, cm ²	40.76	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	273.05	VOLUME OF SOLIDS, cm ³	183.63
TOTAL MASS, g	588.70	VOLUME OF VOIDS, cm ³	89.43
DRY MASS, g	495.79	VOID RATIO	0.49
WATER CONTENT, %	18.7		

SATURATION STAGE

CELL PRESSURE, kPa	490.00	EFFECTIVE CONSOLIDATION STRESS, kPa	10
HEAD PRESSURE, kPa	480.00	DURATION, min	139,397
BACK PRESSURE, kPa	480.00	<i>B</i> COEFFICIENT	0.96

CONSOLIDATION STAGE

CELL PRESSURE, kPa	580.00	EFFECTIVE CONSOLIDATION STRESS, kPa	100
HEAD PRESSURE, kPa	480.00	DURATION, min	1,499
BACK PRESSURE, kPa	480.00	VOLUME CHANGE, cm ³	5.40
		DRAINAGE	Top and Bottom

SPECIMEN PROPERTIES AND DIMENSIONS (AFTER CONSOLIDATION)

SAMPLE HEIGHT, cm	6.65	SAMPLE AREA, cm ²	40.22
SAMPLE DIAMETER, cm	7.16	SAMPLE VOLUME, cm ³	267.68

HYDRAULIC CONDUCTIVITY STAGE

CELL PRESSURE, kPa	593	EFFECTIVE CONSOLIDATION STRESS, kPa	100
HEAD PRESSURE, kPa	493	DURATION, min	4110
BACK PRESSURE, kPa	480	HYDRAULIC GRADIENT, i	20

SPECIMEN PROPERTIES AND DIMENSIONS (FINAL

SAMPLE HEIGHT, cm	6.65	UNIT WEIGHT, kN/m ³	21.63
SAMPLE DIAMETER, cm	7.16	DRY UNIT WEIGHT, kN/m ³	18.16
SAMPLE AREA, cm ²	40.22	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	267.68	VOLUME OF SOLIDS, cm ³	183.63
TOTAL MASS, g	590.29	VOLUME OF VOIDS, cm ³	84.05
DRY MASS, g	495.79	VOID RATIO	0.46
WATER CONTENT, %	19.1		

TEST RESULTS

ELAPSED TIME TO STEADY STATE FLOW (min)	0.0
DURATION OF STEADY STATE FLOW (min)	4110
INFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)	2.2
OUTFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)	2.6
INFLOW TO OUTFLOW RATIO	0.8
HYDRAULIC CONDUCTIVITY (INFLOW) (m/s)	1.11E-10
HYDRAULIC CONDUCTIVITY (OUTFLOW) (m/s)	1.32E-10
HYDRAULIC CONDUCTIVITY, K, m/s	1.21E-10
HYDRAULIC CONDUCTIVITY AT STANDARD TEMPERATURE, K₂₀, m/s	1.13E-10

NOTES

Effective consolidation stress assigned, by client

PERMEANT FLUID Deaired tap water

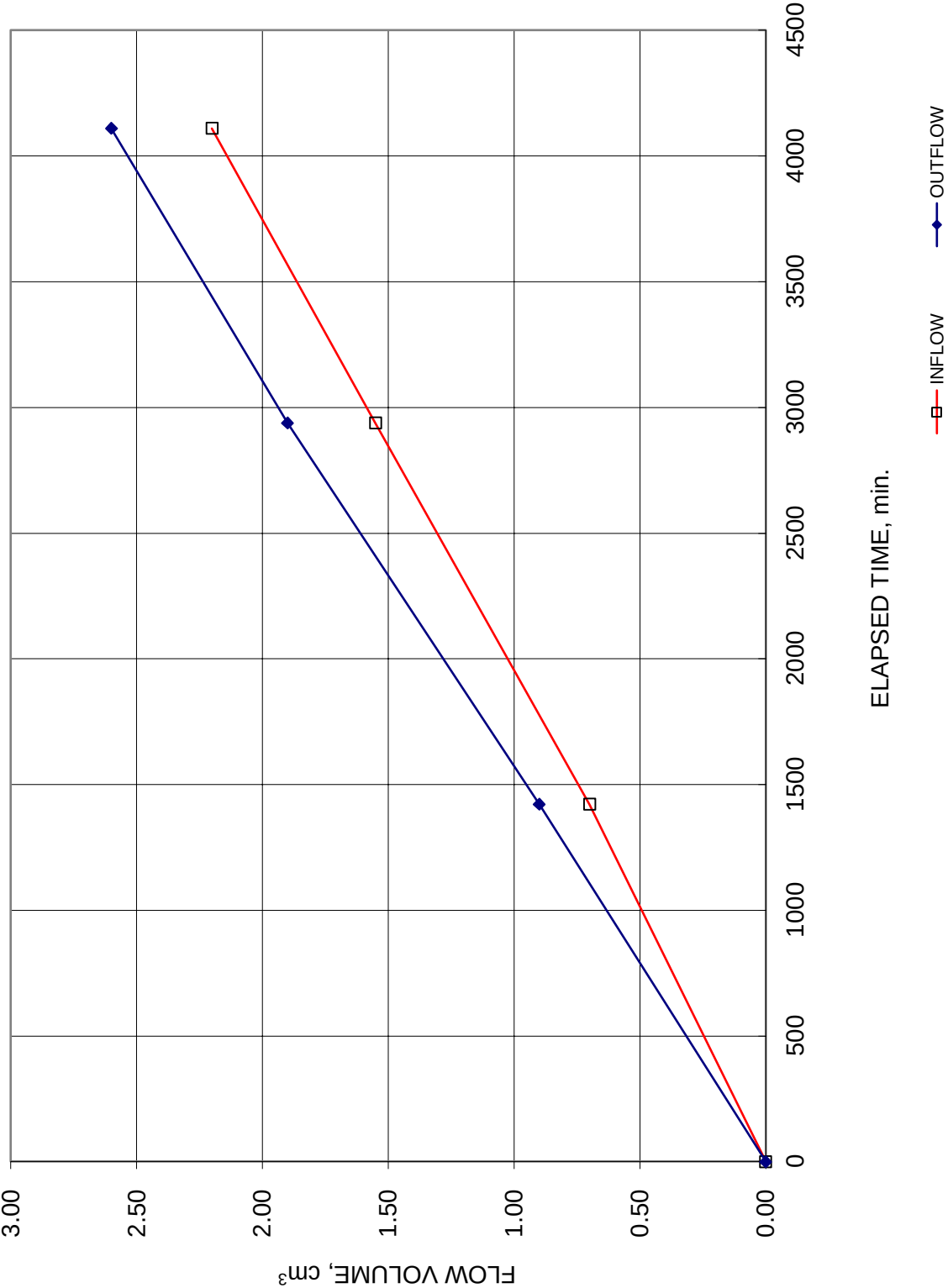
AVERAGE TEST TEMPERATURE 23.0 °C

HYDRAULIC CONDUCTIVITY TEST

2/18/2020

Project title: CityLondon/EOI LongTermSolidWaste
Borehole number: 19-2-2
Sample depth: -

Flow volume vs. Time
BOREHOLE NUMBER - 19-2-2
SAMPLE - SS2



HYDRAULIC CONDUCTIVITY TEST
ASTM D 5084 (CONSTANT HEAD - Method A)

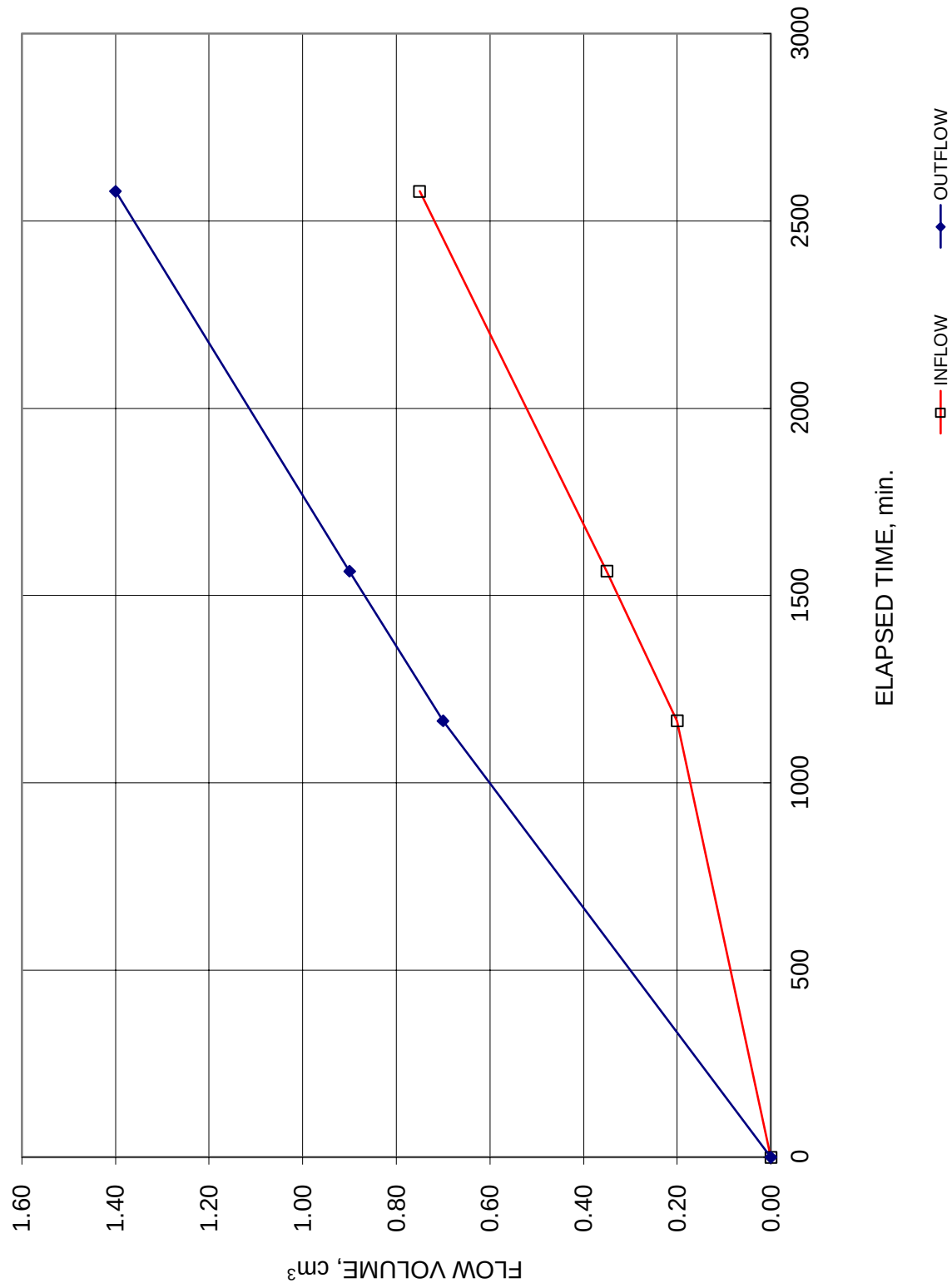
SAMPLE IDENTIFICATION			
PROJECT NUMBER	1648176(6000)	SAMPLE	SS1
PROJECT TITLE	CityLondon/EOI LongTermSolidWaste	SAMPLE DEPTH, m	-
BOREHOLE NUMBER	19-5-2	DATE	2/19/2020
SPECIMEN PROPERTIES AND DIMENSIONS (INITIAL)			
SAMPLE HEIGHT, cm	6.67	UNIT WEIGHT, kN/m ³	20.50
SAMPLE DIAMETER, cm	7.19	DRY UNIT WEIGHT, kN/m ³	16.93
SAMPLE AREA, cm ²	40.55	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	270.48	VOLUME OF SOLIDS, cm ³	172.99
TOTAL MASS, g	565.36	VOLUME OF VOIDS, cm ³	97.48
DRY MASS, g	467.09	VOID RATIO	0.56
WATER CONTENT, %	21.0		
SATURATION STAGE			
CELL PRESSURE, kPa	350.00	EFFECTIVE CONSOLIDATION STRESS, kPa	10
HEAD PRESSURE, kPa	340.00	DURATION, min	8,421
BACK PRESSURE, kPa	340.00	B COEFFICIENT	0.96
CONSOLIDATION STAGE			
CELL PRESSURE, kPa	540.00	EFFECTIVE CONSOLIDATION STRESS, kPa	200
HEAD PRESSURE, kPa	340.00	DURATION, min	1,493
BACK PRESSURE, kPa	340.00	VOLUME CHANGE, cm ³	4.90
		DRAINAGE	Top and Bottom
SPECIMEN PROPERTIES AND DIMENSIONS (AFTER CONSOLIDATION)			
SAMPLE HEIGHT, cm	6.63	SAMPLE AREA, cm ²	40.06
SAMPLE DIAMETER, cm	7.14	SAMPLE VOLUME, cm ³	265.60
HYDRAULIC CONDUCTIVITY STAGE			
CELL PRESSURE, kPa	553	EFFECTIVE CONSOLIDATION STRESS, kPa	200
HEAD PRESSURE, kPa	353	DURATION, min	2579
BACK PRESSURE, kPa	340	HYDRAULIC GRADIENT, i	20
SPECIMEN PROPERTIES AND DIMENSIONS (FINAL)			
SAMPLE HEIGHT, cm	6.63	UNIT WEIGHT, kN/m ³	20.83
SAMPLE DIAMETER, cm	7.14	DRY UNIT WEIGHT, kN/m ³	17.25
SAMPLE AREA, cm ²	40.06	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	265.60	VOLUME OF SOLIDS, cm ³	172.99
TOTAL MASS, g	564.14	VOLUME OF VOIDS, cm ³	92.60
DRY MASS, g	467.09	VOID RATIO	0.54
WATER CONTENT, %	20.8		
TEST RESULTS			
ELAPSED TIME TO STEADY STATE FLOW (min)			1165.0
DURATION OF STEADY STATE FLOW (min)			1414
INFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)			0.6
OUTFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)			0.7
INFLOW TO OUTFLOW RATIO			0.8
HYDRAULIC CONDUCTIVITY (INFLOW) (m/s)			8.09E-11
HYDRAULIC CONDUCTIVITY (OUTFLOW) (m/s)			1.03E-10
HYDRAULIC CONDUCTIVITY, K, m/s			9.20E-11
HYDRAULIC CONDUCTIVITY AT STANDARD TEMPERATURE, K ₂₀ , m/s			8.57E-11
NOTES:			
Effective consolidation stress assigned, by client.			
PERMEANT FLUID	Deaired tap water		
AVERAGE TEST TEMPERATURE	23.0 °C		

HYDRAULIC CONDUCTIVITY TEST

2/19/2020

Project title: CityLondon/EOI LongTermSolidWaste
Borehole number: 19-5-2
Sample depth: -

Flow volume vs. Time
BOREHOLE NUMBER - 19-5-2
SAMPLE - SS1



ASTM D 5084 (CONSTANT HEAD - Method A)

SAMPLE IDENTIFICATION

PROJECT NUMBER	1648176(6000)	SAMPLE	SS2
PROJECT TITLE	CityLondon/EOI LongTermSolidWaste	SAMPLE DEPTH, m	-
BOREHOLE NUMBER	19-5-2	DATE	2/21/2020

SPECIMEN PROPERTIES AND DIMENSIONS (INITIAL)

SAMPLE HEIGHT, cm	6.72	UNIT WEIGHT, kN/m ³	21.53
SAMPLE DIAMETER, cm	6.92	DRY UNIT WEIGHT, kN/m ³	18.09
SAMPLE AREA, cm ²	37.64	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	253.00	VOLUME OF SOLIDS, cm ³	172.88
TOTAL MASS, g	555.37	VOLUME OF VOIDS, cm ³	80.12
DRY MASS, g	466.78	VOID RATIO	0.46
WATER CONTENT, %	19.0		

SATURATION STAGE

CELL PRESSURE, kPa	350.00	EFFECTIVE CONSOLIDATION STRESS, kPa	10
HEAD PRESSURE, kPa	340.00	DURATION, min	9,982
BACK PRESSURE, kPa	340.00	B COEFFICIENT	0.96

CONSOLIDATION STAGE

CELL PRESSURE, kPa	570.00	EFFECTIVE CONSOLIDATION STRESS, kPa	230
HEAD PRESSURE, kPa	340.00	DURATION, min	1,330
BACK PRESSURE, kPa	340.00	VOLUME CHANGE, cm ³	7.60
		DRAINAGE	Top and Bottom

SPECIMEN PROPERTIES AND DIMENSIONS (AFTER CONSOLIDATION)

SAMPLE HEIGHT, cm	6.65	SAMPLE AREA, cm ²	36.89
SAMPLE DIAMETER, cm	6.85	SAMPLE VOLUME, cm ³	245.45

HYDRAULIC CONDUCTIVITY STAGE

CELL PRESSURE, kPa	583	EFFECTIVE CONSOLIDATION STRESS, kPa	230
HEAD PRESSURE, kPa	353	DURATION, min	2804
BACK PRESSURE, kPa	340	HYDRAULIC GRADIENT, i	20

SPECIMEN PROPERTIES AND DIMENSIONS (FINAL

SAMPLE HEIGHT, cm	6.65	UNIT WEIGHT, kN/m ³	22.05
SAMPLE DIAMETER, cm	6.85	DRY UNIT WEIGHT, kN/m ³	18.65
SAMPLE AREA, cm ²	36.89	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	245.45	VOLUME OF SOLIDS, cm ³	172.88
TOTAL MASS, g	551.89	VOLUME OF VOIDS, cm ³	72.57
DRY MASS, g	466.78	VOID RATIO	0.42
WATER CONTENT, %	18.2		

TEST RESULTS

ELAPSED TIME TO STEADY STATE FLOW (min)	0.0
DURATION OF STEADY STATE FLOW (min)	2804
INFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)	1.2
OUTFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)	1.4
INFLOW TO OUTFLOW RATIO	0.9
HYDRAULIC CONDUCTIVITY (INFLOW) (m/s)	9.70E-11
HYDRAULIC CONDUCTIVITY (OUTFLOW) (m/s)	1.13E-10
HYDRAULIC CONDUCTIVITY, K, m/s	1.05E-10
HYDRAULIC CONDUCTIVITY AT STANDARD TEMPERATURE, K₂₀, m/s	9.79E-11

NOTES:

Effective consolidation stress assigned, by client.

PERMEANT FLUID

Deaired tap water

AVERAGE TEST TEMPERATURE

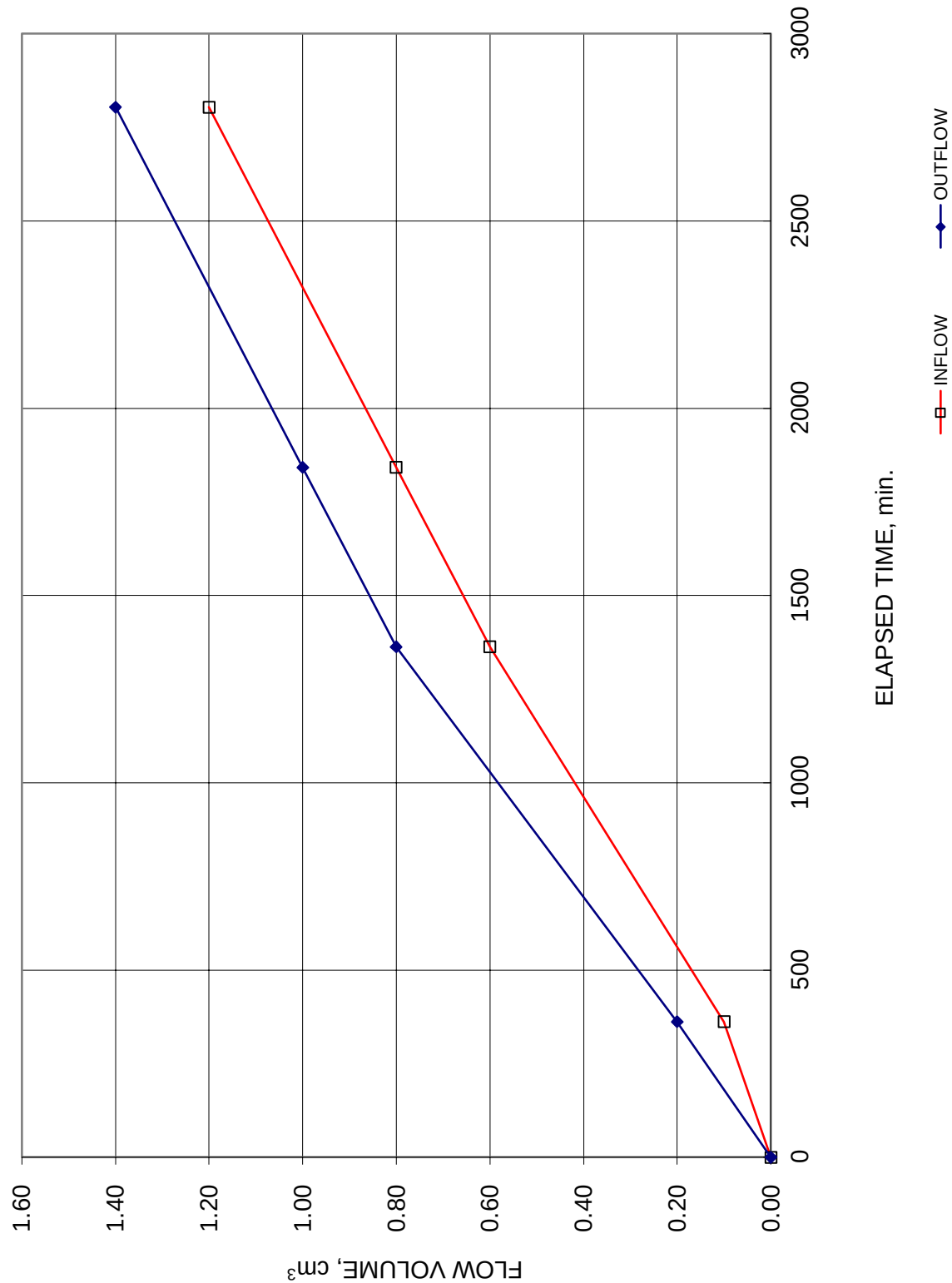
23.0 °C

HYDRAULIC CONDUCTIVITY TEST

2/21/2020

Project title: CityLondon/EOI LongTermSolidWaste
Borehole number: 19-5-2
Sample depth: -

Flow volume vs. Time
BOREHOLE NUMBER - 19-5-2
SAMPLE - SS2



HYDRAULIC CONDUCTIVITY TEST
ASTM D 5084 (CONSTANT HEAD - Method A)

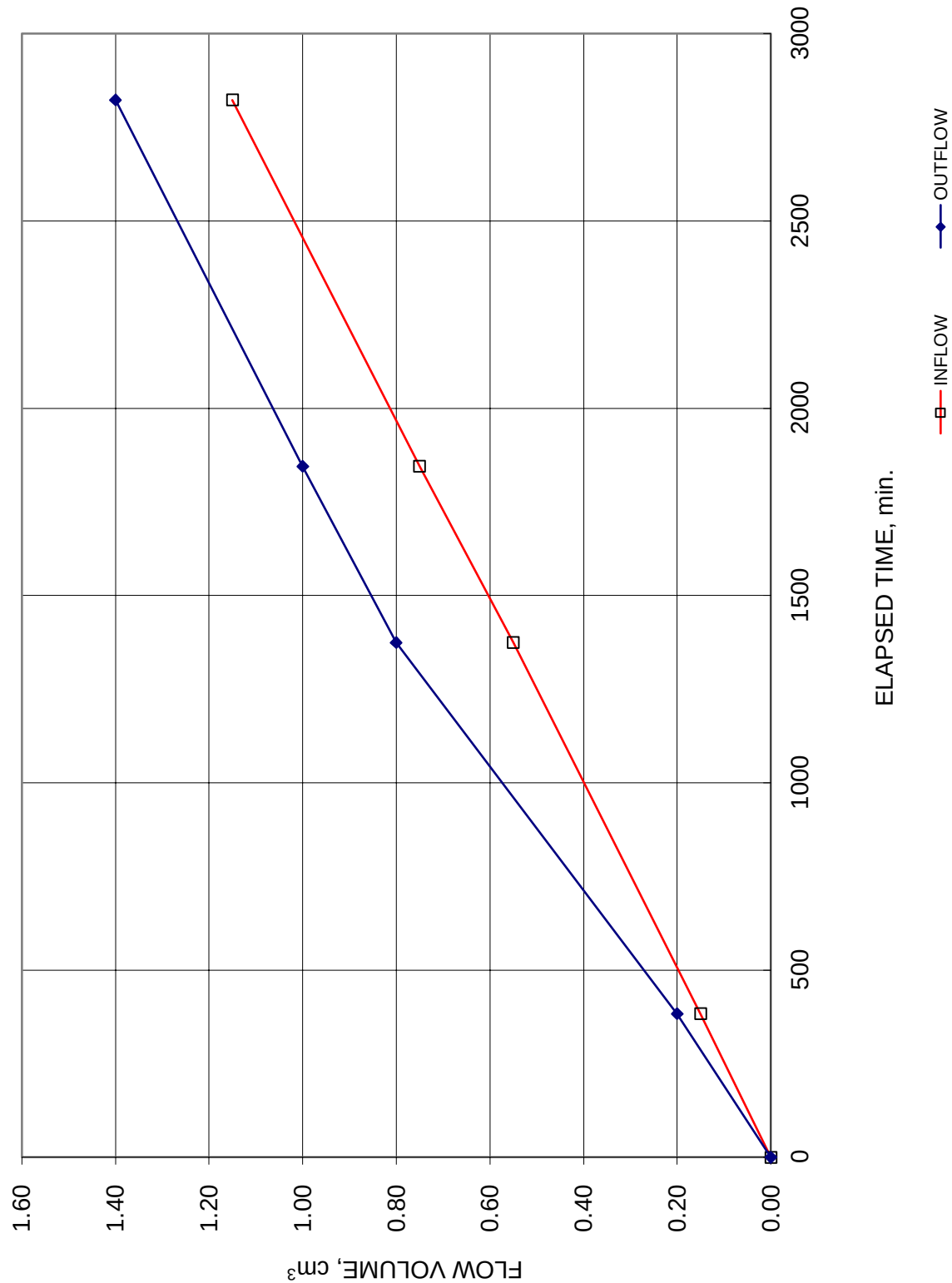
SAMPLE IDENTIFICATION			
PROJECT NUMBER	1648176(6000)	SAMPLE	SS1
PROJECT TITLE	CityLondon/EOI LongTermSolidWaste	SAMPLE DEPTH, m	-
BOREHOLE NUMBER	19-6-2	DATE	2/26/2020
SPECIMEN PROPERTIES AND DIMENSIONS (INITIAL)			
SAMPLE HEIGHT, cm	6.74	UNIT WEIGHT, kN/m ³	21.23
SAMPLE DIAMETER, cm	7.18	DRY UNIT WEIGHT, kN/m ³	17.87
SAMPLE AREA, cm ²	40.43	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	272.52	VOLUME OF SOLIDS, cm ³	183.93
TOTAL MASS, g	589.84	VOLUME OF VOIDS, cm ³	88.58
DRY MASS, g	496.62	VOID RATIO	0.48
WATER CONTENT, %	18.8		
SATURATION STAGE			
CELL PRESSURE, kPa	350.00	EFFECTIVE CONSOLIDATION STRESS, kPa	10
HEAD PRESSURE, kPa	340.00	DURATION, min	7,120
BACK PRESSURE, kPa	340.00	B COEFFICIENT	0.96
CONSOLIDATION STAGE			
CELL PRESSURE, kPa	540.00	EFFECTIVE CONSOLIDATION STRESS, kPa	200
HEAD PRESSURE, kPa	340.00	DURATION, min	1,290
BACK PRESSURE, kPa	340.00	VOLUME CHANGE, cm ³	7.50
		DRAINAGE	Top and Bottom
SPECIMEN PROPERTIES AND DIMENSIONS (AFTER CONSOLIDATION)			
SAMPLE HEIGHT, cm	6.68	SAMPLE AREA, cm ²	39.69
SAMPLE DIAMETER, cm	7.11	SAMPLE VOLUME, cm ³	265.06
HYDRAULIC CONDUCTIVITY STAGE			
CELL PRESSURE, kPa	553	EFFECTIVE CONSOLIDATION STRESS, kPa	200
HEAD PRESSURE, kPa	353	DURATION, min	2823
BACK PRESSURE, kPa	340	HYDRAULIC GRADIENT, i	20
SPECIMEN PROPERTIES AND DIMENSIONS (FINAL)			
SAMPLE HEIGHT, cm	6.68	UNIT WEIGHT, kN/m ³	21.81
SAMPLE DIAMETER, cm	7.11	DRY UNIT WEIGHT, kN/m ³	18.37
SAMPLE AREA, cm ²	39.69	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	265.06	VOLUME OF SOLIDS, cm ³	183.93
TOTAL MASS, g	589.43	VOLUME OF VOIDS, cm ³	81.13
DRY MASS, g	496.62	VOID RATIO	0.44
WATER CONTENT, %	18.7		
TEST RESULTS			
ELAPSED TIME TO STEADY STATE FLOW (min)			0.0
DURATION OF STEADY STATE FLOW (min)			2823
INFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)			1.2
OUTFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)			1.4
INFLOW TO OUTFLOW RATIO			0.8
HYDRAULIC CONDUCTIVITY (INFLOW) (m/s)			8.62E-11
HYDRAULIC CONDUCTIVITY (OUTFLOW) (m/s)			1.05E-10
HYDRAULIC CONDUCTIVITY, K, m/s			9.55E-11
HYDRAULIC CONDUCTIVITY AT STANDARD TEMPERATURE, K ₂₀ , m/s			8.90E-11
NOTES:			
Effective consolidation stress assigned, by client.			
PERMEANT FLUID	Deaired tap water		
AVERAGE TEST TEMPERATURE	23.0 °C		

HYDRAULIC CONDUCTIVITY TEST

2/26/2020

Project title: CityLondon/EOI LongTermSolidWaste
Borehole number: 19-6-2
Sample depth: -

Flow volume vs. Time
BOREHOLE NUMBER - 19-6-2
SAMPLE - SS1



ASTM D 5084 (CONSTANT HEAD - Method A)

SAMPLE IDENTIFICATION

PROJECT NUMBER	1648176(6000)	SAMPLE	SS2
PROJECT TITLE	City/London/EOI LongTermSolidWaste	SAMPLE DEPTH, m	-
BOREHOLE NUMBER	19-6-2	DATE	2/26/2020

SPECIMEN PROPERTIES AND DIMENSIONS (INITIAL)

SAMPLE HEIGHT, cm	6.72	UNIT WEIGHT, kN/m ³	21.06
SAMPLE DIAMETER, cm	7.17	DRY UNIT WEIGHT, kN/m ³	17.56
SAMPLE AREA, cm ²	40.34	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	271.02	VOLUME OF SOLIDS, cm ³	179.74
TOTAL MASS, g	581.97	VOLUME OF VOIDS, cm ³	91.28
DRY MASS, g	485.30	VOID RATIO	0.51
WATER CONTENT, %	19.9		

SATURATION STAGE

CELL PRESSURE, kPa	350.00	EFFECTIVE CONSOLIDATION STRESS, kPa	10
HEAD PRESSURE, kPa	340.00	DURATION, min	6,941
BACK PRESSURE, kPa	340.00	<i>B</i> COEFFICIENT	0.96

CONSOLIDATION STAGE

CELL PRESSURE, kPa	590.00	EFFECTIVE CONSOLIDATION STRESS, kPa	250
HEAD PRESSURE, kPa	340.00	DURATION, min	1,280
BACK PRESSURE, kPa	340.00	VOLUME CHANGE, cm ³	9.65
		DRAINAGE	Top and Bottom

SPECIMEN PROPERTIES AND DIMENSIONS (AFTER CONSOLIDATION)

SAMPLE HEIGHT, cm	6.64	SAMPLE AREA, cm ²	39.39
SAMPLE DIAMETER, cm	7.08	SAMPLE VOLUME, cm ³	261.45

HYDRAULIC CONDUCTIVITY STAGE

CELL PRESSURE, kPa	603	EFFECTIVE CONSOLIDATION STRESS, kPa	250
HEAD PRESSURE, kPa	353	DURATION, min	2819
BACK PRESSURE, kPa	340	HYDRAULIC GRADIENT, i	20

SPECIMEN PROPERTIES AND DIMENSIONS (FINAL)

SAMPLE HEIGHT, cm	6.64	UNIT WEIGHT, kN/m ³	21.74
SAMPLE DIAMETER, cm	7.08	DRY UNIT WEIGHT, kN/m ³	18.20
SAMPLE AREA, cm ²	39.39	SPECIFIC GRAVITY, assumed	2.70
SAMPLE VOLUME, cm ³	261.45	VOLUME OF SOLIDS, cm ³	179.74
TOTAL MASS, g	579.56	VOLUME OF VOIDS, cm ³	81.71
DRY MASS, g	485.30	VOID RATIO	0.45
WATER CONTENT, %	19.4		

TEST RESULTS

ELAPSED TIME TO STEADY STATE FLOW (min)	0.0
DURATION OF STEADY STATE FLOW (min)	2819
INFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)	1.5
OUTFLOW VOLUME UNDER STEADY STATE FLOW (cm ³)	1.4
INFLOW TO OUTFLOW RATIO	1.0
HYDRAULIC CONDUCTIVITY (INFLOW) (m/s)	1.09E-10
HYDRAULIC CONDUCTIVITY (OUTFLOW) (m/s)	1.05E-10
HYDRAULIC CONDUCTIVITY, K, m/s	1.07E-10
HYDRAULIC CONDUCTIVITY AT STANDARD TEMPERATURE, K₂₀, m/s	9.97E-11

NOTES:

Effective consolidation stress assigned, by client.

PERMEANT FLUID Deaired tap water

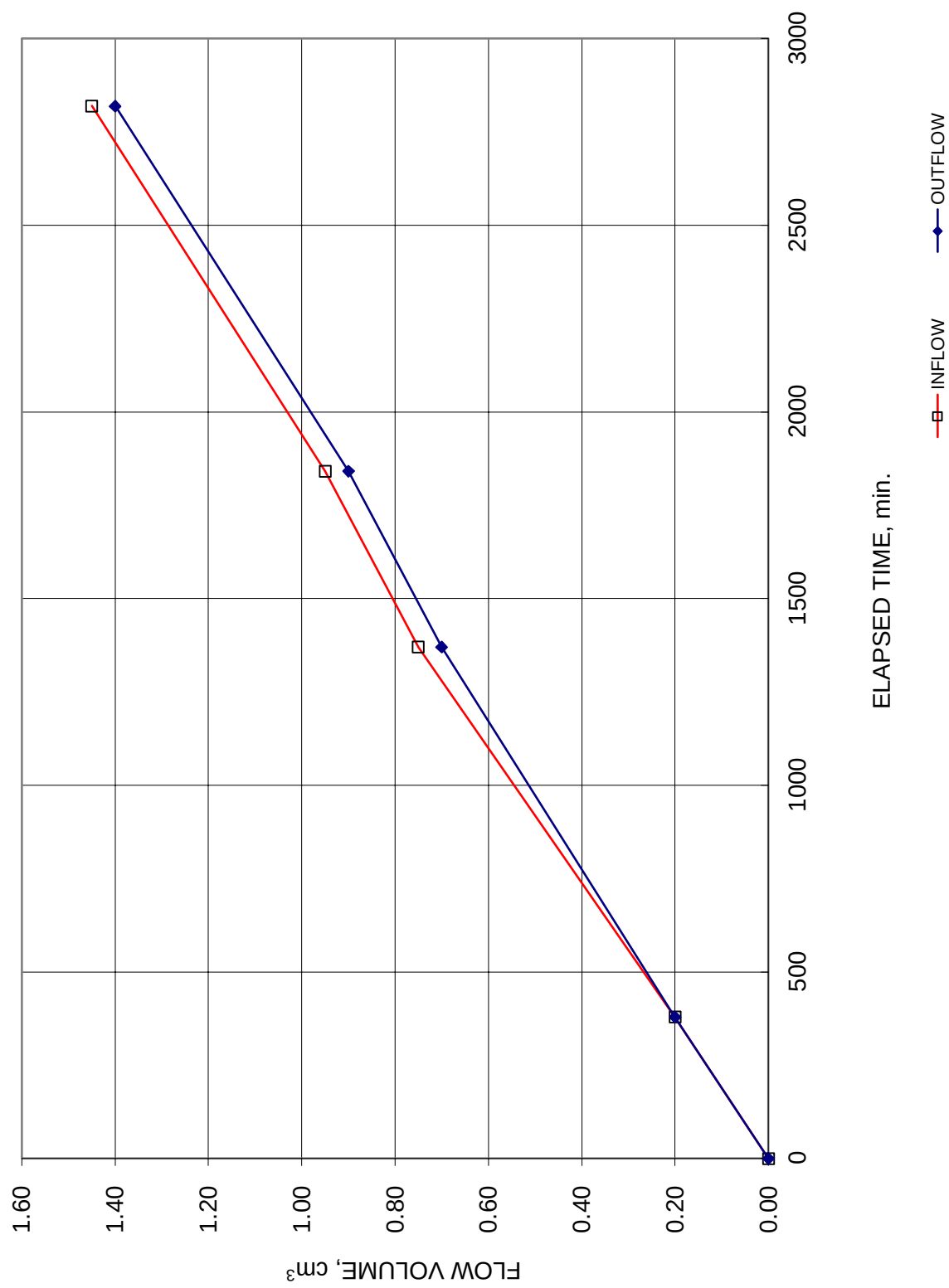
AVERAGE TEST TEMPERATURE 23.0 °C

HYDRAULIC CONDUCTIVITY TEST

2/26/2020

Project title: CityLondon/EOI LongTermSolidWaste
Borehole number: 19-6-2
Sample depth: -

Flow volume vs. Time
BOREHOLE NUMBER - 19-6-2
SAMPLE - SS2



Appendix E

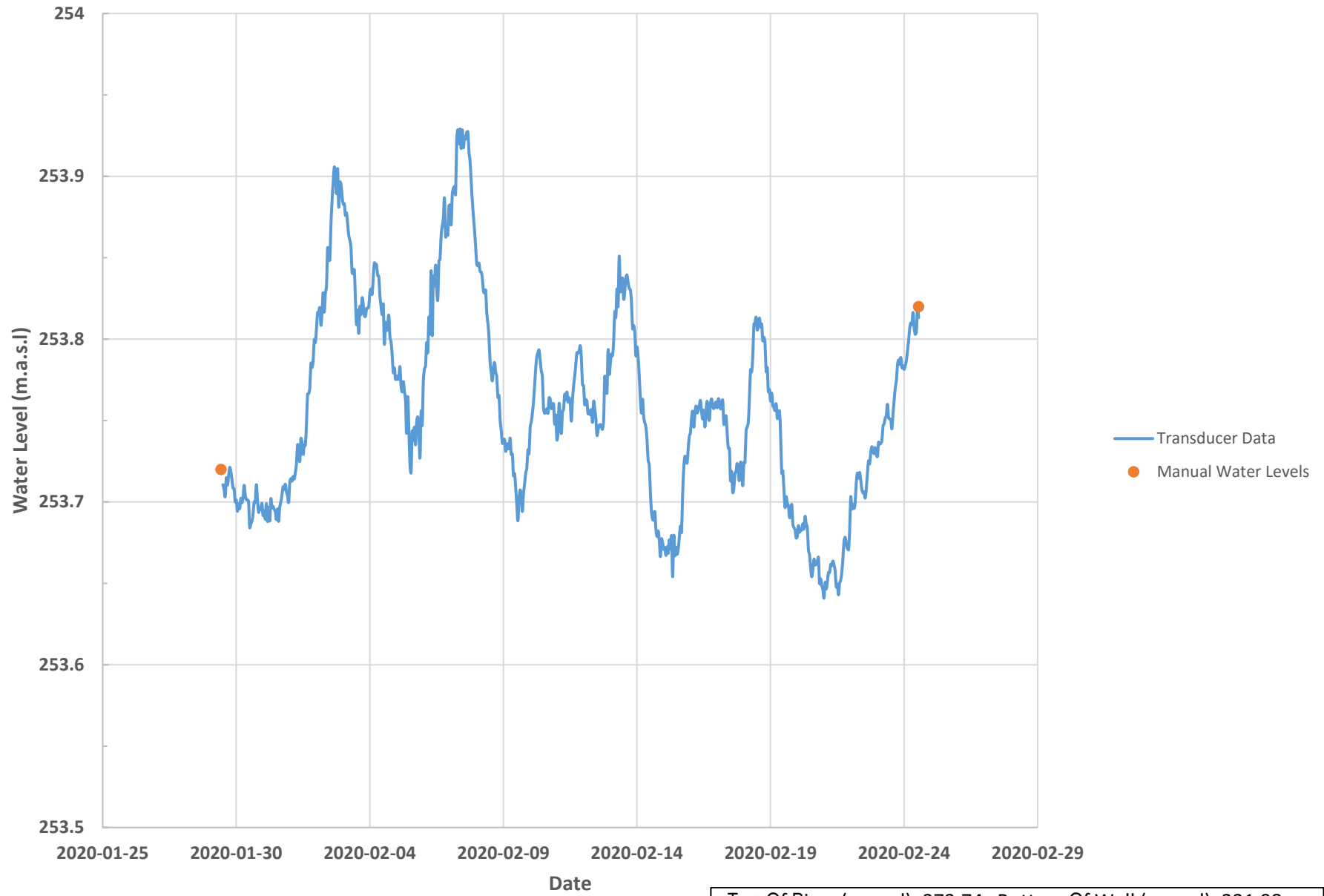
Water Levels and Hydrographs

Monitoring Well Installation Details and Groundwater Level Summary

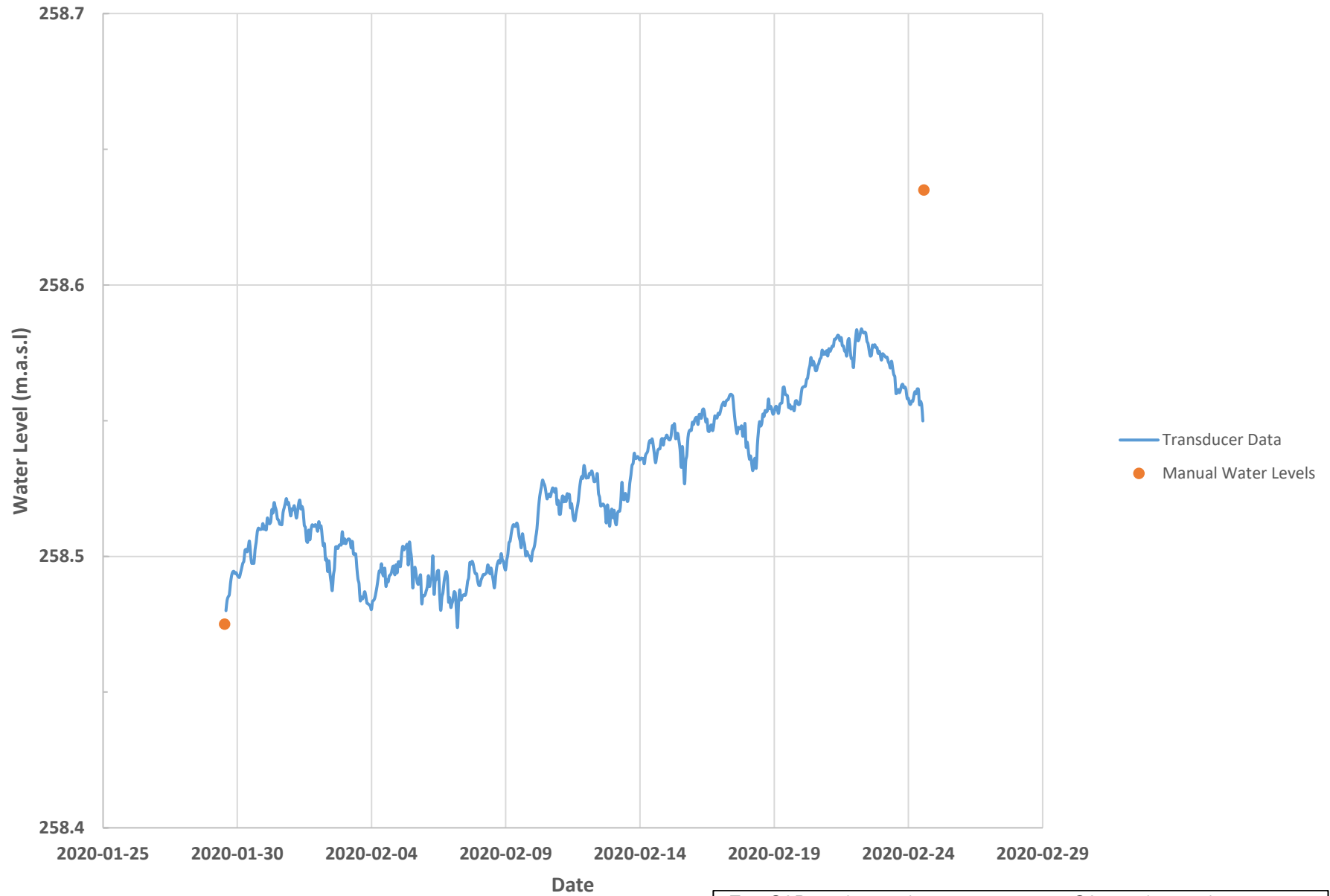
Well Number	Borehole ID	Aquifer	Ground Surface Elevation (masl)	UTM		Well Depth (mbgs)	Well Bottom Elevation (masl)	Top of Riser Elevation (masl)	Top of Well Screen		Bottom of Well Screen		November 27, 2019		January 29, 2020		February 24, 2020	
				Easting (m)	Northing (m)				Depth (mbgs)	Elevation (masl)	Depth (mbgs)	Elevation (masl)	Static Water Level (mbgs)	Static Water Elevation (masl)	Static Water Level (mbgs)	Static Water Elevation (masl)	Static Water Level (mbgs)	Static Water Elevation (masl)
19-1	BH19-1	WOA	272.97	482562	4747433	41.0	232.0	273.739	39.5	233.5	41.0	232.0	19.23	253.74	19.25	253.72	19.15	253.82
19-2a	BH19-2	UA	272.29	482505	4747770	45.6	226.7	273.012	44.1	228.2	45.6	226.7	18.73	253.56	18.34	253.95	18.25	254.04
19-2b	92-7	UA	272.20	482507	4747769	13.8	258.4	272.985	12.3	259.9	13.8	258.4	12.69	259.51	12.76	259.44	12.66	259.54
19-3	BH19-3	WOA	274.34	482425	4748008	48.6	225.8	275.145	47.0	227.3	48.6	225.8	16.67	257.67	15.86	258.48	15.70	258.64
19-4a	BH19-4	WOA	280.34	480896	4748251	39.5	240.9	281.088	38.0	242.4	39.5	240.9	22.08	258.26	21.59	258.75	21.56	258.77
19-4b	BH19-4-2	UA	280.44	480898	4748253	22.8	257.7	281.121	21.3	259.2	22.8	257.7	21.78	258.66	21.66	258.78	21.60	258.84
19-5a	BH19-5	WOA	282.58	481335	4748299	39.5	243.0	283.282	38.0	244.6	39.5	243.0	24.14	258.44	23.80	258.78	23.76	258.82
19-5b	BH19-5-2	UA	282.65	481336	4748300	22.1	260.6	283.439	20.6	262.1	22.1	260.6	21.47	261.19	21.82	260.84	21.79	260.87
19-6a	BH19-6	WOA	280.91	481678	4748289	39.5	241.4	281.647	38.0	242.9	39.5	241.4	22.70	258.21	22.22	258.69	22.17	258.74
19-6b	BH19-6-2	UA	280.92	481679	4748289	12.9	268.0	281.694	11.4	269.5	12.9	268.0	2.88	278.03	1.26	279.65	1.70	279.22
19-7a	BH19-7	WOA	278.49	480718	4748242	41.3	237.2	279.287	39.7	238.7	41.3	237.2	20.05	258.44	19.71	258.78	19.68	258.81
19-7b	BH19-7-2	WOA	278.61	480721	4748242	21.5	257.1	279.373	20.0	258.6	21.5	257.1	19.94	258.67	19.79	258.82	19.77	258.84
19-7c	BH19-7-3	SA	278.55	480715	4748242	5.9	272.6	279.330	4.4	274.1	5.9	272.6	4.80	273.75	1.09	277.46	0.86	277.70

Notes: WOA = White Oaks Aquifer; UA= Upper Aquifer; SA = Surficial Aquitard

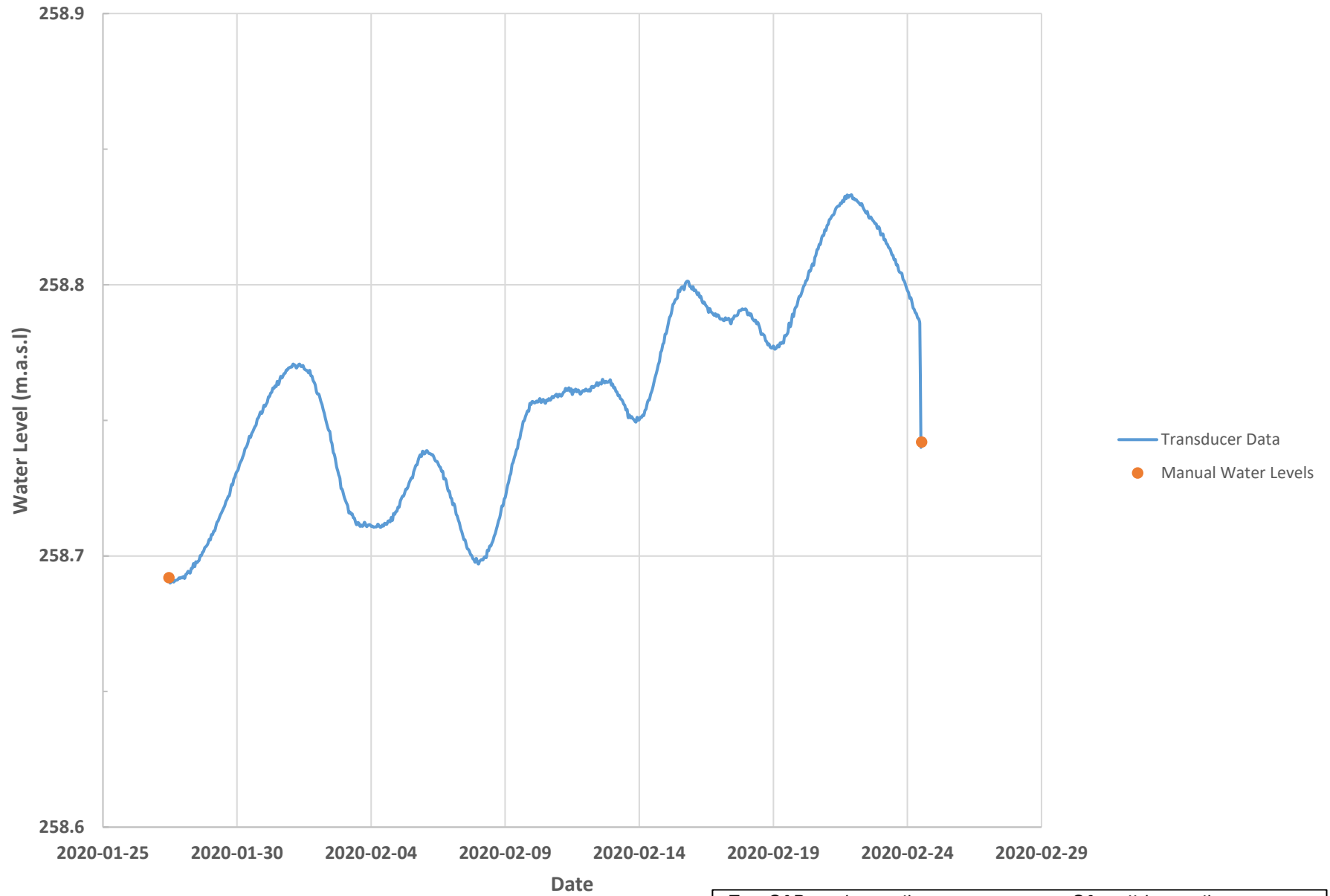
19-1



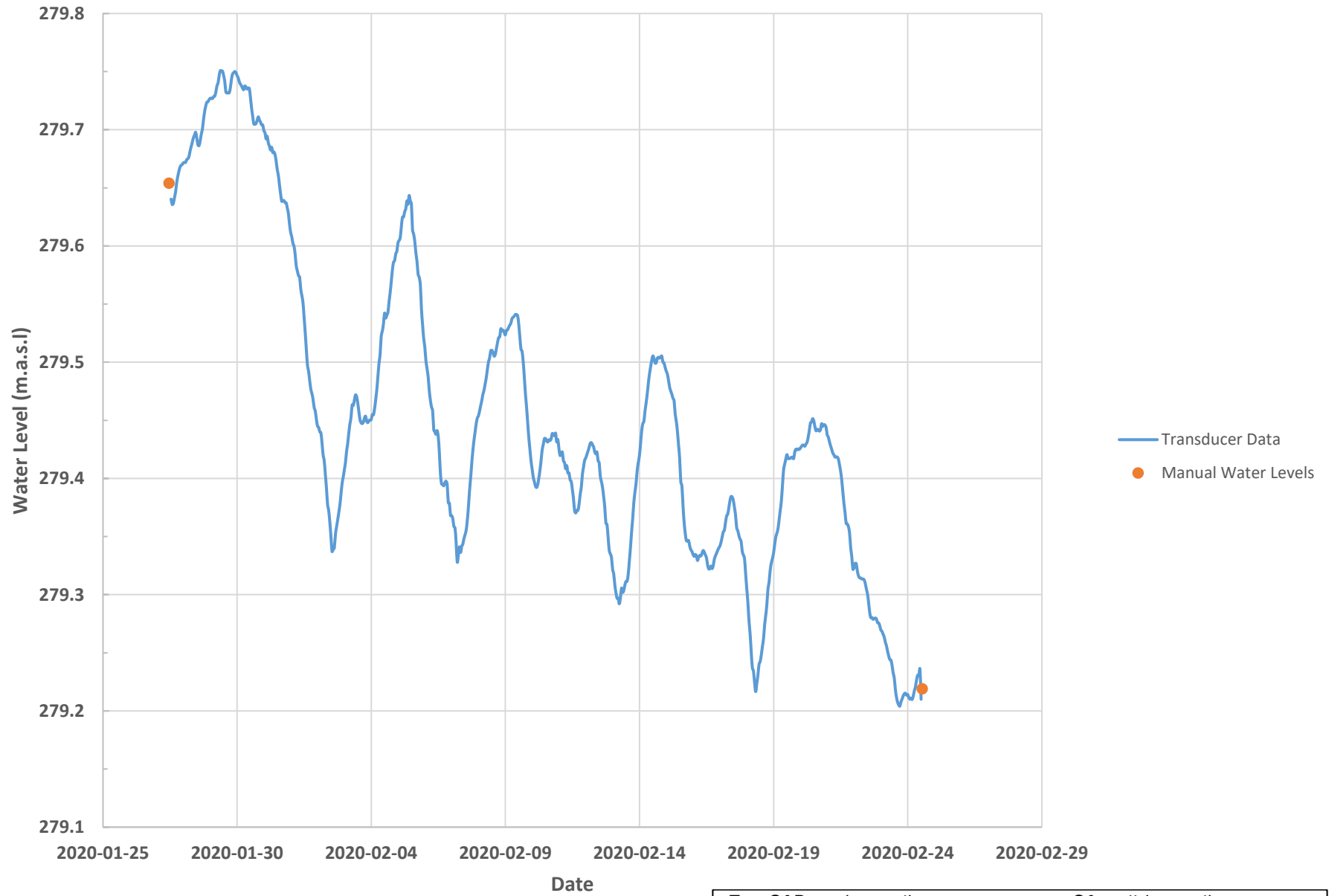
19-3



19-6A

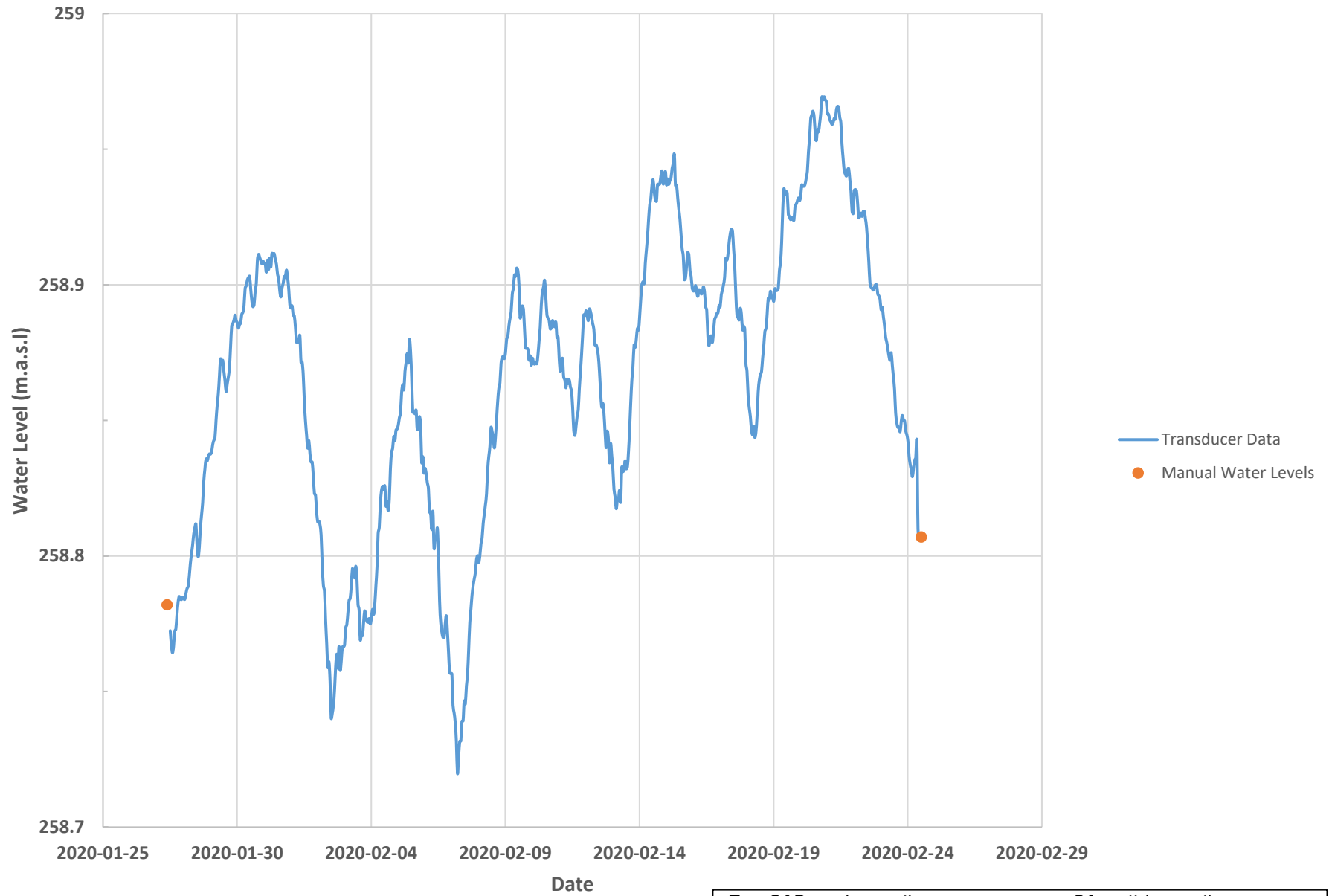


19-6B

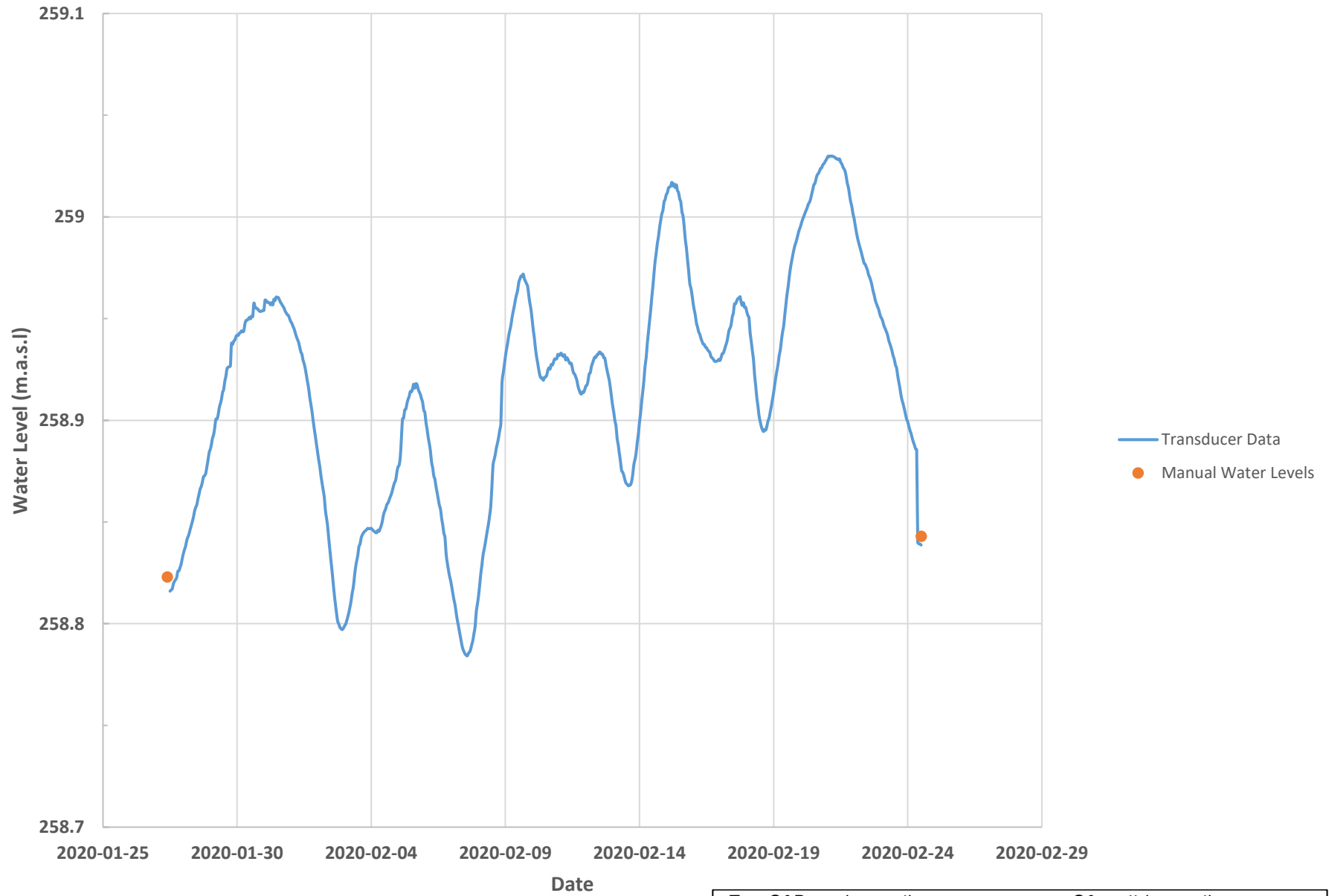


Top Of Riser (m.a.s.l): 281.69 Bottom Of Well (m.a.s.l): 267.98

19-7A

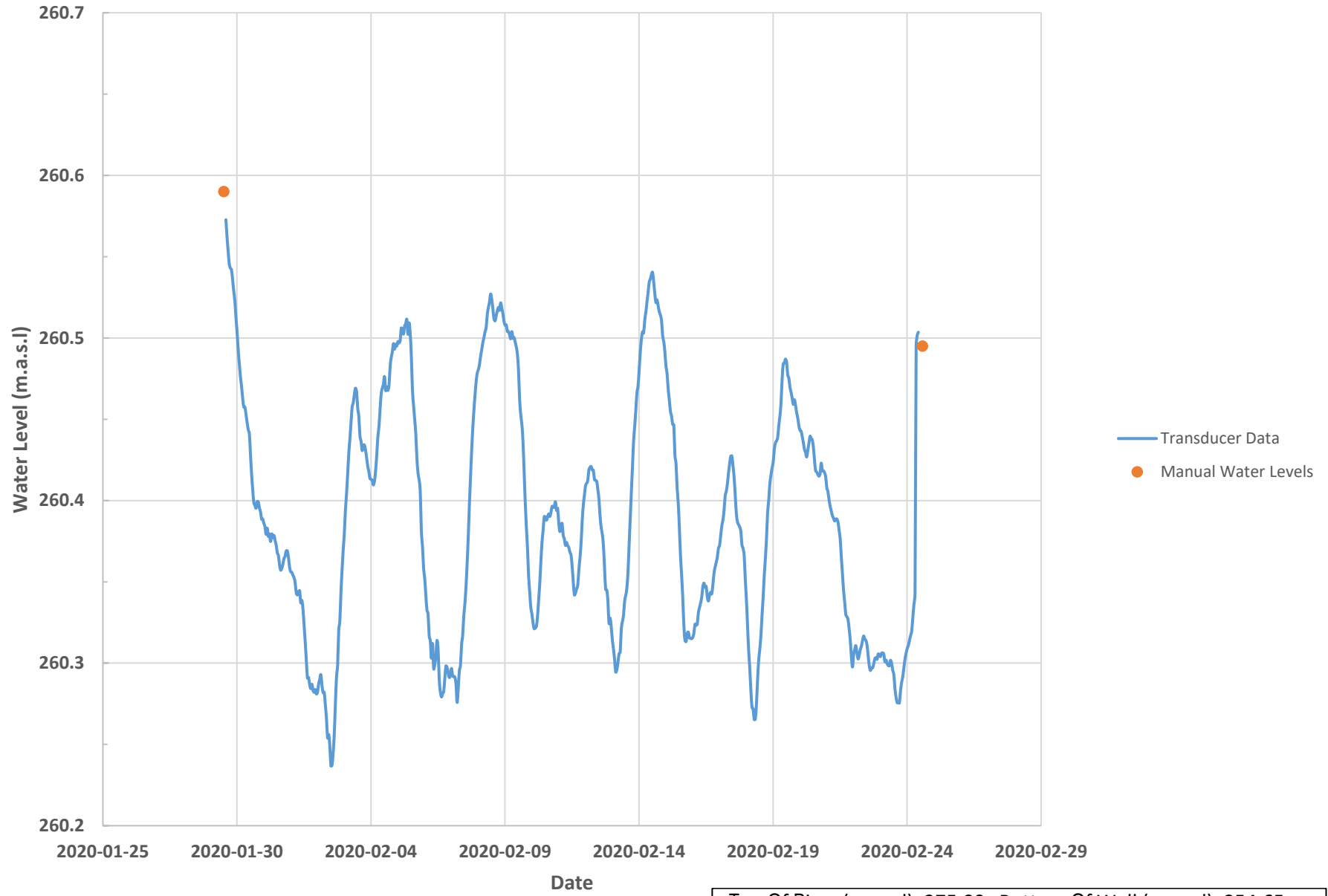


19-7B

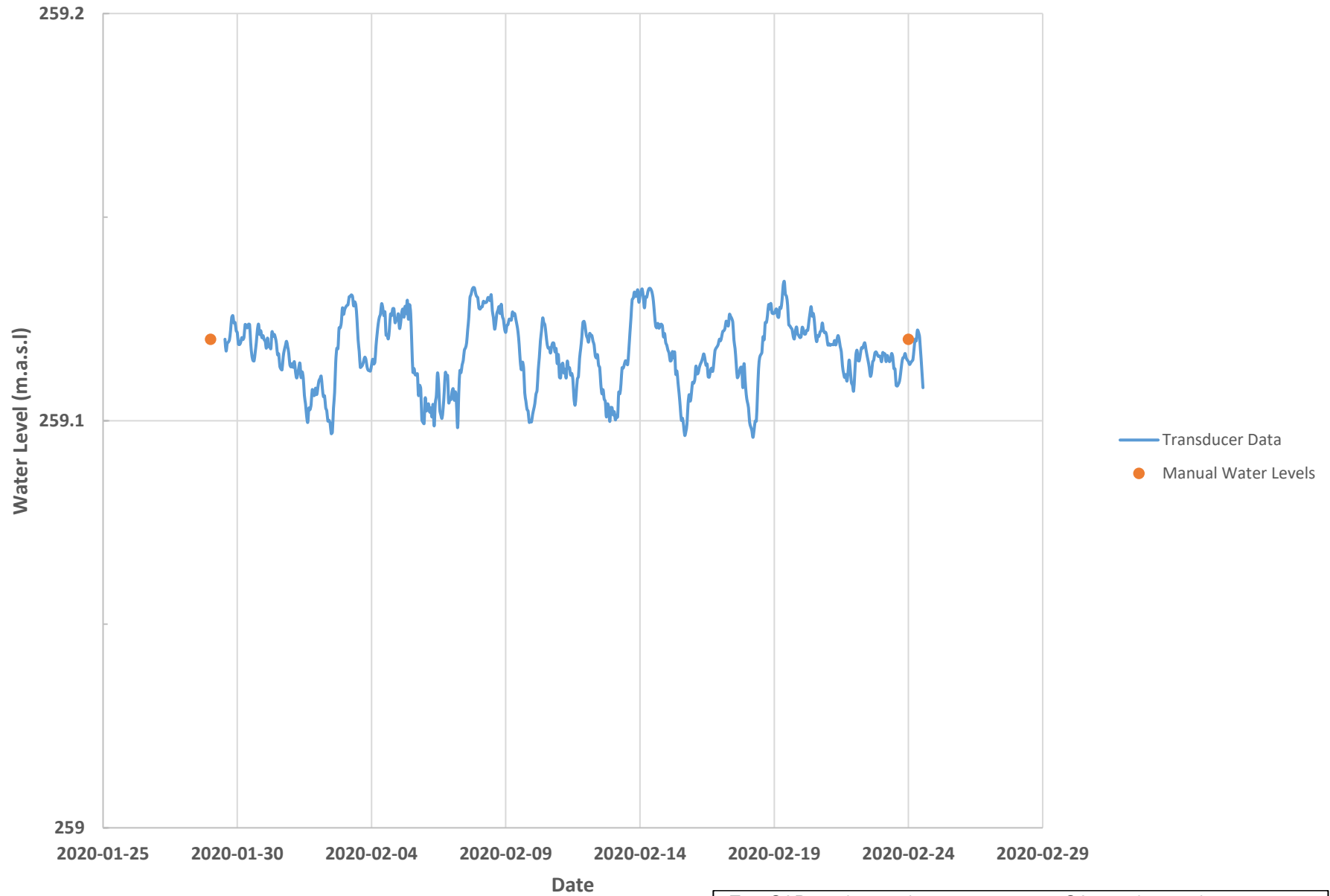


Top Of Riser (m.a.s.l): 279.37 Bottom Of Well (m.a.s.l): 257.12

92-3



92-4



Appendix F

Groundwater Quality

Summary of Groundwater Quality Results

Monitoring Well		19-1	19-3	19-3 (Dup)	19-4a	19-5a	19-6a	19-6b	19-7a	19-7b	19-7c
Sample ID		BH19-1	BH19-3	BH19-31	BH19-4	BH19-5	BH19-6	BH19-6-2	BH19-7	BH19-7-2	BH19-7-3
Date Sampled		10-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019	11-Dec-2019
	Units										
Physical Tests											
Conductivity	umhos/cm	538	393	394	959	975	1660	1920	1380	978	654
pH	pH units	8.08	7.83	7.83	7.69	7.67	7.40	8.07	7.77	7.89	8.02
Anions and Nutrients											
Alkalinity, Total (as CaCO3)	mg/L	522	247	227	290	304	370	654	317	385	273
Ammonia, Total (as N)	mg/L	0.365	0.118	0.110	0.132	0.050	0.073	0.380	0.081	<0.010	0.049
Bromide (Br)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.50	<0.50	<0.50	<0.10	<0.10
Chloride (Cl)	mg/L	8.08	0.97	0.96	52.6	41.3	21.4	8.8	166	32.1	11.2
Fluoride (F)	mg/L	1.04	1.10	1.14	0.177	0.157	0.14	0.70	0.24	0.263	0.278
Nitrate (as N)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.10	<0.10	<0.10	<0.020	0.182
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.050	<0.050	<0.050	<0.010	0.032
Total Kjeldahl Nitrogen	mg/L	0.48	0.49	0.33	0.28	0.26	0.38	0.56	0.26	0.28	0.26
Sulfate (SO4)	mg/L	66.0	1.35	1.68	166	175	694	606	230	162	82.3
Organic / Inorganic Carbon											
Dissolved Organic Carbon	mg/L	6.80	7.68	7.66	18.5	14.5	7.27	3.82	24.4	72.1	3.38
Dissolved Metals											
Arsenic (As)-Dissolved	mg/L	0.00792	0.00057	0.00055	0.00160	0.00105	0.0012	0.0021	0.00056	0.00194	0.00097
Barium (Ba)-Dissolved	mg/L	0.0624	0.368	0.354	0.0606	0.143	0.0421	0.0824	0.0450	0.0639	0.114
Boron (B)-Dissolved	mg/L	0.194	0.096	0.091	0.024	0.028	<0.10	0.25	0.026	0.035	0.073
Cadmium (Cd)-Dissolved	mg/L	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	<0.000050	<0.000050	<0.000010	0.000016	<0.000010
Calcium (Ca)-Dissolved	mg/L	32.4	40.8	40.2	123	123	297	93.8	172	117	59.7
Iron (Fe)-Dissolved	mg/L	0.701	0.450	0.451	1.40	1.91	7.66	<0.10	2.67	0.048	0.018
Lead (Pb)-Dissolved	mg/L	0.000619	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.000050	0.000114	<0.000050
Magnesium (Mg)-Dissolved	mg/L	10.5	14.8	14.5	19.7	26.0	56.4	176	32.5	35.0	40.7
Manganese (Mn)-Dissolved	mg/L	0.0614	0.0201	0.0198	0.167	0.0825	0.156	0.0840	0.108	0.268	0.00189
Nickel (Ni)-Dissolved	mg/L	0.00381	0.00134	0.00137	0.00095	0.00129	<0.0050	<0.0050	0.00130	0.0176	<0.00050
Potassium (K)-Dissolved	mg/L	1.47	1.72	1.68	4.82	2.33	2.57	3.20	3.26	2.65	5.50
Sodium (Na)-Dissolved	mg/L	80.4	31.0	30.7	60.9	56.5	42.4	110	92.2	53.9	20.2
Zinc (Zn)-Dissolved	mg/L	0.0028	0.0014	0.0015	0.0029	0.0038	<0.010	<0.010	0.0031	0.0292	<0.0010
Aggregate Organics											
COD	mg/L	40	109	80	43	68	40	<10	27	291	45
Phenols (4AAP)	mg/L	0.0016	0.0022	0.0025	0.0039	0.0040	0.0045	0.0030	0.0032	0.0046	0.0046
Volatile Organic Compounds											
Acetone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Benzene	ug/L	0.80	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bromodichloromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromoform	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bromomethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Carbon Disulfide	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Carbon tetrachloride	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dibromochloromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.6	<1.0	3.8	<1.0
Chloromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dibromoethane	ug/L	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,2-Dichlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,3-Dichlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,4-Dichlorobenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dichlorodifluoromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,2-Dichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
cis-1,2-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,2-Dichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Dichloromethane	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
1,2-Dichloropropane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
cis-1,3-Dichloropropene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,3-Dichloropropene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Ethylbenzene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
n-Hexane	ug/L	<0.50	0.53	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
2-Hexanone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Methyl Ethyl Ketone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Methyl Isobutyl Ketone	ug/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
MTBE	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Styrene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,1,2-Tetrachloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,1,2,2-Tetrachloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tetrachloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Toluene	ug/L	0.65	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,1-Trichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
1,1,2-Trichloroethane	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Trichloroethylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Trichlorofluoromethane	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
o-Xylene	ug/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
m+p-Xylenes	ug/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Xylenes (Total)	ug/L	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
Trihalomethanes											
Total THMs	ug/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.8	<2.0



The Corporation of the City of London
ATTN: Wesley Abbott
PO Box 5035, 300 Dufferin Ave.,
London ON N6A 4L9

Date Received: 10-DEC-19
Report Date: 17-DEC-19 12:53 (MT)
Version: FINAL

Client Phone: 519-661-2489

Certificate of Analysis

Lab Work Order #: L2394310
Project P.O. #: NOT SUBMITTED
Job Reference: W12A LANDFILL
C of C Numbers:
Legal Site Desc:



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ADDRESS: 309 Exeter Road Unit #29, London, ON N6L 1C1 Canada | Phone: +1 519 652 6044 | Fax: +1 519 652 0671
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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2394310-1 BH19-1								
Sampled By: MAS on 10-DEC-19 @ 09:45								
Matrix: GW								
Physical Tests								
Conductivity		538		3.0	umhos/cm		12-DEC-19	R4942629
pH		8.08		0.10	pH units		12-DEC-19	R4942629
Anions and Nutrients								
Alkalinity, Bicarbonate (as CaCO3)		522		2.0	mg/L		12-DEC-19	R4942629
Alkalinity, Carbonate (as CaCO3)		<2.0		2.0	mg/L		12-DEC-19	R4942629
Alkalinity, Hydroxide (as CaCO3)		<2.0		2.0	mg/L		12-DEC-19	R4942629
Alkalinity, Total (as CaCO3)		522		2.0	mg/L		12-DEC-19	R4942629
Ammonia, Total (as N)		0.365		0.010	mg/L		11-DEC-19	R4941436
Bromide (Br)		<0.10		0.10	mg/L		12-DEC-19	R4942830
Chloride (Cl)		8.08		0.50	mg/L		12-DEC-19	R4942830
Fluoride (F)		1.04		0.020	mg/L		12-DEC-19	R4942830
Nitrate (as N)		<0.020		0.020	mg/L		12-DEC-19	R4942830
Nitrite (as N)		<0.010		0.010	mg/L		12-DEC-19	R4942830
Total Kjeldahl Nitrogen		0.48		0.15	mg/L	12-DEC-19	12-DEC-19	R4942015
Sulfate (SO4)		66.0		0.30	mg/L		12-DEC-19	R4942830
Organic / Inorganic Carbon								
Dissolved Carbon Filtration Location		FIELD				10-DEC-19	12-DEC-19	R4942130
Dissolved Organic Carbon		6.80		0.50	mg/L	10-DEC-19	16-DEC-19	R4944534
Dissolved Metals								
Dissolved Metals Filtration Location		FIELD					12-DEC-19	R4941324
Arsenic (As)-Dissolved		0.00792		0.00010	mg/L	12-DEC-19	13-DEC-19	R4942544
Barium (Ba)-Dissolved		0.0624		0.00010	mg/L	12-DEC-19	13-DEC-19	R4942544
Boron (B)-Dissolved		0.194		0.010	mg/L	12-DEC-19	13-DEC-19	R4942544
Cadmium (Cd)-Dissolved		0.000011		0.000010	mg/L	12-DEC-19	13-DEC-19	R4942544
Calcium (Ca)-Dissolved		32.4		0.050	mg/L	12-DEC-19	13-DEC-19	R4942544
Iron (Fe)-Dissolved		0.701		0.010	mg/L	12-DEC-19	13-DEC-19	R4942544
Lead (Pb)-Dissolved		0.000619		0.000050	mg/L	12-DEC-19	13-DEC-19	R4942544
Magnesium (Mg)-Dissolved		10.5		0.050	mg/L	12-DEC-19	13-DEC-19	R4942544
Manganese (Mn)-Dissolved		0.0614		0.00050	mg/L	12-DEC-19	13-DEC-19	R4942544
Nickel (Ni)-Dissolved		0.00381		0.00050	mg/L	12-DEC-19	13-DEC-19	R4942544
Potassium (K)-Dissolved		1.47		0.050	mg/L	12-DEC-19	13-DEC-19	R4942544
Sodium (Na)-Dissolved		80.4		0.50	mg/L	12-DEC-19	13-DEC-19	R4942544
Zinc (Zn)-Dissolved		0.0028		0.0010	mg/L	12-DEC-19	13-DEC-19	R4942544
Aggregate Organics								
COD		40		10	mg/L		17-DEC-19	R4944530
Phenols (4AAP)		0.0016		0.0010	mg/L		11-DEC-19	R4941406
Volatile Organic Compounds								
Acetone		<20		20	ug/L		16-DEC-19	R4943976
Benzene		0.80		0.50	ug/L		16-DEC-19	R4943976
Bromodichloromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Bromoform		<1.0		1.0	ug/L		16-DEC-19	R4943976
Bromomethane		<0.50		0.50	ug/L		16-DEC-19	R4943976

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2394310-1	BH19-1							
Sampled By: MAS on 10-DEC-19 @ 09:45								
Matrix: GW								
Volatile Organic Compounds								
Carbon Disulfide		<1.0		1.0	ug/L		16-DEC-19	R4943976
Carbon tetrachloride		<0.50		0.50	ug/L		16-DEC-19	R4943976
Chlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Dibromochloromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Chloroethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Chloroform		<1.0		1.0	ug/L		16-DEC-19	R4943976
Chloromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
1,2-Dibromoethane		<0.20		0.20	ug/L		16-DEC-19	R4943976
1,2-Dichlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,3-Dichlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,4-Dichlorobenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Dichlorodifluoromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
1,1-Dichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,2-Dichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1-Dichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
cis-1,2-Dichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
trans-1,2-Dichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Dichloromethane		<2.0		2.0	ug/L		16-DEC-19	R4943976
1,2-Dichloropropane		<0.50		0.50	ug/L		16-DEC-19	R4943976
cis-1,3-Dichloropropene		<0.50		0.50	ug/L		16-DEC-19	R4943976
trans-1,3-Dichloropropene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Ethylbenzene		<0.50		0.50	ug/L		16-DEC-19	R4943976
n-Hexane		<0.50		0.50	ug/L		16-DEC-19	R4943976
2-Hexanone		<20		20	ug/L		16-DEC-19	R4943976
Methyl Ethyl Ketone		<20		20	ug/L		16-DEC-19	R4943976
Methyl Isobutyl Ketone		<20		20	ug/L		16-DEC-19	R4943976
MTBE		<0.50		0.50	ug/L		16-DEC-19	R4943976
Styrene		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1,1,2-Tetrachloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1,2,2-Tetrachloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
Tetrachloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Toluene		0.65		0.50	ug/L		16-DEC-19	R4943976
1,1,1-Trichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
1,1,2-Trichloroethane		<0.50		0.50	ug/L		16-DEC-19	R4943976
Trichloroethylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
Trichlorofluoromethane		<1.0		1.0	ug/L		16-DEC-19	R4943976
Vinyl chloride		<0.50		0.50	ug/L		16-DEC-19	R4943976
o-Xylene		<0.50		0.50	ug/L		16-DEC-19	R4943976
m+p-Xylenes		<1.0		1.0	ug/L		16-DEC-19	R4943976
Xylenes (Total)		<1.1		1.1	ug/L		16-DEC-19	R4943976
Surrogate: 4-Bromofluorobenzene		95.2		70-130	%		16-DEC-19	R4943976

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	Batch
L2394310-1	BH19-1							
Sampled By: MAS on 10-DEC-19 @ 09:45								
Matrix: GW								
Volatile Organic Compounds								
Surrogate: 1,4-Difluorobenzene		100.3		70-130	%		16-DEC-19	R4943976
Trihalomethanes								
Total THMs		<2.0		2.0	ug/L		16-DEC-19	

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Fluoride (F)	MS-B	L2394310-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2394310-1
Matrix Spike	Boron (B)-Dissolved	MS-B	L2394310-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2394310-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2394310-1
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2394310-1
Matrix Spike	Potassium (K)-Dissolved	MS-B	L2394310-1
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2394310-1
Matrix Spike	Ammonia, Total (as N)	MS-B	L2394310-1
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L2394310-1

Sample Parameter Qualifier key listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
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ALK-SPEC-PCT-WT Water Automated Speciated Alkalinity APHA 2320B

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-IC-N-WT Water Bromide in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CL-IC-N-WT Water Chloride by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

COD-T-WT Water Chemical Oxygen Demand APHA 5220 D

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

DOC-WT Water Dissolved Organic Carbon APHA 5310B

Sample is filtered through a 0.45um filter, then injected into a heated reaction chamber which is packed with an oxidative catalyst. The water is vaporized and the organic carbon is oxidized to carbon dioxide. The carbon dioxide is transported in a carrier gas and is measured by a non-dispersive infrared detector.

EC-SCREEN-WT Water Conductivity Screen (Internal Use Only) APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

EC-WT Water Conductivity APHA 2510 B

Water samples can be measured directly by immersing the conductivity cell into the sample.

F-IC-N-WT Water Fluoride in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

MET-D-CCMS-WT Water Dissolved Metals in Water by CRC ICPMS APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et

al.			
NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
PH-WT	Water	pH	APHA 4500 H-Electrode
Water samples are analyzed directly by a calibrated pH meter.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days			
PHENOLS-4AAP-WT	Water	Phenol (4AAP)	EPA 9066
An automated method is used to distill the sample. The distillate is then buffered to pH 9.4 which reacts with 4AAP and potassium ferricyanide to form a red complex which is measured colorimetrically.			
SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
THM-SUM-PPB-CALC-WT	Water	Total Trihalomethanes (THMs)	CALCULATION
Total Trihalomethanes (THMs) represents the sum of bromodichloromethane, bromoform, chlorodibromomethane and chloroform. For the purpose of calculation, results less than the detection limit (DL) are treated as zero.			
TKN-WT	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg D
This analysis is carried out using procedures adapted from APHA Method 4500-Norg "Nitrogen (Organic)". Total Kjeldahl Nitrogen is determined by sample digestion at 380 Celsius with analysis using an automated colorimetric method.			
VOC-ROU-HS-WT	Water	Volatile Organic Compounds	SW846 8260
Aqueous samples are analyzed by headspace-GC/MS.			
XYLENES-SUM-CALC-WT	Water	Sum of Xylene Isomer Concentrations	CALCULATION
Total xylenes represents the sum of o-xylene and m&p-xylene.			

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS
Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid weight of sample
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

Page 2 of 11

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
DOC-WT		Water						
Batch	R4944534							
WG3241256-3	DUP	L2394310-1						
Dissolved Organic Carbon		6.80	7.02		mg/L	3.2	20	16-DEC-19
WG3241256-2	LCS							
Dissolved Organic Carbon			104.5		%		80-120	16-DEC-19
WG3241256-1	MB							
Dissolved Organic Carbon			<0.50		mg/L		0.5	16-DEC-19
WG3241256-4	MS	L2394310-1						
Dissolved Organic Carbon			98.2		%		70-130	16-DEC-19
EC-WT		Water						
Batch	R4942629							
WG3241028-2	LCS							
Conductivity			99.0		%		90-110	12-DEC-19
WG3241028-1	MB							
Conductivity			<3.0		umhos/cm		3	12-DEC-19
F-IC-N-WT		Water						
Batch	R4942830							
WG3240868-4	DUP	L2394310-1						
Fluoride (F)		1.04	1.03		mg/L	0.4	20	12-DEC-19
WG3240868-2	LCS							
Fluoride (F)			103.6		%		90-110	12-DEC-19
WG3240868-1	MB							
Fluoride (F)			<0.020		mg/L		0.02	12-DEC-19
WG3240868-5	MS	L2394310-1						
Fluoride (F)			N/A	MS-B	%		-	12-DEC-19
MET-D-CCMS-WT		Water						
Batch	R4942544							
WG3240627-2	LCS							
Arsenic (As)-Dissolved			98.3		%		80-120	12-DEC-19
Barium (Ba)-Dissolved			104.4		%		80-120	12-DEC-19
Boron (B)-Dissolved			96.6		%		80-120	12-DEC-19
Cadmium (Cd)-Dissolved			96.5		%		80-120	12-DEC-19
Calcium (Ca)-Dissolved			99.97		%		80-120	12-DEC-19
Iron (Fe)-Dissolved			104.0		%		80-120	12-DEC-19
Lead (Pb)-Dissolved			101.6		%		80-120	12-DEC-19
Magnesium (Mg)-Dissolved			101.1		%		80-120	12-DEC-19
Manganese (Mn)-Dissolved			102.4		%		80-120	12-DEC-19
Nickel (Ni)-Dissolved			99.6		%		80-120	12-DEC-19

Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

Page 5 of 11

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-4	DUP	L2394310-1						
1,1,1,2-Tetrachloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1,2,2-Tetrachloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1,1-Trichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1,2-Trichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dibromoethane		<0.20	<0.20	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1-Dichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,1-Dichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dichlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dichloroethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,2-Dichloropropane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,3-Dichlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
1,4-Dichlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
2-Hexanone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
Acetone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
Benzene		0.80	0.80		ug/L	0.0	30	16-DEC-19
Bromodichloromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Bromoform		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Bromomethane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Carbon Disulfide		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Carbon tetrachloride		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Chlorobenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Chloroethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Chloroform		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Chloromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
cis-1,2-Dichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
cis-1,3-Dichloropropene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Dibromochloromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Dichlorodifluoromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Dichloromethane		<2.0	<2.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Ethylbenzene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
m+p-Xylenes		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Methyl Ethyl Ketone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
Methyl Isobutyl Ketone		<20	<20	RPD-NA	ug/L	N/A	30	16-DEC-19
n-Hexane		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19



Quality Control Report

Workorder: L2394310

Report Date: 17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-4	DUP	L2394310-1						
MTBE		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
o-Xylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Styrene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Tetrachloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Toluene		0.65	0.64		ug/L	1.6	30	16-DEC-19
trans-1,2-Dichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
trans-1,3-Dichloropropene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Trichloroethylene		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
Trichlorofluoromethane		<1.0	<1.0	RPD-NA	ug/L	N/A	30	16-DEC-19
Vinyl chloride		<0.50	<0.50	RPD-NA	ug/L	N/A	30	16-DEC-19
WG3239182-1	LCS							
1,1,1,2-Tetrachloroethane			87.3		%		70-130	16-DEC-19
1,1,2,2-Tetrachloroethane			99.6		%		70-130	16-DEC-19
1,1,1-Trichloroethane			88.6		%		70-130	16-DEC-19
1,1,2-Trichloroethane			88.3		%		70-130	16-DEC-19
1,2-Dibromoethane			93.0		%		70-130	16-DEC-19
1,1-Dichloroethane			86.3		%		70-130	16-DEC-19
1,1-Dichloroethylene			83.1		%		70-130	16-DEC-19
1,2-Dichlorobenzene			88.2		%		70-130	16-DEC-19
1,2-Dichloroethane			94.3		%		70-130	16-DEC-19
1,2-Dichloropropane			88.3		%		70-130	16-DEC-19
1,3-Dichlorobenzene			84.7		%		70-130	16-DEC-19
1,4-Dichlorobenzene			85.7		%		70-130	16-DEC-19
2-Hexanone			91.1		%		60-140	16-DEC-19
Acetone			107.1		%		60-140	16-DEC-19
Benzene			93.5		%		70-130	16-DEC-19
Bromodichloromethane			91.7		%		70-130	16-DEC-19
Bromoform			101.3		%		70-130	16-DEC-19
Bromomethane			88.8		%		60-140	16-DEC-19
Carbon Disulfide			90.7		%		70-130	16-DEC-19
Carbon tetrachloride			94.5		%		70-130	16-DEC-19
Chlorobenzene			84.0		%		70-130	16-DEC-19
Chloroethane			98.7		%		70-130	16-DEC-19
Chloroform			90.6		%		70-130	16-DEC-19



Quality Control Report

Workorder: L2394310

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-1	LCS							
Chloromethane			98.4		%		60-140	16-DEC-19
cis-1,2-Dichloroethylene			87.6		%		70-130	16-DEC-19
cis-1,3-Dichloropropene			94.5		%		70-130	16-DEC-19
Dibromochloromethane			95.9		%		70-130	16-DEC-19
Dichlorodifluoromethane			111.3		%		50-140	16-DEC-19
Dichloromethane			91.1		%		70-130	16-DEC-19
Ethylbenzene			85.7		%		70-130	16-DEC-19
m+p-Xylenes			87.5		%		70-130	16-DEC-19
Methyl Ethyl Ketone			111.2		%		60-140	16-DEC-19
Methyl Isobutyl Ketone			98.8		%		50-150	16-DEC-19
n-Hexane			84.0		%		70-130	16-DEC-19
MTBE			87.4		%		70-130	16-DEC-19
o-Xylene			85.1		%		70-130	16-DEC-19
Styrene			86.2		%		70-130	16-DEC-19
Tetrachloroethylene			91.0		%		70-130	16-DEC-19
Toluene			88.1		%		70-130	16-DEC-19
trans-1,2-Dichloroethylene			83.4		%		70-130	16-DEC-19
trans-1,3-Dichloropropene			91.5		%		70-130	16-DEC-19
Trichloroethylene			90.0		%		70-130	16-DEC-19
Trichlorofluoromethane			91.9		%		60-140	16-DEC-19
Vinyl chloride			100.7		%		60-140	16-DEC-19
WG3239182-2	MB							
1,1,1,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,1-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dibromoethane			<0.20		ug/L		0.2	16-DEC-19
1,1-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichloropropane			<0.50		ug/L		0.5	16-DEC-19
1,3-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
1,4-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19



Quality Control Report

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-2	MB							
2-Hexanone			<20		ug/L		20	16-DEC-19
Acetone			<20		ug/L		20	16-DEC-19
Benzene			<0.50		ug/L		0.5	16-DEC-19
Bromodichloromethane			<1.0		ug/L		1	16-DEC-19
Bromoform			<1.0		ug/L		1	16-DEC-19
Bromomethane			<0.50		ug/L		0.5	16-DEC-19
Carbon Disulfide			<1.0		ug/L		1	16-DEC-19
Carbon tetrachloride			<0.50		ug/L		0.5	16-DEC-19
Chlorobenzene			<0.50		ug/L		0.5	16-DEC-19
Chloroethane			<1.0		ug/L		1	16-DEC-19
Chloroform			<1.0		ug/L		1	16-DEC-19
Chloromethane			<1.0		ug/L		1	16-DEC-19
cis-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
cis-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Dibromochloromethane			<1.0		ug/L		1	16-DEC-19
Dichlorodifluoromethane			<1.0		ug/L		1	16-DEC-19
Dichloromethane			<2.0		ug/L		2	16-DEC-19
Ethylbenzene			<0.50		ug/L		0.5	16-DEC-19
m+p-Xylenes			<1.0		ug/L		1	16-DEC-19
Methyl Ethyl Ketone			<20		ug/L		20	16-DEC-19
Methyl Isobutyl Ketone			<20		ug/L		20	16-DEC-19
n-Hexane			<0.50		ug/L		0.5	16-DEC-19
MTBE			<0.50		ug/L		0.5	16-DEC-19
o-Xylene			<0.50		ug/L		0.5	16-DEC-19
Styrene			<0.50		ug/L		0.5	16-DEC-19
Tetrachloroethylene			<0.50		ug/L		0.5	16-DEC-19
Toluene			<0.50		ug/L		0.5	16-DEC-19
trans-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
trans-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Trichloroethylene			<0.50		ug/L		0.5	16-DEC-19
Trichlorofluoromethane			<1.0		ug/L		1	16-DEC-19
Vinyl chloride			<0.50		ug/L		0.5	16-DEC-19
Surrogate: 1,4-Difluorobenzene			100.2		%		70-130	16-DEC-19
Surrogate: 4-Bromofluorobenzene			95.5		%		70-130	16-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943976							
WG3239182-5 MS		L2394310-1						
1,1,1,2-Tetrachloroethane			83.6		%		50-150	16-DEC-19
1,1,2,2-Tetrachloroethane			89.0		%		50-150	16-DEC-19
1,1,1-Trichloroethane			86.1		%		50-150	16-DEC-19
1,1,2-Trichloroethane			80.3		%		50-150	16-DEC-19
1,2-Dibromoethane			82.8		%		50-150	16-DEC-19
1,1-Dichloroethane			82.2		%		50-150	16-DEC-19
1,1-Dichloroethylene			82.5		%		50-150	16-DEC-19
1,2-Dichlorobenzene			87.8		%		50-150	16-DEC-19
1,2-Dichloroethane			83.8		%		50-150	16-DEC-19
1,2-Dichloropropane			85.4		%		50-150	16-DEC-19
1,3-Dichlorobenzene			87.4		%		50-150	16-DEC-19
1,4-Dichlorobenzene			88.2		%		50-150	16-DEC-19
2-Hexanone			73.8		%		50-150	16-DEC-19
Acetone			85.3		%		50-150	16-DEC-19
Benzene			93.7		%		50-150	16-DEC-19
Bromodichloromethane			85.7		%		50-150	16-DEC-19
Bromoform			91.2		%		50-150	16-DEC-19
Bromomethane			87.3		%		50-150	16-DEC-19
Carbon Disulfide			91.9		%		50-150	16-DEC-19
Carbon tetrachloride			93.3		%		50-150	16-DEC-19
Chlorobenzene			83.0		%		50-150	16-DEC-19
Chloroethane			97.6		%		50-150	16-DEC-19
Chloroform			86.7		%		50-150	16-DEC-19
Chloromethane			92.4		%		50-150	16-DEC-19
cis-1,2-Dichloroethylene			84.7		%		50-150	16-DEC-19
cis-1,3-Dichloropropene			96.4		%		50-150	16-DEC-19
Dibromochloromethane			88.3		%		50-150	16-DEC-19
Dichlorodifluoromethane			97.5		%		50-150	16-DEC-19
Dichloromethane			84.7		%		50-150	16-DEC-19
Ethylbenzene			87.3		%		50-150	16-DEC-19
m+p-Xylenes			89.7		%		50-150	16-DEC-19
Methyl Ethyl Ketone			85.6		%		50-150	16-DEC-19
Methyl Isobutyl Ketone			82.3		%		50-150	16-DEC-19
n-Hexane			86.2		%		50-150	16-DEC-19



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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT	Water							
Batch	R4943976							
WG3239182-5 MS		L2394310-1						
MTBE			87.3		%		50-150	16-DEC-19
o-Xylene			85.3		%		50-150	16-DEC-19
Styrene			85.4		%		50-150	16-DEC-19
Tetrachloroethylene			94.1		%		50-150	16-DEC-19
Toluene			89.1		%		50-150	16-DEC-19
trans-1,2-Dichloroethylene			83.7		%		50-150	16-DEC-19
trans-1,3-Dichloropropene			93.7		%		50-150	16-DEC-19
Trichloroethylene			90.5		%		50-150	16-DEC-19
Trichlorofluoromethane			88.8		%		50-150	16-DEC-19
Vinyl chloride			98.8		%		50-150	16-DEC-19

Quality Control Report

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Report Date: 17-DEC-19

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Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

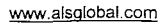
Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

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Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

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The Corporation of the City of London
ATTN: Wesley Abbott
PO Box 5035, 300 Dufferin Ave.,
London ON N6A 4L9

Date Received: 11-DEC-19
Report Date: 19-DEC-19 13:26 (MT)
Version: FINAL

Client Phone: 519-661-2489

Certificate of Analysis

Lab Work Order #: L2395008
Project P.O. #: NOT SUBMITTED
Job Reference: W12A LANDFILL
C of C Numbers:
Legal Site Desc:



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ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-1 GW 11-DEC-19 10:40 BH19-7	L2395008-2 GW 11-DEC-19 11:30 BH19-7-2	L2395008-3 GW 11-DEC-19 11:00 BH19-7-3	L2395008-4 GW 11-DEC-19 12:20 BH19-4	L2395008-5 GW 11-DEC-19 12:50 BH19-5
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (umhos/cm)	1380	978	654	959	975
	pH (pH units)	7.77	7.89	8.02	7.69	7.67
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	317	385	273	290	304
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	317	385	273	290	304
	Ammonia, Total (as N) (mg/L)	0.081	<0.010	0.049	0.132	0.050
	Bromide (Br) (mg/L)	<0.50 ^{DLDS}	<0.10	<0.10	<0.10	<0.10
	Chloride (Cl) (mg/L)	166 ^{DLDS}	32.1	11.2	52.6	41.3
	Fluoride (F) (mg/L)	0.24 ^{DLDS}	0.263	0.278	0.177	0.157
	Nitrate (as N) (mg/L)	<0.10 ^{DLDS}	<0.020	0.182	<0.020	<0.020
	Nitrite (as N) (mg/L)	<0.050 ^{DLDS}	<0.010	0.032	<0.010	<0.010
	Total Kjeldahl Nitrogen (mg/L)	0.26	0.28	0.26	0.28	0.26
	Sulfate (SO4) (mg/L)	230 ^{DLDS}	162	82.3	166	175
Organic / Inorganic Carbon	Dissolved Carbon Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Dissolved Organic Carbon (mg/L)	24.4	72.1 ^{DLM}	3.38	18.5	14.5
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Arsenic (As)-Dissolved (mg/L)	0.00056	0.00194	0.00097	0.00160	0.00105
	Barium (Ba)-Dissolved (mg/L)	0.0450	0.0639	0.114	0.0606	0.143
	Boron (B)-Dissolved (mg/L)	0.026	0.035	0.073	0.024	0.028
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	0.000016	<0.000010	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	172	117	59.7	123	123
	Iron (Fe)-Dissolved (mg/L)	2.67	0.048	0.018	1.40	1.91
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000114	<0.000050	<0.000050	<0.000050
	Magnesium (Mg)-Dissolved (mg/L)	32.5	35.0	40.7	19.7	26.0
	Manganese (Mn)-Dissolved (mg/L)	0.108	0.268	0.00189	0.167	0.0825
	Nickel (Ni)-Dissolved (mg/L)	0.00130	0.0176	<0.00050	0.00095	0.00129
	Potassium (K)-Dissolved (mg/L)	3.26	2.65	5.50	4.82	2.33
	Sodium (Na)-Dissolved (mg/L)	92.2	53.9	20.2	60.9	56.5
	Zinc (Zn)-Dissolved (mg/L)	0.0031	0.0292	<0.0010	0.0029	0.0038
Aggregate Organics	COD (mg/L)	27	291	45	43	68
	Phenols (4AAP) (mg/L)	0.0032	0.0046	0.0046	0.0039	0.0040
Volatile Organic Compounds	Acetone (ug/L)	<20	<20	<20	<20	<20
	Benzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Bromodichloromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-6 GW 11-DEC-19 15:10 BH19-6	L2395008-7 GW 11-DEC-19 14:40 BH19-6-2	L2395008-8 GW 11-DEC-19 13:50 BH19-3	L2395008-9 GW 11-DEC-19 13:50 BH19-31	
Grouping	Analyte					
WATER						
Physical Tests	Conductivity (umhos/cm)	1660	1920	393	394	
	pH (pH units)	7.40	8.07	7.83	7.83	
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	370	654	247	227	
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Alkalinity, Total (as CaCO3) (mg/L)	370	654	247	227	
	Ammonia, Total (as N) (mg/L)	0.073	0.380	0.118	0.110	
	Bromide (Br) (mg/L)	<0.50 ^{DLDS}	<0.50 ^{DLDS}	<0.10	<0.10	
	Chloride (Cl) (mg/L)	21.4 ^{DLDS}	8.8 ^{DLDS}	0.97	0.96	
	Fluoride (F) (mg/L)	0.14 ^{DLDS}	0.70 ^{DLDS}	1.10	1.14	
	Nitrate (as N) (mg/L)	<0.10 ^{DLDS}	<0.10 ^{DLDS}	<0.020	<0.020	
	Nitrite (as N) (mg/L)	<0.050 ^{DLDS}	<0.050 ^{DLDS}	<0.010	<0.010	
	Total Kjeldahl Nitrogen (mg/L)	0.38	0.56	0.49	0.33	
	Sulfate (SO4) (mg/L)	694 ^{DLDS}	606 ^{DLDS}	1.35	1.68	
Organic / Inorganic Carbon	Dissolved Carbon Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Dissolved Organic Carbon (mg/L)	7.27	3.82	7.68	7.66	
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Arsenic (As)-Dissolved (mg/L)	0.0012 ^{DLHC}	0.0021 ^{DLHC}	0.00057	0.00055	
	Barium (Ba)-Dissolved (mg/L)	0.0421 ^{DLHC}	0.0824 ^{DLHC}	0.368	0.354	
	Boron (B)-Dissolved (mg/L)	<0.10 ^{DLHC}	0.25 ^{DLHC}	0.096	0.091	
	Cadmium (Cd)-Dissolved (mg/L)	<0.000050 ^{DLHC}	<0.000050 ^{DLHC}	<0.000010	<0.000010	
	Calcium (Ca)-Dissolved (mg/L)	297 ^{DLHC}	93.8 ^{DLHC}	40.8	40.2	
	Iron (Fe)-Dissolved (mg/L)	7.66 ^{DLHC}	<0.10 ^{DLHC}	0.450	0.451	
	Lead (Pb)-Dissolved (mg/L)	<0.00050 ^{DLHC}	<0.00050 ^{DLHC}	<0.000050	<0.000050	
	Magnesium (Mg)-Dissolved (mg/L)	56.4 ^{DLHC}	176 ^{DLHC}	14.8	14.5	
	Manganese (Mn)-Dissolved (mg/L)	0.156 ^{DLHC}	0.0840 ^{DLHC}	0.0201	0.0198	
	Nickel (Ni)-Dissolved (mg/L)	<0.0050 ^{DLHC}	<0.0050 ^{DLHC}	0.00134	0.00137	
	Potassium (K)-Dissolved (mg/L)	2.57 ^{DLHC}	3.20 ^{DLHC}	1.72	1.68	
	Sodium (Na)-Dissolved (mg/L)	42.4 ^{DLHC}	110 ^{DLHC}	31.0	30.7	
	Zinc (Zn)-Dissolved (mg/L)	<0.010 ^{DLHC}	<0.010 ^{DLHC}	0.0014	0.0015	
Aggregate Organics	COD (mg/L)	40	<10	109	80	
	Phenols (4AAP) (mg/L)	0.0045	0.0030	0.0022 ^{OWP}	0.0025 ^{OWP}	
Volatile Organic Compounds	Acetone (ug/L)	<20	<20	<20 ^{OWP}	<20 ^{OWP}	
	Benzene (ug/L)	<0.50	<0.50	<0.50 ^{OWP}	<0.50 ^{OWP}	
	Bromodichloromethane (ug/L)	<1.0	<1.0	<1.0 ^{OWP}	<1.0 ^{OWP}	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID Description Sampled Date Sampled Time Client ID		L2395008-1	L2395008-2	L2395008-3	L2395008-4	L2395008-5
		GW	GW	GW	GW	GW
		11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19
		10:40	11:30	11:00	12:20	12:50
		BH19-7	BH19-7-2	BH19-7-3	BH19-4	BH19-5
Grouping	Analyte					
WATER						
Volatile Organic Compounds	Bromoform (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Bromomethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Carbon Disulfide (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Carbon tetrachloride (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Chlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Dibromochloromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Chloroethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Chloroform (ug/L)	<1.0	3.8	<1.0	<1.0	<1.0
	Chloromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	1,2-Dibromoethane (ug/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	1,2-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,3-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,4-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Dichlorodifluoromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	1,1-Dichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,2-Dichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	cis-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	trans-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Dichloromethane (ug/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	1,2-Dichloropropane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	cis-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	trans-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Ethylbenzene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	n-Hexane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	2-Hexanone (ug/L)	<20	<20	<20	<20	<20
	Methyl Ethyl Ketone (ug/L)	<20	<20	<20	<20	<20
	Methyl Isobutyl Ketone (ug/L)	<20	<20	<20	<20	<20
	MTBE (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Styrene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,1,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,2,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Tetrachloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Toluene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,1-Trichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	1,1,2-Trichloroethane (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Trichloroethylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID Description Sampled Date Sampled Time Client ID	L2395008-6 GW 11-DEC-19 15:10 BH19-6	L2395008-7 GW 11-DEC-19 14:40 BH19-6-2	L2395008-8 GW 11-DEC-19 13:50 BH19-3	L2395008-9 GW 11-DEC-19 13:50 BH19-31	
Grouping	Analyte						
WATER							
Volatile Organic Compounds	Bromoform (ug/L)	<1.0	<1.0	<1.0	OWP	OWP	
	Bromomethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Carbon Disulfide (ug/L)	<1.0	<1.0	<1.0	OWP	OWP	
	Carbon tetrachloride (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Chlorobenzene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Dibromochloromethane (ug/L)	<1.0	<1.0	<1.0	OWP	OWP	
	Chloroethane (ug/L)	<1.0	<1.0	<1.0	OWP	OWP	
	Chloroform (ug/L)	<1.0	1.6	<1.0	OWP	OWP	
	Chloromethane (ug/L)	<1.0	<1.0	<1.0	OWP	OWP	
	1,2-Dibromoethane (ug/L)	<0.20	<0.20	<0.20	OWP	OWP	
	1,2-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,3-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,4-Dichlorobenzene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Dichlorodifluoromethane (ug/L)	<1.0	<1.0	<1.0	OWP	OWP	
	1,1-Dichloroethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,2-Dichloroethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,1-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	cis-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	trans-1,2-Dichloroethylene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Dichloromethane (ug/L)	<2.0	<2.0	<2.0	OWP	OWP	
	1,2-Dichloropropane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	cis-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	trans-1,3-Dichloropropene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Ethylbenzene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	n-Hexane (ug/L)	<0.50	<0.50	0.53	OWP	OWP	
	2-Hexanone (ug/L)	<20	<20	<20	OWP	OWP	
	Methyl Ethyl Ketone (ug/L)	<20	<20	<20	OWP	OWP	
	Methyl Isobutyl Ketone (ug/L)	<20	<20	<20	OWP	OWP	
	MTBE (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Styrene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,1,1,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,1,2,2-Tetrachloroethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Tetrachloroethylene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Toluene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,1,1-Trichloroethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	1,1,2-Trichloroethane (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	
	Trichloroethylene (ug/L)	<0.50	<0.50	<0.50	OWP	OWP	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L2395008-1	L2395008-2	L2395008-3	L2395008-4	L2395008-5
		Description	GW	GW	GW	GW	GW
		Sampled Date	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19
		Sampled Time	10:40	11:30	11:00	12:20	12:50
		Client ID	BH19-7	BH19-7-2	BH19-7-3	BH19-4	BH19-5
Grouping	Analyte						
WATER							
Volatile Organic Compounds	Trichlorofluoromethane (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0	
	Vinyl chloride (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50	
	o-Xylene (ug/L)	<0.50	<0.50	<0.50	<0.50	<0.50	
	m+p-Xylenes (ug/L)	<1.0	<1.0	<1.0	<1.0	<1.0	
	Xylenes (Total) (ug/L)	<1.1	<1.1	<1.1	<1.1	<1.1	
	Surrogate: 4-Bromofluorobenzene (%)	93.9	94.6	93.7	94.0	94.1	
	Surrogate: 1,4-Difluorobenzene (%)	101.4	101.0	100.9	101.3	101.3	
Trihalomethanes	Total THMs (ug/L)	<2.0	3.8	<2.0	<2.0	<2.0	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L2395008-6	L2395008-7	L2395008-8	L2395008-9	
		Description	GW	GW	GW	GW	
		Sampled Date	11-DEC-19	11-DEC-19	11-DEC-19	11-DEC-19	
		Sampled Time	15:10	14:40	13:50	13:50	
		Client ID	BH19-6	BH19-6-2	BH19-3	BH19-31	
Grouping	Analyte						
WATER							
Volatile Organic Compounds	Trichlorofluoromethane (ug/L)	<1.0	<1.0	<1.0 ^{OWP}	<1.0 ^{OWP}		
	Vinyl chloride (ug/L)	<0.50	<0.50	<0.50 ^{OWP}	<0.50 ^{OWP}		
	o-Xylene (ug/L)	<0.50	<0.50	<0.50 ^{OWP}	<0.50 ^{OWP}		
	m+p-Xylenes (ug/L)	<1.0	<1.0	<1.0 ^{OWP}	<1.0 ^{OWP}		
	Xylenes (Total) (ug/L)	<1.1	<1.1	<1.1	<1.1		
	Surrogate: 4-Bromofluorobenzene (%)	94.2	94.3	92.6	91.5		
	Surrogate: 1,4-Difluorobenzene (%)	101.4	101.0	100.4	99.4		
Trihalomethanes	Total THMs (ug/L)	<2.0	<2.0	<2.0	<2.0		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Laboratory Control Sample	2-Hexanone	MES	L2395008-8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Boron (B)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Iron (Fe)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Potassium (K)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Ammonia, Total (as N)	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Total Kjeldahl Nitrogen	MS-B	L2395008-1, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLDS	Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).
DLM	Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).
MES	Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
OWP	Organic water sample contained visible sediment (must be included as part of analysis). Measured concentrations of organic substances in water can be biased high due to presence of sediment.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SPEC-PCT-WT	Water	Automated Speciated Alkalinity	APHA 2320B
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.			
BR-IC-N-WT	Water	Bromide in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
CL-IC-N-WT	Water	Chloride by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).			
COD-T-WT	Water	Chemical Oxygen Demand	APHA 5220 D
This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.			
DOC-WT	Water	Dissolved Organic Carbon	APHA 5310B
Sample is filtered through a 0.45um filter, then injected into a heated reaction chamber which is packed with an oxidative catalyst. The water is vaporized and the organic carbon is oxidized to carbon dioxide. The carbon dioxide is transported in a carrier gas and is measured by a non-dispersive infrared detector.			
EC-SCREEN-WT	Water	Conductivity Screen (Internal Use Only)	APHA 2510
Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.			
EC-WT	Water	Conductivity	APHA 2510 B
Water samples can be measured directly by immersing the conductivity cell into the sample.			
F-IC-N-WT	Water	Fluoride in Water by IC	EPA 300.1 (mod)
Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.			
MET-D-CCMS-WT	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)
Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.			

Reference Information

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011).

NH3-F-WT	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC
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This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-IC-WT	Water	Nitrite in Water by IC	EPA 300.1 (mod)
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Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-IC-WT	Water	Nitrate in Water by IC	EPA 300.1 (mod)
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Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

PH-WT	Water	pH	APHA 4500 H-Electrode
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Water samples are analyzed directly by a calibrated pH meter.

Analysis conducted in accordance with the Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (July 1, 2011). Holdtime for samples under this regulation is 28 days

PHENOLS-4AAP-WT	Water	Phenol (4AAP)	EPA 9066
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An automated method is used to distill the sample. The distillate is then buffered to pH 9.4 which reacts with 4AAP and potassium ferricyanide to form a red complex which is measured colorimetrically.

SO4-IC-N-WT	Water	Sulfate in Water by IC	EPA 300.1 (mod)
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Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

THM-SUM-PPB-CALC-WT	Water	Total Trihalomethanes (THMs)	CALCULATION
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Total Trihalomethanes (THMs) represents the sum of bromodichloromethane, bromoform, chlorodibromomethane and chloroform. For the purpose of calculation, results less than the detection limit (DL) are treated as zero.

TKN-WT	Water	Total Kjeldahl Nitrogen	APHA 4500-Norg D
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This analysis is carried out using procedures adapted from APHA Method 4500-Norg "Nitrogen (Organic)". Total Kjeldahl Nitrogen is determined by sample digestion at 380 Celsius with analysis using an automated colorimetric method.

VOC-ROU-HS-WT	Water	Volatile Organic Compounds	SW846 8260
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Aqueous samples are analyzed by headspace-GC/MS.

XYLENES-SUM-CALC-WT	Water	Sum of Xylene Isomer Concentrations	CALCULATION
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Total xylenes represents the sum of o-xylene and m&p-xylene.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
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WT	ALS ENVIRONMENTAL - WATERLOO, ONTARIO, CANADA
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Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

mg/kg - milligrams per kilogram based on dry weight of sample.

mg/kg ww - milligrams per kilogram based on wet weight of sample.

mg/kg lw - milligrams per kilogram based on lipid-adjusted weight of sample.

mg/L - milligrams per litre.

< - Less than.

D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.



Quality Control Report

Workorder: L2395008

Report Date: 19-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
COD-T-WT								
Water								
Batch	R4946309							
WG3246025-2	LCS							
COD			96.3		%		85-115	19-DEC-19
Batch	WG3246025-1 MB							
COD			<10		mg/L		10	19-DEC-19
DOC-WT								
Water								
Batch	R4944534							
WG3241256-2	LCS							
Dissolved Organic Carbon			104.5		%		80-120	16-DEC-19
Batch	WG3241256-1 MB							
Dissolved Organic Carbon			<0.50		mg/L		0.5	16-DEC-19
EC-WT								
Water								
Batch	R4943257							
WG3241759-2	LCS							
Conductivity			100.1		%		90-110	13-DEC-19
Batch	WG3241759-1 MB							
Conductivity			<3.0		umhos/cm		3	13-DEC-19
Batch	R4943258							
WG3241761-2	LCS							
Conductivity			100.7		%		90-110	13-DEC-19
Batch	WG3241761-1 MB							
Conductivity			<3.0		umhos/cm		3	13-DEC-19
F-IC-N-WT								
Water								
Batch	R4944045							
WG3241855-4	DUP	L2395008-3						
Fluoride (F)		0.278	0.276		mg/L	1.0	20	13-DEC-19
Batch	WG3241855-2 LCS							
Fluoride (F)			103.0		%		90-110	13-DEC-19
Batch	WG3241855-1 MB							
Fluoride (F)			<0.020		mg/L		0.02	13-DEC-19
Batch	WG3241855-5 MS							
Fluoride (F)		L2395008-3	99.3		%		75-125	13-DEC-19
MET-D-CCMS-WT								
Water								
Batch	R4941530							
WG3241047-2	LCS							
Arsenic (As)-Dissolved			98.2		%		80-120	12-DEC-19
Barium (Ba)-Dissolved			102.9		%		80-120	12-DEC-19
Boron (B)-Dissolved			102.8		%		80-120	12-DEC-19

Quality Control Report

Workorder: L2395008

Report Date: 19-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
SO4-IC-N-WT								
Batch R4944045								
WG3241855-4	DUP	L2395008-3						
Sulfate (SO4)		82.3	82.2		mg/L	0.0	20	13-DEC-19
WG3241855-2	LCS							
Sulfate (SO4)			103.0		%		90-110	13-DEC-19
WG3241855-1	MB							
Sulfate (SO4)			<0.30		mg/L		0.3	13-DEC-19
WG3241855-5	MS	L2395008-3						
Sulfate (SO4)			103.3		%		75-125	13-DEC-19
TKN-WT								
Batch R4944028								
WG3241908-2	LCS							
Total Kjeldahl Nitrogen			97.7		%		75-125	16-DEC-19
WG3241908-1	MB							
Total Kjeldahl Nitrogen			<0.15		mg/L		0.15	16-DEC-19
VOC-ROU-HS-WT								
Batch R4943663								
WG3235779-1	LCS							
1,1,1,2-Tetrachloroethane			87.1		%		70-130	16-DEC-19
1,1,2,2-Tetrachloroethane			99.98		%		70-130	16-DEC-19
1,1,1-Trichloroethane			94.0		%		70-130	16-DEC-19
1,1,2-Trichloroethane			93.2		%		70-130	16-DEC-19
1,2-Dibromoethane			94.4		%		70-130	16-DEC-19
1,1-Dichloroethane			96.2		%		70-130	16-DEC-19
1,1-Dichloroethylene			90.8		%		70-130	16-DEC-19
1,2-Dichlorobenzene			84.6		%		70-130	16-DEC-19
1,2-Dichloroethane			105.3		%		70-130	16-DEC-19
1,2-Dichloropropane			92.2		%		70-130	16-DEC-19
1,3-Dichlorobenzene			88.5		%		70-130	16-DEC-19
1,4-Dichlorobenzene			89.3		%		70-130	16-DEC-19
2-Hexanone			80.4		%		60-140	16-DEC-19
Acetone			101.1		%		60-140	16-DEC-19
Benzene			98.9		%		70-130	16-DEC-19
Bromodichloromethane			94.5		%		70-130	16-DEC-19
Bromoform			88.5		%		70-130	16-DEC-19
Bromomethane			87.6		%		60-140	16-DEC-19
Carbon Disulfide			98.0		%		70-130	16-DEC-19



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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943663							
WG3235779-1	LCS							
Carbon tetrachloride			96.1		%		70-130	16-DEC-19
Chlorobenzene			86.0		%		70-130	16-DEC-19
Chloroethane			102.2		%		70-130	16-DEC-19
Chloroform			98.9		%		70-130	16-DEC-19
Chloromethane			94.9		%		60-140	16-DEC-19
cis-1,2-Dichloroethylene			87.5		%		70-130	16-DEC-19
cis-1,3-Dichloropropene			94.1		%		70-130	16-DEC-19
Dibromochloromethane			87.4		%		70-130	16-DEC-19
Dichlorodifluoromethane			94.8		%		50-140	16-DEC-19
Dichloromethane			93.4		%		70-130	16-DEC-19
Ethylbenzene			87.6		%		70-130	16-DEC-19
m+p-Xylenes			89.0		%		70-130	16-DEC-19
Methyl Ethyl Ketone			99.3		%		60-140	16-DEC-19
Methyl Isobutyl Ketone			86.4		%		50-150	16-DEC-19
n-Hexane			91.5		%		70-130	16-DEC-19
MTBE			95.9		%		70-130	16-DEC-19
o-Xylene			87.4		%		70-130	16-DEC-19
Styrene			87.4		%		70-130	16-DEC-19
Tetrachloroethylene			88.6		%		70-130	16-DEC-19
Toluene			89.5		%		70-130	16-DEC-19
trans-1,2-Dichloroethylene			93.5		%		70-130	16-DEC-19
trans-1,3-Dichloropropene			88.0		%		70-130	16-DEC-19
Trichloroethylene			94.0		%		70-130	16-DEC-19
Trichlorofluoromethane			97.2		%		60-140	16-DEC-19
Vinyl chloride			102.5		%		60-140	16-DEC-19
WG3235779-2	MB							
1,1,1,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2,2-Tetrachloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,1-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1,2-Trichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dibromoethane			<0.20		ug/L		0.2	16-DEC-19
1,1-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,1-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943663							
WG3235779-2 MB								
1,2-Dichloroethane			<0.50		ug/L		0.5	16-DEC-19
1,2-Dichloropropane			<0.50		ug/L		0.5	16-DEC-19
1,3-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
1,4-Dichlorobenzene			<0.50		ug/L		0.5	16-DEC-19
2-Hexanone			<20		ug/L		20	16-DEC-19
Acetone			<20		ug/L		20	16-DEC-19
Benzene			<0.50		ug/L		0.5	16-DEC-19
Bromodichloromethane			<1.0		ug/L		1	16-DEC-19
Bromoform			<1.0		ug/L		1	16-DEC-19
Bromomethane			<0.50		ug/L		0.5	16-DEC-19
Carbon Disulfide			<1.0		ug/L		1	16-DEC-19
Carbon tetrachloride			<0.50		ug/L		0.5	16-DEC-19
Chlorobenzene			<0.50		ug/L		0.5	16-DEC-19
Chloroethane			<1.0		ug/L		1	16-DEC-19
Chloroform			<1.0		ug/L		1	16-DEC-19
Chloromethane			<1.0		ug/L		1	16-DEC-19
cis-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
cis-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Dibromochloromethane			<1.0		ug/L		1	16-DEC-19
Dichlorodifluoromethane			<1.0		ug/L		1	16-DEC-19
Dichloromethane			<2.0		ug/L		2	16-DEC-19
Ethylbenzene			<0.50		ug/L		0.5	16-DEC-19
m+p-Xylenes			<1.0		ug/L		1	16-DEC-19
Methyl Ethyl Ketone			<20		ug/L		20	16-DEC-19
Methyl Isobutyl Ketone			<20		ug/L		20	16-DEC-19
n-Hexane			<0.50		ug/L		0.5	16-DEC-19
MTBE			<0.50		ug/L		0.5	16-DEC-19
o-Xylene			<0.50		ug/L		0.5	16-DEC-19
Styrene			<0.50		ug/L		0.5	16-DEC-19
Tetrachloroethylene			<0.50		ug/L		0.5	16-DEC-19
Toluene			<0.50		ug/L		0.5	16-DEC-19
trans-1,2-Dichloroethylene			<0.50		ug/L		0.5	16-DEC-19
trans-1,3-Dichloropropene			<0.50		ug/L		0.5	16-DEC-19
Trichloroethylene			<0.50		ug/L		0.5	16-DEC-19



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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4943663							
WG3235779-2	MB							
Trichlorofluoromethane			<1.0		ug/L		1	16-DEC-19
Vinyl chloride			<0.50		ug/L		0.5	16-DEC-19
Surrogate: 1,4-Difluorobenzene			102.2		%		70-130	16-DEC-19
Surrogate: 4-Bromofluorobenzene			96.6		%		70-130	16-DEC-19
Batch	R4944729							
WG3243806-1	LCS							
1,1,1,2-Tetrachloroethane			85.0		%		70-130	17-DEC-19
1,1,2,2-Tetrachloroethane			85.2		%		70-130	17-DEC-19
1,1,1-Trichloroethane			98.3		%		70-130	17-DEC-19
1,1,2-Trichloroethane			82.6		%		70-130	17-DEC-19
1,2-Dibromoethane			80.2		%		70-130	17-DEC-19
1,1-Dichloroethane			99.1		%		70-130	17-DEC-19
1,1-Dichloroethylene			98.8		%		70-130	17-DEC-19
1,2-Dichlorobenzene			85.2		%		70-130	17-DEC-19
1,2-Dichloroethane			91.7		%		70-130	17-DEC-19
1,2-Dichloropropane			88.0		%		70-130	17-DEC-19
1,3-Dichlorobenzene			93.7		%		70-130	17-DEC-19
1,4-Dichlorobenzene			94.0		%		70-130	17-DEC-19
2-Hexanone			57.4	MES	%		60-140	17-DEC-19
Acetone			78.6		%		60-140	17-DEC-19
Benzene			99.7		%		70-130	17-DEC-19
Bromodichloromethane			88.0		%		70-130	17-DEC-19
Bromoform			76.9		%		70-130	17-DEC-19
Bromomethane			91.9		%		60-140	17-DEC-19
Carbon Disulfide			107.7		%		70-130	17-DEC-19
Carbon tetrachloride			102.3		%		70-130	17-DEC-19
Chlorobenzene			86.2		%		70-130	17-DEC-19
Chloroethane			110.0		%		70-130	17-DEC-19
Chloroform			97.5		%		70-130	17-DEC-19
Chloromethane			106.9		%		60-140	17-DEC-19
cis-1,2-Dichloroethylene			85.6		%		70-130	17-DEC-19
cis-1,3-Dichloropropene			87.0		%		70-130	17-DEC-19
Dibromochloromethane			79.1		%		70-130	17-DEC-19
Dichlorodifluoromethane			128.0		%		50-140	17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4944729							
WG3243806-1	LCS							
Dichloromethane			89.8		%		70-130	17-DEC-19
Ethylbenzene			91.9		%		70-130	17-DEC-19
m+p-Xylenes			93.6		%		70-130	17-DEC-19
Methyl Ethyl Ketone			72.6		%		60-140	17-DEC-19
Methyl Isobutyl Ketone			62.1		%		50-150	17-DEC-19
n-Hexane			104.1		%		70-130	17-DEC-19
MTBE			96.6		%		70-130	17-DEC-19
o-Xylene			89.1		%		70-130	17-DEC-19
Styrene			85.4		%		70-130	17-DEC-19
Tetrachloroethylene			96.4		%		70-130	17-DEC-19
Toluene			92.9		%		70-130	17-DEC-19
trans-1,2-Dichloroethylene			98.2		%		70-130	17-DEC-19
trans-1,3-Dichloropropene			79.7		%		70-130	17-DEC-19
Trichloroethylene			97.6		%		70-130	17-DEC-19
Trichlorofluoromethane			107.8		%		60-140	17-DEC-19
Vinyl chloride			116.9		%		60-140	17-DEC-19
WG3243806-2	MB							
1,1,1,2-Tetrachloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1,2,2-Tetrachloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1,1-Trichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1,2-Trichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,2-Dibromoethane			<0.20		ug/L		0.2	17-DEC-19
1,1-Dichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,1-Dichloroethylene			<0.50		ug/L		0.5	17-DEC-19
1,2-Dichlorobenzene			<0.50		ug/L		0.5	17-DEC-19
1,2-Dichloroethane			<0.50		ug/L		0.5	17-DEC-19
1,2-Dichloropropane			<0.50		ug/L		0.5	17-DEC-19
1,3-Dichlorobenzene			<0.50		ug/L		0.5	17-DEC-19
1,4-Dichlorobenzene			<0.50		ug/L		0.5	17-DEC-19
2-Hexanone			<20		ug/L		20	17-DEC-19
Acetone			<20		ug/L		20	17-DEC-19
Benzene			<0.50		ug/L		0.5	17-DEC-19
Bromodichloromethane			<1.0		ug/L		1	17-DEC-19
Bromoform			<1.0		ug/L		1	17-DEC-19

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Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
VOC-ROU-HS-WT		Water						
Batch	R4944729							
WG3243806-2	MB							
Bromomethane			<0.50		ug/L		0.5	17-DEC-19
Carbon Disulfide			<1.0		ug/L		1	17-DEC-19
Carbon tetrachloride			<0.50		ug/L		0.5	17-DEC-19
Chlorobenzene			<0.50		ug/L		0.5	17-DEC-19
Chloroethane			<1.0		ug/L		1	17-DEC-19
Chloroform			<1.0		ug/L		1	17-DEC-19
Chloromethane			<1.0		ug/L		1	17-DEC-19
cis-1,2-Dichloroethylene			<0.50		ug/L		0.5	17-DEC-19
cis-1,3-Dichloropropene			<0.50		ug/L		0.5	17-DEC-19
Dibromochloromethane			<1.0		ug/L		1	17-DEC-19
Dichlorodifluoromethane			<1.0		ug/L		1	17-DEC-19
Dichloromethane			<2.0		ug/L		2	17-DEC-19
Ethylbenzene			<0.50		ug/L		0.5	17-DEC-19
m+p-Xylenes			<1.0		ug/L		1	17-DEC-19
Methyl Ethyl Ketone			<20		ug/L		20	17-DEC-19
Methyl Isobutyl Ketone			<20		ug/L		20	17-DEC-19
n-Hexane			<0.50		ug/L		0.5	17-DEC-19
MTBE			<0.50		ug/L		0.5	17-DEC-19
o-Xylene			<0.50		ug/L		0.5	17-DEC-19
Styrene			<0.50		ug/L		0.5	17-DEC-19
Tetrachloroethylene			<0.50		ug/L		0.5	17-DEC-19
Toluene			<0.50		ug/L		0.5	17-DEC-19
trans-1,2-Dichloroethylene			<0.50		ug/L		0.5	17-DEC-19
trans-1,3-Dichloropropene			<0.50		ug/L		0.5	17-DEC-19
Trichloroethylene			<0.50		ug/L		0.5	17-DEC-19
Trichlorofluoromethane			<1.0		ug/L		1	17-DEC-19
Vinyl chloride			<0.50		ug/L		0.5	17-DEC-19
Surrogate: 1,4-Difluorobenzene			101.5		%		70-130	17-DEC-19
Surrogate: 4-Bromofluorobenzene			94.5		%		70-130	17-DEC-19

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Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
MES	Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Appendix G

Isotope Analysis



Isotope Analyses for:
Dillon Consulting

IT2 FILE #
190229

2020-02-24

Approved by:

Orfan SStash

Orfan Shouakar-Stash, PhD
Director

Isotope Tracer Technologies Inc.

695 Rupert St. Unit B, Waterloo, ON, N2V 1Z5

Tel: 519-886-5555 | Fax: 519-886-5575

Email: orfan@it2isotopes.com

Website: www.it2isotopes.com



Client: Dillon Consulting Limited
Address: 130 Dufferin Ave. Suite 130
 London, Ontario
Tel: 519-438-6192
Attn.: Rob Kell
E-mail: rkell@dillon.ca

File Number: 190229
Project P.O.: W12A London Landfill (19-1230)

#	Sample ID	Sample #	$\delta^{18}\text{O}$	Aver	Stdv	$\delta^2\text{H}$	Aver	Stdv
			H_2O	VSMOW		H_2O	VSMOW	
1	15'-BH19-3-SS2	60412	X	-9.60	0.02	X	-64.6	0.2
2	20'-BH19-3-SS3	60413	X	-9.54	0.03	X	-64.6	0.4
3	30'-BH19-3-SS5	60414	X	-8.84	0.04	X	-61.9	0.3
4	40'-BH19-3-SS7	60415	X	-8.99	0.02	X	-62.3	0.1
5	15'-BH19-5-SS1	60416	X	-8.82	0.01	X	-59.8	0.4
6	30'-BH19-5-SS4	60417	X	-8.97	0.03	X	-61.4	0.2
7	45'-BH19-5-SS7	60418	X	-9.42	0.03	X	-62.6	0.3
8	55'-BH19-5-SS10	60419	X	-8.52	0.04	X	-59.6	0.3

^{18}O & ^2H (CRDS)

Instrument Used: Cavity Ring Down Spectroscopy (CRDS)
 CRDS (Model L2130-i) (Picarro, California, USA).

Standard Used:
 IT2-2B / IT2-11B / IT2-13B Calibrated with IAEA Standards (V-SMOW, SLAP, and GISP)

Typical Standard deviation:

$(^{18}\text{O} \pm 0.1\text{‰})$ $(^2\text{H} \pm 1\text{‰})$

Approved by:

Orfan S-Stash

Orfan Shouakar-Stash, PhD

Director

Isotope Tracer Technologies Inc.

695 Rupert St. Unit B, Waterloo, ON, N2V 1Z5

Tel: 519-886-5555 | Fax: 519-886-5575

Email: orfan@it2isotopes.com

Website: www.it2isotopes.com



Client: Dillon Consulting Limited
Address: 130 Dufferin Ave. Suite 130
London, Ontario
Tel: 519-438-6192
Attn.: Rob Kell
E-mail: rkell@dillon.ca

File Number: 190229
Project P.O.: W12A London Landfill (19-1230)

#	Sample ID	Sample #	E ³ H	Result	± 1σ
1	15'-BH19-3-SS2	60412	X	3.7	1.0
2	20'-BH19-3-SS3	60413	X	< 0.8	0.7
3	30'-BH19-3-SS5	60414	X	2.0	0.8
4	40'-BH19-3-SS7	60415	X	< 0.8	0.7
5	15'-BH19-5-SS1	60416	X	4.1	0.8
6	30'-BH19-5-SS4	60417	X	1.4	0.7
7	45'-BH19-5-SS7	60418	X	0.9	0.6
8	55'-BH19-5-SS10	60419	X	2.3	0.9

E³H ANALYSES

Tritium is reported in Tritium Units.

1TU = 3.221 Picocuries/L per IAEA, 2000 Report.

1TU = 0.11919 Becquerels/L per IAEA, 2000 Report.

Approved by:

Orfan S-Stash

Orfan Shouakar-Stash, PhD

Director

Isotope Tracer Technologies Inc.

695 Rupert St. Unit B, Waterloo, ON, N2V 1Z5

Tel: 519-886-5555 | Fax: 519-886-5575

Email: orfan@it2isotopes.com

Website: www.it2isotopes.com

ATTACHMENT B

**Groundwater Impact Assessment –
Golder Associates Ltd.**



REPORT

Groundwater Impact Assessment

W12A Landfill Expansion EA, City of London, Ontario

Submitted to:

Mike Losee, Division Manager, Solid Waste Management

City of London

300 Dufferin Avenue

London, Ontario

PO BOX 5035

N6A 4L9

Submitted by:

Golder Associates Ltd.

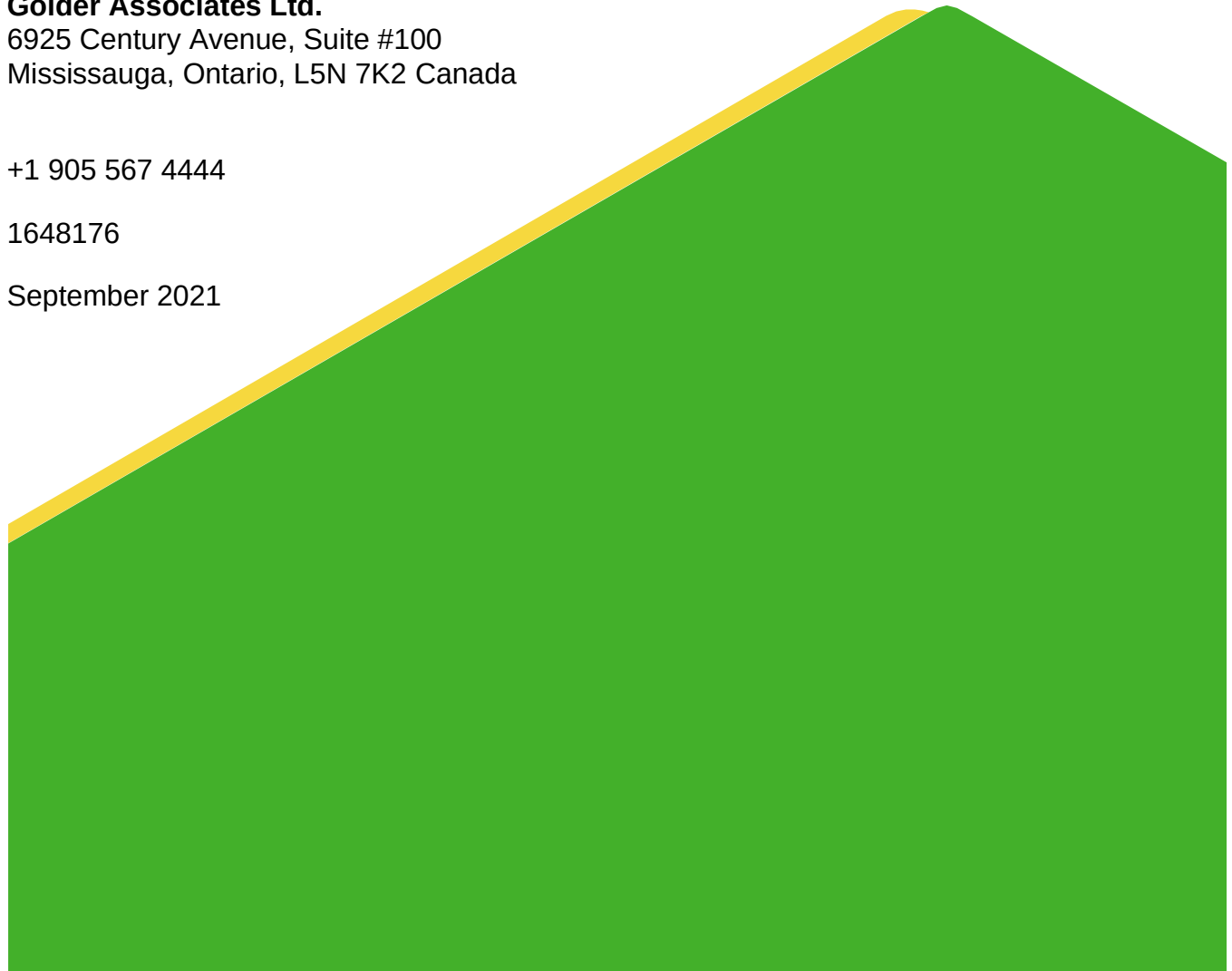
6925 Century Avenue, Suite #100

Mississauga, Ontario, L5N 7K2 Canada

+1 905 567 4444

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September 2021



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APPENDICES

APPENDIX A

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APPENDIX B

Example POLLUTE Output File

APPENDIX C

Service Life

Acronyms and Glossary of Terms

Term / Acronym	Definition
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
EPA	<i>Environmental Protection Act</i>
f_{oc}	fraction organic carbon
HELP	Hydrologic Evaluation of Landfill Performance
k	hydraulic conductivity
K_{oc}	soil/organic carbon partition coefficient
LCS	Leachate Collection System
LFG	Landfill Gas
m	metres
m^2	square metres
m^3	cubic metres
masl	Metres Above Sea Level
MECP	Ministry of Environment, Conservation and Parks
mg/L	milligram per litre
mg/kg	milligram per kilogram
mL/g	millilitre per gram
MNRF	Ministry of Natural Resources and Forestry
MRF	Material Recovery Facility
ODWQS	Ontario Drinking Water Quality Standards
POLLUTE	contaminant transport model
RUC	Reasonable Use Criteria
RUG	Reasonable Use Guidelines
ToR	Terms of Reference
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London Ontario.

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the assessment of impacts on long-term groundwater quality and quantity for the Environment Assessment (EA) of the proposed W12A Landfill expansion. This work has been conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR), dated February 2019 and the Work Plan dated November 2019 that was developed with input from First Nation Communities (Aamjiwnaang First Nation, Chippewas of the Thames First Nation, Munsee-Delaware First Nation, Oneida First Nation) and their consultant (Dragun Corporation) and circulated to the Ministry of the Environment, Conservation and Parks (MECP). In addition, the work also included additional contaminant transport modelling as a result of feedback from a First Nation Communities workshop held in August 2020.

This report is a supporting document to the Environmental Assessment Study Report (EASR).

2.0 PROJECT DESCRIPTION

2.1 General Description

During the first 25 years of operations at the W12A Landfill (1977 to 2002), approximately 5 million tonnes of waste was deposited in six cells that comprise the Phase 1 area of the landfill. Phase 1 covers 59.3 ha and occupies the eastern portion of the landfill footprint (Appendix A, Figure 1.3-1 of the EASR). It currently has final cover in place throughout its full area.

Phase 2 of the existing landfill covers an area of 47.7 ha and occupies the western portion of the landfill. Phase 2 has been the active area of landfilling from the time it received regulatory approval in 2002. It has an approved waste fill capacity of 5.5 million tonnes divided amongst eight cells as shown in Appendix A, Figure 1.3-1 of the EASR.

As shown in Figure 8.1.-1 of the EASR (Appendix A), a vertical expansion of the existing approved waste fill area (i.e., vertical expansion of the Phase 1 and 2 areas) is being proposed, to provide an additional 13.8 million m³ of airspace for waste and daily cover. The vertical expansion will have a final peak elevation (top of waste and daily cover) of 318.43 masl.

To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be expanded northward to Scotland Drive and a 100 m buffer width will be provided on the east side of the landfill footprint. In addition, some additional area will be provided at the southeast corner of the site to tie into the adjacent Material Recovery Facility (MRF) property line. As shown in Figure 8.1.-1 of the EASR (Appendix A) this proposed expansion of the landfill site boundary results in an overall landfill site area of 191.7 ha.

2.2 Landfill Phasing and Development

The proposed vertical expansion will be developed sequentially in eight phases, referred to as Areas 1E through 8E (Appendix A, Figure 8.1-2 of the EASR), progressing from west to east. The duration of landfilling in each Area will be approximately 2.5 to 3.5 years based on an expected typical annual air space consumption of 500,000 m³ per year, which corresponds to an average annual waste receipt of 370,000 tonnes per year. The estimated operating period of the landfill expansion to reach the proposed final contours is approximately 25 years.

A separate cell dedicated for disposal of the non-decomposable portion of the waste stream will be provided in the southeastern area of the landfill expansion. Filling in this non-decomposable waste cell will take place in lifts over the 25 year expansion period, and will be blended in to meet the temporary sideslopes in the adjacent Areas 7E and 8E as they are developed. As only non-decomposable waste will be placed in this cell, daily cover will not be applied; however, if it is observed that specific materials are generating odours or are otherwise of concern if left uncovered, daily cover material will be placed. Final cover will be placed progressively over the fill areas as the waste fill reaches the design final contours.

To commence filling in each Area of the proposed landfill expansion, the existing cover material will be progressively stripped from a large enough area (approximately 4 ha) to accommodate one year of disposal. The surface area of exposed waste on any given day of operation will be limited to that needed to spread, compact and cover the waste received on that day, and will have dimensions typically ranging from approximately 40 m by 25 m (1,000 m²) to 50 m by 30 m (1,500 m²). The working face of the waste fill will be advanced as a 3 m high layer, with the waste spread/compacted in 0.6 m thick lifts to the 3 m height. All exposed waste will be covered daily.

For the southern Fill Areas of the proposed vertical expansion (Areas 1E, 3E, 5E and 7E), the waste will be placed initially to build a berm along the south side of the landfill and will be covered with final cover soil and seeded to establish vegetation; the berm will screen the view of subsequent filling operations north of the berm (Areas 2E, 4E, 6E and 8E) from off-Site vantage points to the south. The south side perimeter waste berm will be raised sequentially and filled in behind until the peak elevation is reached. On an annual or biannual basis, final cover will be constructed over areas reaching final grade.

2.3 Leachate Control and Management

Phase 2 utilizes the clay till as a natural low permeability liner, and has a continuous granular leachate drainage blanket and piping system over a shaped subgrade to collect leachate and direct it by gravity to the south end of the Phase 2 area where the collected leachate is removed for subsequent off-site treatment. This existing leachate collection system will continue to be used to collect and remove leachate from the proposed vertically expanded Phase 2 area.

The waste in the Phase 1 area rests directly on the underlying natural low permeability clay till and does not have a continuous granular drainage blanket to collect leachate over its base area. Instead, Phase 1 has a perimeter leachate collection system (LCS) around the north, east and south sides to intercept lateral leachate seepage through the upper weathered/fractured clay till. The leachate collected by this perimeter leachate collection system either drains into the Phase 2 granular drainage blanket or into a separate storage tank from where it is removed for subsequent off-site treatment. For the vertical expansion above the Phase 1 area, it is proposed to replace the existing perimeter LCS with a new perimeter LCS that will more effectively serve the same function as the existing system. Furthermore, to control the potential for leachate seeps along the perimeter sideslopes that could occur as a result of leachate mounding and/or perched leachate in Phase 1, it is proposed to construct granular finger drains along the north, east and south perimeter slopes of the Phase 1 area and connect them into the replacement Phase 1 perimeter LCS.

The leachate collected from the Phase 1 and Phase 2 LCS will continue to be routed through on-Site piping to the main leachate pumping station located at the southeast corner of the Site. From this station, the leachate will be pumped off-Site through a leachate forcemain to the Dingman Drive pump station, where it will be combined with municipal sewage and conveyed via the municipal sanitary sewer system to the Greenway Wastewater Treatment Plant (WWTP).

2.4 Closure and Post-closure

Each Area of the proposed vertical expansion will be progressively closed as final waste contours are reached in that Area. The final cover will consist of a 600 mm thick soil layer topped with a 150 mm thick vegetated topsoil layer. Vertical landfill gas (LFG) extraction wells will be installed to collect gas from within the expanded waste mass as part of the progressive construction of the final cover system (horizontal gas collectors will be used for interim control of landfill gas during the landfilling period).

Post-closure activities will involve continued operation and maintenance of the leachate collection and removal system, the LFG control system and the stormwater management system. In addition to general inspection of the Site, there will be inspection of the landfill cover for evidence of erosion, leachate seeps or instability, and maintenance / repair as required.

3.0 ASSESSMENT OF LONG-TERM GROUNDWATER QUALITY IMPACTS

3.1 Regulatory Objectives

Modelling of long-term groundwater quality impacts for new or expanding landfill sites is required under O.Reg. 232/98 (Ministry of Environment, Conservation and Parks (MECP), 1998) to demonstrate that the proposed design will meet the requirements of the MECP Reasonable Use Guideline (RUG) B-7 (MECP, 1994). The Reasonable Use Guideline B-7 establishes a quantitative benchmark for protecting off-Site groundwater quality for drinking water purposes. The Reasonable Use Guideline makes the following statement regarding groundwater impact at the landfill property boundary:

“In the case of drinking water, the quality must not be degraded by an amount in excess of 50% of the difference between background and the Ontario Drinking Water Objectives for non-health related parameters and in excess of 25% of the difference between background and the Ontario Drinking Water Objectives for health related parameters. Background is considered to be the quality of the groundwater prior to any man-made contamination.”

3.2 Contaminant Transport Model

The assessment of potential long-term groundwater quality impacts from the expanded landfill was carried out using the contaminant transport model POLLUTE (Rowe et. al., 1994). POLLUTE is a one-dimensional, analytical contaminant transport model that can simulate vertical contaminant migration from a landfill situated on a multi-layered soil deposit. The model considers individual cross-sections through the landfill that are oriented in the direction of principal groundwater flow. The geologic units below the landfill for each cross-section are modelled as individual layers, with each assigned a set of physical and chemical parameters.

The time zero for the modelling ($t=0$) was taken as the Year 1987 for Phase 1 and 2010 for Phase 2, corresponding to ten years from the start of landfilling in each Phase. The simulation period was for 1000 years ($t=1000$ years).

The boundary condition used for contaminant source concentrations in the landfill is that of a depleting contaminant concentration with time from an initial representative peak value occurring at $t=0$ years and then from a second representative peak value occurring during the landfill expansion period. The depletion in contaminant source concentration is due to wash-out by moisture infiltration/percolation through the waste mass and to bio-chemical decay (for organic contaminants). The rate of concentration decrease with time is a function of the bio-chemical decay half-life, the representative peak leachate concentration, the contaminant mass inventory in the landfill and the moisture infiltration rate through the landfill cover. POLLUTE does not account for volatilization of volatile organic contaminants and, as such, is conservative in this respect.

Transport mechanisms modelled by POLLUTE are advection and dispersion (which includes mechanical mixing and molecular diffusion). Advection refers to the process whereby the solute is transported as a result of groundwater movement. Dispersion, on the other hand, refers to spreading of the solute due to a gradient in its concentration (the diffusion mechanism), and due to mechanical mixing of groundwater arising from heterogeneity in the

size and geometry of soil pores (the hydrodynamic mechanism). The model can also account for adsorption onto the soil solids and biological/chemical decay, which are processes that remove the solute from the porewater phase and hence decrease the net rate of migration. The adsorption process is modelled according to a linear/reversible isotherm and the biological/chemical decay process according to a first order decay rate.

The POLLUTE model output is in the form of calculated concentrations versus time at any specified depth below the waste, at the down-gradient edge of the landfill cross-section.

3.3 Geological and Hydrogeological Input Parameters

Based on the site geological and hydrogeological conditions described in the document entitled “Existing Groundwater Conditions” (Dillon, 2020) that is meant to be a companion study to this report, the landfill is underlain by the following soil layers in sequence starting from the base of the waste fill:

- Surficial Aquitard (Silty Clay)
- Upper Aquifer (Sand)
- Lower Aquitard (Silty Clay)
- Lower Sand Aquifer (White Oak Aquifer)

The selected locations of the POLLUTE model cross-sections are shown in Figure 1 in relation to the Upper Aquifer groundwater piezometric surface contours and Surficial Aquitard thickness contours. The cross-sections with the greatest potential to impact groundwater quality beneath the landfill are Sections A-A' and B-B' through Phase 1, which does not have an underdrain leachate collection system. Section A-A' passes through the central part of Phase 1 where the post-expansion waste fill thickness (up to 36 m) and landfill footprint length in the direction of groundwater flow (800 m) are the greatest. Section B-B' is through the southeastern portion of Phase 1 where the thickness of the Surficial Aquitard beneath the waste fill is the least.

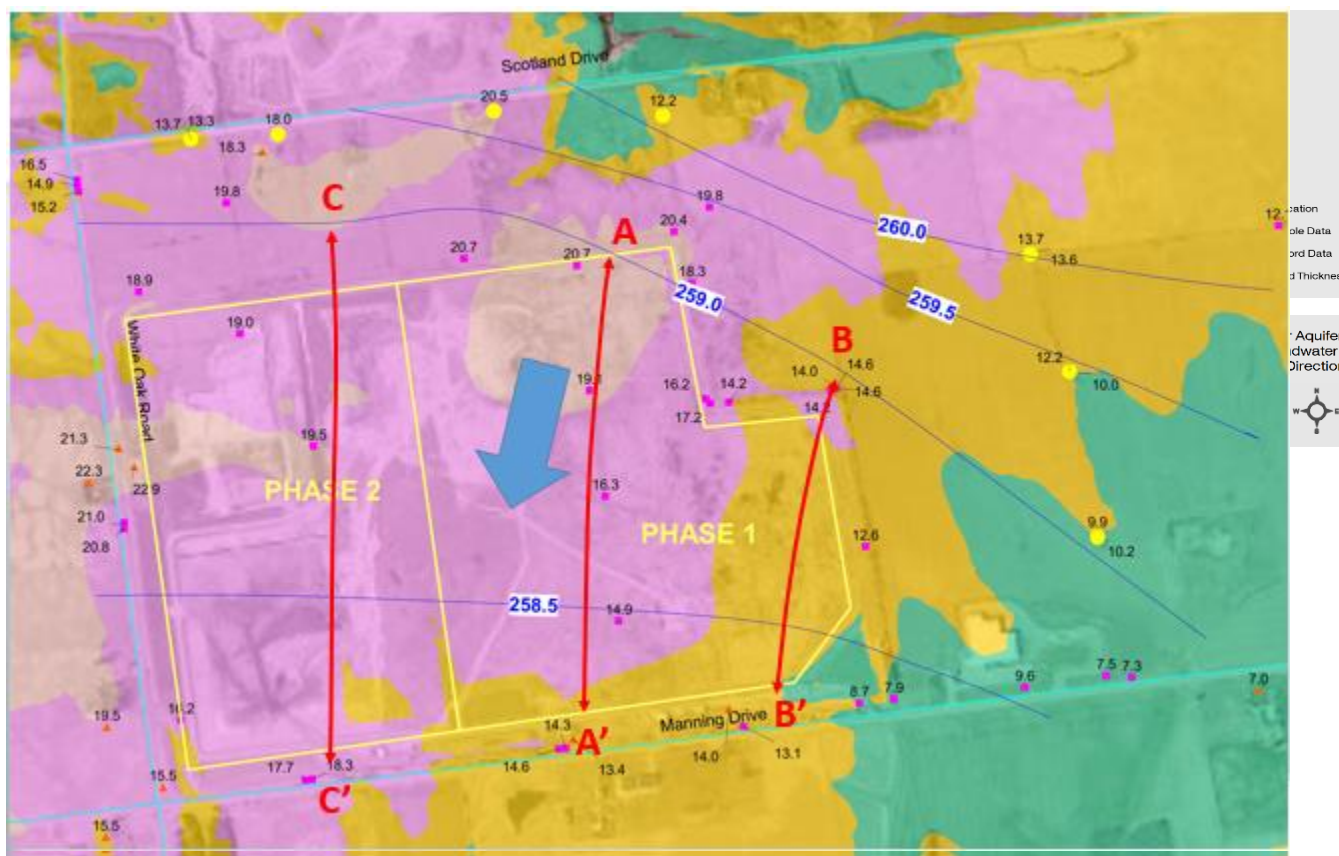


Figure 1: Plan View of The Landfill Showing Modelled Cross-Sections (A-A', B-B' and C-C'), Inferred Thickness of the Surficial Aquitard and Fall 2019 Groundwater Elevations in the Upper Aquifer (Based on Dillon, 2020).

The geological and hydrogeological input parameters used for the POLLUTE model cross-sections are based on the information provided in the Existing Groundwater Conditions Report (Dillon, 2020) and are summarized below:

Section A-A'

The soil layer thicknesses beneath the waste fill for Section A-A' are as follows:

- 14 metres (m) Surficial Aquitard - from Figure 1, the inferred average thickness of Surficial Aquitard relative to the original (pre-landfilling) ground surface along Section A-A' is approximately 17 m, of which the uppermost approximately 5 m is fractured. Considering that construction of the Phase 1 base grade involved excavation to approximately 3 m below grade, the average Surficial Aquitard thickness beneath the waste fill for Section A-A' was taken as 14 m, of which 2 m is fractured. It is noted, however, that based on an investigation of the Surficial Aquitard conducted by the University of Western Ontario (Western, 2000) any fractures originally present beneath Phase 1 may have self-healed due to consolidation of the clay from the overlying effective stress (weight) of the waste fill.

- 0.4 m unsaturated Upper Aquifer - the water level in the Upper Aquifer is consistently below the interface with the overlying Surficial Aquitard except for the southwest corner and hence the Upper Aquifer was divided into an upper unsaturated and an underlying saturated zone
- 7.6 m saturated Upper Aquifer
- 20 m Lower Aquitard
- 3 m thick White Oak Aquifer

The vertical hydraulic conductivity of the unfractured Surficial Aquitard was found to vary between 1.4×10^{-10} m/sec and 9×10^{-11} m/sec with a geometric mean value of 1.0×10^{-10} m/sec, based on the results of laboratory testing summarized in the Existing Groundwater Conditions Report (Dillon, 2020). There are no measurements of the hydraulic conductivity of the fractured Surficial Aquitard; however, the University of Western Ontario (Western, 2000) have indicated that the fractures self heal under the effective stress (weight) induced by the overlying waste fill placement. The hydraulic conductivity of the fractured zone has been assumed to be 1×10^{-7} m/sec, similar to other clays/tills regionally under natural conditions. Assuming 2 m of fractured zone with a hydraulic conductivity of 1×10^{-7} m/sec and 12 m of unfractured zone with a hydraulic conductivity of 1×10^{-10} m/sec, the calculated harmonic mean hydraulic conductivity for the Surficial Aquitard beneath Section A-A' is 1.2×10^{-10} m/sec. To account for a reduction in hydraulic conductivity due to consolidation of the aquitard material under the weight of the waste fill, the harmonic mean is rounded down to 1×10^{-10} m/sec. The Surficial Aquitard was therefore modelled as one unit with a thickness of 14 m and a hydraulic conductivity of 1×10^{-10} m/sec.

The fraction organic carbon content of the Surficial Aquitard was calculated to be 0.21%, which is the average of six fraction organic carbon analyses completed on samples obtained in 2019 as reported in the Existing Groundwater Conditions Report (Dillon, 2020). It is noted that the University of Western Ontario (Western, 2000) also completed a fraction organic carbon analysis from one sample in the fractured zone of the Surficial Aquitard and obtained a value of 0.4%. Conservatively, the modelling used the fraction organic carbon results from 2019.

The saturated portion of the Upper Aquifer was modelled as a horizontal "sink" to reflect lateral migration of contaminants out of this layer from beneath the landfill footprint. Using the Hazen formula, the hydraulic conductivity of the Upper Aquifer was estimated at approximately 1.1×10^{-5} m/sec based on grain size distributions from four samples obtained in 2019 (Dillon, 2020). The groundwater flow direction in the Upper Aquifer is to the southwest as shown in Figure 1. The hydraulic gradient in the Upper Aquifer upgradient of the landfill was taken as 0.0036 based on the groundwater piezometric surface shown in Figure 1.

The hydrogeologic characteristics of the Lower Aquitard have not been studied. This unit is described in the borehole records as silty clay and, as such, was assigned a low hydraulic conductivity of 1×10^{-10} m/sec for the purpose of the POLLUTE modelling similar to the unfractured Surficial Aquitard.

The top three metres of the White Oak Aquifer (assumed mixing zone of landfill contaminants within this aquifer) was included in the POLLUTE modelling. Using the Hazen formula, the hydraulic conductivity of the White Oak Aquifer was estimated at approximately 5.3×10^{-6} m/sec based on grain size distributions from four samples obtained in 2019. Based on groundwater level monitoring data, the primary groundwater flow path within the White Oak Aquifer is interpreted to be to the southeast at a horizontal hydraulic gradient of approximately 0.0004 (Dillon, 2020).

Section B-B'

The geological and hydrogeological input parameters for Section B-B' are the same as those for Section A-A', except that the Surficial Aquitard beneath the waste was assigned a smaller thickness of 9 m (versus 14 m for Section A-A').

Section C-C'

The geological and hydrogeological input parameters for the Phase 2 Section C-C' are the same as those for Section A-A' except that the Surficial Aquitard beneath the waste was assigned a greater thickness of 16 m (versus 14 m for Section A-A').

3.4 Leachate Generation Rates

The potential percolation rate of atmospheric water through the daily/interim and final cover of the W12A Landfill was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 (USEPA, 1997).

The HELP model is a quasi-two-dimensional water-balance model for water movement in the landfill (Schroeder et. al., 1994). The model accepts the weather data and landfill design data and uses solution techniques that account for the effect of different processes such as surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetation growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage and leakage through liners (Schroeder et. al., 1994 and Sharma and Lewis, 1994). The site-specific runoff, evapotranspiration, infiltration, drainage, leachate collection and liner leakage can be determined using the HELP model.

3.5 Climatological Input Parameters

Daily precipitation and temperature input data for the W12A Landfill Site were synthetically generated using the HELP model (Ref. 1). This involved taking 30 years of continuous precipitation and temperature data for Detroit, Michigan, USA (nearest reference station included in the HELP model database) and then adjusting the data with mean monthly precipitation and temperature values based on the average values for the London Airport meteorological station as shown in Table 1.

Daily solar radiation data was synthetically generated using the HELP model by taking the Detroit, Michigan solar radiation data (included in the HELP model database) and correcting the latitude for the W12A Landfill Site.

Average quarterly relative humidity and average annual wind speed for the London Airport meteorological station were used (refer to Table 2).

Table 1: Normal Mean Monthly Precipitation and Temperature at London Airport Meteorological Station

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Total Precipitation	mm	74.2	65.5	71.5	83.4	89.8	91.7	82.7	82.9	103	81.3	98	87.5
Temperature	°C	-5.6	-4.5	-0.1	6.8	13.1	18.3	20.8	19.7	15.5	9.2	3.4	-2.6

Climate ID: 6144475**Elevation:** 278.0 masl**Latitude:** 43°01'59.000" N**Longitude:** 81°09'04.000" W

Source: Canadian Climate Normals 1981-2010 (Environment Canada).

Table 2: Normal Relative Humidity and Windspeed at London Airport Meteorological Station

	units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Relative Humidity at 06:00	%	83.5	81.4	81.2	79.8	80.7	84.5	88.1	91.0	90.7	87.2	84.9	84.4
Relative Humidity at 15:00	%	75.9	71.9	65.0	56.9	54.8	57.0	57.6	59.7	59.9	63.1	72.0	76.9
Average Quarterly Relative Humidity	%	76			69			75			78		
Windspeed	km/h	17.3	16.2	16.3	16.3	14.0	11.9	10.6	9.7	11.1	13.4	15.6	16.5
Average Annual Windspeed	km/h	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1

Climate ID: 6144475**Elevation:** 278.0 m masl**Latitude:** 43°01'59.000" N**Longitude:** 81°09'04.000" W

Source: Canadian Climate Normals 1981-2010 (Environment Canada).

3.5.1 Daily/Interim Cover, Final Cover and Waste Layer Input Parameters

The HELP model input parameters for the daily/interim cover, final cover and waste are summarized in Table 3. The values used in the HELP model for total porosity, field capacity and wilting point are according to the HELP model default values as shown in Table 3.

The initial water content was taken as equal to or greater than the field capacity water content, which is the water content at which the soil can no longer absorb/retain additional moisture under free drainage. With respect to modelling the leachate generation rate, this is a conservative assumption as it reduces the time to reach peak leachate generation.

The model for the filling period was run for a daily/interim cover slope of 1 % and drainage path length of 500 m. The model for the post closure period was run for a final cover slope of 5 % and drainage path length of 500 m.

Table 3: HELP Model Input Parameters

Input Parameters [†]	Units	Daily/Interim Cover	Final Cover Topsoil	Final Cover Cover Soil	Waste
HELP Model Soil Texture Class [†]	[-]	8	8	11	18
USDA Soil Texture Class	[-]	Loam (L)	Loam (L)	Clayey Loam (CL)	Municipal Waste
Thickness	m	0.15	0.15	0.60	35
Total porosity	[-]	0.463	0.463	0.464	0.67
Field capacity	[-]	0.232	0.232	0.310	0.29
Wilting point	[-]	0.116	0.116	0.187	0.08
Initial volumetric water content	[-]	0.232	0.232	0.310	0.29
Hydraulic Conductivity [*]	cm/sec	3.7E-4	3.7E-4	6.4E-5	1.0E-3

Notes:

[†] HELP model default soil texture class were used together with model default parameters for total porosity, field capacity, wilting point, initial volumetric water content and hydraulic conductivity.

^{*} Effective saturated hydraulic conductivity.

3.5.2 Vegetation Input Parameters

The HELP model requires input data for the type and extent of vegetation growing on the cover, as well as input data for the evaporative zone depth. For daily/interim cover, a bare ground condition was assumed with a maximum leaf area index of 0. The leaf area index is defined as the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the final cover. For the final cover, a good stand of grass with a maximum leaf area index of 4 was used.

For the daily/interim cover, an evaporative zone depth of 15 cm was assumed. The evaporative zone depth is defined as the maximum depth from which water may be removed by evapotranspiration. For the post-closure period, an evaporative zone depth of 55 cm was assumed for loam / clayey loam soil with good stand of grass.

3.5.3 Results

The average annual water balance and peak daily values obtained from the HELP modelling are provided in Table 4. The average annual percolation rate through daily/interim cover during the filling period is approximately 245 mm/year. The average annual percolation rate through the final cover during the post-closure period is approximately 235 mm/year. The peak daily percolation rates are approximately 5 mm in 24 hours for the filling period and approximately 4 mm in 24 hours for the post closure period.

**Table 4: HELP Model Output
(Average Annual Water Balance and Peak Daily Percolation Rate)**

Average Annual	Daily/Interim Cover	Final Cover
Precipitation	995 mm/year	995 mm/year
Runoff	305 mm/year	210 mm/year
Evapotranspiration	445 mm/year	550 mm/year
Percolation into the Waste	245 mm/year	235 mm/year
Peak Daily		
Percolation into the Waste	5 mm/day (24 hours)	4 mm/day (24 hours)

3.6 Landfill Key Contaminants and Associated Transport Parameters

In accordance with O.Reg. 232/98 (MECP, 1998), the key leachate contaminants modelled to address long-term compliance with the MECP Reasonable Use Guideline (RUG) B-7 (MECP, 1994) are: benzene, cadmium, chloride, lead, 1,4-dichlorobenzene, dichloromethane, toluene and vinyl chloride. These are the parameters that the MECP has determined to have the greatest potential to cause exceedances of the Guideline B-7 values at municipal landfill sites, because they have relatively high initial source concentrations, higher ability to diffuse through liner systems and natural soil deposits, and/or lower decay rates and adsorption ability. Chloride is typically the critical inorganic parameter for landfill compliance and therefore is the focus of this modelling.

Modelling input parameters required for each key landfill leachate contaminant are the representative peak leachate source concentration, mass inventory in the landfill (i.e., contaminant mass as a proportion of total mass of waste), half-life in the groundwater flow system, soil diffusion coefficient and soil adsorption coefficient. As shown on Table 5, the input for representative peak leachate source concentration, mass inventory and half-life are conservatively the same as the values recommended in Table 1 of O.Reg. 232/98, which are based on historical leachate quality monitoring for a number of municipal solid waste landfill sites in Ontario.

The soil adsorption coefficients for the organic contaminants were calculated using literature values for soil/organic carbon partition coefficient (i.e., K_{oc}) and a laboratory fraction organic carbon (f_{oc}) for the Surficial Aquitard. Soil adsorption coefficients for the metals (i.e., cadmium and lead) were assumed based on literature values for similar soil types. Diffusion coefficients for all parameters were assumed based on literature values for similar soil types.

The background concentrations in groundwater in the Upper Aquifer are based on the median of concentrations in background monitoring wells 92-11, 82-6 and 01-14 from 2015 to 2019, using the data presented in the 2019 Annual Monitoring Report (City of London, 2020).

Table 5: Key Contaminants and Associated Soil Transport Parameters

Key Contaminant	Representative Peak Leachate Source Concentration ¹ (mg/L)	Mass Proportion of Total (Wet) Mass of Waste ¹ (mg/kg)	Half-Life ¹ (years)	Soil Adsorption Coefficient (mL/g)	Soil Diffusion Coefficient ² (m ² /year)	Background Concentration in Upper Aquifer ⁵ (mg/L)	Ontario Drinking Water Quality Objective ⁶ (mg/L)
Chloride	2,000 to 2,500 ⁷	1,800	Infinite	0	0.02	5	250 (A)
Cadmium	0.05	0.035	Infinite	70 ³	0.02	<0.0002	0.005 (H)
Lead	0.6	0.42	Infinite	1900 ³	0.02	<0.002	0.01 (H)
Benzene	0.02	0.014	25	0.12 ⁴	0.02	<0.0005	0.005 (H)
1,4-Dichlorobenzene	0.01	0.007	50	1.3 ⁴	0.02	<0.0005	0.005 (H)
Dichloromethane	3.3	2.3	10	0.03 ⁴	0.02	<0.0020	0.05 (H)
Toluene	1	0.7	15	0.38 ⁴	0.02	0.00075	0.024 (A)
Vinyl Chloride	0.055	0.039	25	0.12 ⁴	0.02	<0.0005	0.002 (H)

Notes:

¹ Values taken from Table 1 of O.Reg. 232/98 for municipal solid waste.

² Assumed diffusion coefficient based on literature values for similar soils.

³ Rowe et.al., 2004.

⁴ Based on a fraction organic carbon content (foc) of 0.21% for the Surficial Aquitard and soil/organic carbon partition coefficients (Koc) of 59 ml/g for benzene, 617 ml/g for 1,4-dichlorobenzene, 12 ml/g for dichloromethane, 182 ml/g for toluene and 56 ml/g for vinyl chloride, (Ref. USEPA Technical Fact Sheets)

⁵ Median of concentrations in background monitoring wells 92-11, 82-6 and 01-14 from 2015 to 2019.

⁶ Ontario Drinking Water Quality Standards.

⁷ Used 2,000 mg/L for the existing waste fill based on leachate monitoring data and then 2,500 mg/L per Reg 232/98 for the vertically expanded landfill.

(A) Denotes aesthetic drinking water objective.

(H) Denotes health related drinking water objective.

3.7 Landfill Leachate Mound Height

For Phase 1, which does not have a continuous leachate drainage blanket, the existing maximum leachate mound height relative to the base of the landfill is approximately 12 m based on monitoring of leachate levels at monitoring wells screened within the waste fill. Using this maximum leachate mound height together with the maximum distance of 800 m between the perimeter leachate collector on the north and south sides of Phase 1 and the HELP Model infiltration rate of 0.235 m/y through the existing Phase 1 final cover soil, an average waste hydraulic conductivity of 8×10^{-6} m/sec was back-calculated using the Harr Equation:

$$h_{max} = 0.5L \sqrt{\frac{q_{net}}{k_w}}$$

or

$$k_w = \left(\frac{0.5L}{h_{max}} \right)^2 q_{net}$$

where,

h_{max} = maximum mound height (m) = 12 m

q_{net} = infiltration rate = 0.235 m (based on HELP model)

L = maximum distance between the perimeter leachate collector systems on the north and south sides of Phase 1 = 800 m

k_w = hydraulic conductivity of waste (m/year)

Using the back-calculated waste hydraulic conductivity, an average leachate head (h_{avg}) of 9.5 m was calculated for the Phase 1 Section A-A' pre-expansion using the Harr Equation:

$$h_{avg} = 0.393L \sqrt{\frac{q_{net}}{k_w}}$$

After vertical expansion, an average mound height of 19 m was calculated for Phase 1 Section A-A' using a reduced waste hydraulic conductivity k_w of 2×10^{-6} m/sec based on the range of literature values for similar thickness of waste fill (up to 36 m thick). The reduced hydraulic conductivity accounts for further compression of waste after expansion. The average mound height of 19 m was estimated to be reached approximately 22 years after the start of the vertical expansion.

For the Phase 1 Cross-Section B-B', a leachate head (h) of 7 m was calculated using the Harr Equation for estimating mound height at distance (x = 75 m) from the perimeter collector:

$$h = \sqrt{\frac{q_{net}}{k_w} (L - x) x}$$

The 7 m leachate head for Section B-B' applies to the periods prior to and after the vertical expansion, as this cross-section is located along the perimeter slope (southeast corner of the landfill) where there will be only a minor increase in waste thickness and hence a minor if any decrease in waste hydraulic conductivity.

For Phase 2 (Cross-Section C-C'), which has a blanket leachate collection system over its full base area, the average leachate head above the base of the landfill was assumed to remain constant at 0.3 m for 100 years from the start time (t=0) of the POLLUTE modelling (where t=0 corresponds to 10 years from the start of landfilling in the Phase 2 area). This 100 year period represents the assumed service life of the leachate drainage layer as specified in Regulation 232/98 for the purpose of contaminant transport modelling. It is noted that in the application to amend the W12A ECA for Phase 2 (Earth Tech, 2003) the calculated service life of the site-specific leachate collection system design was 200 years. The service life is limited by bio-chemical clogging of the drainage layer over time. After failure of the leachate drainage layer, a leachate mound will develop in Phase 2. Using the waste hydraulic conductivity of 2×10^{-6} m/sec for the post-expansion period, an average mound height of 19 m was calculated. This average mound height was estimated to be reached approximately 35 years after the failure of the leachate collection system.

3.8 Vertical Leakage Rates

The average leachate head, leachate removal rates via the leachate collection systems, Darcy fluxes and horizontal Darcy (rate of removal) via the cross flow in the Upper Aquifer (Sink Layer) are presented in Table 6 for the Phase 1 Cross Section A-A', in Table 7 for the Phase 1 Cross Section B-B' and in Table 8 for the Phase 2 Cross-Section C-C'.

Table 6: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 1 Cross-Section A-A')

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
1987-1991	0	0.0032	1.560	0.0003	0.0669	0.037
1991-1996	2.0	0.0037	1.607	0.0003	0.0669	0.049
1996-2002	4.4	0.0042	1.663	0.0003	0.0669	0.061
2002-2010	7.5	0.0049	1.738	0.0003	0.0669	0.157
2010-2015	9.5	0.0054	1.785	0.0003	0.0669	0.218
2015-2023	9.5	0.0054	1.785	0.0003	0.0669	0.230
2023-2030	11.0	0.0057	1.821	0.0003	0.0669	0.239
2030-2043	15.2	0.0067	1.920	0.0003	0.0669	0.228
2043-4043	19.0	0.0075	2.010	0.0003	0.0669	0.227

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (1977) in Phase 1.
- ² Stabilized average mound heights of 9.5 m prior to expansion and 19 m after expansion were calculated using Harr Equation as described in the previous section. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux in the Upper Aquifer of 1.25 m/year in the Phase 1 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0875$ in Phase 1 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ Leachate collected between 1987 to 2002 was based on 73% of the recorded total pumping rate from the perimeter LCS pump station. The percentage of leachate in the pumped volume is based on the average chloride concentration in leachate wells compared to the LCS pump station pumped volume from the perimeter LCS pump station. Leachate collection rate between 2002 to 2023 is assumed to gradually increase as the mound height increases. Leachate collection rate after 2023 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard.

Table 7: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 1 Cross-Section B-B')

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
1987-1991	0	0.0033	1.447	0.0003	0.0669	0.037
1991-1996	1.0	0.0036	1.469	0.0003	0.0669	0.049
1996-2002	2.1	0.0040	1.496	0.0003	0.0669	0.061
2002-2010	3.7	0.0046	1.532	0.0003	0.0669	0.112
2010-2015	4.7	0.0049	1.555	0.0003	0.0669	0.144
2015-2023	7.0	0.0057	1.608	0.0003	0.0669	0.195
2023-2030	7.0	0.0057	1.608	0.0003	0.0669	0.239
2030-2045	7.0	0.0057	1.608	0.0003	0.0669	0.229
2045-4045	7.0	0.0057	1.608	0.0003	0.0669	0.229

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (1977) in Phase 1.
- ² Stabilized mound height of 7.0 m was calculated using Harr Equation as described in the previous section for prior to and after expansion. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux in the Upper Aquifer of 1.25 m/year in the Phase 1 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0875$ in Phase 1 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ The rate of leachate collection between 1987 to 2002 was based on 73% of the recorded total pumping rate from the perimeter LCS pump station. The percentage of leachate in the pumped volume is based on the average chloride concentration in leachate wells compared to the LCS pump station. The leachate collection rate between 2002 to 2023 is assumed to gradually increase as the mound height increases. Leachate collected after 2023 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard.

Table 8: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 2)

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
2010-2040	0.3	0.0033	1.536	0.0001	0.0669	0.242
2040-2050	0.3	0.0033	1.536	0.0001	0.0669	0.242
2050-2110	0.3	0.0033	1.536	0.0001	0.0669	0.232
2110-2117	4.0	0.0040	1.614	0.0001	0.0669	0.000
2227-2124	7.8	0.0048	1.691	0.0001	0.0669	0.046
2024-2131	11.5	0.0055	1.769	0.0001	0.0669	0.091
2131-2138	15.3	0.0062	1.846	0.0001	0.0669	0.137
2138-2145	19.0	0.0070	1.924	0.0001	0.0669	0.228
2145-4145	19.0	0.0070	1.924	0.0001	0.0669	0.228

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (2010) in Phase 2.
- ² Mound height assumed to remain constant at 0.3 m up to 100 years at which the LCS fails. Stabilized mound height of 19 m was calculated using Harr Equation and estimated to be reached at 35 years after the failure of the LCS. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux into the Upper Aquifer of 1.2 m/year for the Phase 2 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0225$ in Phase 2 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ Leachate collected between 2010 to 2110 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard. It was assumed that no leachate was collected between 2110 to 2117 after the failure of LCS. Leachate collected between 2117 and 2145 is assumed to gradually increase as the mound height increases and leachate flows laterally to a perimeter leachate collector system. The rate of leachate collection after 2145 is based on the infiltration rate obtained from the HELP model minus the Darcy Flux through the Surficial Aquitard.

3.9 Results of Contaminant Transport Modelling

The results of the hydrogeologic/contaminant transport modelling are described below. An example of the POLLUTE output file is provided in Appendix B. The results of the modelling for all key landfill leachate contaminants are summarized in Table 9 for the Phase 1 and Phase 2 cross-sections. The results are presented as predicted peak concentration and time of peak concentration in the Upper Aquifer at the downgradient (southern) limit of the waste fill. For all parameters modelled, the Reasonable Use Criteria for the Upper Aquifer is met over the 1000 year modelling time frame except for chloride at the Phase 1 Section A-A, which gave a peak impact of 129 mg/L versus the Reasonable Use Guideline value of 128 mg/L at approximately $t=700$ years. Figures 2, 3 and 4 show the predicted concentrations for chloride versus time in the Upper Aquifer at the downgradient (southern) limit of the waste fill for the modelling cross-sections. The modelling indicated no impacts on the Lower Aquifer (White Oak Aquifer).

The negligible predicted impact for the organic contaminants (i.e., benzene, 1,4-dichlorobenzene, dichloromethane, toluene and vinyl chloride) on the Upper Aquifer relates primarily to biodegradation, mass removal through leachate collection, the very slow (diffusion controlled) rate of transport into the Surficial Aquitard and adsorption uptake within the Surficial Aquitard. For lead and cadmium, the negligible impact is due to the same processes noted above, except that biodegradation does not apply for these parameters.

Table 9: Predicted Concentrations of Key Leachate Contaminants in the Upper Aquifer

Contaminant	Background Concentration in the Aquifer (mg/L) ¹	Ontario Drinking Water Quality Objective ² (mg/L)	Reasonable Use Guideline ³ (mg/L)	Phase 1 (Section A-A') Predicted Peak Conc.* (mg/L)	Phase 1 (Section A-A') Time of Peak Conc.** (years)	Phase 1 (Section B-B') Predicted Peak Conc.* (mg/L)	Phase 1 (Section B-B') Time of Peak Conc.** (years)	Phase 2 (Section C-C') Predicted Peak Conc.* (mg/L)	Phase 2 (Section C-C') Time of Peak Conc.** (years)
Chloride	5	250 (A)	128	129	706	75	808	72	855
Cadmium	<0.0002	0.005 (H)	0.0014	<0.00002	>1000	<0.00002	>1000	<0.00002	>1000
Lead	<0.002	0.01 (H)	0.004	<0.0002	>1000	<0.0002	>1000	<0.0002	>1000
Benzene	<0.0005	0.005 (H)	0.0016	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000
1,4-Dichlorobenzene	<0.0005	0.005 (H)	0.0008	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000
Dichloromethane	<0.0020	0.05 (H)	0.014	<0.0002	>1000	<0.0002	>1000	<0.0002	>1000
Toluene	0.00075	0.024 (A)	0.0124	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000
Vinyl Chloride	<0.0005	0.002 (H)	0.0009	<0.00005	>1000	<0.00005	>1000	<0.00005	>1000

Notes:

¹ Median of 2015 to 2019 concentration in background monitoring wells 92-11, 82-6 and 01-14.

² Ontario Drinking Water Quality Standards (ODWQS).

³ Reasonable Use Guideline = Background Concentration + X (ODWQS Criteria - Background Concentration):
where X = 0.25 for health related drinking water parameters
= 0.50 for aesthetic related drinking water parameters

* Based on a 1,000 year contaminant transport modelling time frame, has been added to the background concentration.

** Relative to year 10 of the landfilling period.

(A) Denotes aesthetic drinking water objective.

(H) Denotes health related drinking water objective.

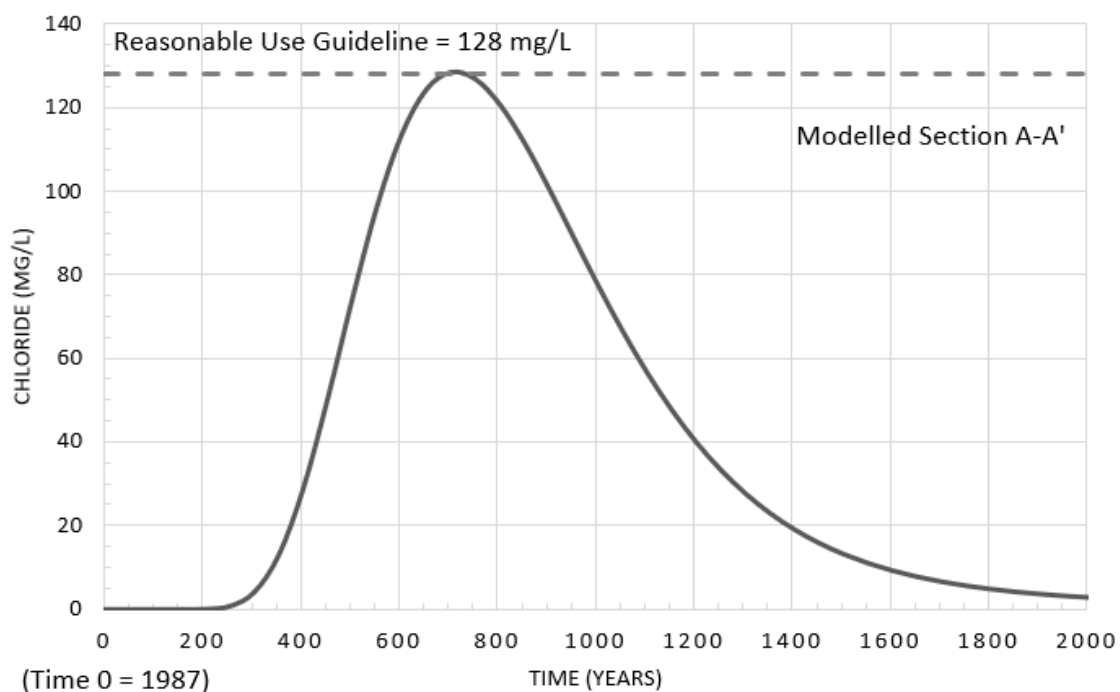


Figure 2: Chloride Concentration Versus Time for Cross-Section A-A'

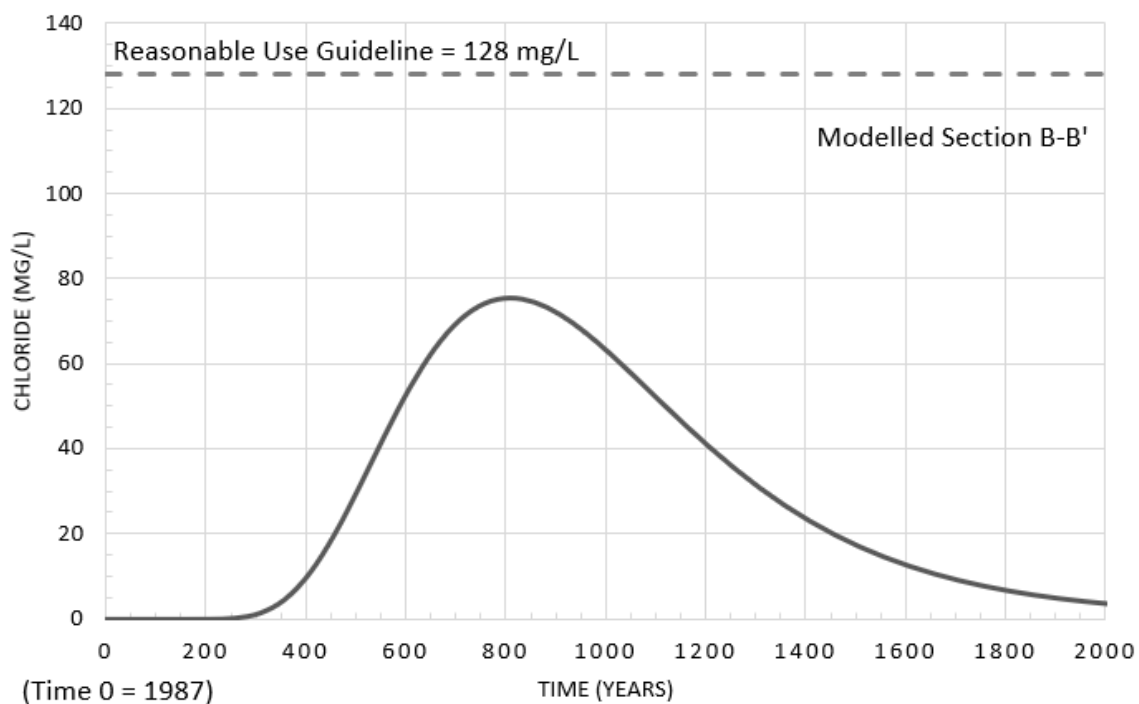


Figure 3: Chloride Concentration Versus Time for Cross-Section B-B'

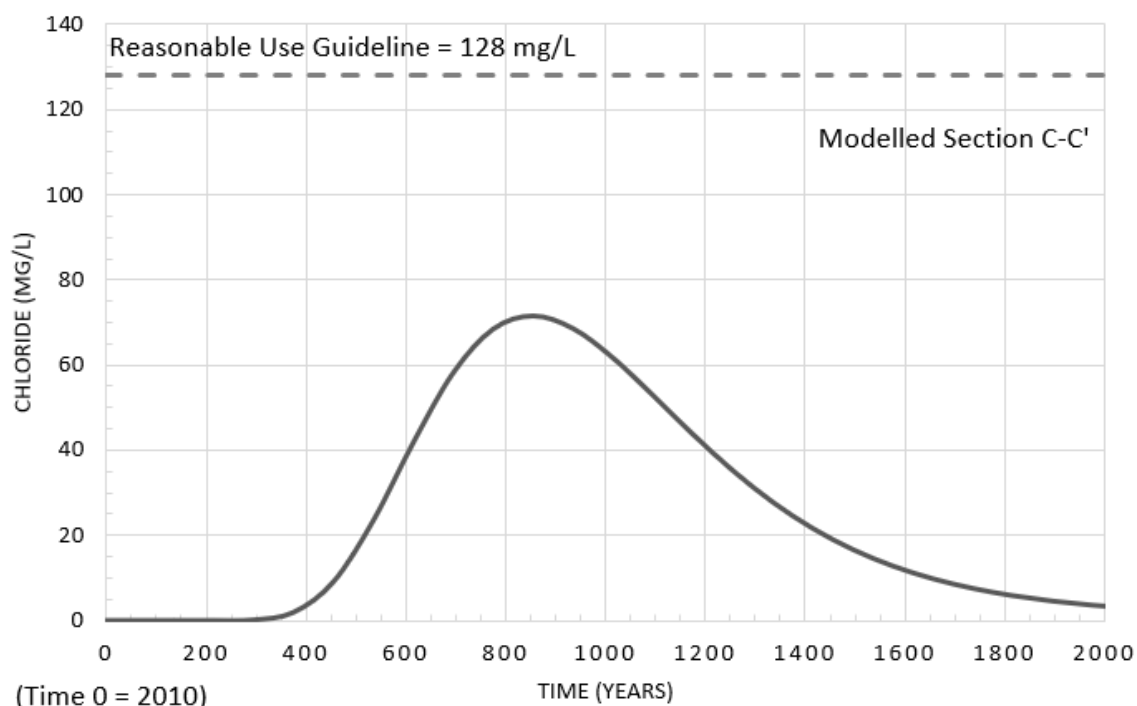


Figure 4: Chloride Concentration Versus Time for Cross-Section C-C'

4.0 ASSESSMENT OF GROUNDWATER QUANTITY IMPACTS

As described in the Existing Groundwater Conditions report, the W12A landfill is underlain by a deposit of low permeability clayey till that is about 15 to 20 m thick beneath much of the landfill and decreasing to about 10 m in the southeast corner area. This is in turn underlain by a sandy Upper Aquifer layer (a local aquifer) that is about 2 to 8 m thick, then about 20 m of clayey till (Lower Aquitard) and then the White Oak Aquifer (a regional scale aquifer). Because the upper few metres of the Surficial Aquitard is fractured to a variable degree, precipitation can infiltrate towards the lower limit of the fracture zone; however, because of the low permeability and very slow groundwater velocity associated with the unfractured remainder of the Surficial Aquitard deposit, the infiltration of precipitation to greater depth is very low. The sand and gravel deposits exposed at ground surface and ponds in the gravel pits in the area north of Scotland Drive (north of the landfill site) have been identified as the groundwater recharge zone to both the Upper Aquifer and White Oak Aquifer, since both of these aquifers are directly connected to these exposed sand and gravel deposits. The groundwater flow direction in the Upper Aquifer is generally from northeast to southwest/south, while the flow direction in the regional White Oak Aquifer is from northwest to southeast.

Because of the existing landfill's location overlying the Surficial Aquitard, its presence does not affect the recharge of the groundwater system and has no effect on groundwater levels or groundwater quantity in the Upper and White Oak Aquifers beneath the landfill or off-Site further to the south of the landfill site. With the proposed landfill expansion consisting of a vertical expansion above the existing landfill footprint, the expansion will not have an effect on

downgradient groundwater levels or groundwater quantity off-Site to the south of the landfill site. As such, the expansion is not expected to affect: the groundwater supply available to water supply wells in the area; groundwater baseflow to off-Site watercourses or other natural environment features in the area of the landfill, or; off-Site groundwater levels that support vegetation.

5.0 ADDITIONAL MITIGATION MEASURES

The results of the groundwater impact assessment indicate that the leachate control systems currently proposed in the design of the proposed vertical expansion will result in the W12A Landfill complying with MECP requirements for impacts on off-Site groundwater quality, with the exception of potentially chloride that gave a predicted peak concentration slightly higher than that allowed by the Reasonable Use Guideline in the Upper Aquifer at the downgradient (south) limit of the Phase 1 waste fill area at Section A-A' (i.e., 129 mg/L peak impact versus the RUG value of 128 mg/L, at approximately time $t=700$ years). The exceedance is primarily the result of leachate mounding within the Phase 1 area, which unlike the Phase 2 area does not have a leachate drainage layer throughout its base.

To address the predicted RUG exceedance for chloride at the downgradient limit of the Phase 1 waste fill, consideration was given to acquisition of an additional approximately 50 m of buffer zone lands downgradient (south) of the landfill, with the objective of meeting the RUG for chloride at the limit of the buffer zone. However, by applying the POLLUTE model to simulated one-dimensional (horizontal) advective-dispersive transport within the Upper Aquifer downgradient of the landfill, it was determined that the additional buffer zone would have very little effect in attenuating chloride impacts. Chloride does not undergo adsorption or biochemical decay reactions and therefore the attenuation mechanism would be by longitudinal dispersion and mixing with the downgradient recharge to the Upper Aquifer, which in this case is minimal given the low vertical hydraulic conductivity of the Surficial Aquitard.

Consideration was also given to incorporating leachate collection into the design of a first tier of horizontal landfill gas collector trenches installed in a north-south direction at 30 m spacing and to a depth of 3 m into the existing waste fill over the top surface of the Phase 1 area prior to the vertical expansion. These trenches would be backfilled with 50 mm clear stone and connect to the perimeter leachate collector system to allow leachate removal. The POLLUTE modelling for chloride was repeated for Phase 1 Section A-A' with mound control by these horizontal collectors over a service life period of 100 years from the start of the vertical expansion in Phase 1 (refer to Appendix C for service life calculation with respect to biochemical clogging). The input parameters used for this modelling are presented in Table 10. The results of the modelling indicate a peak chloride concentration of 120 mg/L, which meets the RUG of 128 mg/L (Table 11). It is therefore recommended that the horizontal landfill gas collectors be designed for dual purpose as gas and leachate collectors, at the horizontal spacing/depth described above.

Table 10: Average Darcy Fluxes, Rate of Removals and Leachate Collected (Phase 1 Cross-Section A-A' with Mound Control)

Time ¹ (years)	Average Leachate Head on Surficial Aquitard ² (m)	Darcy Flux through Surficial Aquitard ³ (m/year)	Rate of Removal in Upper Aquifer ⁴ (m/year)	Darcy Flux through Lower Aquitard ⁵ (m/year)	Rate of Removal in White Oak Aquifer ⁶ (m/year)	Collected Leachate ⁷ (m ³ /m ² /year)
1987-1991	0	0.0032	1.560	0.0003	0.0669	0.037
1991-1996	2.0	0.0037	1.607	0.0003	0.0669	0.049
1996-2002	4.4	0.0042	1.663	0.0003	0.0669	0.061
2002-2010	7.5	0.0049	1.738	0.0003	0.0669	0.157
2010-2015	9.5	0.0054	1.785	0.0003	0.0669	0.218
2015-2023	9.5	0.0054	1.785	0.0003	0.0669	0.230
2023-2030	10.6	0.0056	1.811	0.0003	0.0669	0.239
2030-2038	11.8	0.0059	1.840	0.0003	0.0003	0.229
2038-2124	14.5	0.0065	1.904	0.0003	0.0003	0.228
2124-2135	17.0	0.0071	1.963	0.0003	0.0003	0.228
2135-4135	19.0	0.0075	2.010	0.0003	0.0003	0.227

Notes:

- ¹ Model starts at 10 years from the beginning of landfilling (1977) in Phase 1.
- ² Stabilized average mound heights of 9.5 m prior to expansion and 19 m after expansion were calculated using Harr Equation as described in the previous section. Mound height was assumed to increase gradually during the intermediate timesteps.
- ³ Vertical flux in the Surficial Aquitard calculated using Darcy's Law [where, $k = 1 \times 10^{-10}$ m/sec and $i = (\text{mound height} + \text{thickness of Surficial Aquitard} + \text{thickness of unsaturated aquifer}) / \text{thickness of Surficial Aquitard}$].
- ⁴ Calculated using continuity of flow and upgradient horizontal flux in the Upper Aquifer of 1.25 m/year in the Phase 1 area.
- ⁵ Vertical flux in the Lower Aquitard calculated using Darcy's Law (where, $k = 1 \times 10^{-10}$ m/sec and $i = 0.0875$ in Phase 1 area).
- ⁶ Horizontal flux in the White Oak Aquifer calculated using Darcy's Law (where, $k = 5.3 \times 10^{-6}$ m/sec and $i = 0.0004$).
- ⁷ Leachate collected between 1987 to 2002 was based on 73% of the recorded total pumping rate from the perimeter LCS pump station. The percentage of leachate in the pumped volume is based on the average chloride concentration in leachate wells compared to the LCS pump station pumped volume from the perimeter LCS pump station. Leachate collection rate between 2002 to 2023 is assumed to gradually increase as the mound height increases. Leachate collection rate after 2023 is based on the infiltration rate obtained from the HELP model minus the Darcy flux through the Surficial Aquitard.

**Table 11: Predicted Concentrations of Key Leachate Contaminants in the Upper Aquifer
(Phase 1 Cross-Section A-A' with Mound Control)**

Contaminant	Background Concentration in the Aquifer (mg/L) ¹	Ontario Drinking Water Quality Objective ² (mg/L)	Reasonable Use Guideline ³ (mg/L)	Phase 1 (Section A-A' with Mound Control) Predicted Peak Conc.* (mg/L)	Phase 1 (Section A-A' with Mound Control) Time of Peak Conc.** (years)
Chloride	5	250 (A)	128	120	708
Cadmium	<0.0002	0.005 (H)	0.0014	<0.00002	>1000
Lead	<0.002	0.01 (H)	0.004	<0.0002	>1000
Benzene	<0.0005	0.005 (H)	0.0016	<0.00005	>1000
1,4-Dichlorobenzene	<0.0005	0.005 (H)	0.0008	<0.00005	>1000
Dichloromethane	<0.0020	0.05 (H)	0.014	<0.0002	>1000
Toluene	0.00075	0.024 (A)	0.0124	<0.00005	>1000
Vinyl Chloride	<0.0005	0.002 (H)	0.0009	<0.00005	>1000

Notes:

¹ Median of 2015 to 2019 concentration in background monitoring wells 92-11, 82-6 and 01-14.

² Ontario Drinking Water Quality Standards (ODWQS).

³ Reasonable Use Guideline = Background Concentration + X (ODWQS Criteria - Background Concentration):
where X = 0.25 for health related drinking water parameters
= 0.50 for aesthetic related drinking water parameters

* Based on a 1,000 year contaminant transport modelling time frame, has been added to the background concentration.

** Relative to year 10 of the landfilling period.

(A) Denotes aesthetic drinking water objective.(H) Denotes health related drinking water objective.

Although the results of the contaminant transport modelling indicate that the proposed expanded landfill will meet the Reasonable Use Guideline B-7 criteria for the Upper and Lower Aquifer layers, for the successful performance of the landfill in this regard it is important that the perimeter leachate collection system (i.e., perimeter leachate collector trench and sideslope finger drains) for the Phase 1 area and the Phase 2 area (to be installed when the Phase 2 blanket leachate collection system reaches the end of its service life) be maintained over the long term to protect against leachate break-out to surface. These perimeter control systems are accessible for inspection, maintenance and replacement as necessary. The implications of not maintaining these systems over the long-term include potential impacts to surface water, aesthetic impacts (e.g. leachate staining on the perimeter slopes and along perimeter drainage ditches) and erosion/vegetation kill on the final cover.

6.0 GROUNDWATER AND LEACHATE MONITORING PROGRAM

The City of London has an existing comprehensive groundwater monitoring program for the existing landfill that has been updated to reflect current Site information and the proposed landfill expansion. A summary of the proposed groundwater monitoring program for the landfill expansion, leachate and neighbouring water wells is provided in Table 12, Table 13 and Table 14, respectively and locations are shown on Figure 5. The monitoring parameters are provided in Table 15.

Table 12: Groundwater Monitoring Program

Monitoring Wells Description	Monitoring Wells Identification #	Parameters	Sampling Dates
<i>Shallow Aquifer – On-site</i> All monitoring wells located at or near the property boundary that are screened in the shallow aquifer	01-12b, 01-14, 13-1a, 13-3a, 91-4a, 84-5b, 82-6, 92-11, 94-1, 94-3, 01-9a, 04-2a, 06-1, 06-2, 92-7a, 19-4b, 19-5b	Comprehensive List Indicator List	June April, October
<i>Shallow Aquifer – Off-site</i> Representative monitoring wells located in adjacent City owned properties that are screened in the shallow aquifer	04-6a, 05-1, 05-2, 05-3	Indicator List	June
<i>White Oak Aquifer</i> Representative monitoring wells (on-site and off-site) that are screened in the White Oak Aquifer	92-8, 92-9, 92-10, 92-12, 94-2, 01-3a, 14	Indicator List	June

Monitoring Wells Description	Monitoring Wells Identification #	Parameters	Sampling Dates
<i>Till</i>	00-7a (Till monitor below garbage) Additional monitoring wells will be installed in the upper fractured clay till zones at key locations on the east and/or south sides of the Phase 1 area, with the details to be determined as part of the subsequent EPA approvals process for the expansion.	Comprehensive List	June
<i>All Monitoring Wells</i>	Monitoring wells listed above plus 92-1, 92-2, 92-3, 92-4, 92-7, 01-12a, 01-13, 00-3a, 00-3b, 05-4, 05-5, 19-1, 19-2, 19-3, 19-4a, 19-5a, 19-6a, 19-6b, 19-7a, 19-7b, 19-7c, 92-10a	Water levels	April, June, October

Table 13: Leachate Monitoring Program

Location	Parameters	Sampling Dates
<i>Representative Leachate Monitoring Wells</i> Monitoring wells 97-2, 97-5 and 97-7	Comprehensive List Indicator List	June April, October
<i>Leachate Loading Station</i> Leachate loading station #2	Comprehensive List Indicator List	June April, September, November
<i>All Leachate Monitoring Wells</i> Monitoring wells 97-2, 97-3, 97-4, 97-5 and 97-7	Water Levels	June

Table 14: Water Well Monitoring Program

Location	Parameters	Sampling Dates
Water Wells – Off-site Upgradient and Downgradient Wells if access granted by owner and if not destroyed/decommissioned by owner – 9, 20, 21, 23, 24, 25, 26, 27, 31, 32, 33, 36, 113, 131	Comprehensive List Indicator List	June 2017, 2020, etc. June

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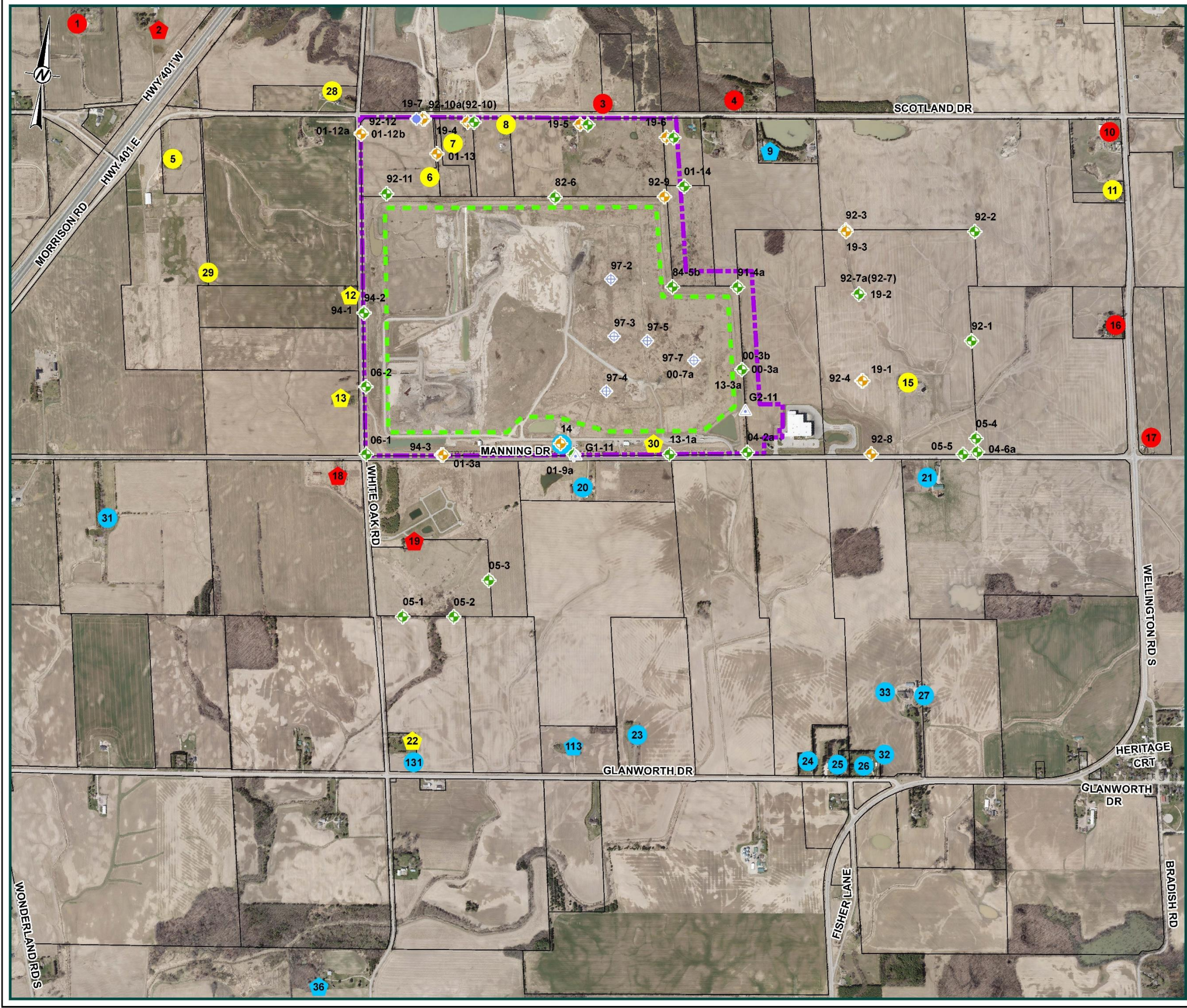


Table 15: Parameters Monitored

Parameter	Groundwater Monitoring Wells Comp.	Groundwater Monitoring Wells Indicator	Leachate Monitoring Comp.	Leachate Monitoring Indicator	Water Wells Comp.	Water Wells Indicator
General						
Alkalinity	X	X	X	X	X	X
Biological Oxygen Demand ₅			X	X		
Chemical Oxygen Demand	X	X	X	X		
Conductivity	X	X	X	X	X	X
Dissolved Organic Carbon	X	X	X	X	X	X
pH	X	X	X	X	X	X
Phenols	X		X		X	
Sulphate	X	X	X	X	X	X
Suspended Solids			X	X		
General - Nutrients						
Ammonia	X	X	X	X		
Nitrate	X		X		X	X
Nitrite	X		X			
Total Kjeldahl Nitrogen	X		X			
Total Phosphorus			X			

Parameter	Groundwater Monitoring Wells Comp.	Groundwater Monitoring Wells Indicator	Leachate Monitoring Comp.	Leachate Monitoring Indicator	Water Wells Comp.	Water Wells Indicator
General – Major Ions						
Chloride	X	X	X	X	X	X
Calcium	X	X	X	X	X	X
Iron	X	X	X	X	X	X
Magnesium	X	X	X	X	X	X
Manganese	X		X			
Potassium	X	X	X	X	X	X
Sodium	X	X	X	X	X	X
Trace Metals						
Arsenic	X		X		X	
Barium	X		X		X	
Boron	X		X		X	
Cadmium	X		X		X	
Chromium	X		X		X	
Copper	X		X		X	
Lead	X		X		X	
Mercury	X		X			
Nickel	X		X		X	
Selenium			X		X	

Parameter	Groundwater Monitoring Wells Comp.	Groundwater Monitoring Wells Indicator	Leachate Monitoring Comp.	Leachate Monitoring Indicator	Water Wells Comp.	Water Wells Indicator
Silver					X	
Strontium					X	
Zinc	X		X		X	
Volatiles						
EPA 624 Scan	X		X			
Field						
Conductivity	X	X	X	X	X	X
pH	X	X	X	X	X	X
Temperature	X	X				

Notes:

The parameters to be tested for in the groundwater and leachate are the same as the parameters suggested in the Landfill Standards (MECP, 1998) except for:

- Potassium – added to groundwater and leachate indicator and included in Environmental Compliance Approval (ECA)
- Selenium – added to leachate comprehensive and tested for in water wells
- EPA 624 VOC Scan – added to groundwater and leachate comprehensive as recommended from leachate characterization study but not included on water wells
- Temperature – added to groundwater comprehensive and indicator lists
- Nitrate – removed from groundwater and leachate indicator lists and will add based on results of groundwater and leachate comprehensive list analysis
- Total Phosphorus – removed from groundwater comprehensive list and will be added if leachate testing shows a need
- Total Dissolved Solids – removed from groundwater and leachate indicator and comprehensive lists as not considered necessary to evaluate water quality.

As described in the Design and Operation Report (Volume IV, Appendix D.13) a leachate mound monitoring component in the Phase 1 area of the landfill is required to assess groundwater predictions and future performance. The mound monitoring wells would be installed in the central part (not necessarily on the peak but in the higher parts of the waste) of the Phase 1 area after completion of each of Phases 5E through 8E. These mound monitoring wells would be evaluated for leachate levels following the same schedule for leachate levels outlined in Table 13.

7.0 OTHER APPROVALS

The groundwater component of this EA will also require approval under the *Environmental Protection Act* (EPA) as part of the ECA waste disposal approval.

8.0 LIMITATIONS / USE OF THE REPORT

8.1 General

This report has been prepared for the exclusive use of the City of London. The factual information, descriptions, interpretations and summary comments contained herein are specific to the scope of work described in this report and do not apply to any other project or site. Under no circumstances may this information be used for any other purposes than those specified in the scope of work unless explicitly stipulated in the text of this report or formally authorized by Golder. This report must be read in its entirety as some sections could be falsely interpreted when taken individually or out-of-context. As well, the final version of this report and its content supersedes any other text, opinion or preliminary version produced by Golder.

8.2 Groundwater Modelling Limitations

Hydrogeological 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 complicated beyond human capability to evaluate them comprehensively in detail, and we invariably do not have sufficient data to do so. 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 hydrogeological system. While the model itself obviously lacks the detailed reality of the existing hydrogeological 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, the site geochemistry, the fate and transport of the dissolved compounds, and on the quality and degree of accuracy of the data entered. Therefore, every groundwater model is a simplification of a reality and the models described herein are not an exception.

The groundwater modelling 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 science professions currently practising under similar conditions, subject to the quantity and quality of available data, the time limits and financial and physical constraints applicable to the services. Unless otherwise specified, the results of previous or simultaneous

work provided by sources other than Golder and quoted and/or used herein are considered as having been obtained according to recognised and accepted professional rules and practices, and therefore deemed valid. This model provides a predictive scientific tool to evaluate the impacts on a real groundwater system of specified hydrological stresses and/or to compare various scenarios in a decision-making process. However, and despite the professional care taken during the construction of the model and in conducting the simulations, its accuracy is bound to the normal uncertainty associated to groundwater modelling and no warranty, express or implied, is made.

Noting the intended use of this report, any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

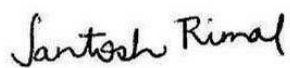
The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

9.0 REFERENCES

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Signature Page

Golder Associates Ltd.



Santosh Rimal, Ph.D., P.Eng.
Geotechnical Engineer



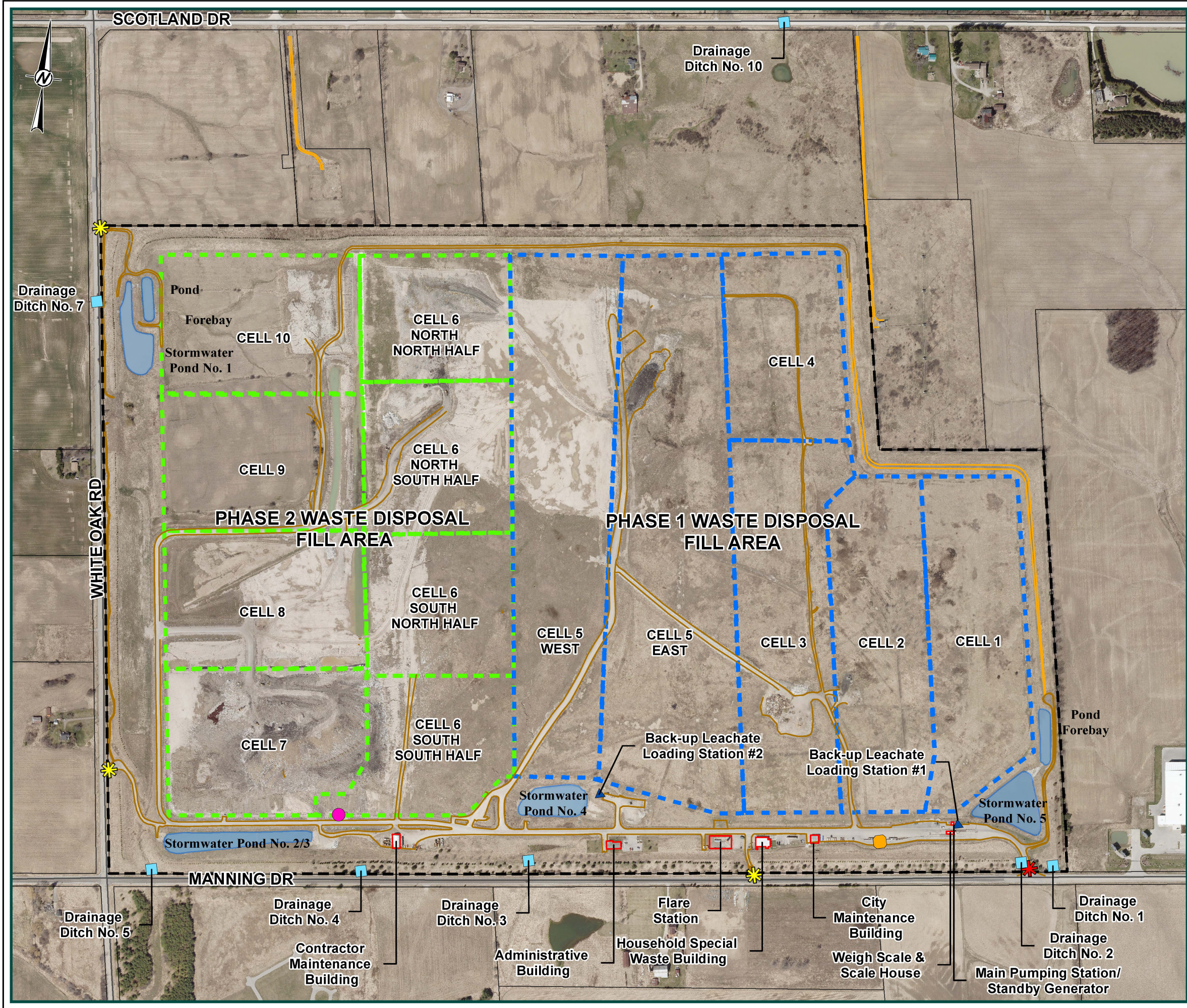
Frank Barone, Ph.D., P.Eng.
Principal

SR/FSB/PLE/PAS/sg

[https://golderassociates.sharepoint.com/sites/114635/project files/5 technical work/1.0 - technical components/03 - hydrogeology/3.8 report pollute modelling-ia/1648176-report w12a-landfill_pollute_modelling-sep2021.docx](https://golderassociates.sharepoint.com/sites/114635/project%20files/5%20technical%20work/1.0%20-%20technical%20components/03%20-%20hydrogeology/3.8%20report%20pollute%20modelling-ia/1648176-report%20w12a-landfill_pollute_modelling-sep2021.docx)

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APPENDIX A
Reference Figures



LEGEND

- LANDFILL SITE ENTRANCE
- LANDFILL SITE SECONDARY ENTRANCE
- PUBLIC DROP OFF AREA
- MH 701 PUMPING STATION/STANDBY GENERATOR
- LEACHATE STORAGE
- DRAINAGE DITCH
- LANDFILL ACCESS ROADS
- MONITORING ACCESS ROADS
- PHASE 1 WASTE DISPOSAL FILL AREA (59.3 HA)
- PHASE 2 WASTE DISPOSAL FILL AREA (47.7 HA)

PROPERTY INFORMATION

- EXISTING W12A LANDFILL
- STORMWATER PONDS/FOREBAY
- BUILDINGS

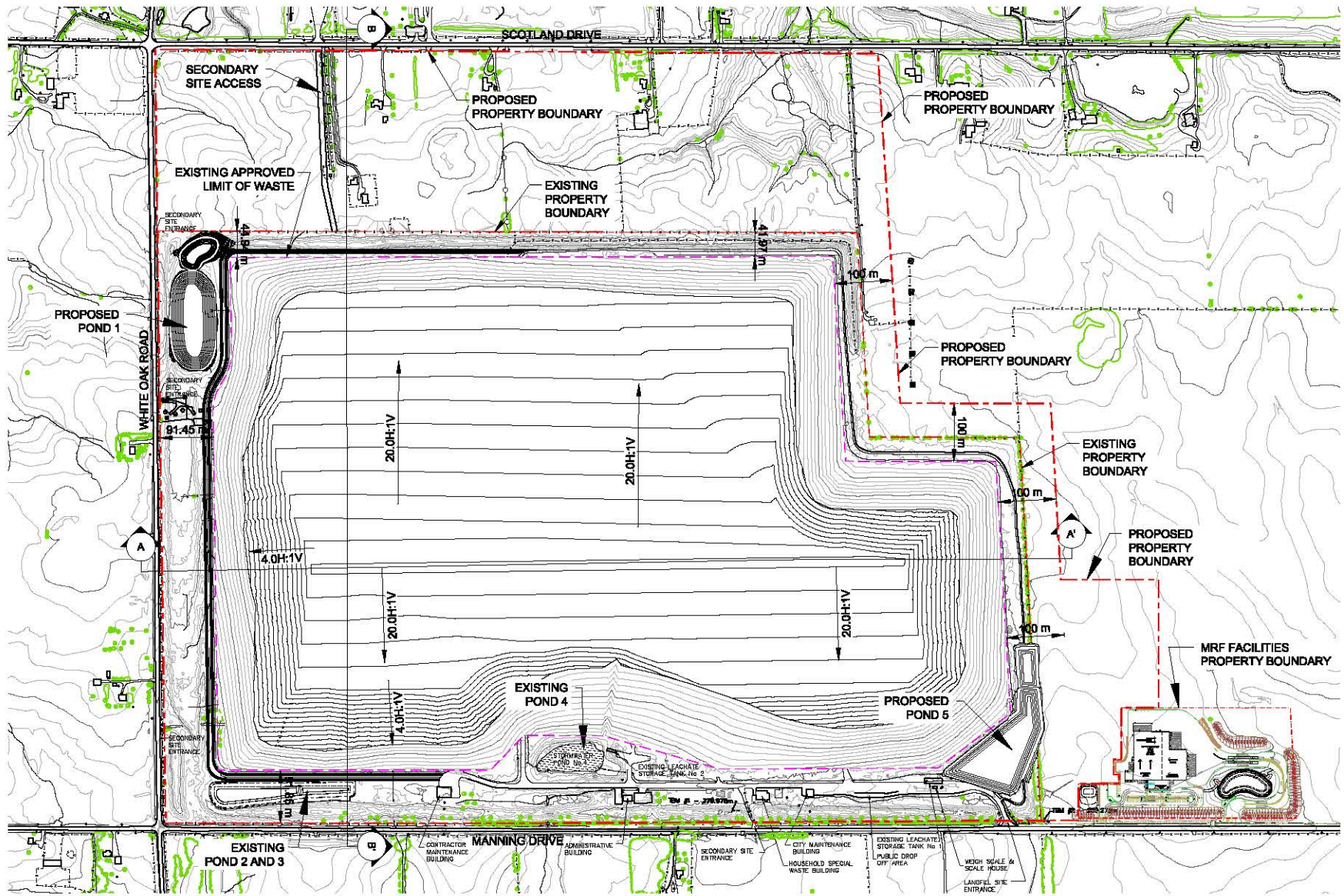
REFERENCE(S)

1. DATA PROVIDED BY THE CITY OF LONDON
2. CITY OF LONDON AERIAL PHOTOGRAPHY, APRIL 2016
3. SITE FEATURES PREPARED BY CALLON DIETZ INC. LTD., OCTOBER 19, 2016.
4. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

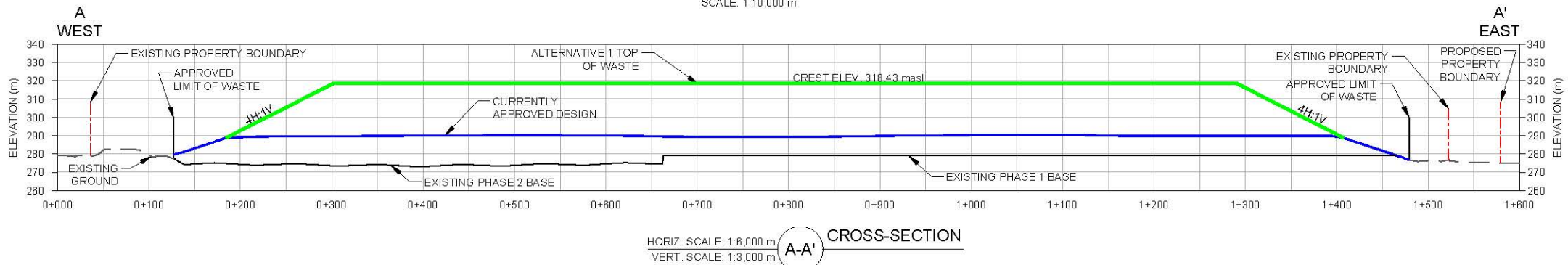


CLIENT CORPORATION OF THE CITY OF LONDON			
PROJECT INDIVIDUAL EA OF THE PROPOSED W12A LANDFILL EXPANSION			
TITLE EXISTING LANDFILL SITE DEVELOPMENT PLAN			
CONSULTANT		YYYY-MM-DD	2020-09-08
		DESIGNED	----
		PREPARED	JEM
		REVIEWED	TG
		APPROVED	PAS
PROJECT NO. 1648176	CONTROL 0017	REV. 0	FIGURE 1.3-1

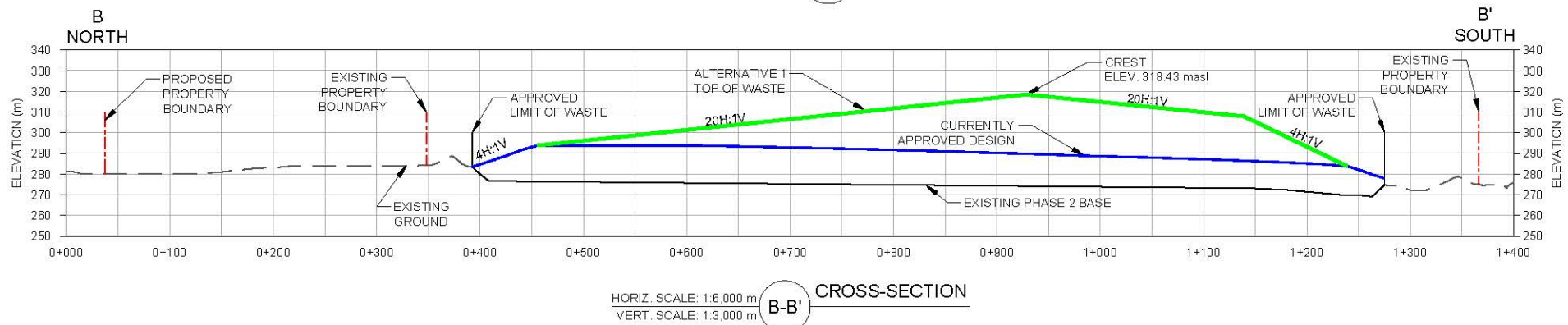
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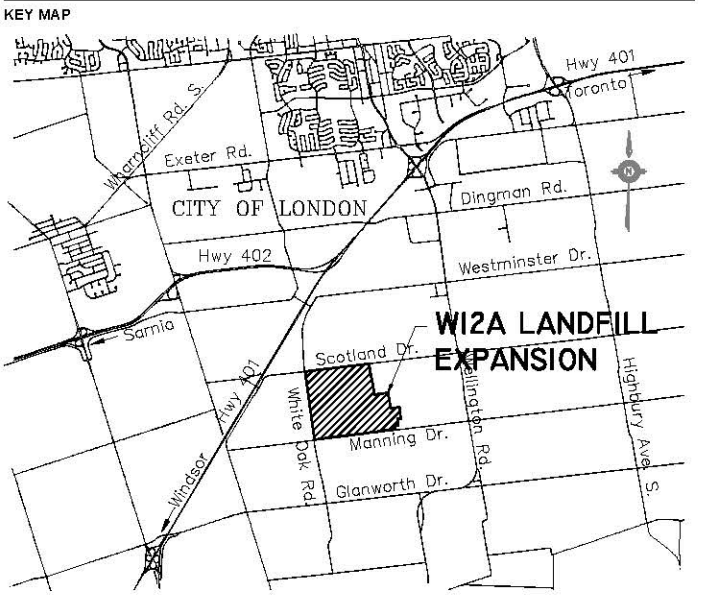
SITE PLAN
SCALE: 1:10,000 m



A-A' CROSS-SECTION



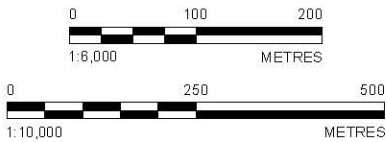
B-B' CROSS-SECTION



NOTE(S)
1. ELEVATION CONTOURS SHOWN ARE TOP OF WASTE, masl.

REFERENCE(S)
BASE INFORMATION AND EXISTING CONTOURS AS PER CITY OF LONDON SURVEY DATED NOVEMBER 22, 2016.

NOT FOR CONSTRUCTION
DRAFT



CLIENT
CITY OF LONDON
LONDON, ONTARIO
CANADA
PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED
W12A LANDFILL EXPANSION, CITY OF LONDON
TITLE
**LANDFILL EXPANSION FINAL CONTOUR PLAN AND
CROSS-SECTIONS**

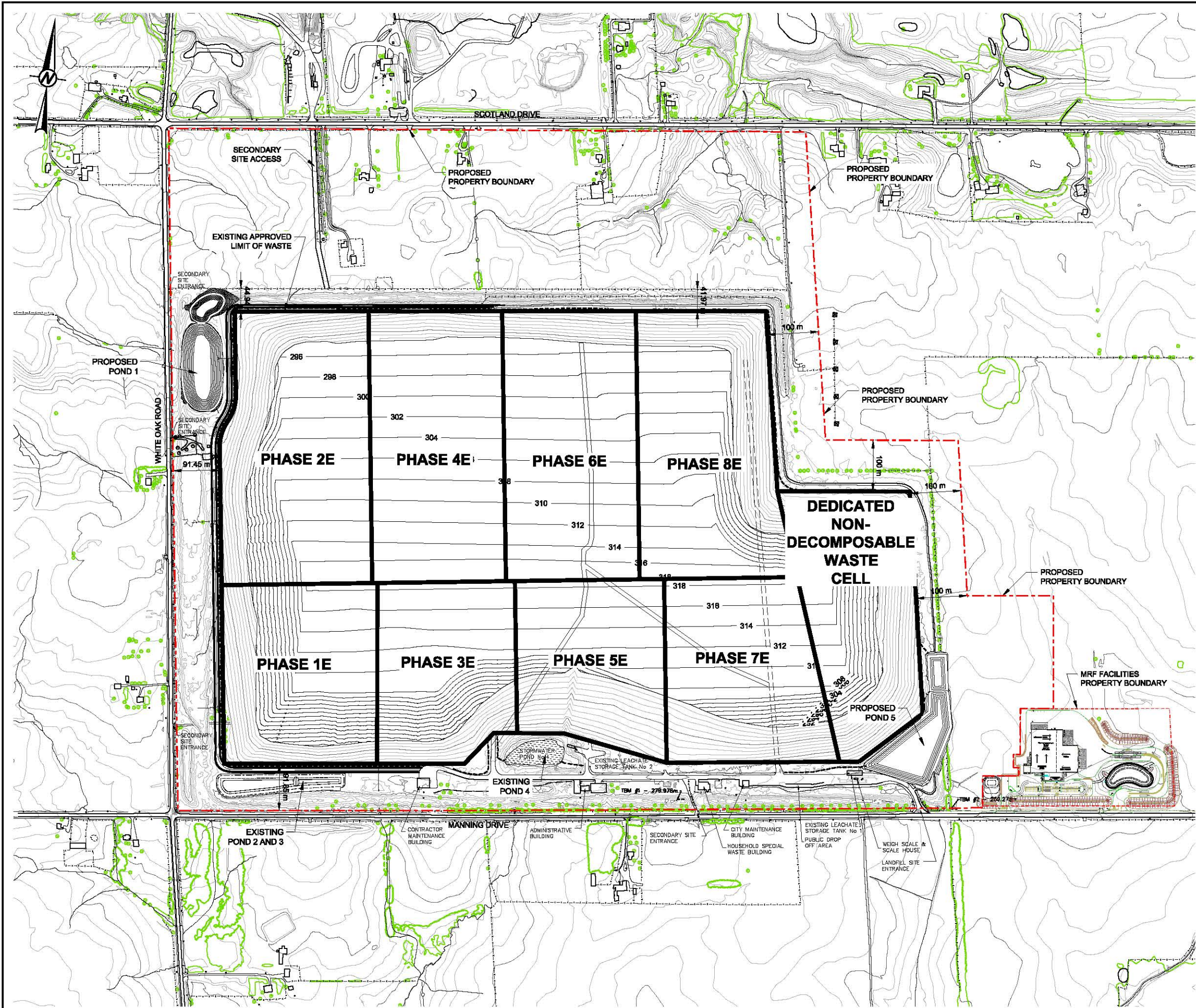
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PREPARED	MLF	
REVIEWED	PAS	
APPROVED	PAS	



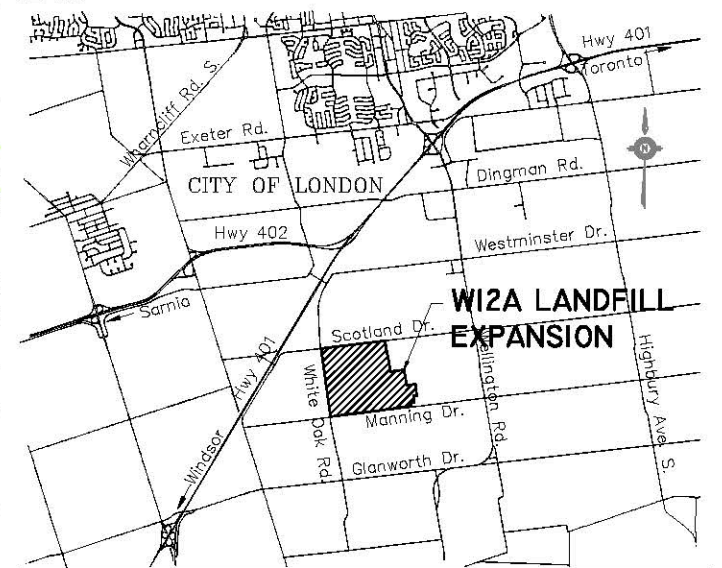
PROJECT NO. 1648176 CONTROL 0017 REV. A FIGURE 8.1-1

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

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KEY MAP



LEGEND

- LANDFILL ROAD THAT CAN HANDLE HEAVY TRAFFIC WITHOUT FURTHER UPGRADE
- LANDFILL ROAD THAT NEEDS TO BE UPGRADED TO HANDLE HEAVY TRAFFIC

NOTE(S)

- ELEVATION CONTOURS SHOWN ARE TOP OF WASTE, masl.
- REVISED WASTE FOOTPRINT AREA = 108.26 ha.

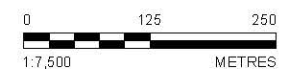
REFERENCE(S)

BASE INFORMATION AND EXISTING CONTOURS AS PER CITY OF LONDON SURVEY DATED NOVEMBER 22, 2016.

PHASE NO.	AIR SPACE (Mm³)	APPROX. OPERATING PERIOD (YEARS)
PHASE 1E	1.32	2.6
PHASE 2E	1.39	2.7
PHASE 3E	1.57	3.1
PHASE 4E	1.69	3.3
PHASE 5E	1.73	3.4
PHASE 6E	1.67	3.3
PHASE 7E	1.87	3.6
PHASE 8E	1.50	3
NON-DECOMPOSABLE	1.05	25

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CITY OF LONDON
LONDON, ONTARIO
CANADA

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED
W12A LANDFILL EXPANSION, CITY OF LONDON

TITLE
LANDFILL EXPANSION PHASING PLAN

CONSULTANT	YYYY-MM-DD	2020-05-21
DESIGNED		
PREPARED	MLF	
REVIEWED	PAS	
APPROVED	PAS	

PROJECT NO. 1648176 CONTROL 0017 REV. A FIGURE 8.1-2



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM A3/B

APPENDIX B

Example POLLUTE Output File

POLLUTEv7

Version 7.13

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Phase 2 - Chloride

THE VARIABLE VELOCITY AND/OR CONCENTRATION OPTION HAS BEEN USED
NOTE THAT THE ACCURACY OF THE CALCULATIONS WITH THIS OPTION WILL DEPEND ON THE NUMBER
OF SUBLAYERS USED

THE PASSIVE SINK OPTION HAS BEEN USED
NOTE : THE USER IS RESPONSIBLE FOR ENSURING THAT VELOCITY
CHANGES ARE CONSISTENT WITH THE PASSIVE SINK

Layer Properties

Layer	Thickness	Number of Sublayers	Coefficient of Hydrodynamic Dispersion	Matrix Porosity	Distributon Coefficient	Dry Density
Till	16 m	62	0.02 m ² /a	0.35	0 m ³ /kg	1.8 g/cm ³
Unsaturated	0.4 m	5	0.02 m ² /a	0.3	0 m ³ /kg	1.8 g/cm ³
Upper Aquifer	7.6 m	20	5 m ² /a	0.35	0 m ³ /kg	1.8 g/cm ³
Upper Aquifer	20 m	40	0.02 m ² /a	0.35	0 m ³ /kg	1.8 g/cm ³
Lower Aquitard						

Boundary Conditions

Finite Mass Top Boundary

Fixed Outflow Bottom Boundary

Landfill Length = 800 m

Landfill Width = 1 m

Base Thickness = 3 m

Base Porosity = 0.3

VARIATION IN PROPERTIES WITH TIME:

TIME PERIODS WITH THE SAME SOURCE AND VELOCITY

Period	Start Time	No. of Steps	Time Step	Source Conc	Rate of Change	Height of Leachate	Volume Collected
1	0 year	5	6 year	2500 mg/L	0	9 m	0.242 m/a
2	30 year	5	2 year	2500 mg/L	0	13 m	0.242 m/a
3	40 year	5	12 year	-1 mg/L	0	13 m	0.232 m/a
4	100 year	7	1 year	-1 mg/L	0	13 m	0 m/a
5	107 year	7	1 year	-1 mg/L	0	13 m	0.046 m/a
6	114 year	7	1 year	-1 mg/L	0	13 m	0.091 m/a
7	121 year	7	1 year	-1 mg/L	0	13 m	0.137 m/a
8	128 year	7	1 year	-1 mg/L	0	13 m	0.228 m/a
9	135 year	25	80 year	-1 mg/L	0	13 m	0.228 m/a

Period	Start Time	End Time	Darcy Velocity	Dispersivity	Base Velocity
1	0 year	30 year	1 m/a	0 m	0.0669 m/a
2	30 year	40 year	1 m/a	0 m	0.0669 m/a
3	40 year	100 year	1 m/a	0 m	0.0669 m/a
4	100 year	107 year	1 m/a	0 m	0.0669 m/a
5	107 year	114 year	1 m/a	0 m	0.0669 m/a
6	114 year	121 year	1 m/a	0 m	0.0669 m/a
7	121 year	128 year	1 m/a	0 m	0.0669 m/a
8	128 year	135 year	1 m/a	0 m	0.0669 m/a
9	135 year	2135 year	1 m/a	0 m	0.0669 m/a

VELOCITY AND SINK PROFILE:

Time Period	Minimum Depth	Maximum Depth	Vertical Velocity	Horizontal Outflow
1 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
1 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 1	0 m	16.4 m	0.0033 m/a	0 m/a

	16.4 m 24 m	24 m 44 m	0 m/a 0.0001 m/a	1.536 m/a 0 m/a
2 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
2 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 1	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 2	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 3	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
3 / 4	0 m 16.4 m 24 m	16.4 m 14 m 44 m	0.0033 m/a 0 m/a 0.0001 m/a	0 m/a 1.536 m/a 0 m/a
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4 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
4 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
4 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
4 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a

4 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
4 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
4 / 7	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.004 m/a 0 m/a 0.0001 m/a	0 m/a 1.614 m/a 0 m/a
5 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
5 / 7	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0048 m/a 0 m/a 0.0001 m/a	0 m/a 1.691 m/a 0 m/a
6 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a
6 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a
6 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a
6 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a

6 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a
6 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a
6 / 7	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0055 m/a 0 m/a 0.0001 m/a	0 m/a 1.769 m/a 0 m/a
7 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
7 / 7	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.0062 m/a 0 m/a 0.0001 m/a	0 m/a 1.846 m/a 0 m/a
8 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
8 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
8 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
8 / 4	0 m 16.4 m	16.4 m 24 m	0.007 m/a 0 m/a	0 m/a 1.924 m/a

	24 m	44 m	0.0001 m/a	0 m/a
8 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
8 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
8 / 7	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 1	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 2	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 3	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 4	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 5	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 6	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 7	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 8	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 9	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 10	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 11	0 m	16.4 m	0.007 m/a	0 m/a

	16.4 m 24 m	24 m 44 m	0 m/a 0.0001 m/a	1.924 m/a 0 m/a
9 / 12	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 13	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 14	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 15	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 16	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 17	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 18	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 19	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 20	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 21	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 22	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 23	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
9 / 24	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a

9 / 25	0 m 16.4 m 24 m	16.4 m 24 m 44 m	0.007 m/a 0 m/a 0.0001 m/a	0 m/a 1.924 m/a 0 m/a
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Laplace Transform Parameters

TAU = 7 N = 200 SIG = 0 RNU = 20

Calculated Concentrations at Selected Times and Depths

Time year	Depth m	Concentration mg/L
6	0.000E+00 1.640E+01 2.020E+01	2.095E+03 2.974E-49 5.306E-50
12	0.000E+00 1.640E+01 2.020E+01	1.772E+03 3.260E-33 9.933E-34
18	0.000E+00 1.640E+01 2.020E+01	1.503E+03 5.926E-27 2.438E-27
24	0.000E+00 1.640E+01 2.020E+01	1.275E+03 3.750E-22 1.376E-22
30	0.000E+00 1.640E+01 2.020E+01	1.083E+03 5.720E-19 2.663E-19
32	0.000E+00 1.640E+01 2.020E+01	2.400E+03 9.353E-19 4.422E-19
34	0.000E+00 1.640E+01 2.020E+01	2.308E+03 1.522E-18 7.306E-19
36	0.000E+00 1.640E+01 2.020E+01	2.221E+03 2.430E-18 1.186E-18
38	0.000E+00 1.640E+01 2.020E+01	2.138E+03 3.820E-18 1.895E-18
40	0.000E+00 1.640E+01 2.020E+01	2.057E+03 5.919E-18 2.981E-18

52	0.000E+00 1.640E+01 2.020E+01	1.654E+03 6.351E-17 3.503E-17
64	0.000E+00 1.640E+01 2.020E+01	1.332E+03 4.874E-16 2.866E-16
76	0.000E+00 1.640E+01 2.020E+01	1.074E+03 2.184E-14 1.445E-14
88	0.000E+00 1.640E+01 2.020E+01	8.665E+02 1.068E-12 7.938E-13
100	0.000E+00 1.640E+01 2.020E+01	6.999E+02 1.746E-11 1.305E-11
101	0.000E+00 1.640E+01 2.020E+01	6.998E+02 1.919E-11 1.401E-11
102	0.000E+00 1.640E+01 2.020E+01	6.998E+02 2.149E-11 1.521E-11
103	0.000E+00 1.640E+01 2.020E+01	6.997E+02 2.438E-11 1.669E-11
104	0.000E+00 1.640E+01 2.020E+01	6.996E+02 2.806E-11 1.854E-11
105	0.000E+00 1.640E+01 2.020E+01	6.996E+02 3.278E-11 2.086E-11
106	0.000E+00 1.640E+01 2.020E+01	6.995E+02 3.888E-11 2.382E-11
107	0.000E+00 1.640E+01 2.020E+01	6.994E+02 4.677E-11 2.759E-11
108	0.000E+00 1.640E+01 2.020E+01	6.967E+02 5.691E-11 3.232E-11
109	0.000E+00 1.640E+01	6.941E+02 7.098E-11

	2.020E+01	3.868E-11
110	0.000E+00 1.640E+01 2.020E+01	6.915E+02 8.917E-11 4.705E-11
111	0.000E+00 1.640E+01 2.020E+01	6.889E+02 1.128E-10 5.797E-11
112	0.000E+00 1.640E+01 2.020E+01	6.863E+02 1.434E-10 7.220E-11
113	0.000E+00 1.640E+01 2.020E+01	6.838E+02 1.830E-10 9.069E-11
114	0.000E+00 1.640E+01 2.020E+01	6.812E+02 2.342E-10 1.147E-10
115	0.000E+00 1.640E+01 2.020E+01	6.762E+02 2.987E-10 1.447E-10
116	0.000E+00 1.640E+01 2.020E+01	6.713E+02 3.875E-10 1.851E-10
117	0.000E+00 1.640E+01 2.020E+01	6.665E+02 5.008E-10 2.380E-10
118	0.000E+00 1.640E+01 2.020E+01	6.616E+02 6.453E-10 3.063E-10
119	0.000E+00 1.640E+01 2.020E+01	6.569E+02 8.294E-10 3.941E-10
120	0.000E+00 1.640E+01 2.020E+01	6.521E+02 1.063E-09 5.065E-10
121	0.000E+00 1.640E+01 2.020E+01	6.474E+02 1.359E-09 6.498E-10
122	0.000E+00 1.640E+01 2.020E+01	6.404E+02 1.724E-09 8.260E-10
123	0.000E+00	6.335E+02

	1.640E+01 2.020E+01	2.217E-09 1.059E-09
124	0.000E+00 1.640E+01 2.020E+01	6.266E+02 2.833E-09 1.357E-09
125	0.000E+00 1.640E+01 2.020E+01	6.199E+02 3.604E-09 1.735E-09
126	0.000E+00 1.640E+01 2.020E+01	6.132E+02 4.565E-09 2.212E-09
127	0.000E+00 1.640E+01 2.020E+01	6.066E+02 5.762E-09 2.810E-09
128	0.000E+00 1.640E+01 2.020E+01	6.001E+02 7.248E-09 3.559E-09
129	0.000E+00 1.640E+01 2.020E+01	5.895E+02 9.051E-09 4.462E-09
130	0.000E+00 1.640E+01 2.020E+01	5.790E+02 1.145E-08 5.633E-09
131	0.000E+00 1.640E+01 2.020E+01	5.688E+02 1.439E-08 7.108E-09
132	0.000E+00 1.640E+01 2.020E+01	5.587E+02 1.800E-08 8.945E-09
133	0.000E+00 1.640E+01 2.020E+01	5.489E+02 2.242E-08 1.122E-08
134	0.000E+00 1.640E+01 2.020E+01	5.392E+02 2.784E-08 1.402E-08
135	0.000E+00 1.640E+01 2.020E+01	5.297E+02 3.446E-08 1.747E-08
215	0.000E+00 1.640E+01 2.020E+01	1.295E+02 1.364E-03 9.625E-04

295	0.000E+00 1.640E+01 2.020E+01	3.252E+01 1.621E-01 1.310E-01
375	0.000E+00 1.640E+01 2.020E+01	8.468E+00 2.176E+00 1.886E+00
455	0.000E+00 1.640E+01 2.020E+01	2.332E+00 1.003E+01 9.052E+00
535	0.000E+00 1.640E+01 2.020E+01	7.006E-01 2.538E+01 2.350E+01
615	0.000E+00 1.640E+01 2.020E+01	2.375E-01 4.445E+01 4.186E+01
695	0.000E+00 1.640E+01 2.020E+01	9.270E-02 6.119E+01 5.830E+01
775	0.000E+00 1.640E+01 2.020E+01	4.134E-02 7.141E+01 6.863E+01
855	0.000E+00 1.640E+01 2.020E+01	2.045E-02 7.415E+01 7.173E+01
935	0.000E+00 1.640E+01 2.020E+01	1.085E-02 7.071E+01 6.876E+01
1015	0.000E+00 1.640E+01 2.020E+01	6.021E-03 6.333E+01 6.183E+01
1095	0.000E+00 1.640E+01 2.020E+01	3.440E-03 5.410E+01 5.300E+01
1175	0.000E+00 1.640E+01 2.020E+01	2.005E-03 4.461E+01 4.382E+01
1255	0.000E+00 1.640E+01 2.020E+01	1.185E-03 3.583E+01 3.527E+01
1335	0.000E+00 1.640E+01 2.020E+01	7.080E-04 2.821E+01 2.784E+01

1415	0.000E+00 1.640E+01 2.020E+01	4.268E-04 2.191E+01 2.166E+01
1495	0.000E+00 1.640E+01 2.020E+01	2.592E-04 1.687E+01 1.670E+01
1575	0.000E+00 1.640E+01 2.020E+01	1.584E-04 1.293E+01 1.282E+01
1655	0.000E+00 1.640E+01 2.020E+01	9.727E-05 9.897E+00 9.831E+00
1735	0.000E+00 1.640E+01 2.020E+01	6.002E-05 7.597E+00 7.557E+00
1815	0.000E+00 1.640E+01 2.020E+01	3.719E-05 5.866E+00 5.843E+00
1895	0.000E+00 1.640E+01 2.020E+01	2.312E-05 4.568E+00 4.557E+00
1975	0.000E+00 1.640E+01 2.020E+01	1.442E-05 3.598E+00 3.594E+00
2055	0.000E+00 1.640E+01 2.020E+01	9.022E-06 2.871E+00 2.872E+00
2135	0.000E+00 1.640E+01 2.020E+01	5.659E-06 2.326E+00 2.329E+00

NOTICE

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APPENDIX C
Service Life

This calculation sheet is for the service life of the proposed dual purpose gas/leachate horizontal collector trenches installed at 30 m spacing and to a depth of 3 m into the existing waste fill surface over the Phase 1 area prior to the vertical expansion. The service life calculation is with respect to bio-chemical clogging of the 50 mm clear stone backfill to the extent that the trenches no longer convey leachate to the perimeter leachate collector system.

The service life calculation uses the methodology described in the document "Evaluation of Service Life of the Engineered Components of Landfills" prepared for the Ontario Interim Waste Authority (IWA) by R. Kerry Rowe Inc, Golder Associates, Fenco MacLaren and Dillon, dated October 1994, with the assumptions that:

- i) all dissolved calcium in leachate entering the horizontal collector trenches precipitates to form bio-chemical clog matter that occupies the pore spaces between the clear stone particles, and,
- ii) as shown in Figure 1, the height of the clog zone in the collector trench relative to the base of the trench varies linearly from 0 m at the uphill (north) end of the trench (i.e., crest of the Phase 1 north slope crest) to the full 3 m height of the clear stone backfill over a distance of 725 m to the crest of the Phase 1 south slope.

The width of the horizontal collector trenches is 1m.

For these conditions, the total volume of clogged clear stone backfill at the end of the service life is 1,088 m³ (i.e., 0.5 x 725 m x 3 m x 1 m). The porosity reduction at any given point in the clogged zone of the clear stone at the end of the service life is 0.45 (i.e. a reduction in porosity from an initial value of 0.48 to a final value of 0.03). Therefore, the total volume of clog material (V_{CLOG}) at the end of the service life is approximately 490 m³ (i.e., 1,088 m³ x 0.45). The time frame to generate this volume of clog corresponds to the service life of the horizontal collector with respect to leachate drainage, and can be conservatively estimated using the equation:

$$T = \frac{V_{CLOG} \times P_{CLOG} \times f_{ca}}{q_o \times L \times S \times C_{ca}}$$

where,

T = service life of the horizontal leachate collector with respect to bio-chemical clogging (years),

V_{CLOG} = total volume of clog material in the collector drain at the end of its service life (m³)
= 490 m³

P_{CLOG} = dry density of the clog material = 1,500 kg/m³

f_{ca} = fraction of calcium in the clog material
= 0.26

Horizontal Collector Service Life Calculation**W12A Landfill, London, Ontario**

Job No: 1648176

Prepared by: F. Barone

Reviewed by: T. Edmond

Date: September 18, 2020

- q_o = annual average leachate generation rate via moisture percolation through the final cover
= 0.235 m/y
- L = length of the horizontal collector installed from the south to north end of the existing Phase 1 top surface
= 725 m
- S = spacing of the horizontal collectors
= 30 m
- C_{ca} = average calcium concentration in leachate entering the horizontal collectors
= 250 mg/L (from leachate monitoring wells installed in Phase 1, refer to Figure 2)
= 0.25 kg/m³

Substituting the above values into the equation gives a service life of approximately 150 years for the horizontal collectors with respect to biochemical clogging and leachate drainage. Allowing for additional conservatism, a service life of 100 years is recommended for the POLLUTE modelling.

Horizontal Collector Service Life Calculation

W12A Landfill, London, Ontario

Job No: 1648176

Prepared by: F. Barone

Reviewed by: T. Edmond

Date: September 18, 2020

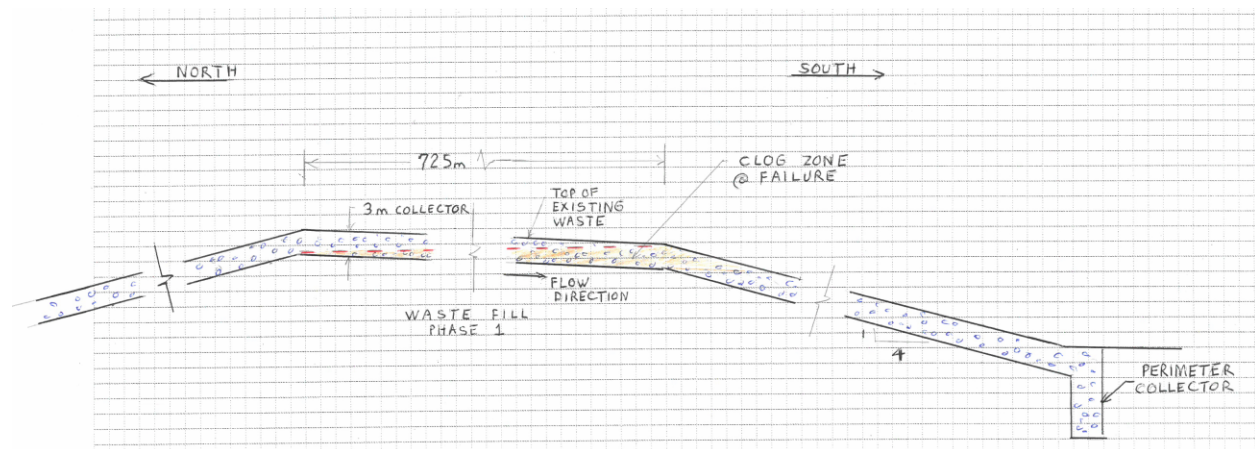


Figure 1: Cross-Section of Horizontal Collector

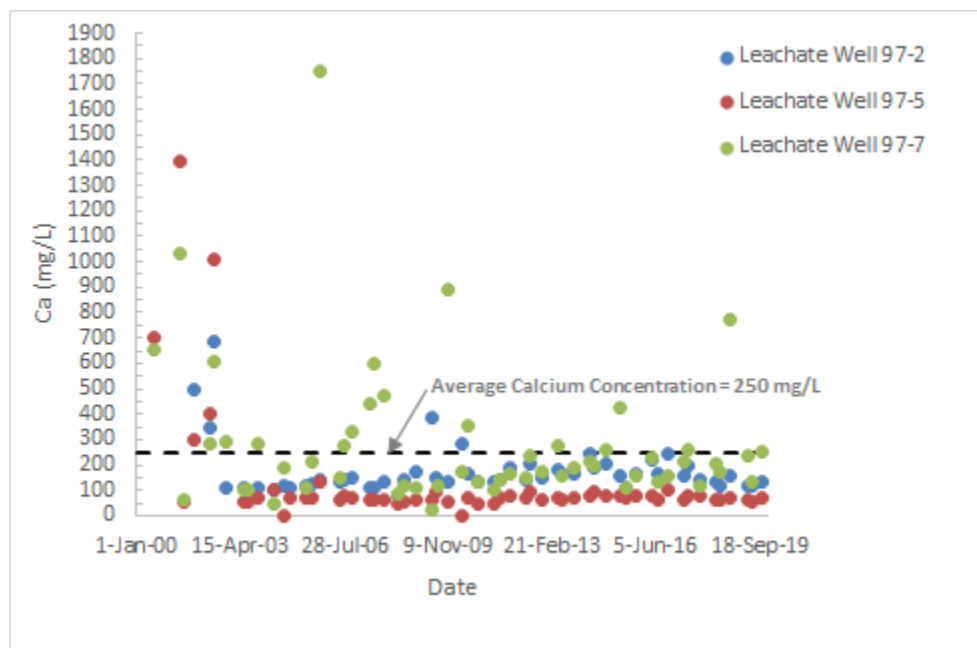


Figure 2: Historical Calcium Concentrations from the Leachate Monitoring Wells in Phase 1.



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