FINAL REPORT

Limerick Landfill Closure Plan

724 Limerick Road, Bothwell, Municipality of Southwest Middlesex

Submitted to:

Director

Client Services and Permissions Branch (CSPB)
Ministry of the Environment, Conservation and Parks (MECP)
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December 2019

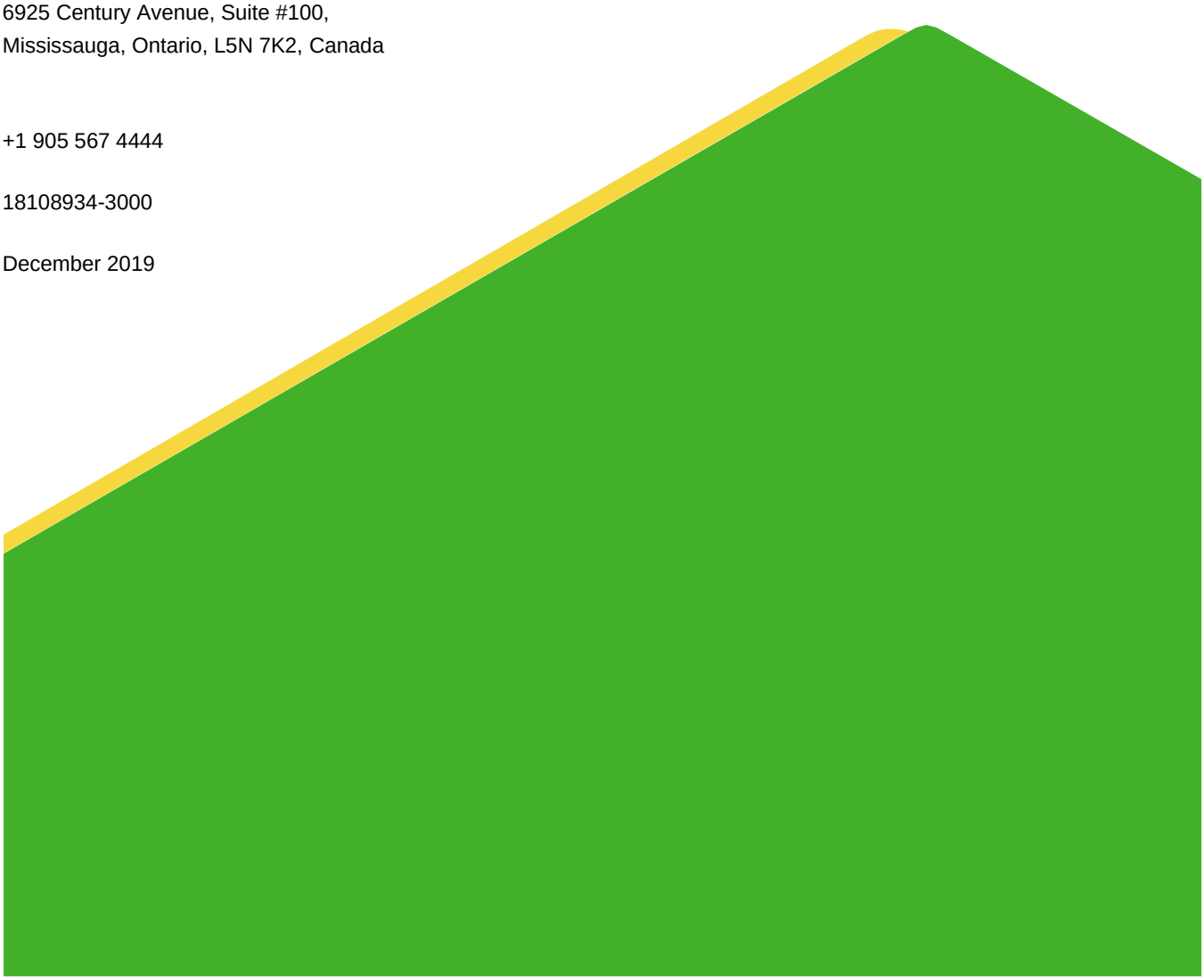

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Table of Contents

RELEVANT OPSD (ONTARIO PROVINCIAL STANDARD DRAWINGS)

APPENDICES

1.0 INTRODUCTION

The Ministry of Environment, Conservation and Parks (MECP) completed an inspection of the Limerick Landfill and issued an Inspection Report on January 29, 2018 requiring the Municipality of Southwest Middlesex (the "Municipality") to implement operational improvements and submit a Closure Plan in case a decision is made to close the landfill (Appendix A). The Municipality made the decision to close the landfill and subsequently retained Golder Associates Ltd. ("Golder") to complete subsurface investigation work and prepare the Closure Plan as required by the MECP Inspection Report above noted.

The purpose of this Closure Plan report is to document the field investigations completed by Golder and to outline the proposed plan and procedures for the closure of the Limerick Landfill, including requirements for inspection, maintenance, monitoring and contingencies.

2.0 SITE BACKGROUND

The Limerick Landfill, also referred as Limerick Road Landfill or Township of Mosa Landfill (the "Site"), is located at 724 Limerick Road, Bothwell, Ontario (Figure 1). The legal property description is Lot 23, Concession 3, Township of Mosa, Southwest Middlesex, Ontario.

The Site has been operational since 1971 and consists of a property with a triangular shape and area of 6.27 hectares (Ha). Provisional Certificate of Approval (C of A) No. A041902 for the Site was issued on August 28, 1980 for the operation of a waste disposal area of 6 Ha (Appendix B). The Site is approved to accept domestic and non-hazardous industrial waste.

2.1 Land Use

As shown in Figure 2, the Site is zoned as M3-2 (Rural Industrial/Municipal Landfill Site) and the permitted use is for waste disposal under the Municipality of Southwest Middlesex Zoning By-Law No. 2011/065 (consolidated version dated December 2018). The lands adjacent to the Site are zoned as A1 (General Agricultural). See Figure 2 for Zoning Map.

2.2 Previous Investigations

A hydrogeological assessment was previously conducted at the Site by the Ontario Ministry of the Environment in 1981. Findings of the study were provided in the report entitled "*Mosa Township Solid Waste Disposal Site (Lot 23, Concession III, Mosa Township), a Preliminary Hydrogeological Assessment*", dated January 1981 (MOE, 1981). The assessment was requested by the then-existing London District Office, Municipal and Private Abatement Section and involved review of the available information from the Ministry of the Environment (e.g., maps, water well records), correspondence pertaining to Site operation, Site inspection reports and field reconnaissance records. In addition, field work was carried out including collection of water samples. The report concluded that the Limerick Landfill had a low leachate mound height and no measurable impact to water supplies in the area, but identified possible periodic and localized impacts to the ditch along the west side of the Site and to Fansher Creek immediately north of the Site.

Surface water quality in the vicinity of the Site was characterized in an investigation carried out by RWDI AIR Inc. ("RWDI") in 2017. Findings of the investigation were presented in the report entitled "*Surface Water Characterization, Limerick Landfill Site, Southwest Middlesex, Ontario"*, dated August 16, 2017, RWDI Reference

No.: 1703470.2000 (RWDI, 2017). The study involved evaluating surface water quality in the vicinity of the Site in accordance with the 2012 Ministry of the Environment and Climate Change Landfill Standards prepared in consideration of Ontario Regulation 232/98 (MOE, 1998). Two off-site surface water samples were collected in Fansher Creek north the Site. The samples were collected east and west of Limerick Road corresponding to upstream and downstream locations, respectively, relative to the confluence of the drainage ditch along the west side of the Site. One surface water sample was also collected from the depression located in the central portion of the Site. The results indicated that concentrations of parameters above the PWQO criteria were not attributed to landfill impacts. However, it was recommended that a surface water quality monitoring program be developed for the Site, given its proximity to Fansher Creek (RWDI, 2017).

Additional relevant information from the above noted investigations has been incorporated into this report where appropriate.

2.3 Recent Investigations

Golder observed and documented a series of test pits excavated at the Site over the period of October 17 to 26, 2018. The test pit locations (59 test pits in total) are shown in Figure 3. The test pits were excavated to depths ranging from 0.3 m to 2.0 m using the Municipality's backhoe/operator under the direction/observation of Golder. The objectives of the test pit investigation were to delineate the approximate limit of the waste fill and to measure the thickness of the existing soil cover. The findings of the test pit investigation are presented in Section 2.4.1.

Golder retained AGM to complete a legal survey as well as a topographic survey for the entire Limerick Landfill property. The topographic survey also captured the coordinates and elevations of the test pits described above. The survey was completed in November 2018 and is presented in Figure 3. A discussion on Site topography is provided in Section 2.4.2. The legal survey was certified by an AGM certified Ontario Land Surveyor (Appendix C).

The lack of an environmental monitoring program was identified in the Inspection Report issued by the MECP on January 11, 2018. The establishment of a monitoring program is required to direct the collection of groundwater, surface water and landfill gas data to support site-specific characterization and assessment of potential impacts to the environment. To address this requirement, Golder prepared a monitoring program in consultation with the MECP/London Regional Office Hydrogeologist. Golder then retained Direct Environmental Drilling Inc. to advance boreholes and install monitoring wells at the Site over the period of December 3 to 12, 2018. Golder supervised the drilling and monitoring well installations and prepared the borehole logs (Appendix D). The borehole locations (seven in total) are shown in Figure 3. The monitoring program is presented in Section 6.0.

2.4 Physical Site Setting

To assess the potential impacts on groundwater and surface water from the landfill post-closure, a physiographic and hydrogeological summary of the Site was prepared and is presented herein.

2.4.1 Limit of Waste Fill and Description of Existing Soil Cover

A total of 59 test pits were completed to depths ranging from 0.3 m to 2.4 m to confirm the limit of waste fill and the thickness/type of existing cover soil overtop the waste fill.

The inferred limit of waste fill based on the test pit investigation is shown in Figure 3 and covers an area of approximately 3.16 Ha (i.e., approximately 50% of the overall 6.27 Ha property area).

Table 1 summarizes the findings of the test pits with respect to the thickness/type of the existing soil cover over the waste fill. The existing soil cover thickness at the test pits that encountered waste ranged from 0.1 m to 1.65 m. The average thickness of the existing cover soil is 0.6 m (Table 1). The cover soil consists mostly of silty sand material. Of note however are three localized areas of waste piles with no soil cover. These isolated piles consist of construction and demolition waste such as shingles and concrete rubble.

For the closure of the landfill, a minimum thickness of 0.6 m (600 millimetres) of soil cover, plus an additional 150 millimetres of soil capable of sustaining vegetation (topsoil) will be placed, across the waste fill area (Figure 8, Detail G).

2.4.2 Topography and Drainage

The topography at the Site was previously reported as generally sloping to the west (MOE, 1981). The recent (2018) site topographic survey (Figure 3) indicates that the Site is relatively flat with a waste fill mound of approximately 1.5 metre (m) above original ground and three isolated waste piles up to 2.5 m in height within the inferred limit of waste fill. A slight depression in ground surface elevation is present in the central portion of the Site and is associated with an unidentified wetland area consisting of vegetated brush and a depression feature. The ground elevation within the inferred waste limit varies between 208.5 metres above mean sea level (masl) along the periphery to as much as approximately 211.5 masl at the top of the waste piles. Minimum ground surface elevations at the Site are generally located along the west property boundary and to the north towards Fansher Creek. The topography of the Site is shown on Figure 3. Two cross-sections of the Site (from south to north and from west to east) showing the existing ground are provided in Figure 8. Regionally, the ground surface generally slopes to the west towards the Sydenham River located approximately 14 km from the Site (Figure 1, Key Map).

The closest surface water feature is Fansher Creek, located about 30 m north of the Site. Surface water in the creek flows west towards the Sydenham River, which ultimately flows southwest and drains to Lake St. Clair. Stormwater flow in the eastern portion of the Site is expected to flow towards the existing depression in the central portion of the Site based on existing topography. Stormwater flow in the western portion of the Site flows to a ditch located along the western property boundary adjacent to Limerick Road.

Agricultural fields are located to the west, north and northeast of the Site, with drainage likely directed to Fansher Creek. Vegetated and forested lands are located to the south and southeast.

According to the previous hydrogeological assessment conducted at the Site (MOE, 1981), agricultural clay tiles (located at about 0.6 metres below ground surface (mbgs) and spaced at approximately 20 m) were in 1981 reportedly evident along the southern bank of Fansher Creek northwest of the Site.

2.4.3 Geology

The Site is located within the Bothwell Sand Plain physiographic region (Chapman, 1984). The surficial materials of the Bothwell Sand Plain physiographic region are comprised of coarse-textured glaciolacustrine deposits of sand and gravel with minor amounts of silt and clay, associated with a delta of the Thames River in glacial Lake Warren. The coarse-textured glaciolacustrine deposits are typically less than 2 m in thickness at regional scale and overly a predominantly clay soil. Poor drainage of the Bothwell Sand Plains also results in the presence of wet-mesic forests and swamps.

The Site is situated between clay physiographic regions to the northeast (Ekfrid Clay Plains) and northwest (St. Clair Clay Plains). Sand dunes are mapped to the west-southwest of the Site towards the Town of Bothwell and to the northeast towards the Town of Newbury.

Records for the 2018 borehole investigation at the Site are included in Appendix D. The stratigraphy encountered at the boreholes is shown in the cross sections in Figures 4 and 5. The subsurface conditions encountered are generally consistent with the geological mapping referenced above and the previous preliminary hydrogeological assessment completed at the Site in 1981 (MOE, 1981). In general, the native overburden deposits encountered at the Site during the 2018 borehole investigation consist of the following units (starting from ground surface):

- organic topsoil layer with thickness ranging from 0.06 m to 0.27 m;
- native brown silty sand to a depth of approximately 2.0 to 2.7 mbgs. Thin layers (up to 0.5 m thick) of silty sand fill were encountered below the topsoil in the northern portion of the Site, indicating landfill related activities. Loose to compact grey silty sand, with some clay, was encountered below the brown silty sand at some borehole locations;
- some or trace gravel was found in the native brown and grey silty sand layers at most boreholes;
- silty clay with trace to some sand and trace gravel was encountered at all boreholes beneath the silty sand layer at a depth ranging from 2.3 to 4.3 mbgs; and
- all boreholes were terminated within the silty clay layer, however only the three deep boreholes BH-101D, BH-103D and BH-104D were advanced through the full thickness of this layer. Borehole BH-101D is located in the northern portion of the Site and was terminated in a gravel layer at about 22 mbgs on inferred bedrock surface. The silty clay layer thickness at BH-101D is 19.5 m. Borehole BH-103D is located at the southeast corner of the Site and was terminated at 26.5 mbgs on inferred bedrock surface. The silty clay layer thickness at BH-103D is 23.0 m. Borehole BH-104D is located at the southwest corner of the Site and was terminated at 28.8 mbgs on inferred bedrock surface. The silty clay layer thickness at BH-104D is 24.5 m.

Based on available mapping, the Site is underlain by Middle Devonian bedrock of the Hamilton Group of Formations consisting of grey calcareous shale and minor limestone. Based on a review of the MECP water well database for wells located within 2 km of the Site (Figure 1), the bedrock was reported at depths ranging from about 17.1 to 27.1 mbgs, which is consistent with the findings of this borehole investigation (i.e., bedrock depths ranging from 22.0 to 28.8 mbgs).

Boreholes MW-101S, MW-101D and MW-102 had surficial silty sand fill and some pieces of plastic bags, indicating previous landfill activities.

Borehole LW-101 was advanced within the waste footprint and encountered 1.5 m of cover soil followed by 4.3 m of typical municipal type waste. The waste material was intermixed with clayey soil and consisted of diapers, rags, clothes, plastic lids, garbage bags and plastic bags. The borehole was terminated 2 m into the native silty clay beneath the waste fill.

2.4.4 Hydrogeology

The hydrostratigraphy in the area of the Site consists of a shallow unconfined silty sand aquifer which is approximately 1.5 m to 4.0 m thick. The thickness of the unconfined aquifer generally decreases from the southern to the northern portion of the Site. Underlying the shallow flow system below the Site is a 19.5 to 24.5 m thick silty clay layer followed by bedrock.

Six shallow groundwater monitoring wells MW-101S, MW-102, MW-103S, MW-104S, MW-105 and MW-106 were installed with screen sections within the silty sand aquifer unit or across the silty sand aquifer/silty clay interface. Three deep monitoring wells MW-101D, MW-103D and MW-104D were installed with screen sections within the lower portion of the silty clay layer at the inferred bedrock surface adjacent to the shallow monitoring wells MW-101S, MW-103S and MW-104S, respectively. In addition, a leachate well LW-101 was installed with a screen section in the lower portion of the waste fill (4.3 m waste fill thickness) down to the contact with the underlying silty clay unit. A summary of the groundwater monitoring well details is provided in Table 2.

Groundwater levels at the monitoring wells were measured at completion of the well installation and then again on several dates within one month of installation. The measured groundwater levels are presented in Table 3.

Within the waste footprint at LW-101, the leachate level stabilized at an elevation of approximately 208.3 masl (0.9 mbgs), which is as much as 1 m higher than shallow groundwater levels at the monitoring wells outside of the waste fill footprint indicating slight leachate mounding with the waste fill area. This minor amount of leachate mounding is as expected considering that the height of the landfill surface above original ground is only about 1.5 m.

Outside the waste footprint, groundwater levels measured in the unconfined surficial silty sand aquifer stabilized at elevations ranging from a high of 208.5 masl at the south end of the Site (MW-103S and MW-104S) to a low of 207.3 masl at the north end (MW-101S), indicating a northerly groundwater flow direction towards Fansher Creek as depicted in the shallow groundwater piezometric surface in Figure 10. Also evident from Figure 10 are slight easterly and westerly shallow groundwater flow components emanating from the northern half of the landfill, driven by the slight leachate mounding in the landfill as measured at LW-101.

Stabilized groundwater levels measured in the paired (shallow and deep) monitoring wells indicate a slightly downward groundwater flow gradient through the silty clay layer ranging between approximately 0.06 and 0.40 m/m. Furthermore, the deep groundwater monitoring wells (screened in the lower portion of the silty clay at the top of bedrock) indicate a southeasterly groundwater flow direction as depicted in Figure 11. This deep groundwater flow direction is consistent with the southerly dip in bedrock surface elevation at the site.

Based on the available mapping of the geology and hydrogeology in the vicinity of the Site, the Site is located within the St. Clair watershed which on a regional basis drains southward to Lake St. Clair. However, local topography at the Site generally slopes to the west and north and, based on groundwater conditions measured at the Site in January 2019, local shallow groundwater flow is northerly across the Site towards Fansher Creek located approximately 30 m north of the Site (Figure 10). The deep groundwater flow direction is southeasterly (Figure 11), generally consistent with the regional groundwater flow direction.

Surface water in Fansher Creek flows west to its junction with the Sydenham River which ultimately flows southwest and drains to Lake St. Clair. Fansher Creek reportedly cuts into the underlying silty clay deposit by about 2.1 m (MOE, 1981). The preliminary hydrogeological assessment (MOE, 1981) reported that Fansher Creek is used by downstream landowners with free access to the creek for livestock water purposes.

The preliminary hydrogeological assessment (MOE, 1981) reported that dug and bored water wells were installed in the shallow water table aquifer and within the fractured and weathered zone at the top of the shale bedrock. A review of the MECP water well database shows that 19 well records were reported within 2 km of the Site (refer to Figure 1 for locations). Six of the wells are used for domestic water supply; three wells are used for domestic and

livestock water supply; two wells are for observation; and six are abandoned water supply wells. Of the active water supply wells, eight are reportedly installed in the overburden and three are installed in the bedrock.

Based on mapping provided by the Ministry of Natural Resources and Forestry (MNRF 2019), Skunk's Misery Wetland Complex is located about 3 km south and east of the Site. This wetland is designated a provincially significant wetland; however, it is located upgradient of the Site based on the inferred northward groundwater flow direction. Non-provincially significant wetlands forming part of the West Newbury Swamp are located about 1.7 and 3 km northeast of the Site and are considered to be cross-gradient of the Site based on the inferred northward shallow groundwater flow direction across the Site. A recent surface water investigation (RWDI, 2017) reported a wetland area is also present in the central portion the Site. RWDI (2017) recommended that the local Conservation Authority be consulted to evaluate whether the onsite wetland area is a natural feature or if it occurs as a result of historical activities at the Site; however, based on available mapping (MNRF 2019) the Site is not identified as being covered by wetland.

3.0 HISTORICAL AND CURRENT OPERATIONS

The Preliminary Hydrogeological Assessment issued by the Ontario Ministry of the Environment on January, 1981 (MOE, 1981) provides the following information regarding historical operation of the Limerick Landfill:

- operations first started at the northern portion of the Site (Figure 2);
- the trench and fill method was employed to dispose wastes. This method consisted of excavation of trenches of approximately 45 metres length, 8 metres width and 3.5 m depth. Waste was dumped close to the edge of the trench and pushed into the trench. Once the trench was filled to a height likely just above the original ground surface, a new trench was excavated, and the same process was followed;
- due to shallow groundwater and highly permeable surficial soils, the trenches had the bottom 2 metres filled with water at the time of disposal;
- the Site had piles of car tires, concrete rubble and scrap metal;
- there was a fence along Limerick Road and the original entrance gate was located at the north end of the Site;
- an attendant trailer was located near the waste disposal areas; and
- a tile drain in the farm field immediately north of the Site was discharging leachate impacted water to the Fansher Creek. It should be noted that Golder performed a site visit on December 6, 2018 and observed groundwater discharging from a drainage tile located at the south bank of Fansher Creek approximately 50 metres east of Limerick Road; the water was observed running clear with no visual evidence of leachate impact.

Currently, the entrance gate is further south at Limerick Road as depicted in Figure 3. There is currently a sign at the entrance gate indicating that the Site is closed. The sign also has the Site name, CofA number, and telephone contact numbers for alternate disposal locations and emergency.

The Site currently has the waste covered with soil, except for a few uncovered piles of construction and demolition waste such as shingles and concrete rubble. Based on the test pits and boreholes completed in 2018, the existing

waste consists of material typically found in municipal landfills such as plastic bags and other plastics, paper, glass, rags, plastic lids, clothes, diapers, mattresses, steel, concrete, bricks, rubber, cans, Styrofoam and asphalt (Table 1).

The Site has not accepted waste since the MECP Inspection Report was issued in early 2018. Continued operation of the Landfill would have required amendments to the existing CofA, which would likely include conditions of approval consistent with modern landfill approvals of similar size in Ontario. The Municipality decided to permanently close the Site.

4.0 ASSESSMENT OF POTENTIAL IMPACTS

4.1 Groundwater Quality Assessment

As described in the above sections, nine groundwater monitoring wells and one leachate monitoring well were installed at the Site in December 2018. Six of these monitoring wells were installed in the shallow unconfined silty sand aquifer layer to assess the potential lateral movement of leachate impacted groundwater. Leachate impacted groundwater within the silty sand aquifer has the potential to discharge in local creeks or ditches and for this reason monitoring wells were installed on each side of the landfill property. Three monitoring wells are deep groundwater wells completed to obtain information on the soil profile and groundwater levels at the bedrock surface, which will assist in quantifying the rate of groundwater flow and potential contaminant migration downwards to bedrock. One monitoring well is a leachate well screened within the waste fill to allow monitoring of the height of the leachate mound, collection of leachate samples for laboratory chemical analysis, and confirmation of the waste fill thickness at a specific location.

In January 2019, the groundwater monitoring wells and the leachate well were developed and sampled for chemical analysis. For the groundwater wells, the following parameters were analyzed:

- **General Chemistry:** Alkalinity, chemical oxygen demand (COD), conductivity, dissolved organic carbon (DOC), pH, total dissolved solids (TDS) and phenols;
- **Major Ions:** Chloride, calcium, magnesium, sodium and sulphate;
- **Metals:** Barium, boron and iron;
- **Nutrients:** Ammonia-N and nitrate-N; and
- **Field Measurements:** pH and conductivity.

The leachate well LW-101 was analysed for the following parameters:

- **General Chemistry:** Alkalinity, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids, dissolved organic carbon (DOC), phenols, pH and conductivity;
- **Major Ions:** Chloride, calcium, magnesium, sodium, potassium and sulphate;
- **Metals:** Arsenic, barium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury and zinc;
- **Nutrients:** Ammonia-N, total kjeldahl nitrogen (TKN), nitrite-N and phosphorous;

- **VOC:** Benzene, bromodichloromethane, 1,4-dichlorobenzene, methylene chloride (dichloromethane), toluene and vinyl chloride; and
- **Field Measurements:** pH and conductivity.

As shown in Figure 10, shallow groundwater flow is generally to the north and towards Fansher Creek, which is located about 30 m north of the Site. Based on the northern groundwater flow direction towards Fansher Creek, groundwater quality results for the shallow wells located downgradient of the waste footprint (i.e., MW-101S, MW-102, MW-105 and MW-106) and for the leachate well LW-101 (located within the waste footprint) are compared to Provincial Water Quality Objectives (PWQO) (MOEE 1994a). An assessment is also carried out for compliance with the MECP (formerly the Ministry of the Environment and Energy) Guideline B-7 (MOEE, 1994b).

Shallow monitoring wells MW-103S and MW-104S, which are located on-Site and upgradient of the waste footprint with respect to the inferred northward shallow groundwater flow direction, are considered background monitoring wells specific to the Site.

The deep monitoring wells were installed as part of the site characterization, i.e., to determine soil stratigraphy, confirm bedrock depth, deep groundwater levels, deep groundwater flow direction and vertical hydraulic gradient. Groundwater quality monitoring is of limited value for these deep wells considering that contaminant migration from this relatively small landfill facility is unlikely to penetrate the thick silty clay layer (i.e., 19.5 to 24.5 m thick) underlying the waste fill. DeSaulniers[1] et al. (1981) reported hydraulic conductivities for the clay tills of southwestern Ontario of between 10^{-9} and 10^{-6} centimetres per second (cm/s) and vertical (downward) groundwater velocities of between 0.04 and 0.46 centimetres per year in the non-fractured portion of the till. For this range of downward groundwater velocity, contaminant transport would be dominated by molecular diffusion and it would take thousands of years for contaminants to migrate vertically into the bedrock aquifer. By that time, contaminant impacts at the bedrock level would be negligible due to natural attenuation.

The results of the initial groundwater monitoring round are presented in Tables 3 to 6. Laboratory Certificates of Analysis are provided in Appendix E.

4.1.1 Upgradient Shallow Wells

MW-103S

Shallow monitoring well MW-103S is located adjacent to the southeastern corner of the Site and upgradient of the waste footprint. This shallow well was installed to a depth of about 4.3 mbgs and is screened in the lower part of the shallow unconfined silty sand aquifer. Groundwater quality at this well is considered representative of background conditions un-impacted by the presence of the Limerick Landfill.

Concentrations of analysed parameters in the groundwater samples collected from MW-103S are below PWQO values except for unionized ammonia (0.06 mg/L versus PWQO of 0.02 mg/L). The slightly elevated ammonia relative to PWQO may be related to the agricultural land use on the adjacent land to the east.

On the Piper Diagram (Figure 12), the water quality plots as a predominantly sodium bicarbonate water.

MW-104S

[1] Desaulniers, Donald E.; Cherry, John A.; Fritz, Peter ,1981. *Origin, age and movement of pore water in argillaceous quaternary deposits at four sites in southwestern Ontario*. Journal of Hydrology, Volume 50 p 231-257.

Monitoring well MW-104S is located adjacent to the southwest corner of the Site and upgradient of the waste footprint. This shallow well was installed to a depth of about 4.0 mbgs and is screened within the silty sand layer. Groundwater quality at this well is considered representative of background conditions un-impacted by the presence of the Limerick Landfill.

Concentrations of analysed parameters in the groundwater samples collected from MW-104S are below PWQO values.

On the Piper Diagram (Figure 12), the water quality plots as a mixed calcium, sodium, chloride and bicarbonate water.

4.1.2 Leachate Well

LW-101

LW-101 is screened within the waste fill of the Limerick landfill. As a result, the water quality at this well has been used to assess leachate quality.

Concentrations of analysed parameters in the leachate sample collected from LW-101 (Table 4) are below the PWQO for all parameters except for phosphorus (0.11 mg/L versus 0.03 mg/L), boron (1,400 µg/L versus 200 µg/L), iron (43,000 µg/L versus 300 µg/L) and unionized ammonia (0.241 mg/L versus 0.02 mg/L).

The analyses for select volatile organic compounds (VOC) indicate concentrations below the respective method detection limits, except for benzene, which was detected at a concentration of 3.7 µg/L which is well below the PWQO of 100 µg/L.

The following list of parameters have been identified as leachate indicator parameters (LIPs) based on their elevated concentration in the sample from LW-101 compared to concentrations in samples from the shallow background wells MW-103S and MW-104S:

- **General Chemistry:** Alkalinity, COD, conductivity, DOC and TDS;
- **Major Ions:** Chloride and sodium;
- **Metals:** Boron, barium, calcium, magnesium and iron; and
- **Nutrients:** Ammonia.

The field pH of the sample from LW-101 (6.8) is below the range of values measured in the shallow background wells (7.3 to 8.7).

4.1.3 Downgradient Shallow Wells

MW-101S

Shallow monitoring well MW-101S is located adjacent to the north property boundary, north of the waste footprint and is inferred to be downgradient with respect to the groundwater flow direction. The well was installed to a depth of about 4.4 mbgs and is screened across the interface between the silty sand and silty clay layers.

Concentrations of analysed parameters in the groundwater sample collected from MW-101S are below PWQO values except for boron (1,200 µg/L versus the interim PWQO of 200 µg/L).

Concentrations of the LIPs conductivity, chloride, boron, magnesium and sodium are above the range of concentrations detected in the background shallow monitoring wells, indicating potential influence from the Limerick Landfill in the silty sand aquifer layer.

MW-102

Shallow monitoring well MW-102 is located adjacent to the waste footprint in the eastern portion of the Site and is inferred to be downgradient with respect to the groundwater flow direction. MW-102 was installed to a depth of about 4.4 mbgs and is screened mostly in the upper part of the silty clay layer but straddles the interface between the clay and overlying silty sand layer.

Concentrations of analysed parameters in the groundwater sample collected from MW-102 are below PWQO values for all parameters except for boron (1,200 µg/L versus 200 µg/L), iron (3,000 µg/L versus 300 µg/L) and unionized ammonia (0.077 mg/L versus 0.02 mg/L).

Concentrations of the LIPs ammonia, conductivity, alkalinity, barium, boron, calcium, chloride, DOC, iron and magnesium are above the range of concentrations detected in the background wells, indicating potential influence from the Limerick Landfill at this monitoring location.

MW-105

Shallow monitoring well MW-105 is located adjacent to the waste footprint in the western portion of the Site and is inferred to be downgradient with respect to the groundwater flow direction. MW-105 was installed to a depth of about 4.4 mbgs. It is screened mostly in silty sand layer but crosses the interface between the silty sand and underlying silty clay.

Concentrations of analysed parameters in the groundwater sample collected from MW-105 are below PWQO values except for boron (260 µg/L versus 200 ug/L) and iron (370 µg/L versus 300 µg/L).

Concentrations of the LIPs ammonia, conductivity, alkalinity, barium, calcium, chloride, DOC, magnesium and iron are above the range of concentrations detected in the background wells, indicating potential influence from the Limerick Landfill at this monitoring location.

MW-106

Shallow monitoring well MW-106 is located adjacent to the waste footprint in the northwest portion of the Site and is inferred to be downgradient with respect to the groundwater flow direction. MW-106 was installed to a depth of about 4.4 mbgs and is screened mostly in silty sand layer but crosses the interface with the underlying silty clay.

Concentrations of analysed parameters in the groundwater sample collected from MW-106 are below PWQO values except for boron (360 µg/L versus 200 µg/L).

Concentrations of the LIPs ammonia, conductivity, alkalinity, nitrate, boron, calcium and magnesium are above the range of concentrations detected in the background wells. Furthermore, pH detected in the sample from MW-106 is below the range of values for the background wells. The data therefore indicate potential influence from the Limerick Landfill at this monitoring location

4.1.4 Upgradient Deep Well

MW-101D

Deep monitoring well MW-101D is located adjacent to the north property boundary, north of the waste footprint, and is screened in the lower portion of the clay unit at the bedrock contact. It is upgradient of the landfill with respect to the deep groundwater flow direction (Figure 11).

When plotted on the Piper Diagram (Figure 12), the water quality for this well is indicative of a predominantly sodium chloride water, clearly different than shallow background groundwater quality which is more of a mixed calcium, sodium chloride and bicarbonate water.

4.1.5 Downgradient Deep Wells

MW-103D and MW-104D

Deep monitoring wells MW-103D and MW-104D are located adjacent to the south property boundary, south of the waste footprint and are downgradient of the landfill with respect to the deep groundwater flow direction (Figure 11).

When plotted on the Piper Diagram (Figure 12), the water quality is indicative of a predominantly sodium chloride and bicarbonate water, similar to the upgradient deep bedrock well MW-101D. There is no indication of leachate impact at these downgradient deep wells.

4.1.6 Compliance with MECP Guideline B-7 – Shallow Wells

Operational landfills are required to comply with the Reasonable Use Criteria (RUC), as outlined in MECP Guideline B-7 (MOEE, 1994b) at the downgradient site boundary. The Guideline addresses the levels of off-Site leachate impact on groundwater considered acceptable by the MECP and defines the level of impact on groundwater beyond which some form of mitigation measure(s) would be warranted.

The Reasonable Use Guideline B-7 (MOEE, 1994b) 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."*

The methodology for the calculation of the Reasonable Use Criteria (RUC) for the shallow groundwater at the Site is summarized as follows.

- The maximum allowable concentration (C_m) at the downgradient property boundary was calculated for the LIP that have Ontario Drinking Water Quality Standards (ODWQS) according to the following formula:

$$C_m = C_b + x(C_c - C_b)$$

where:

C_b = average background concentration obtained from monitoring wells MW-103S and MW-104S

Cc = maximum concentration allowed by ODWQS,

x = a "safety factor" of 0.25 for health-related criteria or 0.5 for non-health related criteria.

Where both health related and non-health related criteria exist for a single groundwater quality parameter, the more conservative (lower) resulting maximum allowable concentration was selected.

The RUC values for the leachate indicator parameters which have an ODWQS value are provided in Table 6.

LIPs for which concentrations in samples from downgradient shallow (i.e., silty sand layer) monitoring wells located near the property boundary are above the RUC are as follows:

- MW-101S
  - TDS, chloride and sodium.
- MW-102
  - TDS, DOC, alkalinity and iron.
- MW-105
  - TDS, DOC, alkalinity, chloride, iron and sodium.
- MW-106
  - TDS, DOC, alkalinity, iron and nitrate.

It should be noted however that these RUC exceedances in the shallow groundwater are unlikely to affect offsite water supply wells as the primary receptor of the groundwater is considered to be Fansher Creek located about 30 m north of the Site's north property boundary. The extent of offsite contaminant migration to the east and west of the landfill property boundary is inferred to be very minor based on the shallow groundwater piezometric surface shown in Figure 10. The piezometric surface shows very little leachate mounding in the landfill (less than 1 m above perimeter groundwater levels) reflecting the very small height of the landfill above perimeter grade (typically about 1.5 m height). For this condition, lateral hydraulic gradients are not enough to direct groundwater flow a significant distance beyond the east and west property boundaries. On this basis and considering that the proposed closure/capping of the landfill (Section 5) will reduce leachate generation and improve downgradient shallow groundwater quality over time, mitigative measures to address the RUC exceedances in the shallow groundwater are not recommended at this time. However, continued groundwater monitoring and site characterization as outlined in Section 6 is important to confirm site conditions and the overall improvement in groundwater quality following closure.

4.2 Surface Water Assessment

Based on the physical and hydrogeological setting of the Site, Fansher Creek likely represents the ultimate discharge point for potentially leachate-impacted groundwater via shallow groundwater flow system within the silty sand layer. Fansher Creek is located about 30 m north of the Site's north property boundary and is reported to fully penetrate the silty sand layer and approximately 2.1 m into the low-permeability silty clay layer (MOE, 1981). Groundwater at the shallow monitoring wells screened in the silty sand layer downgradient of the Site (MW-101S, MW-102, MW-105 and MW-106) is inferred to be impacted by landfill leachate and is migrating towards Fansher Creek. In addition, drainage tiles installed in the adjacent farm field to the east may represent preferential pathways for leachate-impacted groundwater to reach Fansher Creek. Surface water samples were not collected from Fansher Creek as part of the current investigation. Therefore, the surface water assessment is based on previous investigations as discussed below.

The previous hydrogeological assessment (MOE, 1981) reported elevated concentrations of potassium, iron, phenols and organic carbon in water samples from ponded water at the Site in 1976. The elevated concentrations were attributed to landfill leachate. In 1980, surface water samples collected from Fansher Creek at locations upstream and downstream relative to the Site and from drainage tiles discharging to the creek immediately north of the Site showed considerably higher concentrations in the drainage tile effluent for parameters including iron, chloride, sodium, potassium, sulphate, ammonia-N and dissolved organic carbon. The lower concentrations in the creek for these parameters were attributed to dilution of the tile effluent in the creek. Localized leachate impacts to the stream (i.e. rusty colour at the point of tile discharge) were visually observed downstream of the tile effluent discharge points (MOE, 1981).

Surface water samples collected in the Fansher Creek and in the wetland area on-Site by RWDI (2017) contained concentrations below the PWQO criteria for all parameters analysed, expect for phosphorous in all samples and iron in the Fansher Creek samples. However, higher concentrations for phosphorous and iron were obtained in the samples collected upstream of the landfill compared to the downstream samples, indicating that the Limerick Landfill was not having a measurable impact on Fansher Creek water quality.

Golder performed a site visit on December 6, 2018 and observed groundwater discharging from a drainage tile located at the south bank of Fansher Creek approximately 50 metres east of Limerick Road. The water was observed running clear with no visual evidence of leachate impact.

4.3 Lateral Gas Migration Assessment

At landfill sites, the potential for lateral subsurface migration of landfill gas (LFG) and associated potential explosion hazard of methane (should it migrate and collect in confined spaces) is commonly assessed. Methane gas is lighter than air and is explosive when present at a concentration of between 5 and 15 percent by volume in air. It migrates primarily within the upper unsaturated soil (i.e., above the groundwater table) under both concentration and pressure gradients.

As landfill gas is generated within the landfill waste mass, a low pressure builds up and slowly pushes the gas through the pore spaces of waste or soil before it is released to the atmosphere. The gas moves through the path of least resistance. Gas permeability of a soil is a measure of how well gases or liquids flow through pore spaces. Dry, sandy soils have relatively high gas permeability (larger interconnected pore spaces available for gas to travel through) and would be a preferential gas pathway. On the other hand, clay has low permeability, i.e., it has small pore spaces, and for this reason it inhibits the subsurface movement of landfill gas. If the soil is saturated (i.e., the pore spaces are filled with groundwater), landfill gas will not displace water in the pore spaces because the gas pressure does not have enough driving force to push the water through the soil pore spaces. In a site with a high groundwater table elevation, the gas migration is limited to only the unsaturated pore spaces above the water table. A creek, farm ditch or drain would create a discontinuity in the gas pathway through the unsaturated soil zone and would let landfill gas be vented to the atmosphere through the unsaturated portion of the bank.

LFG lateral subsurface migration potential is influenced by various site-specific factors such as type of native soil and groundwater elevation. The methane gas explosion potential at the receptor depends on factors specific to the receptor including separation distance from the waste disposal area, construction characteristics and engineering controls to prevent build-up of methane gas concentrations at the receptor.

In the case of the Limerick Landfill, most of the LFG migrates through the surficial unsaturated portion of the silty sand layer which is in direct contact with the waste fill. As shown on Figure 2, the Site is isolated and regionally surrounded by Fansher Creek, farm ditches and creek tributaries, which will vent any LFG migrating through the

shallow unsaturated soils. The nearest potential receptor is a residential building located approximately 720 m northeast of the Site. In addition to the long separation distance to this nearest receptor, Fansher Creek runs between this receptor and the Site. A few other receptors exist but are farther away. In addition, the landfill gas generation rate is expected to be small given the relatively small amount of waste fill, the low waste acceptance rate and the age of the waste (up to 40 years old). Therefore, there is no significant potential for environmental impacts related to landfill gas.

As part of the field investigations conducted at the Site in January 2019, combustible gas (methane) readings were collected at three monitoring locations (designated GP-101, GP-103 and GP-104) associated with groundwater monitoring wells MW-101S, MW-103S and MW-104S, respectively. GP-101 is located downstream of the waste footprint and GP-103 and GP-104 are located upstream of the waste footprint with respect to the shallow groundwater flow direction. Combustible gas concentrations were found to be below the detection limit (i.e., 0%) at all three monitoring locations. It should be noted however that groundwater levels at the time that gas measurements were essentially at ground surface and hence slightly above the top of the well screens at GP-103 (MW-103S) and GP-104 (MW-104S). At GP-101 (MW-101S), the groundwater level was approximately 0.3 m below the top of the well screen. Based on the high groundwater level elevations at the time of this gas monitoring and the fact that LFG migration occurs primarily above the groundwater level, data from GP-101 and GP-103 for this monitoring event were not considered useful to assess methane gas migration. Nevertheless, the high groundwater levels (i.e., minimal thickness of unsaturated zone) would prevent any significant lateral migration of LFG from the landfill.

5.0 LANDFILL CLOSURE

As presented in the following sections, the permanent closure of the Site will involve removing or spreading the existing waste piles, regrading the area within the inferred limit of waste fill and construction of stormwater management control works such as ditches, erosion control and flow control measures.

5.1 Final Contours and Final Cover Design

The existing waste piles will be removed to the Trillium Landfill or another licensed waste disposal facility, recycled or used as fill at the Limerick Landfill as part of the proposed regrading.

As discussed in Section 2.4.1, a total of 59 test pits were completed to confirm the thickness and type of the existing cover soils and the limit of waste fill. The existing soil cover thickness at the test pits that encountered waste ranged from 0.1 m to 1.65 m. The average thickness of the existing cover soil is 0.6 m (Table 1). The cover soil consisted mostly of silty sand material.

The Site will be regraded to promote surface water drainage from the waste fill area to the proposed ditches as shown on Figures 6 to 8. A minimum grade of 4.3% for the final contours is proposed to minimize Site disturbance and to minimize the amount of regrading fill to be imported or exported. The landfill regrading including excavations for the proposed ditches will involve a total cut and fill of approximately 15,900 m^3 and 11,400 m^3, respectively, indicating an excess cut of 4,500 m^3 (surplus). The cut material will include soil from the existing silty sand cover and waste from the three isolated waste piles. Topsoil material will be stripped, segregated, stockpiled and reused for final cover construction. The volume of topsoil stripping is included in the cut volume of approximately 15,900 m^3 mentioned above. Most of the soil surplus volume of approximately 4,500 m^3 is expected to be topsoil sourced on Site during the regrading; the remainder soil surplus will be used to construct

steeper grades. The existing silty sand soil cover will be used as regrading fill as an imported clayey cover is proposed to minimize infiltration and associated leachate impacts. As part of the regrading, the leachate well LW-101 will be extended as necessary.

In the event that fill becomes available from other sites (e.g., remediation sites), the final contour grades (prior to final cover placement) could be steepened to accommodate the additional fill material underneath the final cover. In this case, any soil fill imported and placed for the regrading should be tested for Toxicity Characteristic Leaching Procedure (TCLP) and classified as non-hazardous when compared to O.Reg. 558/00 standards. Consideration will be given to the MECP document “Management of Excess Soil – A Guide for Best Management Practices” (2014) when assessing and importing soil for the fill area.

For the closure of the landfill, a minimum thickness of 0.6 m (600 millimetres) of soil cover, plus an additional 150 millimetres of soil capable of sustaining vegetation (topsoil) will be placed across the waste fill area (Figure 8, Detail G). The final soil cover should consist of clayey soil and will be imported. It is not necessary to specify a particular soil gradation envelope. The fill material should be placed in 200 to 300 millimetre thick lifts and compacted to at least 92 percent of the maximum standard Proctor dry density. Following placement of the final cover soil layer and topsoil, the Site will be hydraulically seeded using a mix of shallow rooted and early successional species of grasses. The goal is to include a mixture of annual species that establish quickly and perennial species that will remain over the long term and will control erosion. The seed type and percentage will be determined in accordance with OPSS.MUNI 804. Pollinator friendly plants and associated maintenance practices protective of their health will be used in the seed mixture in accordance with the OWMA document on Enhancing Pollinator Habitats at Waste Management Sites (July 2017). If necessary, a follow-up fertilization and reseeding will be undertaken to support vegetation establishment.

In accordance with Section 6.11.2 of the Landfill Standards (MOE, 2012), the concentrations of chemical parameters in the final cover soil and topsoil layers must not exceed the concentrations specified in the MECP document entitled Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (MOE, 2011) for the intended land use of the Site upon closure. The Municipality intends to permanently close the Site and keep it as a closed municipal landfill, i.e., the Site will stay vacant and managed as a closed landfill. The clayey soil to be imported for cover material should be sampled for analysis and meet MECP Table 3 Full Depth Generic Site Condition Standards in a Non-Potable Groundwater Condition (MECP Table 3 Standards) for Industrial / Commercial / Community (ICC) as presented in the MOE, 2011 document.

The required volumes of the 600 mm thick final cover clayey soil layer and the 150 mm thick topsoil layer are estimated at 18,978 m^3 and 4,745 m^3, respectively. The clayey soil required for final cover construction will be imported and it should meet the MECP Table 3 Standards. Topsoil sourced on Site may be supplemented by imported topsoil as required.

5.2 Stormwater Management Design

The proposed ditches shown on Figures 6 to 8 will collect stormwater from the entire waste fill area and will discharge to either a culvert at Limerick Road or to Fansher Creek.

Stormwater from the southern portion of the Site currently sheet flows to Coltsfoot Drive and during intense rainfall events this road can have stormwater overflow. The proposed south ditches will collect stormwater from the southern portion of the Site and will help with this drainage issue.

There will be a ditch high point at the southwest corner of the Site. The ditches will have a minimum depth of 0.2 m near the high point and maximum depth of 1.6 m to maintain positive drainage along the entire perimeter.

Rip rap aprons are proposed to control erosion as shown on Figures 6 and 8.

A rock check dam and a 300 mm pipe installed with a 100 mm orifice place will provide quantity control at the north end of the Site, i.e., before the merged ditches discharge stormwater to Fansher Creek.

The existing 150 mm diameter culvert that crosses Limerick Road south of the existing Site Entrance will be replaced with a 300 mm diameter corrugated steel pipe culvert.

There will be minor changes to the existing catchment areas; however, the proposed design is considered an improvement as it mitigates the overflow impact along Coltsfoot Drive and will drain stormwater away of the landfill.

A Stormwater Design Report was prepared for the Site (Appendix F). The Stormwater Management Report includes details and a hydrogeological model for the proposed conditions.

5.3 Other Closure and Post-Closure Considerations

The existing chain link fence should be relocated or replaced as needed as part of the closure works. The Site should remain fenced and gate(s) locked.

As the landfill will be closed, there are no procedures considered necessary to minimize or remediate noise, odour, dust, vehicles tracking mud off-site, litter, birds, vectors or vermin.

5.4 End Use

The closed landfill will remain as vacant and protected land via institutional controls, including zoning of the landfill Site to M3-2 (Rural Industrial/Municipal Landfill Site) Zone pursuant to the Zoning By-Law and Official Plan of the Municipality of Southwest Middlesex.

6.0 PROPOSED MONITORING AND MAINTENANCE PROGRAM

The proposed monitoring program for post-closure is summarized in the following sections. The overall objectives of the post-closure monitoring program are:

- to continue to monitor background groundwater quality, surface water quality, leachate quality, and groundwater quality within the area impacted by landfill leachate; and
- to conduct ongoing assessments of site compliance with respect to the groundwater and surface water regime.

6.1 Groundwater and Leachate Monitoring

6.1.1 Groundwater Monitoring Locations and Frequency

The proposed groundwater monitoring program for post-closure is summarized in Appendix G. This monitoring program is similar to the sampling program conducted at the Site in January 2019, with the exclusion of the following wells:

- MW-101D - There is a health and safety concern with this well since it is screened in a gravel layer just above the bedrock that had natural gas under pressure during well installation, i.e., purging this well before sampling may activate the natural gas flow and would require additional health and safety procedures and substantially increase the sampling efforts. This well will be used for groundwater level measurement monitoring and may be decommissioned in the future; and
- MW-104D - As there is negligible potential for impact to groundwater quality at the bedrock contact given the small size of the site and the thickness of the underlying clay layer, one downgradient deep well (i.e., MW-103D) is considered adequate to characterize longer-term groundwater quality conditions. Due on its relative distance from the waste footprint and inferred groundwater flow direction based on the groundwater elevations contours (Figure 11), monitoring well MW-103D is considered to be more likely representative of downgradient deep groundwater quality.

Groundwater monitoring at a frequency of twice per year (Spring and Fall) is proposed for the first three years of post-closure monitoring and may be revised upon review of the analytical results against trigger mechanisms outlined in Section 7.1.

During each monitoring event, groundwater levels should be measured in all functional groundwater monitoring wells including MW-101D and MW-104D which as noted above will not be monitored for groundwater quality.

Based on the number of monitoring locations, one field blank and one field duplicate sample should be prepared during each monitoring session as part of the Quality Assurance/Quality Control (QA/QC) program.

The groundwater sampling protocols followed during the most recent monitoring program should be adhered to during subsequent groundwater monitoring sessions. Field blank samples should be prepared with distilled water, using the same protocol as the regular groundwater samples (i.e., filtration and preservation). All laboratory analyses on groundwater samples should be performed by a private analytical laboratory and the method detection limits (MDLs) for the specific analyses should be commensurate with the standards established in the Ontario Drinking Water Quality Standards, Objectives and Guidelines (MOE, 2003) or the Provincial Water Quality Objectives (MOEE, 1994a), whichever is lower.

6.1.2 Monitoring Parameters

The groundwater samples collected should be submitted to a private laboratory for analysis of the selected Leachate Indicator Parameters (LIPs) listed in Appendix G. The temperature, pH and conductivity of the groundwater samples should be measured in the field at the time of sample collection. The selected LIPs are based on comparison of leachate quality (i.e., sample from LW-101) and background groundwater quality (i.e., samples from MW-103S and MW-104S) as discussed in Section 4.1.2.

6.2 Surface Water

Based on the findings of the recent surface water characterization study (RWDI, 2017), it is proposed that the surface water monitoring events for Fansher Creek be carried out during the Spring and Fall (similar to the groundwater sampling) over three additional years after permanent closure.

Two monitoring locations are proposed: Location Lim-1 located upstream of the confluence with the proposed ditch extension from the north end of the landfill to represent background surface water quality and Lim-2 located downgradient of the confluence (Figure 9).

The need to extend the surface water monitoring beyond three years after closure may be reassessed based on the monitoring results.

The parameters for the proposed surface water monitoring program are provided in Appendix G.

6.3 Landfill Gas Migration Monitoring

Based on the findings of the groundwater monitoring and recent landfill gas monitoring results, one round of landfill gas monitoring is recommended following closure. Combustible gas concentrations readings should be collected at all monitoring locations (GP-101, GP-103 and GP-104) during the winter (January or February) under frozen ground conditions. Winter is generally a period of lower groundwater levels, which is important to ensure that the upper portion of the gas probe screens extend above the groundwater table. The need for routine landfill gas monitoring for the post-closure monitoring program should be reassessed based on the results. Due to the high groundwater levels at the site (i.e., minimal thickness of unsaturated zone) and the age/quantity of the waste fill, lateral migration of LFG from the landfill is expected to be insignificant.

6.4 Monitoring Reporting

It is proposed that a monitoring report for the Limerick landfill Site be prepared and submitted to the MECP yearly by March 31, starting in the year following closure and then for the next two years. Based on the monitoring results, consideration can be given to reducing the reporting frequency to biennial (once every two years). The monitoring report will provide a discussion of the groundwater geochemistry (including apparent trends over time) in the vicinity of the Site. The groundwater quality in the shallow (silty sand layer) monitoring wells will be compared to PWQO. The report will also evaluate the landfill Site's performance relative to the MECP Guideline B-7 Reasonable Use Criteria (RUC) (MOEE, 1994b). Groundwater quality data will be reviewed following each monitoring event with any significant changes (i.e., with potential to affect site compliance) reported immediately to the Municipality and the MECP.

7.0 COMPLIANCE EVALUATION AND TRIGGER CONCENTRATIONS

7.1 Groundwater Trigger (For Surface Water Protection)

Given the close proximity of Fansher Creek to the Site, the primary receptor to potential leachate impacts is the creek; therefore, the PWQO should be used to assess landfill compliance.

The trigger mechanism should be based on prevention of increasing trends of concentrations in the shallow groundwater for parameters for which there are Provincial Water Quality Objectives (PWQO). Due to the lack of a statistically significant dataset at this time, the proposed trigger criteria is three consecutive sampling events with increasing concentrations and an increase of equal to or greater than 25% relative to the first of three sampling events. When a statistically significant data set is established, the trigger mechanism may be altered to provide a statistical basis for the trend analysis.

For the purpose of the trigger mechanism, the following shall apply:

- Groundwater compliance will be assessed using the LIPs listed in Section 4.1 that have a PWQO.
- Compliance will be evaluated at the shallow monitoring wells located closest to the downgradient property boundaries (as indicated on Figure 9) as follows: MW-101S, MW-102, MW-105 and MW-106.

- The Remedial Action Plan shall be implemented when the trigger mechanism described above is encountered at a compliance evaluation monitoring well.

Any observed trigger of the remedial action plan will be verified by re-sampling for the parameter(s) of concern within one month of the original sampling session at which non-compliance with the trigger was initially measured. If the exceedance is not confirmed by the follow-up sample (special monitoring session), then the initial exceedance will be considered anomalous and will be discounted.

Concurrent with the additional monitoring round will be the initiation of a three-step process for the purpose of determining whether implementation of an additional investigation program and/or the Remedial Action Plan is warranted. The three-step process will be as follows:

Step 1 - Assess whether non-compliance with the applicable trigger concentration is likely due to migration of the landfill leachate plume as a whole or whether it is partially or wholly explicable by other factors. This will be achieved by considering trends in parameter concentrations at all relevant monitoring locations.

Step 2 - Discuss the results of Step 1 among the Municipality, consultants, and the MECP to decide whether implementation of an additional investigation program and/or the remedial action plan is warranted; and,

Step 3 - If the conclusion to Step 2 is affirmative, then the additional investigation program and/or remedial action plan would be formulated and implemented.

7.2 Compliance With RUC

As discussed in Section 4.1.6, contaminant impacts exceeding the MECP Guideline B-7 RUC (MOEE, 1994b) have already occurred at the downgradient (north, east and west) property boundaries in the shallow (i.e. silty sand layer) groundwater system. These RUC exceedances in the shallow groundwater are unlikely to affect offsite water supply wells as the primary receptor of the shallow groundwater is considered to be Fansher Creek located about 30 m north of the Site's north property boundary. The extent of offsite contaminant migration to the east and west of the landfill property boundary is inferred to be very minor based on the shallow groundwater piezometric surface shown in Figure 10. The piezometric surface shows very little leachate mounding in the landfill (less than 1 m above perimeter groundwater levels) reflecting the very small height of the landfill above perimeter grade (typically about 1.5 m height). For this condition, lateral hydraulic gradients are not enough to direct groundwater flow a significant distance beyond the east and west property boundaries. On this basis and considering that the proposed closure/capping of the landfill will reduce leachate generation and improve downgradient shallow groundwater quality over time, mitigative measures to address the RUC exceedances in the shallow groundwater are not recommended at this time. However, continued groundwater monitoring and site characterization as outlined in Section 6 is important to confirm site conditions and the overall improvement in groundwater quality post-closure.

7.3 Remedial Action Plan

The triggering mechanism presented above is intended to define a course of action to be followed by the Municipality in the event that continued monitoring defines an increased potential for unacceptable impacts associated with the migration of leachate-impacted groundwater from the landfill site to Fansher Creek. Should further monitoring define that unacceptable impacts have or are likely to occur, the Municipality shall prepare and present a Remedial Action Plan for the approval of the MECP Director or the District Manager.

It is not the intent of this post-closure plan to define or dictate the form of the Remedial Action Plan. The MECP is aware that different options are available to the Municipality to deal with potential surface water contamination associated with the migration of leachate-impacted groundwater from the landfill site. The MECP is also aware that these options may change in the future. Thus, for the purpose of this post-closure plan, the Municipality is responsible for preventing unacceptable surface water impacts to Fansher Creek.

Should the ongoing groundwater monitoring program define the existence of or potential for unacceptable impacts to off-site groundwater quality in relation to groundwater usage, remedial action will be required to gain control over the migration of contaminated groundwater and/or minimizing further leachate generation within the landfill

(e.g. through installation of an impermeable geosynthetic final cover). Alternatively, consideration can be given to gaining control over adjacent properties for Contaminant Attenuation Zone.

8.0 POST-COSURE INSPECTIONS AND MAINTENANCE PROGRAM

It is expected that the Site will require long-term post-closure care.

The Site should be inspected regularly, and repairs or replacements should be completed as soon as possible according to the proposed Inspection and Maintenance Program (Table 7).

9.0 LIMITATIONS AND USE OF REPORT

This report was prepared for the exclusive use of the Municipality of Southwest Middlesex (Municipality) in accordance with the scope and conditions agreed upon between these parties, acknowledging that this report is intended for submission to applicable regulatory agencies for their review.

The report, which specifically includes all tables, figures and appendices, is based on data and information collected by Golder and is based solely on the conditions of the properties at the time of the work, supplemented by historical information and data obtained by Golder as described in this report. Each of these reports must be read and understood collectively and can only be relied upon in their totality.

Golder has relied in good faith on all information provided and does not accept responsibility for any deficiency, misstatements, or inaccuracies contained in the reports as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation.

The assessment of environmental conditions at this Site has been made using the results of physical measurements and chemical analyses of liquids from a number of locations. The Site conditions between sampling locations have been inferred based on conditions observed at borehole locations. Subsurface conditions may vary from these sampled locations.

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

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 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, including excavations, borings, or other studies, Golder should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

Signature Page

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https://golderassociates.sharepoint.com/sites/32886g/deliverables/limerick closure report/18108934 (3000) limerick closure report 2019dec16.docx

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Tables

Test Pits Summary
Limerick Landfill
Closure Report
Municipality of Southwest Middlesex

Test Pit ID	Depth (m) From	Depth (m) To	Existing Cover Thickness (m)	Soil Description	Comment
TP-1	0	0.3		FILL- Silty sand, trace gravel, organics, dark brown	
	0.3	0.6		FILL- Sandy clay, grey to dark brown	
	0.6	1.5		Silty sand, light brown	
TP-2	0	0.3		FILL- Sandy clay, some silt, trace gravel, organics, dark brown	
	0.3	0.6	1.2	FILL- Silty sand, grey brown	Waste encountered at approximately 1.2 m
	0.6	1.5		FILL- Silty sand, light brown, plastic bag, paper, golf ball	
TP-3	0	0.25	0.3	FILL- Silty sand, trace gravel, dark brown to black	
	0.25	0.3		FILL- Silty sand, trace gravel, dark brown to black, plastic, paper	
TP-4	0	0.3	0.3	FILL- Silty clay, some sand, trace gravel, organics, dark brown	
	0.3	0.45		FILL- Silty clay, some sand, trace gravel, organics, dark brown, plastic, paper, mattress	
TP-5	0	0.3		FILL- Silty sand, some clay, trace gravel, organics, dark brown	
	0.3	0.9	1.0	FILL- Silty sand, light brown	
	0.9	1.2		FILL- Silty sand, some clay, berlap bag, paper, odour, grey to black	
TP-6	0	0.3		Sandy TOPSOIL, organics (roots), dark brown	
	0.3	1.5		Silty SAND, light brown	
TP-7	0	0.3		Sandy TOPSOIL, organics (roots), dark brown	
	0.3	1.5		Silty sand, light brown	
TP-8	0	0.3		Sandy TOPSOIL, roots, organics, brown	Surficial waste (inferred from waste pile runoff)
	0.3	0.6		Silty sand, black	
	0.6	0.9		Silty sand, light brown	
	0.9	1.2		Silty sand, some clay, grey brown	
TP-9	0	0.3		Sandy TOPSOIL, organics (roots), dark brown	
	0.3	1.8		Silty sand, light brown	
TP-10	0	0.3		Sandy TOPSOIL, organics (roots), dark brown	
	0.3	2.4		Silty sand, light brown	
TP-11	0	0.3		FILL- Sand and gravel, some silt, organics	
	0.3	0.6	1.0	FILL- Silty sand, trace gravel, grey	
	0.6	0.9		FILL- Silty sand, trace gravel, plastic bags, odour	
TP-12	0	0.3	0.3	FILL- Silty sand, trace gravel, organics, brown	
	0.3	4		FILL- Silty sand, organics, trace gravel, brown, plastic bag, paper, odour	
TP-13	0	0.3	0.6	FILL- Silty sand, trace gravel, organics (roots), dark brown	Waste encountered at approximately 0.6 m
	0.3	0.6		FILL- Silty sand, grey/brown, odour, plastic, paper	
TP-14	0	0.45		FILL- Silty sand, organics (roots), brown	
	0.45	0.75	1.0	FILL- Silty sand, light brown	
	0.75	1.5		FILL- Silty sand, some clay, brown	
TP-15	0	0.3	0.6	FILL- Silty sand, trace gravel, organics (roots), dark brown	Waste encountered at approximately 0.6 m
	0.3	0.6		FILL- Silty sand, grey/brown, odour, plastic, paper	

Table 1

Test Pits Summary

Limerick Landfill

Closure Report

Municipality of Southwest Middlesex

Test Pit ID	Depth (m) From	Depth (m) To	Existing Cover Thickness (m)	Soil Description	Comment
TP-16	0	0.6	1.5	FILL- Silty gravelly sand, organics (0' - 1') brown	Waste encountered at approximatle 1.5 m
	0.6	1.5		FILL- Silty sand, brown	
	1.5	1.8		FILL- Silty sand, brown, plastic bag, paper, odour, decay, brown	
TP-17	0	0.3	1.5	FILL- Silty sand, trace gravel, organics (0' - 1') brown	Waste encountered at approximatle 1.5 m
	0.6	0.6		FILL- Silty gravelly sand, brown	
	0.6	1.5		FILL- Silty sand, brown	
	1.5	1.8		FILL- Silty sand, brown, plastic bag, paper, odour, decay, brown	
TP-18	0	0.3	0.65	FILL- Silty sand, organics (roots), black	Waste encountered at approximatle 0.65 m
	0.3	0.6		FILL- Silty sand, some clay, grey	
	0.6	0.65		FILL- Silty sand, some clay, grey, plastic bag, paper	
TP-19	0	0.3	0.3	FILL- Silty sand, organics (roots), brown	
	0.3	0.45		FILL- Silty sand, roots, organics, brown, plastic bags, paper, metal, plastic	
TP-20	0	0.2	0.6	FILL- Silty sand, trace gravel, organics, dark brown	
	0.2	0.3		FILL- Silty sand, trace gravel, organics, dark brown, brick, clay pipe	
	0.3	0.6		FILL- Silty sand, trace gravel, organics, no debris, trace clay, grey	
	0.6	0.9		FILL- Silty sand, trace gravel, organics, trace clay, grey, plastic garbage bag	
TP-21	0	0.3	0.3	FILL- Silty sand, organics, roots, brown	
	0.3	0.6		FILL- Silty sand, organics, roots, plastic garbage, grey	
TP-22	0	0.15	0.15	FILL- Silty sand, organics, roots, dark brown	
	0.15	0.3		FILL- Silty sand, organics, roots, dark brown, plastic bags, paper, plastic, metal, odour	
TP-23	0	0.3	0.45	FILL- Silty sand, organics, roots, black to dark brown	Waste encountered at approximatly 0.45 m
	0.3	0.45		FILL- Silty sand, organics, roots, light brown, plastic bags	
TP-24	0	0.75	1.2	FILL- Clay, organics, brick fragments, concrete	
	0.75	1.2		FILL- Silty sand, brown	
TP-25	0	0.9	1.5	Fill- Silty sand, tree brances, roots, decomposing organic pile, dark brown	Brush pile on edge of marsh
	0.9	1.5		Silty sand, some silt, organics (roots), dark brown	
TP-26	0	0.75	1.65	FILL- Sandy clay, organics (roots), steel, dark brown	
	0.75	1.2		FILL- Silty sand, organics, dark brown	
	1.2	1.65		FILL- Silty sand, brown	
TP-27	0	0.6	1.5	FILL- Silty sand, organics, dark brown	
	0.6	1.5		FILL- Silty sand, plastics, steel, light brown	
TP-28	0	0.6	0.6	FILL- Silty sand, dark brown	Significant fill pile 2m high at east edge into marsh area
	0.6	1.2		FILL- Silty sand, plastic bags, brick, light brown	
TP-29	-	-	0.0	Fill- Silty sand, asphalt, shingles	
TP-30	0	0.6	0.3	FILL- Silty sand, organics (roots), plastic, steel, brown	
TP-31	0	0.1	0.1	FILL- Silty sand, organics, dark brown	
	0.1	0.15		FILL- Silty sand, organics, plastic, steel, dark brown	
TP-32	0	0.1	0-0.1	FILL- Silty sand, plastic, steel, glass, brown	

Table 1

Test Pits Summary

Limerick Landfill

Closure Report

Municipality of Southwest Middlesex

Test Pit ID	Depth (m) From	Depth (m) To	Existing Cover Thickness (m)	Soil Description	Comment
TP-33	0.2	0.4	0.2	FILL- Silty sand, plastic bags, dark brown	
TP-34	0.1	0.3	0.1	FILL- Silty sand, plastic bags, dark brown	
TP-35	0	0.78	0.8	FILL- Clay, some gravel, organics, asphalt, plastic bags, odour, dark brown	Waste encountered at approximatly 0.8 m
TP-36	0	0.4	0.0	FILL- Silty sand, some clay, glass, plastic, dark brown	
TP-37	0	0.8	0.8	FILL- Clay, plastic bags, rubber, dark brown	Waste encountered at approxiamtely 0.8 m
TP-38	0	0.3	0.2	Fill - Silty sand, plastic bags, steel, dark brown	
TP-39	0	0.1	0.2	FILL- Silty sand, organics, dark brown	
	0.1	0.3		FILL- Silty sand, plastic bags, styrofoam, light brown	
TP-40	0	0.75		FILL-Silty sand, organics, dark brown	Surficial waste - shingles, garbage
	0.75	1.4		Silty sand, light brown	
TP-41	0	0.1	0.1	FILL- Silty sand, organics, plastic bags, glass, dark brown	
TP-42	0	0.3		Fill- Silty sand, organics, plastic, dark brown	
	0.3	1		TOPSOIL, organic (roots), black	
	1	1.8		Silty SAND, light brown	
TP-43	0	1	1.0	FILL- Silty sand, organics, trace steel, dark brown	
	1	1.35		FILL- Silty sand, plastic bags, light brown	
TP-44	0	0.15	0.15	FILL - Clayey silt, organics, dark brown	
	0.15	0.48		FILL-Silty sand, shingles, plastic, garbage bags, brown	
TP-45	0	0.3	0.15	FILL- Silty sand, organics, brick, plastic, steel, dark brown	
TP-46	0	0.6	0.6	FILL- Silty sand, organics (roots), dark brown	
	0.6	1		FILL- Silty sand, organics, pastic bags, steel, hose, black	
TP-47	0	0.6		sandy TOPSOIL, organics, dark brown	
	0.6	0.75		sandy TOPSOIL, organics, black	
	0.75	0.9		SAND, light brown	
TP-48	0	0.1	0.1	FILL- Silty sand, organics, plastic bags, container, steel, plastic, dark brown	
TP-49	0	0.1	0.1	FILL- Silty sand, organics, dark brown	
	0.1	0.3		FILL- silty sand, plastic bags, cans, light brown	
TP-50	0	0.45		Sandy TOPSOIL, organics, thick roots, dark brown	
	0.45	0.9		Silty SAND, light brown	
TP-51	0	0.1	0.1	FILL- Silty sand, organics, dark brown	
	0.1	0.3		FILL- Silty sand, organics, plastic bags, glass, brown	
TP-52	0	0.15		Sandy TOPSOIL, organics, roots, dark brown	Surficial debris
	0.15	0.45		Silty SAND, brown	
	0.45	0.6		Silty SAND, dark brown	
	0.6	0.9		Silty SAND, brown	
TP-53	0	0.45		Sandy TOPSOIL, organics, roots, dark brown	
	0.45	1		Silty SAND, brown	

Table 1

Test Pits Summary

Limerick Landfill

Closure Report

Municipality of Southwest Middlesex

Test Pit ID	Depth (m) From	Depth (m) To	Existing Cover Thickness (m)	Soil Description	Comment
TP-54	0	0.15		Sandy TOPSOIL, organics, thick roots, dark brown	
	0.15	0.3		silty SAND, light brown	
TP-55	0	0.1	0.1	FILL- Silty sand, organics, dark brown	
	0.1	0.3		FILL- Silty sand, organics, plastic bags, steel, glass, dark brown	
TP-56	0	0.2		SandyTOPSOIL, dark brown	Surficial waste
	0.2	0.9		Silty SAND, light brown	
	0.9	1		Silty SAND, dark brown	
TP-57	0	0.15		Sandy TOPSOIL, organics, thick roots, dark brown	
	0.15	0.9		Silty SAND, light brown	
TP-58	0	0.3		Black organic sandy topsoil	
	0.3	0.9		Silty sand, light brown	
TP-59	0	0.3		Sandy TOPSOIL, organics, roots, dark brown	
	0.3	0.9		Silty SAND, light brown	
Average Cover Thickness (m)			0.6		

Table 2

Monitoring Well Details

Limerick Landfill

Closure Report

Municipality of Southwest Middlesex

Well ID	Date Installed	Easting	Northing	Ground Surface Elevation (masl)	Top of Pipe Elevation (masl)	Well Diameter (mm)	Screen Length (m)	Screen Interval (mbgs)	Borehole Depth (mbgs)	Lithology at Screen
LW-101	07-Dec-18	431648	4724156	209.17	210.10	51	4.6	3.1 - 6.1	7.6	WASTE
MW-101S	04-Dec-18	431576	4724318	208.47	209.28	51	3.1	0.9 - 4.0	4.4	SILTY SAND and SILTY CLAY
MW-101D	04-Dec-18	431577	4724319	208.41	209.19	51	1.9	21.2 - 22.7	22.9	SILTY CLAY and GRAVEL
MW-102	12-Dec-18	431691	4724216	208.63	209.39	51	2.4	2.0 - 4.1	4.4	SILTY SAND and SILTY CLAY
MW-103S	11-Dec-18	431806	4724087	209.27	210.13	51	3.1	1.2 - 4.3	4.4	SILTY SAND and SILTY CLAY
MW-103D	11-Dec-18	431805	4724086	209.13	209.93	51	2.0	25 - 26.5	26.5	SILTY CLAY
MW-104S	10-Dec-18	431585	4723902	208.79	209.72	51	3.1	0.9 - 4.0	4.4	SILTY SAND, SAND and GRAVEL
MW-104D	10-Dec-18	431584	4723901	208.74	209.42	51	2.0	27.3 - 28.8	29.0	SILTY CLAY and sandy SILTY CLAY
MW-105	03-Dec-18	431577	4724044	209.03	209.80	51	3.1	0.9 - 4.0	4.4	SILTY SAND and SILTY CLAY
MW-106	03-Dec-18	431584	4724196	208.94	209.66	51	3.1	0.9 - 4.0	4.4	SILTY SAND and SILTY CLAY

Notes

m	Metre.
mm	Millimetre.
mbgs	Metres below ground surface.
masl	Metres above sea level.
--	Oct-19

Table to be read in conjunction with accompanying report.

Table 3
Groundwater Elevations
Limerick Landfill
Closure Report
Municipality of Southwest Middlesex

Well ID	Date Installed	Easting	Northing	Ground Surface Elevation (masl)	Top of Pipe Elevation (masl)	Groundwater Elevation (masl)					Groundwater Elevation (masl)				
						Encountered at Completion of Well Installation	04-Dec-18	07-Dec-18	11-Dec-18	12-Dec-18	02-Jan-19	03-Jan-19	08-Jan-19	10-Jan-19	16-Jan-19
LW-101	07-Dec-18	431648	4724156	209.17	210.10	207.04	--	--	208.10	208.07	--	--	208.34	--	208.26
MW-101S	04-Dec-18	431576	4724318	208.47	209.28	206.61	--	207.11	207.06	207.06	207.29	--	--	207.34	--
MW-101D	04-Dec-18	431577	4724319	208.41	209.19	--	--	205.35	206.02	206.05	206.64	--	--	--	--
MW-102	12-Dec-18	431691	4724216	208.63	209.39	206.77	--	--	--	207.18	204.52	--	207.54	--	--
MW-103S	11-Dec-18	431806	4724087	209.27	210.13	207.20	--	--	--	208.21	--	208.45	208.51	--	--
MW-103D	11-Dec-18	431805	4724086	209.13	209.93	--	--	--	--	201.64	--	198.96	187.08	--	--
MW-104S	10-Dec-18	431585	4723902	208.79	209.72	208.03	--	208.30	208.28	208.26	208.52	208.52	208.55	--	--
MW-104D	10-Dec-18	431584	4723901	208.74	209.42	--	--	--	204.30	204.27	204.20	--	204.36	--	--
MW-105	03-Dec-18	431577	4724044	209.03	209.80	207.05	207.96	207.87	207.80	207.79	208.12	--	208.14	--	--
MW-106	03-Dec-18	431584	4724196	208.94	209.66	206.96	207.31	207.30	207.35	207.35	207.64	--	207.67	--	--

Notes

m	Metre.
mbgs	Metres below ground surface.
masl	Metres above sea level.
Encountered	Encountered water level during drilling
--	Not measured.
	Table to be read in conjunction with accompanying report.

Table 4
Shallow Groundwater Quality in Silty Sand Layer
Limerick Landfill
Closure Report
Municipality of Southwest Middlesex

			Well ID	LW-101	MW-101S	MW-102	MW-103S	MW-104S	MW-105	MW-106
			Well Location	Waste Footprint	Downgradient (north)	Downgradient (east)	Upgradient (southeast)	Upgradient (southwest)	Downgradient (west)	Downgradient (northwest)
			Sampling Date	8-Jan-19	10-Jan-19	8-Jan-19	8-Jan-19	8-Jan-19	8-Jan-19	8-Jan-19
Parameter	Units	PWQO [1]								
Field Parameter										
pH	--		6.77	8.12	6.92	8.77	7.27	6.83	6.58
Conductivity	uS/m		3078	1675	1664	556	1538	2267	1382
VOCs										
Benzene	µg/L	100	3.7	--	--	--	--	--	--
Bromodichloromethane	µg/L	200	<1.0	--	--	--	--	--	--
1,4-Dichlorobenzene	µg/L	4	<1.0	--	--	--	--	--	--
Methylene Chloride (Dichloromethane)	µg/L	100	<2.5	--	--	--	--	--	--
Toluene	µg/L	0.8	<1.0	--	--	--	--	--	--
Vinyl Chloride	µg/L	600	<1.0	--	--	--	--	--	--
Calculated Parameters										
Calculated TDS [2]	mg/L	--	1800	990	1100	380	900	1500	840
Un-ionized Ammonia- N	mg/L	0.02	0.241	0.006	0.077	0.061	0.002	0.014	0.008
Inorganics										
Total Ammonia-N [2]	mg/L	--	150	0.17	34	0.44	0.48	7.7	7.5
Total BOD	mg/L	--	40	--	--	--	--	--	--
Total Chemical Oxygen Demand (COD) [2]	mg/L	--	130	12	58	18	6.9	48	20
Conductivity [2]	µmho/cm	--	3400	1900	1900	630	1700	2400	1200
Total Dissolved Solids	mg/L	--	1390	1000	1010	1770	1010	1560	755
Total Kjeldahl Nitrogen (TKN)	mg/L	--	130	--	--	--	--	--	--
Dissolved Organic Carbon (DOC) [2]	mg/L	--	45	4.3	19	8.7	20	20	8.8
pH	pH	6.5 - 8.5	7.29	8.04	7.45	8.65	7.79	7.54	7.48
Phenols-4AAP	mg/L	1	0.007	--	--	--	--	--	--
Total Phosphorus	mg/L	0.02, 0.01 or 0.03 [4]	0.11	--	--	--	--	--	--
Total Suspended Solids	mg/L	--	100	--	--	--	--	--	--
Dissolved Sulphate (SO4)	mg/L	--	<1.0	56	44	33	29	71	49
Alkalinity (Total as CaCO3) [2]	mg/L	--[5]	1300	290	910	260	290	1100	610
Dissolved Chloride (Cl-) [2]	mg/L	--	320	380	82	41	350	210	40
Nitrate (N)	mg/L	--	--	<0.10	<0.10	<0.10	<0.10	<0.10	18
Nitrate + Nitrite (N)	mg/L	--	<0.10	--	--	--	--	--	--
Metals [3]					--	--	--	--	--
Mercury (Hg)	µg/L	0.2	<0.1	--	--	--	--	--	--
Arsenic (As)	µg/L	100 (5)	2.5	--	--	--	--	--	--
Barium (Ba) [2]	µg/L	--	250	82	260	17	210	410	150
Boron (B) [2]	µg/L	(200)	1400	1200	1200	83	49	260	360
Cadmium (Cd)	µg/L	0.2[6]	<0.10	--	--	--	--	--	--
Calcium (Ca) [2]	µg/L	--	160000	59000	200000	11000	180000	260000	210000
Chromium (Cr)	µg/L	8.9	<5.0	--	--	--	--	--	--
Copper (Cu)	µg/L	1 or 5[7]	<1.0	--	--	--	--	--	--
Iron (Fe) [2]	µg/L	300	43000	<100	3000	150	120	370	<100
Lead (Pb)	µg/L	5, 10, 20 or 25[8]	<0.50	--	--	--	--	--	--
Magnesium (Mg) [2]	µg/L	--	78000	47000	59000	1400	31000	51000	28000
Manganese (Mn)	µg/L	--	450	--	--	--	--	--	--
Potassium (K)	µg/L	--	89000	--	--	--	--	--	--
Sodium (Na) [2]	µg/L	--	180000	220000	69000	120000	130000	230000	30000
Zinc (Zn)	µg/L	30 (20)	<5.0	--	--	--	--	--	--

Non-detect
At or Below PWQO
Exceeds PWQO

Notes:

1. PWQO Guidelines Provincial Water Quality Objectives, Ministry of The Environment (MOE), July, 1994, rev. 1998. Values in brackets are interim PWQO.
2. Leachate Indicator Parameter.
3. Criteria are for total metals whereas results are presented for dissolved metals.
4. The interim PWQO for total phosphorus is 20, 10 or 30 µg/L. Average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L to avoid nuisance concentrations of algae in lakes. Total phosphorus concentrations for the ice-free period should not exceed 10 µg/L for a high level of protection against aesthetic deterioration, which sould be applied to all lakes naturally below this level. Total phosphorous concentration should not exceed 30 µg/L to prevent excessive plant growth in rivers and streams.
5. should not be decreased by >25% of natural concentration
6. The PWQO is 0.2. The interim PWQO is 0.1 when hardness=0-100, 0.5 when hardness>100.
7. 1 when hardness=0-20, 5 when hardness>20
8. 5 when alkalinity<20, 10 when alkalinity=20-40, 20 when alkalinity=40-80 and 25 when alkalinity>80

Table 5
Deep Groundwater Quality in Clay Layer at Bedrock Contact
Limerick Landfill
Closure Report
Municipality of Southwest Middlesex

		Well ID	MW-101D	MW-103D	MW-104D
		Well Location	Upgradient (north)	Downgradient (southeast)	Downgradient (southwest)
		Sampling Date	14-Jan-19	14-Jan-19	8-Jan-19
Parameter	Units	PWQO [1]			
Field Parameter					
pH	--		8.57	8.04	8.01
Conductivity	uS/m		1784	872	571
VOCs					
Benzene	µg/L	100	--	--	--
Bromodichloromethane	µg/L	200	--	--	--
1,4-Dichlorobenzene	µg/L	4	--	--	--
Methylene Chloride (Dichloromethane)	µg/L	100	--	--	--
Toluene	µg/L	0.8	--	--	--
Vinyl Chloride	µg/L	600	--	--	--
Calculated Parameters					
Calculated TDS [2]	mg/L	--	880	500	320
Un-ionized Ammonia- N	mg/L	0.02	0.042	0.010	0.005
Inorganics					
Total Ammonia-N [2]	mg/L	--	0.46	0.35	0.2
Total BOD	mg/L	--	--	--	--
Total Chemical Oxygen Demand (COD) [2]	mg/L	--	5.8	70	<4.0
Conductivity [2]	µmho/cm	--	1800	850	600
Total Dissolved Solids	mg/L	--	915	570	350
Total Kjeldahl Nitrogen (TKN)	mg/L	--	--	--	--
Dissolved Organic Carbon (DOC) [2]	mg/L	--	2.3	24	1.5
pH	pH	6.5 - 8.5	8.25	8.01	8.17
Phenols-4AAP	mg/L	1	--	--	--
Total Phosphorus	mg/L	0.02, 0.01 or 0.03 [4]	--	--	--
Total Suspended Solids	mg/L	--	--	--	--
Dissolved Sulphate (SO4)	mg/L	--	1.3	200	2.4
Alkalinity (Total as CaCO3) [2]	mg/L	--[5]	190	130	180
Dissolved Chloride (Cl-) [2]	mg/L	--	410	43	80
Nitrate (N)	mg/L	--	<0.10	<0.10	<0.10
Nitrate + Nitrite (N)	mg/L	--	--	--	--
Metals [3]			--	--	--
Mercury (Hg)	µg/L	0.2	--	--	--
Arsenic (As)	µg/L	100 (5)	--	--	--
Barium (Ba) [2]	µg/L	--	210	33	190
Boron (B) [2]	µg/L	(200)	2000	310	1000
Cadmium (Cd)	µg/L	0.2[6]	--	--	--
Calcium (Ca) [2]	µg/L	--	22000	29000	18000
Chromium (Cr)	µg/L	8.9	--	--	--
Copper (Cu)	µg/L	1 or 5[7]	--	--	--
Iron (Fe) [2]	µg/L	300	210	<100	<100
Lead (Pb)	µg/L	5, 10, 20 or 25[8]	--	--	--
Magnesium (Mg) [2]	µg/L	--	9900	9900	6600
Manganese (Mn)	µg/L	--	--	--	--
Potassium (K)	µg/L	--	--	--	--
Sodium (Na) [2]	µg/L	--	310000	130000	95000
Zinc (Zn)	µg/L	30 (20)	--	--	--

Non-detect
At or Below PWQO
Exceeds PWQO

Notes:
1. PWQO Guidelines Provincial Water Quality Objectives, Ministry of The Environment (MOE), July, 1994, rev. 1998. Values in brackets are interim PWQO.
2. Leachate Indicator Parameter.
3. Criteria are for total metals whereas results are presented for dissolved metals.
4. The interim PWQO for total phosphorus is 20, 10 or 30 µg/L. Average total phosphorus concentrations for the ice-free period should not exceed 20 µg/L to avoid nuisance concentrations of algae in lakes. Total phosphorus concentrations for the ice-free period should not exceed 10 µg/L for a high level of protection against aesthetic deterioration, which sould be applied to all lakes naturally below this level. Total phosphorous concentration should not exceed 30 µg/L to prevent excessive plant growth in rivers and streams.

5. should not be decreased by >25% of natural concentration
6. The PWQO is 0.2. The interim PWQO is 0.1 when hardness=0-100, 0.5 when hardness>100.
7. 1 when hardness=0-20, 5 when hardness>20
8. 5 when alkalinity<20, 10 when alkalinity=20-40, 20 when alkalinity=40-80 and 25 when alkalinity>80

Prepared By: VT
Checked By: LJJ

Table 6
Groundwater Proposed RUC Comparison - Shallow Wells
Limerick Landfill
Closure Report

						Well ID	**MW-103S**	**MW-104S**					**MW-101S**	**MW-102**	**MW-105**	**MW-106**
						Well Location	**Upgradient (southeast)**	**Upgradient (southwest)**	**Avg**	**Cb**	**Cm**	**75% Cm**	**Downgradient (north)**	**Downgradient (east)**	**Downgradient (west)**	**Downgradient (northwest)**
						Sample Date	**8-Jan-19**	**8-Jan-19**					**10-Jan-19**	**8-Jan-19**	**8-Jan-19**	**8-Jan-19**
Parameter	Units	ODWS [1]		RUC Variables [4]							Proposed RUC	Proposed 75% of RUC				
		MAC & IMAC [2]	AO & OG [3]	Cc	x											
VOCs																
Benzene	µg/L	1	--	1	0.25		--	--	--	--	--	--	--	--	--	--
1,4-Dichlorobenzene	µg/L	5	1	5	0.5		--	--	--	--	--	--	--	--	--	--
Methylene Chloride (Dichloromethane)	µg/L	50	--	50	0.25		--	--	--	--	--	--	--	--	--	--
Toluene	µg/L	60	24	60	0.5		--	--	--	--	--	--	--	--	--	--
Vinyl Chloride	µg/L	1	--	1	0.25		--	--	--	--	--	--	--	--	--	--
Calculated Parameters																
Calculated TDS [5]	mg/L	--	500	500	0.5		380	900	640	640	500	375	990	1100	1500	840
Inorganics																
Total Ammonia-N [5]	mg/L	--	--	--	--		0.44	0.48	0.46	0.46	--	--	0.17	34	7.7	7.5
Total Chemical Oxygen Demand (COD) [5]	mg/L	--	--	--	--		18	6.9	9.0	9.0	--	--	12	58	48	20
Conductivity [5]	µmho/cm	--	--	--	--		630	1700	1165	1165	--	--	1900	1900	2400	1200
Total Dissolved Solids [5]	mg/L	--	500	500	0.25		*1770*	1010	1390	1390	500	375	1000	1010	*1560*	755
Dissolved Organic Carbon (DOC) [5]	mg/L	--	5	5	0.5		8.7	20	14.4	14.4	5	4	4.3	19	20	8.8
pH	pH	--	6.5 - 8.5	6.5	0.5		8.65	7.79	8.2	8.2	--	--	8.04	7.45	7.54	7.48
Phenols-4AAP	mg/L	--	--	--	--		--	--	--	--	--	--	--	--	--	--
Dissolved Sulphate (SO4)	mg/L	--	500	500	0.5		33	29	31	31	265.5	199	56	*44*	*71*	*49*
Alkalinity (Total as CaCO3) [5]	mg/L	--	30 - 500	500	0.5		260	290	275	275	388	291	290	910	1100	610
Dissolved Chloride (Cl-) [5]	mg/L	--	250	250	0.5		41	*350*	196	196	223	167	380	82	210	40
Nitrate (N)	mg/L	10	--	10	0.25		<0.10	<0.10	<0.10	0.10	2.6	1.9	<0.10	<0.10	<0.10	18
Nitrate + Nitrite (N)	mg/L	1	--	1	0.25		--	--	--	--	--	--	--	--	--	--
Metals							--	--	--	--	--	--		--	--	--
Mercury (Hg)	mg/L	1	--	1	--		--	--	--	--	--	--	--	--	--	--
Arsenic (As)	µg/L	25	--	25	--		--	--	--	--	--	--	--	--	--	--
Barium (Ba) [5]	µg/L	1000	--	1000	0.5		17	210	114	114	557	418	82	*260*	*410*	150
Boron (B) [5]	µg/L	5000	--	5000	0.25		83	49	66	66	1300	975	1200	1200	260	360
Cadmium (Cd)	µg/L	5	--	5	0.25		--	--	--	--	--	--	--	--	--	--
Calcium (Ca) [5]	µg/L	--	--	--	--		11000	*180000*	95500	95500	--	--	59000	*200000*	*260000*	*210000*
Chromium (Cr)	µg/L	50	--	50	0.25		--	--	--	--	--	--	--	--	--	--
Copper (Cu)	µg/L	--	1000	1000	0.5		--	--	--	--	--	--	--	--	--	--
Iron (Fe) [5]	µg/L	--	300	300	0.5		150	120	100	100	200	150	<100	3000	370	<100
Lead (Pb)	µg/L	10	--	10	0.25		--	--	--	--	--	--	--	--	--	--
Manganese (Mn)	µg/L	--	50	50	0.25		--	--	--	--	--	--	--	--	--	--
Sodium (Na) [5]	µg/L	--	200000	200000	0.5		120000	130000	125000	125000	162500	121875	*220000*	69000	*230000*	*30000*
Zinc (Zn)	µg/L	--	5000	5000	0.5		--	--	--	--	--	--	--	--	--	--

Non-detect
At or Below RUC Cm
Above RUC Cm
Above OWDS and RUC Cm if applicable
Proposed RUC for LIP
Above 75% RUC but below RUC
Concentration above concentration detected in the leachate well LW-01.

Notes:
1. ODWS is Ontario Drinking Water Standard (MOE, 2002)
2. MAC & IMAC - (Interim) Maximum Acceptable Concentration
3. AO & OQ - Aesthetic Objective and Operational Guideline
4. RUC - Reasonable Use Criteria
5. Leachate Indicator Parameter

Prepared By: VT
Checked By: LJJ

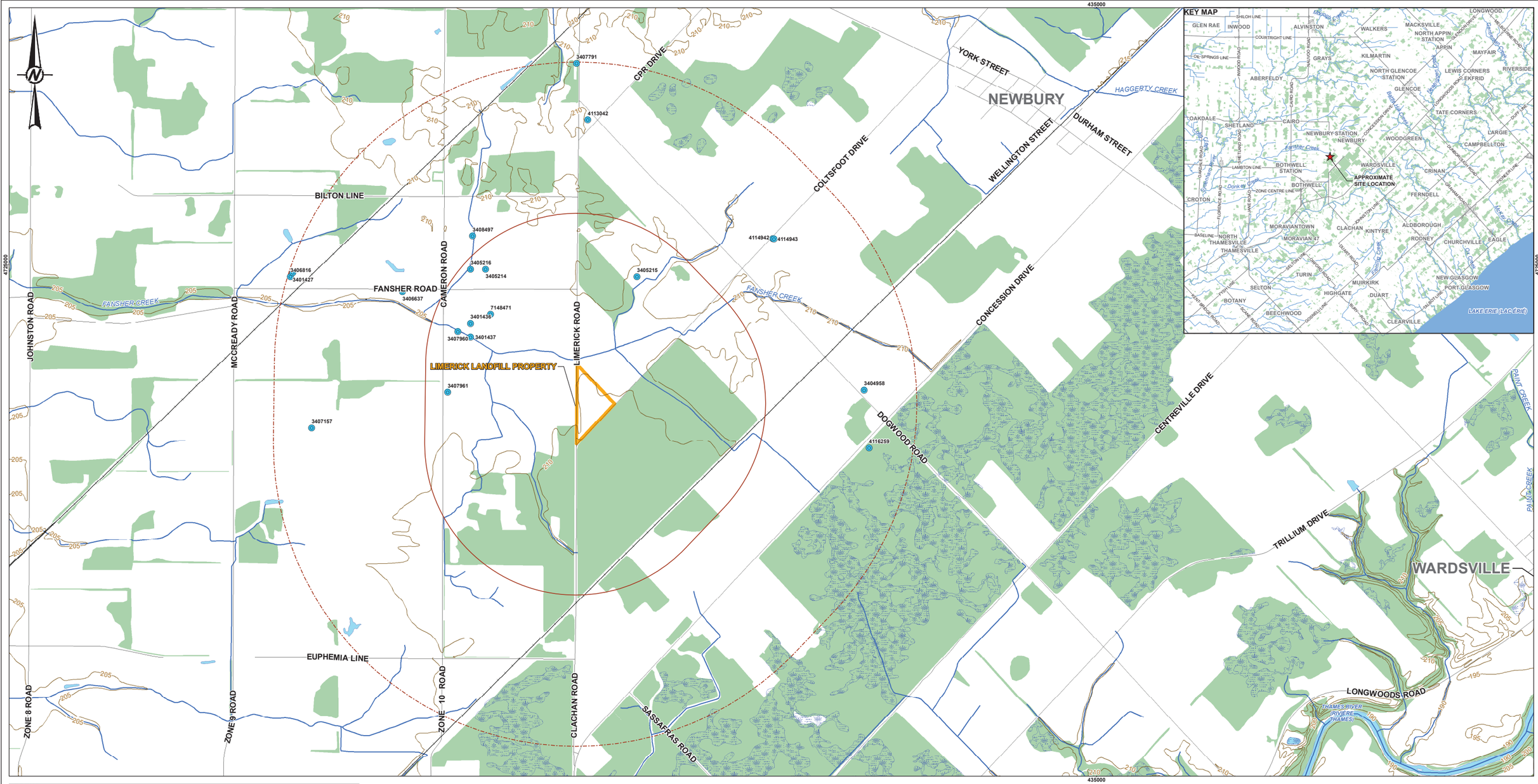
Site Inspection and Maintenance Schedule

Limerick Landfill

Closure Report

Inspection			Maintenance Program
Location	**Frequency**	**Items**	
Landfill Final Cover	Monthly for the first six months, quarterly until the second year from construciton and twice a year thereafter	Deficient vegetation	Apply new topsoil, re-seed
		Evidence of erosion, cover failure or exposed waste	Place suitable soil, topsoil and re-seed
		Presence of leachate seeps	Excavate soft cover, install a stone pit as needed, apply final cover (low permeability soil) in 200 to 300 millimetre lifts and compacted to at least 92 percent of the maximum standard Proctor dry density. Apply topsoil and re-seed
		Areas of ponded water or any areas of landfill settlement affecting site drainage	Place suitable fill, grade to promote positive drainage, apply topsoil and re-seed
Ditches, Culverts, Chack Dam, Rip Rap Aprons	Annually	Presence of sediments/debris, damage to ditches, culverts, check dams or culvert aprons	Clean and repair as needed as per approved design
Monitoring Wells	Annually	Monitoring wells that are not in the sampling program and no longer functional	Decommissioned in accordance with Ontario Regulation 903
		Damages to monitoring wells or casing	Repair or replace as needed
		Broken or missing lock	Replace
Site Signage	Twice a Year	Site signage	Repair as needed
			Maintain in clear and readable condition
			Update information as needed
Site Fencing, Gates and Locks	Twice a Year	Site fences, gates and locks	Repair or replace as needed

Figures



LEGEND

- MECP WATER WELL LOCATION
- ROAD
- RAILWAY
- WATERCOURSE
- CONTOUR - 5 M INTERVAL
- WETLAND
- WATERBODY
- WOODED AREA
- PROPERTY BOUNDARY (6.27 Ha)
- 1KM RADIUS FROM PROPERTY LINE
- 2KM RADIUS FROM PROPERTY LINE

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1.BASE DATA: MNR LIO, OBTAINED 2018 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
2. MECP WATER WELLS - MOECC, OBTAINED 2018-10-17
3.PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

MECP APPROVAL

FINAL

0 1,000 2,000

METRES

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

CONSULTANT
GOLDER

YYYY-MM-DD	2019-09-30
DESIGNED	FRG
PREPARED	ST
REVIEWED	FRG
APPROVED	FSB

PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL, SOUTHWEST MIDDLESEX, ONTARIO

TITLE
SITE LOCATION PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
18108934	0002	A	1

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

0 25mm

PATH: S:\Clients\Municipality_of_Southwest_Middlesex\Limerick_Landfill\99_PRO\18108934_Landfill_Services\40_PROD\0002_Closure_Plan\18108934-0002-CW-0001.mxd PRINTED ON: 2019-09-30 AT: 12:22:36 PM

LEGEND

- ROAD
- WETLAND
- PROPERTY BOUNDARY (6.27 Ha)

ZONING

- A1, GENERAL AGRICULTURAL
- A3, RESTRICTED AGRICULTURAL
- M3-2, RURAL INDUSTRIAL/MUNCICPAL LANDFILL SITE
- RR, RURAL RESIDENTIAL

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

1.BASE DATA: MNR LIO, OBTAINED 2018 PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2019
2. ZONING, OBTAINED FROM SCHEDULE A ZONING BY-LAW, SOUTHWEST MIDDLESEX, 2019
3. IMAGERY,SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
© 2019 MICROSOFT CORPORATION © 2019 DIGITALGLOBE ©CNES (2019) DISTRIBUTION AIRBUS DS , 2017
4.PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

MECP APPROVAL

FINAL

0 250 500

METRES

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

CONSULTANT
GOLDER

YYYY-MM-DD	2019-09-27
DESIGNED	FRG
PREPARED	ST
REVIEWED	FRG
APPROVED	FSB

PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL, SOUTHWEST MIDDLESEX, ONTARIO

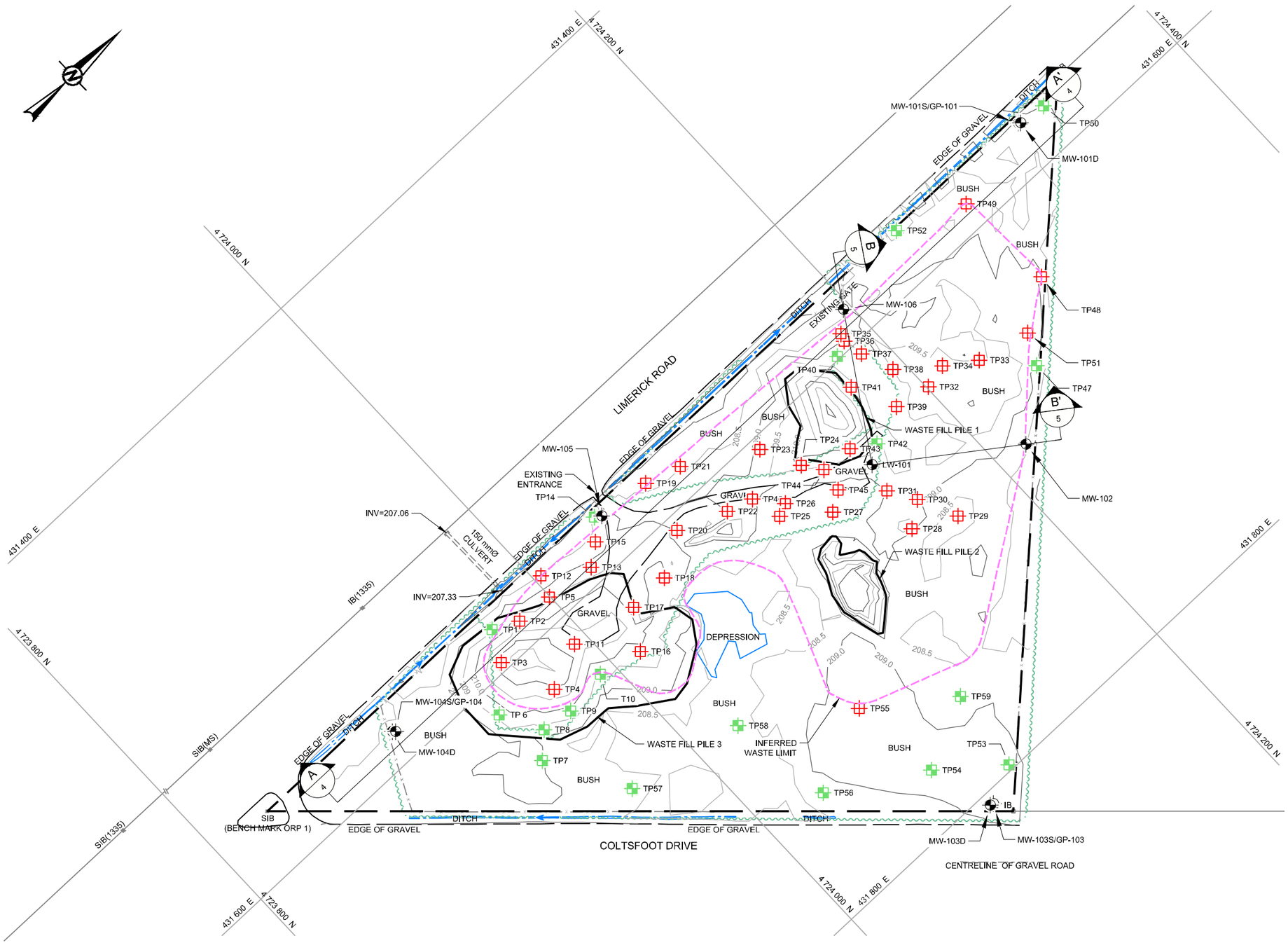
TITLE
ZONING MAP

PROJECT NO.	CONTROL	REV.	FIGURE
18108934	0002	A	2

PATH: S:\Clients\Municipality_of_Southwest_Middlesex\Limerick_Landfill\99_PROJ\18108934_Landfill_Services\40_PROD\0002_Closure_Plan\18108934-0002-GW-0002.mxd PRINTED ON: 2019-09-27 AT: 1:07:11 PM

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

0 25mm



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- 209.0 — EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- 208.5 — EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- TP55 — TEST PIT (WASTE)
- TP54 — TEST PIT (NO WASTE)
- LW-101 — ACTIVE LEACHATE MONITORING WELL
- MW-106 — ACTIVE GROUNDWATER MONITORING WELL
- INFERRED WASTE LIMIT (3.16 ha)

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 50 100
1:2,000 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

SEAL

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

CONSULTANT

GOLDER ASSOCIATES LTD.
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www.golder.com

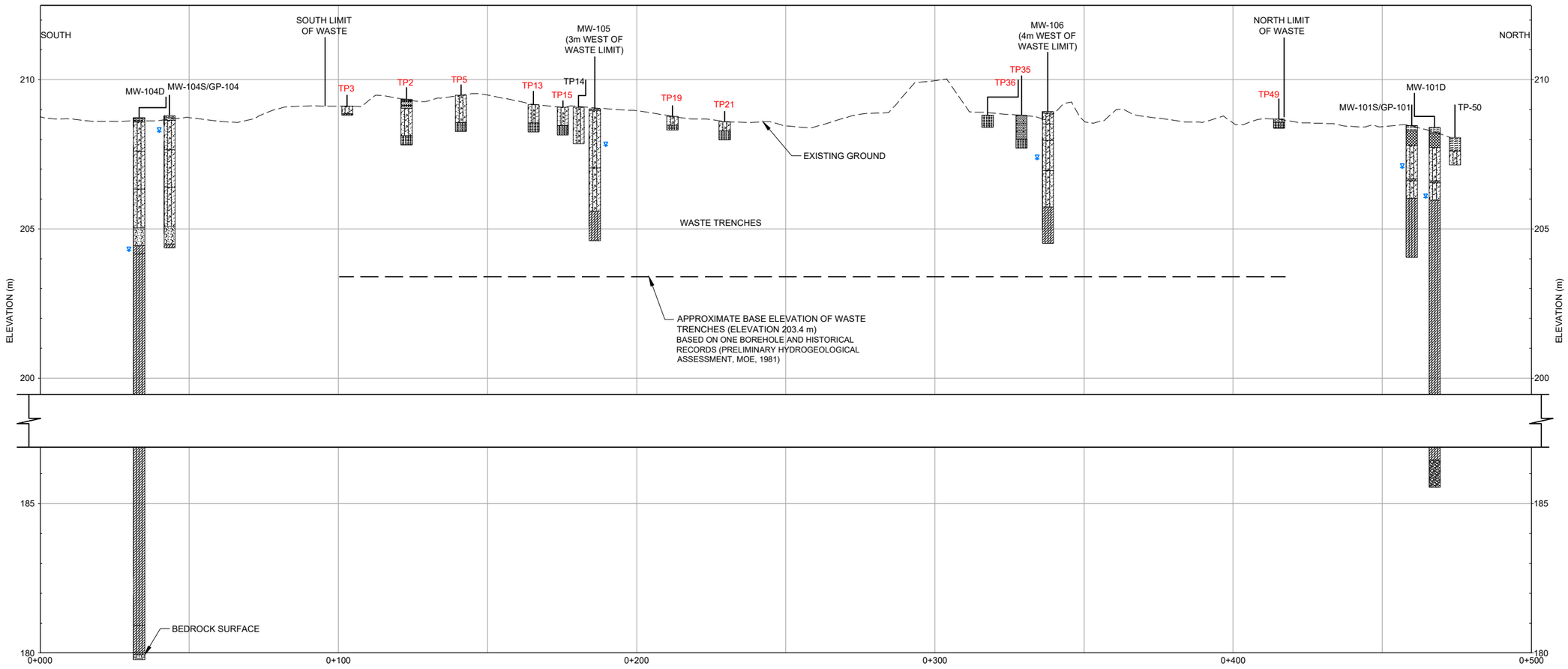
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
EXISTING CONDITIONS AND BOREHOLE/TEST PIT LOCATIONS

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	3 of 11	3

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

25 mm
0



SCALE 1:1500 / VERT. SCALE 1:150 m — A 3 — CROSS SECTION A-A'

LEGEND

- FILL/OVERBURDEN
- WASTE
- SILTY CLAY
- ORGANICS/TOPSOIL
- SILTY SAND
- GRAVEL
- SAND AND GRAVEL
- BEDROCK
- CLAY

MW-104D — MW /TP ID
MW /TP LOCATION
GROUNDWATER ELEVATION -ON DEC. 12, 2018
TP21 — DENOTES TEST PIT TERMINATED AT TOP OF WASTE FILL

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82 m.

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 25 50
1:1,500 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	LJ	AZ	LJ	FRG
A	2019-09-30	CLIENT REVIEW	LJ	AZ	LJ	FRG

SEAL

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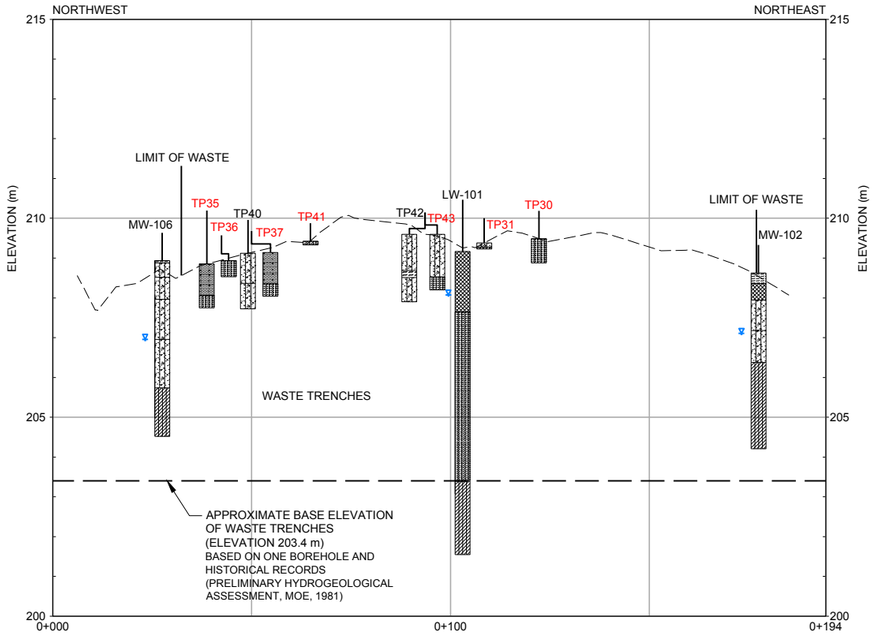
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
CROSS SECTION A-A'

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	4 of 11	4

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

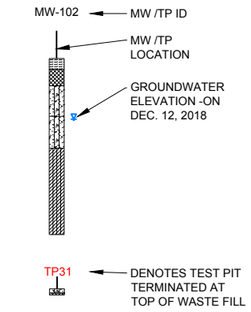
0 25 mm



SCALE 1:1500 / VERT. SCALE 1:150 m — B / 3 — CROSS SECTION B-B'

LEGEND

- FILL/OVERBURDEN
- WASTE
- SILTY CLAY
- ORGANICS/TOPSOIL
- SILTY SAND
- CLAY



NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82 m.

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 25 50
1:1,500 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

SEAL

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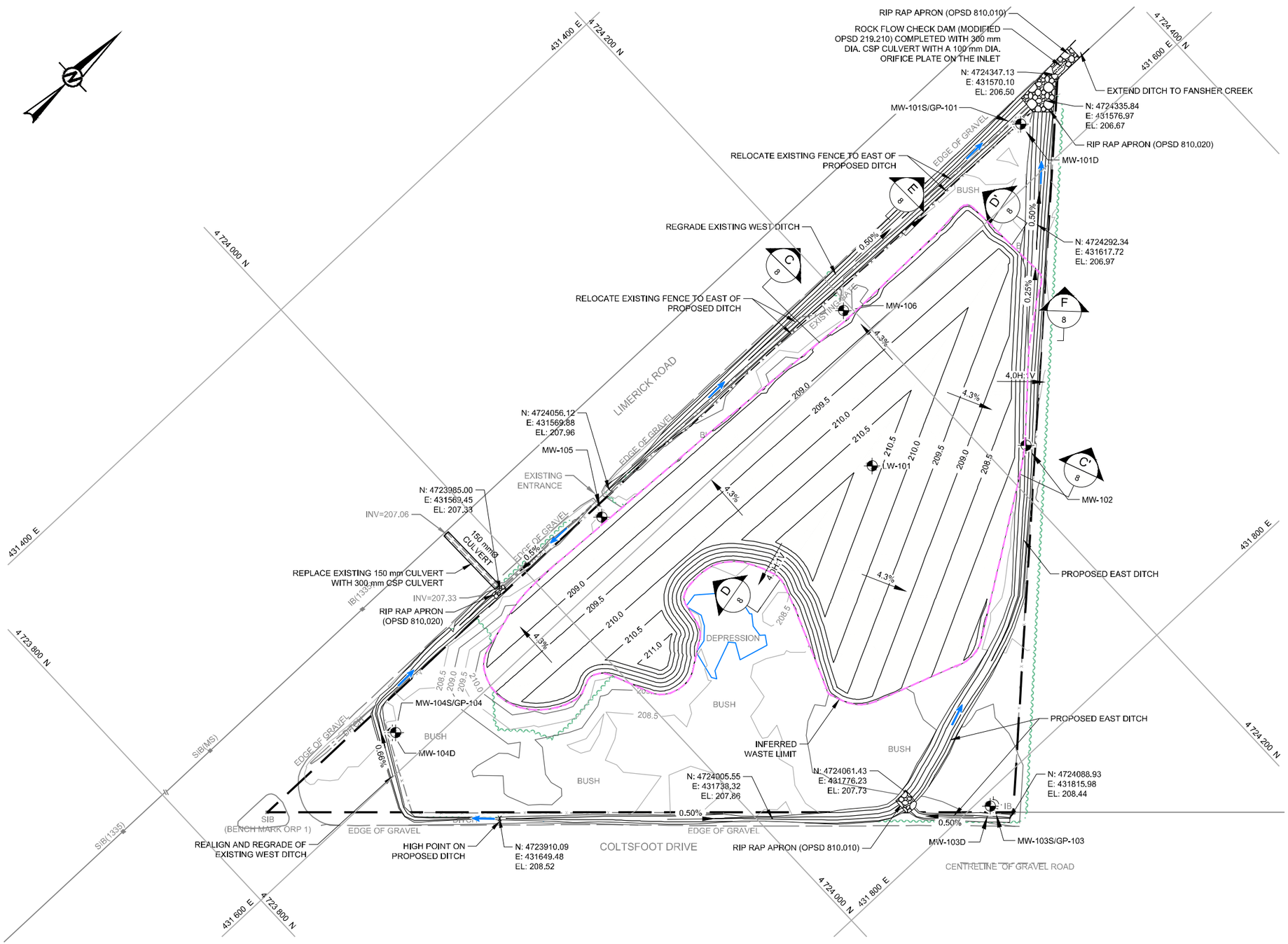
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
CROSS SECTION B-B'

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	5 of 11	5



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- PROPOSED MAJOR CONTOUR (INTERVAL 1 m) PRIOR TO FINAL COVER
- PROPOSED MINOR CONTOUR (INTERVAL 0.5 m) PRIOR TO FINAL COVER
- PROPOSED DITCH AND FLOW DIRECTION
- INFERRED WASTE LIMIT (3.16 ha)
- LW-101 ACTIVE LEACHATE MONITORING WELL
- MW-106 ACTIVE GROUNDWATER MONITORING WELL
- 0.50% GRADE ALONG PROPOSED DITCH

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
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POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

3. TOTAL WASTE FILL AREA REGRADING:
   CUT =11,772 m³
   FILL =11,440 m³
   NET CUT= 332 m³
4. TOTAL DITCH CUT=4,120 m³

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 50 100
1:2,000 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

SEAL

CLIENT
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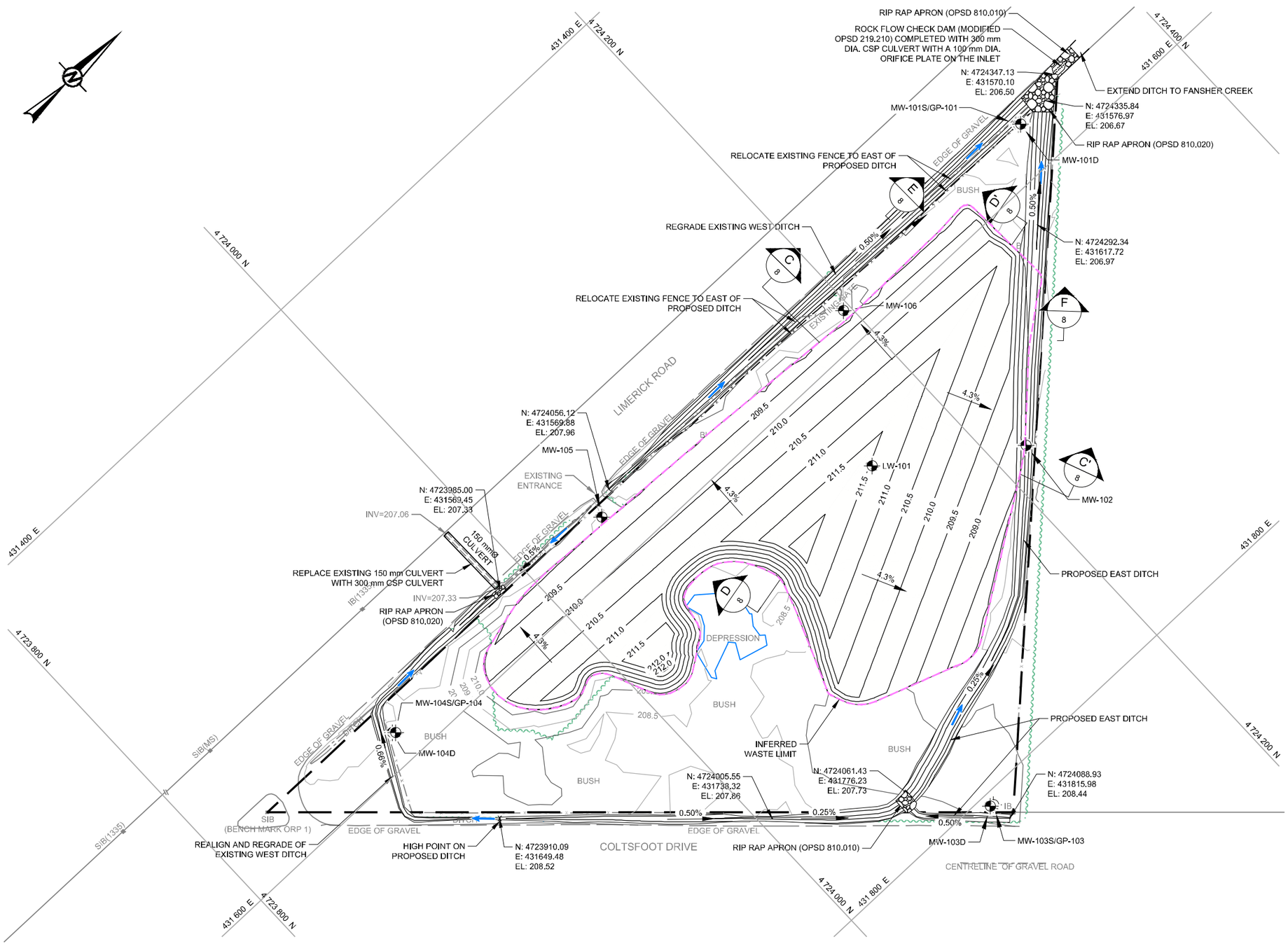
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
PROPOSED SITE REGRADING PLAN (PRIOR TO FINAL COVER CONSTRUCTION)

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	6 of 11	6

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



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- PROPOSED MAJOR CONTOUR (TOP OF FINAL COVER)
- PROPOSED MINOR CONTOUR (TOP OF FINAL COVER)
- PROPOSED DITCH
- INFERRED WASTE LIMIT (3.16 ha)
- LW-101 — ACTIVE LEACHATE MONITORING WELL
- MW-106 — ACTIVE GROUNDWATER MONITORING WELL
- N: 4724088.93 E: 431815.98 EL: 208.44 — PROPOSED DITCH BOTTOM ELEVATION AND COORDINATE
- 0.50% — GRADE ALONG PROPOSED DITCH

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

3. FINAL COVER — TOPSOIL (AVAILABLE ON SITE) VOLUME = 4,745 m³; CLAYEY SOIL (IMPORTED) VOLUME = 18,978 m³; TOTAL VOLUME = 23,723 m³

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 50 100
1:2,000 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

SEAL

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

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CANADA
[+1] (905) 567-4444
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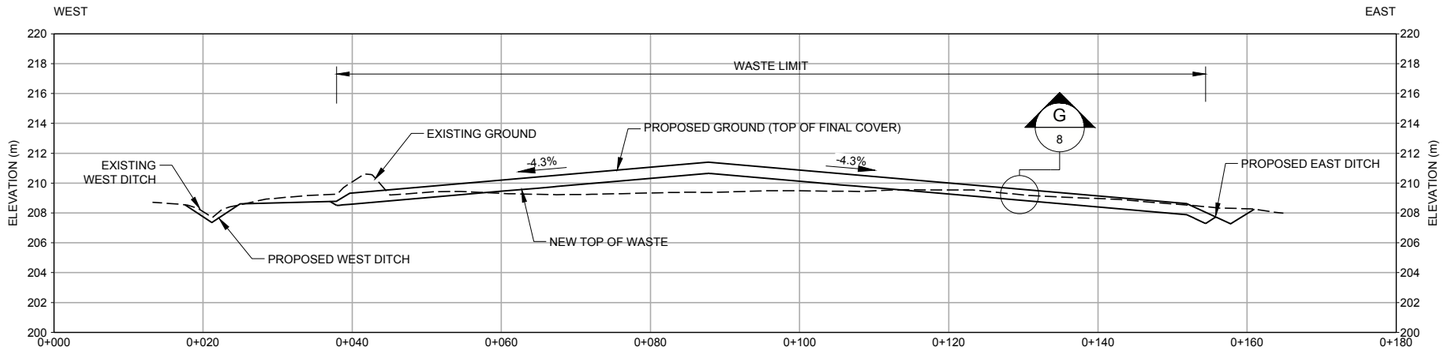
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
PROPOSED SITE REGRADING PLAN (AFTER FINAL COVER CONSTRUCTION)

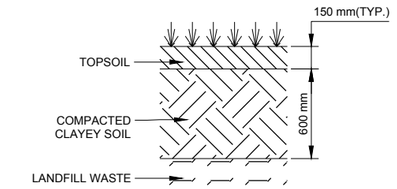
PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	7 of 11	7

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

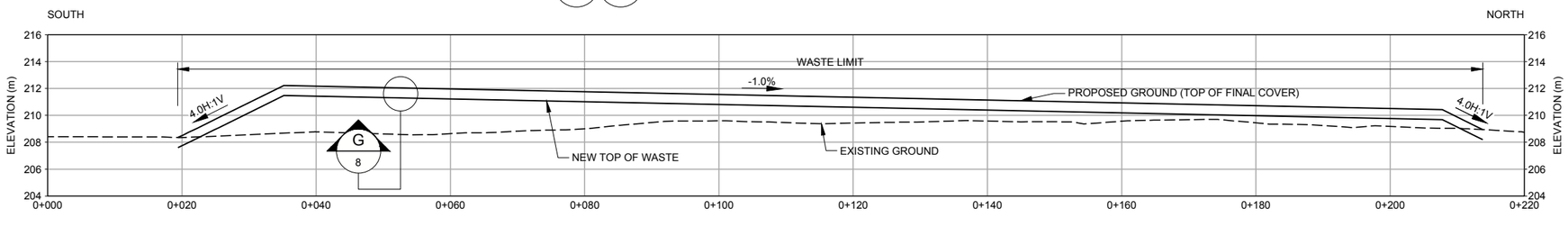
0 — 25 mm



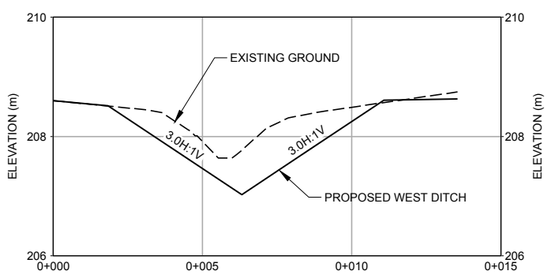
SCALE 1:800 m
VERT. SCALE 1:400 m
C 6 7
CROSS SECTION C-C'



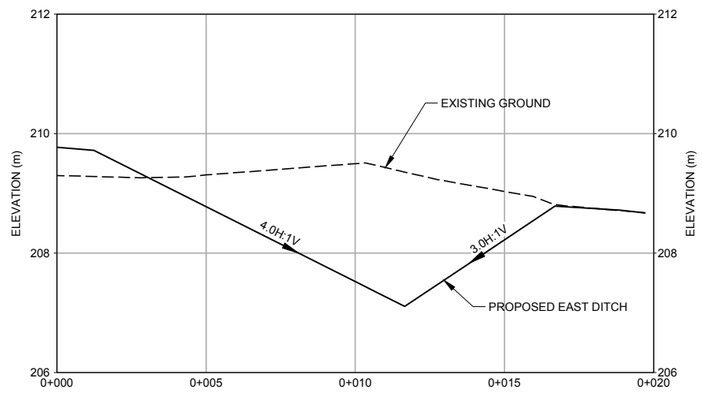
SCALE 1:40 m
G 8
PROPOSED FINAL COVER DETAIL



SCALE 1:800 m
VERT. SCALE 1:400 m
D 6 7
CROSS SECTION D-D'



SCALE 1:200 m
VERT. SCALE 1:100 m
E 6 7
CROSS SECTION E-E'



SCALE 1:200 m
VERT. SCALE 1:100 m
F 6 7
CROSS SECTION F-F'

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82 m.

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

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PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
CROSS SECTIONS

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	8 of 11	8

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

0 25 mm

LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- LW-101 ACTIVE LEACHATE MONITORING WELL
- MW-106 ACTIVE GROUNDWATER MONITORING WELL
- LIM 1 SURFACE WATER MONITORING LOCATION
- INFERRED WASTE LIMIT (3.16 ha)

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 50 100
1:2,000 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

SEAL

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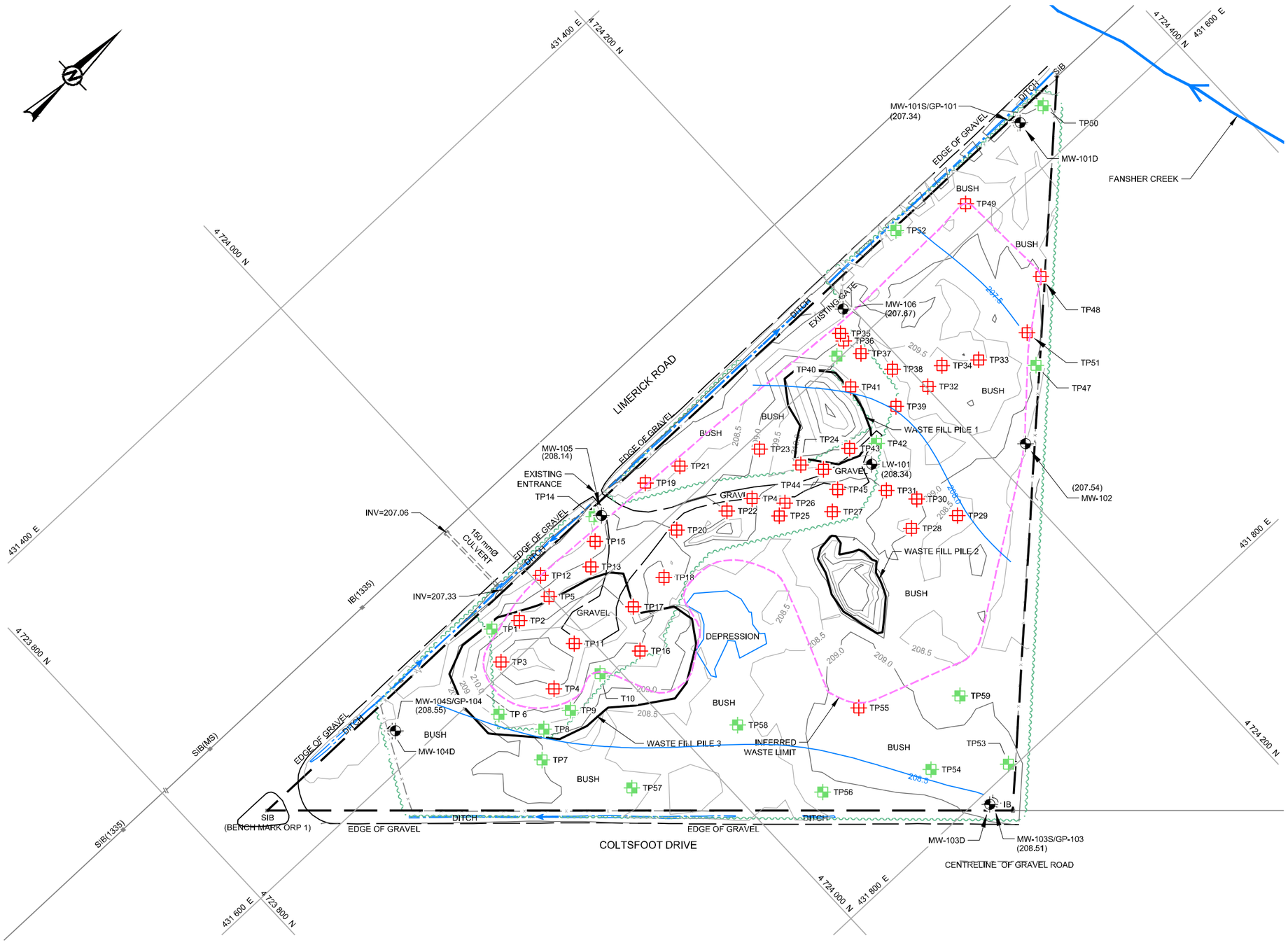
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
MONITORING PROGRAM

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	9 of 11	9

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

0 25 mm



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- 209.0 — EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- 208.5 — EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- TP55 — TEST PIT (WASTE)
- TP54 — TEST PIT (NO WASTE)
- LW-101 — ACTIVE LEACHATE MONITORING WELL
- MW-106 — ACTIVE GROUNDWATER MONITORING WELL
- INFERRED WASTE LIMIT (3.16 ha)
- (207.34) — GROUNDWATER ELEVATIONS (MASL), JANUARY 8, 2019
- 208.5 — GROUNDWATER SHALLOW WELL ELEVATIONS CONTOUR

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 50 100
1:2,000 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

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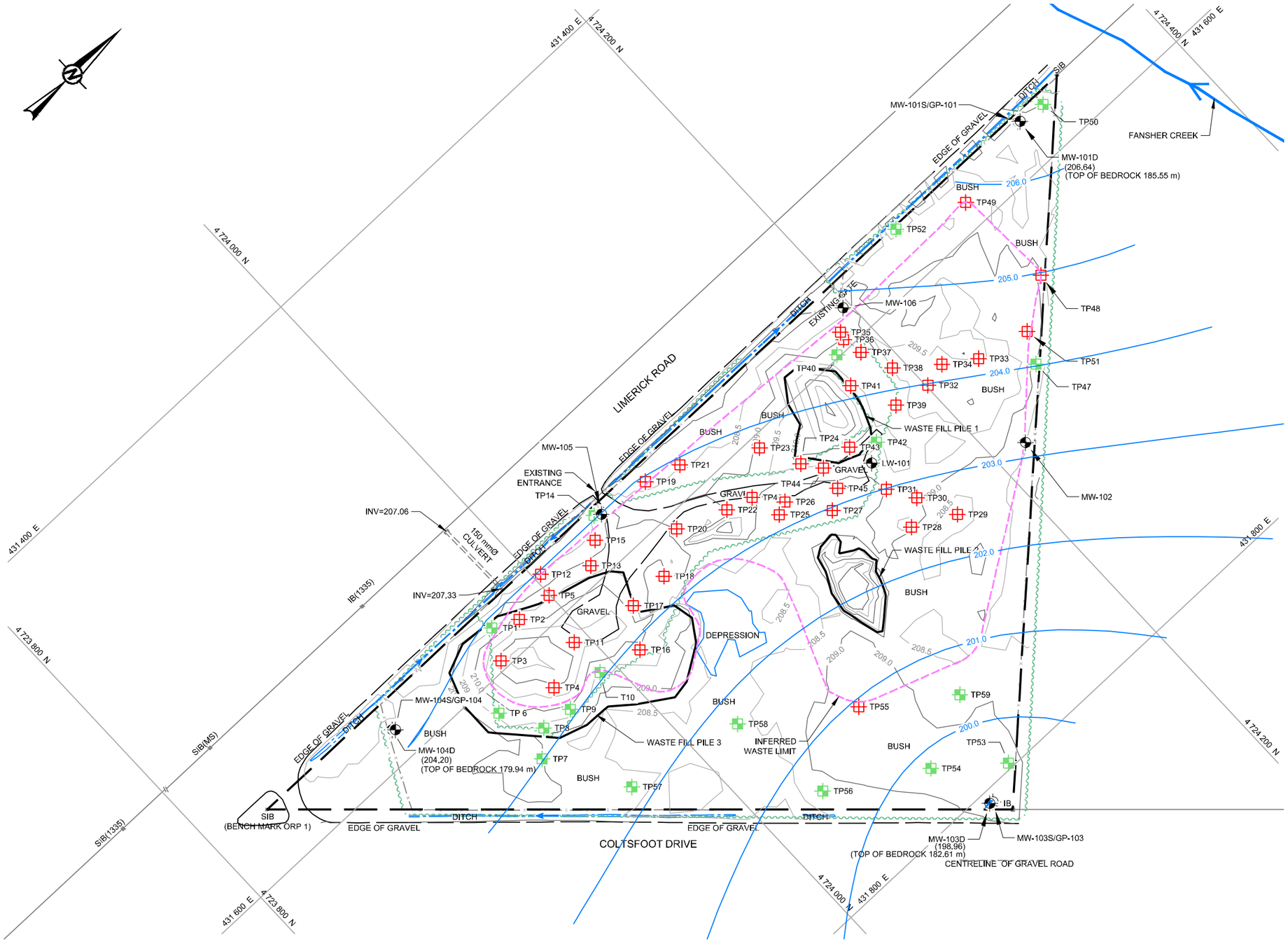
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
GROUNDWATER ELEVATIONS - SHALLOW WELLS

PROJECT NO.	CONTROL	REV.	FIGURE
18108934	0002	B	10 of 11 10



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- 209.0 EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- 208.5 EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- TP55 TEST PIT (WASTE)
- TP54 TEST PIT (NO WASTE)
- LW-101 ACTIVE LEACHATE MONITORING WELL
- MW-106 ACTIVE GROUNDWATER MONITORING WELL
- INFERRED WASTE LIMIT (3.16 ha)
- (206,64) GROUNDWATER ELEVATIONS (MASL), JANUARY 2 TO 8, 2019
- 202.0 GROUNDWATER DEEP WELL ELEVATIONS CONTOUR

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

MECP APPROVAL

FINAL

0 50 100
1:2,000 METRES

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
B	2019-11-25	MECP SUBMISSION	FRG	AZ	FRG	FSB
A	2019-09-30	CLIENT REVIEW	FRG	AZ	FRG	FSB

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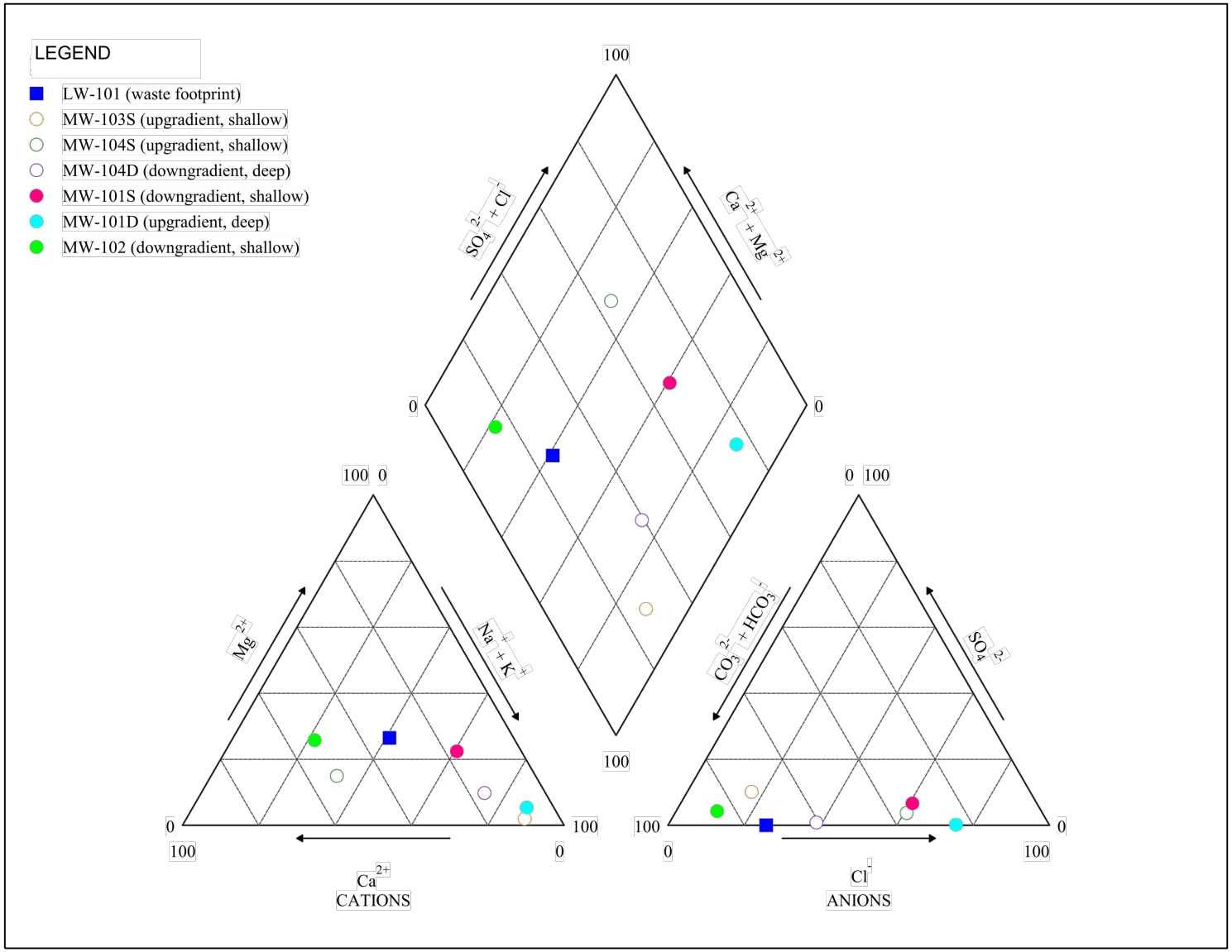
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
GROUNDWATER ELEVATIONS - DEEP WELLS

PROJECT NO.	CONTROL	REV.		FIGURE
18108934	0002	B	11 of 11	11

Last Edited By: axzhang Date: 2019-12-09 Time:4:03:25 PM | Printed By: AXZhang Date: 2019-12-11 Time:2:51:29 PM
Path: \\golder.gds\gal\mississauga\sim\Clients\Municipality_of_Southwest_Middlesex\Limerick_Landfill\99_PROJ\18108934_Landfill_Services\40_PROD\0002_Closure_Plan\ | File Name: 18108934-0002-CW-0012.dwg



MECP APPROVAL

FINAL

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

CONSULTANT
GOLDER

YYYY-MM-DD	2019-12-09
DESIGNED	FRG
PREPARED	AZ
REVIEWED	FRG
APPROVED	FSB

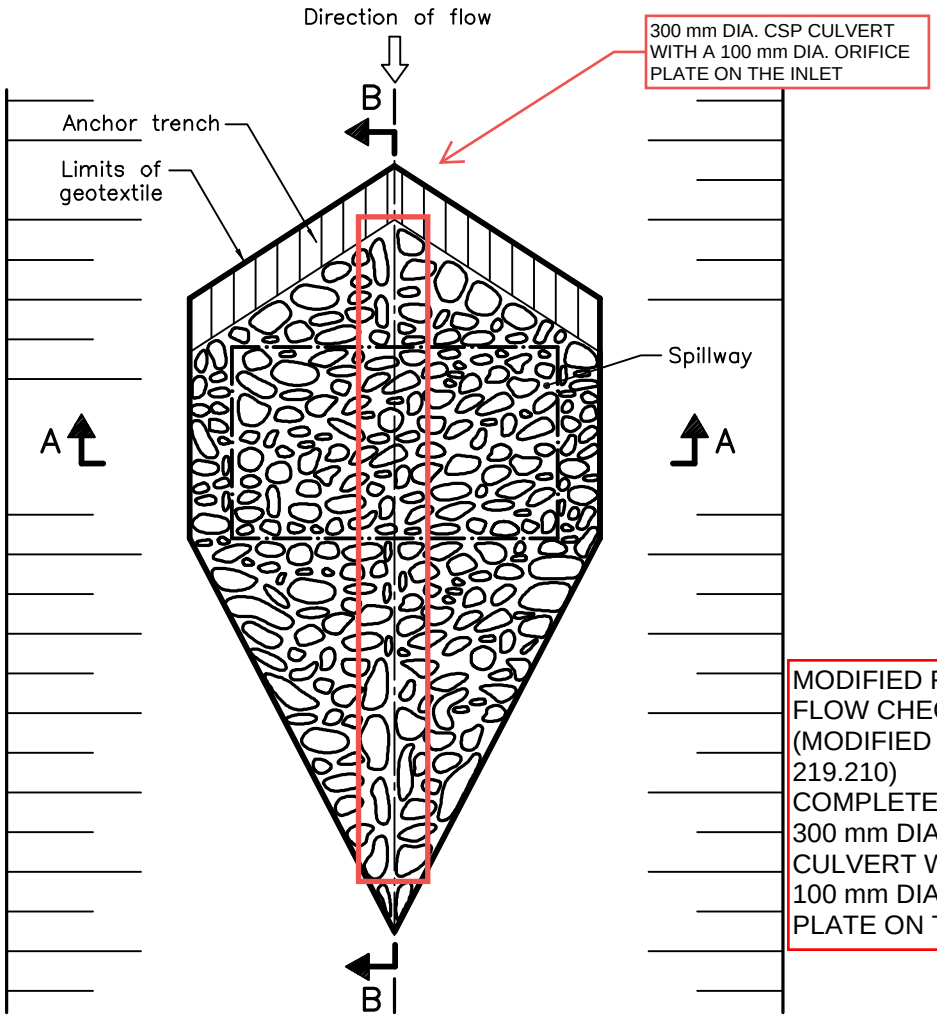
PROJECT
LANDFILL CLOSURE PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
PIPER DIAGRAM FOR GROUNDWATER QUALITY

PROJECT NO.	CONTROL	REV.	FIGURE
18108934	0002	B	12

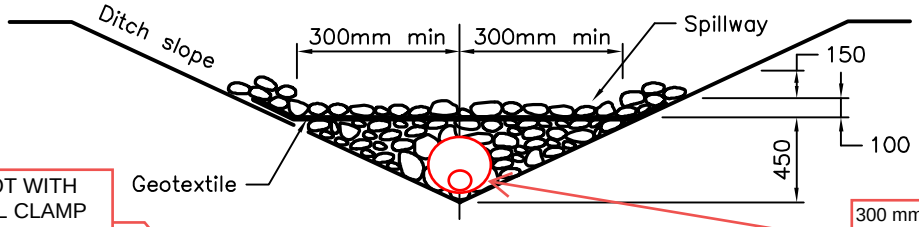
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
0 25 mm

Relevant OPSD (Ontario Provincial Standard Drawings)



MODIFIED ROCK FLOW CHECK DAM (MODIFIED OPSD 219.210) COMPLETED WITH 300 mm DIA. CSP CULVERT WITH A 100 mm DIA. ORIFICE PLATE ON THE INLET

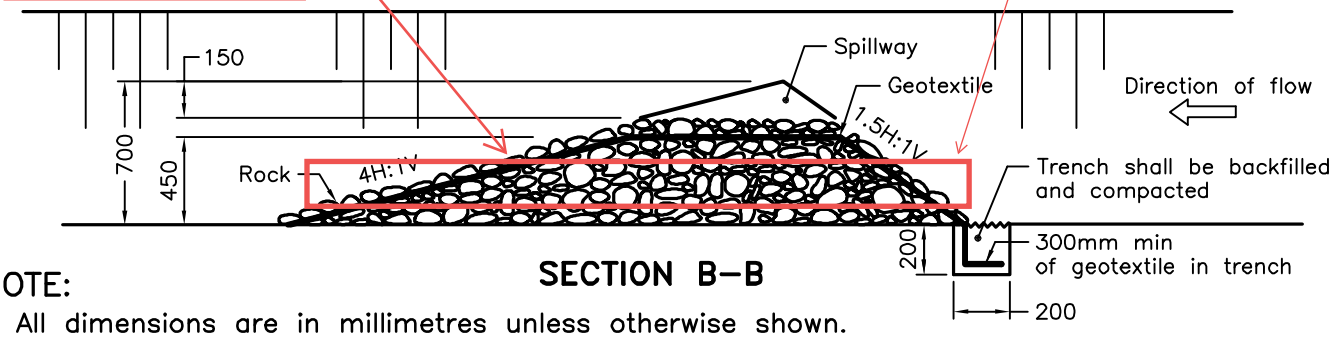
PLAN
SPILLWAY



GEOTEXTILE BOOT WITH STAINLESS STEEL CLAMP AROUND CULVERT PROTRUSION

300 mm DIA. CSP CULVERT WITH A 100 mm DIA. ORIFICE PLATE ON THE INLET

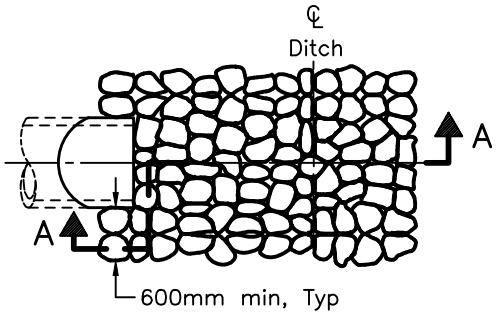
SECTION A–A



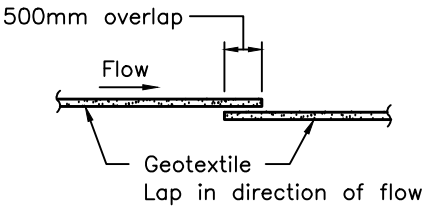
SECTION B–B

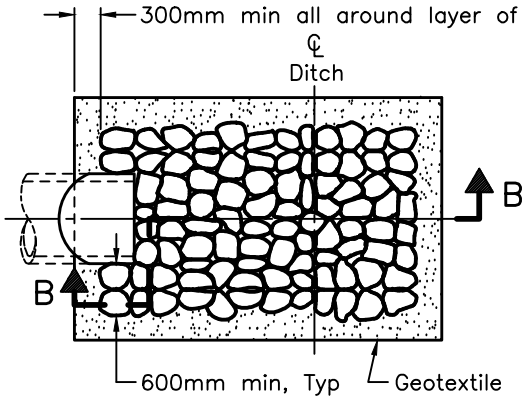
NOTE:
A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING	Nov 2015	Rev 2
TEMPORARY ROCK FLOW CHECK DAM V–DITCH	(MODIFIED)	OPSD 219.210

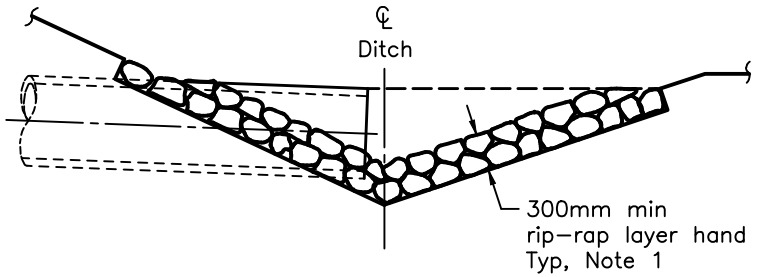


PLAN
CUT OR FILL

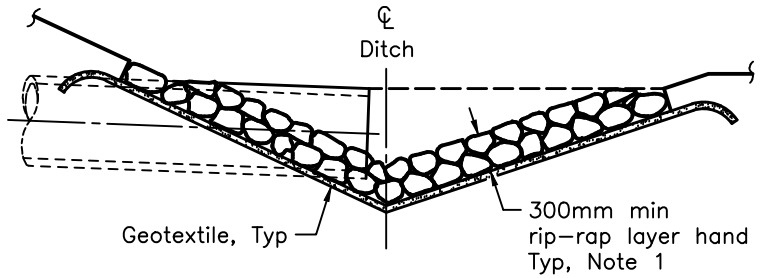




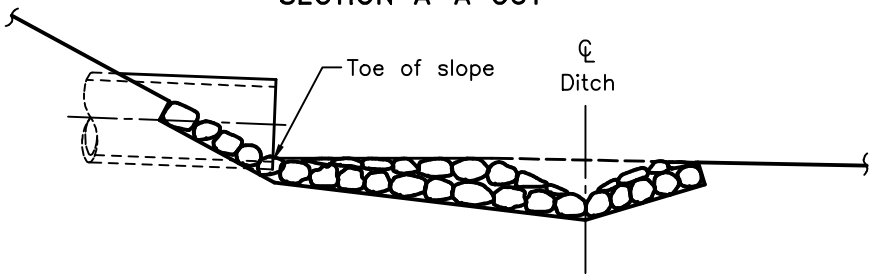
PLAN
CUT OR FILL



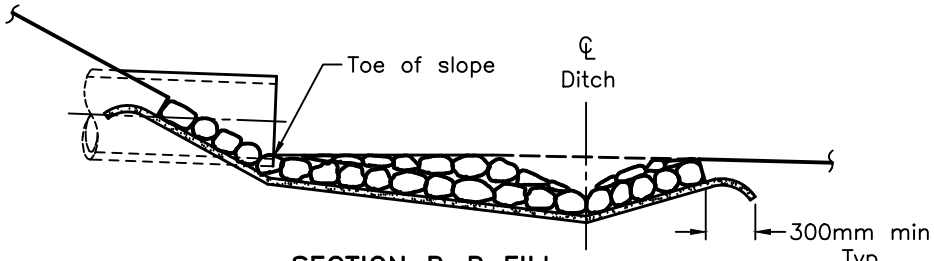
SECTION A–A CUT



SECTION B–B CUT



SECTION A–A FILL



SECTION B–B FILL

TYPE A – WITHOUT GEOTEXTILE

TYPE B – WITH GEOTEXTILE

NOTES:

1 The thickness of the rip–rap layer shall be at least 1.5 times the rip–rap mean diameter.

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

GENERAL RIP–RAP LAYOUT FOR SEWER AND CULVERT OUTLETS

Nov 2018 | Rev 3

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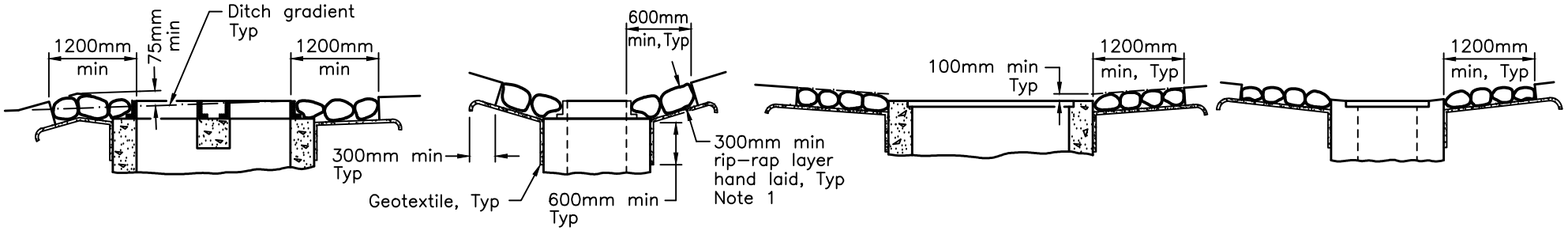
OPSD 810.010

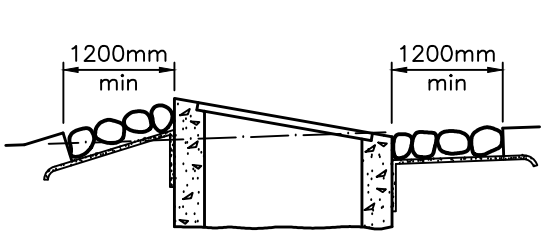


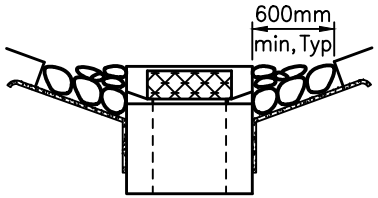
Ditch Longitudinal Section — Ditch Cross–Section

TWIN INLET–INTERMEDIATE

Ditch Longitudinal Section — Ditch Cross–Section

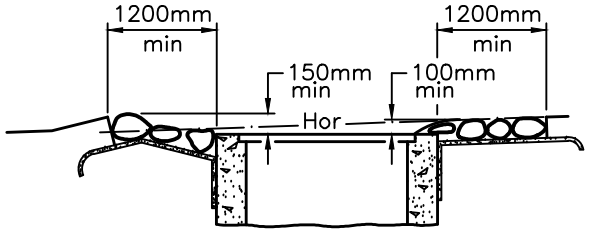
SINGLE INLET–SUMP

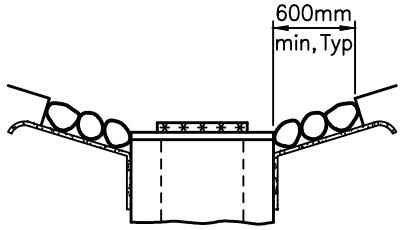




Ditch Longitudinal Section — Ditch Cross–Section

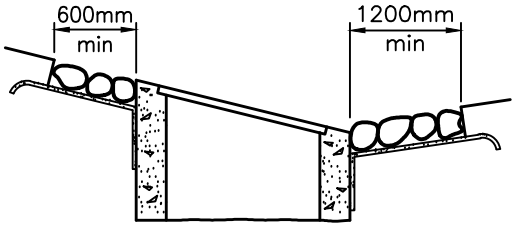
SINGLE INLET–INTERMEDIATE

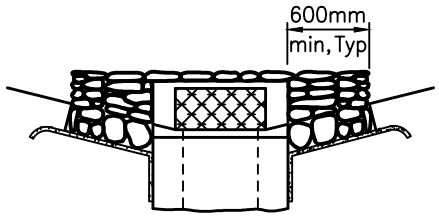




Ditch Longitudinal Section — Ditch Cross–Section

SINGLE INLET–INTERMEDIATE





Ditch Longitudinal Section — Ditch Cross–Section

SINGLE INLET–END OF DITCH

NOTES:

1 The thickness of the rip–rap layer shall be at least 1.5 times the rip–rap mean diameter.

A All dimensions are in millimetres unless otherwise shown.

ONTARIO PROVINCIAL STANDARD DRAWING

GENERAL RIP–RAP LAYOUT FOR DITCH INLETS

Nov 2018 | Rev 3

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OPSD 810.020

APPENDIX A

Inspection Report Issued by MECP

Ontario

Ministry of the Environment and Climate Change
Ministère de l'Environnement et de l'Action en matière de changement climatique

Solid Non-Hazardous Waste Disposal Site Inspection Report

Client:	The Corporation of the Municipality of Southwest Middlesex Mailing Address: 153 McKellar St, Post Office Box, 218, Glencoe, Ontario, Canada, N0L 1M0 Physical Address: 153 McKellar St, Southwest Middlesex, Municipality, County of Middlesex, Ontario, Canada, N0L 1M0 Telephone: (519)287-2015, FAX: (519)287-2359, email: jfrancisco@southwestmiddlesex.ca Client #: 2308-4XUQEP, Client Type: Municipal Government, NAICS: 913910		
Inspection Site Address:	Limerick Road Landfill (Mosa Landfill) Address: Lot: 23, Concession: 3, Geographic Township: MOSA, Southwest Middlesex, Municipality, County of Middlesex District Office: London - District GeoReference: Map Datum: NAD83, Zone: 17, Accuracy Estimate: 10-30 metres eg. Medium Quality GPS, Method: GPS, UTM Easting: 431559, UTM Northing: 4724065, , LIO GeoReference: Zone: , UTM Easting: , UTM Northing: , Latitude: 42.6661, Longitude: -81.8336 Site #: 6536-62NRPU		
Contact Name:	Jill Bellchamber-Glazier	**Title:**	CAO/Clerk
Contact Telephone:	519-287-2015 **ext**109	**Contact Fax:**	
Last Inspection Date:	2016/12/07		
Inspection Start Date:	2018/01/11	**Inspection Finish Date:**	2018/01/11
Region:	Southwestern		

1.0 INTRODUCTION

On January 11, 2018 a solid non-hazardous waste disposal site inspection was conducted by Nicole Does at the Limerick Road Landfill, located on Lot 23, Concession 3, in the Municipality of Southwest Middlesex. The inspection consisted of a file review at the municipal office, followed by a tour of the landfill. Present during the inspection was Provincial Officer John McGlynn, Public Works Manager Tara Clayton, and CAO/Clerk Jill Bellchamber-Glazier.

The site is surrounded by agricultural land and forested areas, and is several metres south of the Fansher Creek. It services Southwest Middlesex and Chatham-Kent Zone, and is open on Wednesdays from 12PM to 5PM, and Saturdays from 9AM to 5PM.

This planned and scheduled inspection is part of the Ministry of Environment and Climate Change (MOECC) London District Office's 2017/2018 inspection program. The purpose of the inspection is to assess compliance with the requirements of the Environmental Protection Act, the Ontario Water Resources Act, Regulation 347 (Waste), Certificate of Approval #A041902, and all other applicable MOECC policies and guidelines.

2.0 INSPECTION OBSERVATIONS

Certificate of Approval Number(s):
A041902

Certificate of Approval # A041902 was issued originally in 1971, and renewed each year until its final issuance in 1980, which was not given an expiry date. It approves the use of 6 hectares (15 acres) for the disposal of domestic

and non-hazardous solid industrial (limited to fencing etc., from agriculture) wastes.

The Approval has two conditions, including:
-Requirement to register to approval on file
-no burning of domestic waste at the site (as of August 28, 1980)

2.1 FINANCIAL ASSURANCE:

Specifics:
Financial Assurance is not applicable for the Limerick Landfill as it is owned by the municipality.

2.2 APPROVED AREA OF THE SITE:

Specifics:
The site does not have a waste footprint defined in the Approval. The municipality is unable to identify what areas have been landfilled in the past. Mike Sholdice, the contractor in charge of operating the site, stated during an MOECC inspection in December of 2016 that most of the 6 hectares have been filled at some point, with the exception of the wooded area to the south. The current active cell is located to the south of the entrance, landfilled using the trench and fill method. No deposited waste or blown litter was observed outside the perimeter of the site.

2.3 APPROVED CAPACITY:

Specifics:
There is no approved maximum waste capacity listed in the Approval. The municipality is unaware of what the current waste capacity at the site is. No records are kept of the quantity or type of waste coming in, with the exception of some tipping fee receipts which only document the amount paid by the individual who deposited the waste.

2.4 ACCESS CONTROL:

Specifics:
There is fencing around the site with a gate and an informative sign at the entrance.
During the inspection, the entrance gate was not locked, however Mr. Sholdice was on-site performing maintenance on equipment. The fence surrounding the property was damaged in some areas along the west end, and there was no fencing visible along the south end. It is recommended that fencing be installed on the south end, and maintenance be done on the surrounding fence perimeter to ensure the site is properly secured. This is a standard practice for both open and closed landfills.

2.5 COVER MATERIAL:

Specifics:
Ms. Clayton stated that cover is now being used on an as-needed basis. Cover material was piled beside the active cell and is re-stocked every 12 weeks by Public Works. During the inspection, the active waste cell was uncovered. A cat was observed around the waste, and there was evidence of animal trails around/through the waste. Ms. Clayton acknowledged the presence of a rat population as well.
On Friday January 12th, an email was received from Mr. Sholdice stating that he had pushed and covered all exposed waste approximately a few hours after the inspection. He mentioned that waste is generally covered within 24 hours after the landfill has been open.


Active waste cell during inspection


Active waste cell later that afternoon (pushed and covered). Picture taken and sent by Mr. Sholdice

2.6 WASTE BURNING:

Specifics:
Condition 2 in the Certificate of Approval states that no burning of municipal waste is permitted. Burning still takes place at the site on an as-needed basis. During the inspection, there was evidence of burning other than clean wood and brush. Observed were the remains of wood furniture, door knobs, table frame/legs, other pressure treated wood, cans and other unidentifiable debris. The burning of waste other than clean wood and brush has been an ongoing issue communicated in past MOECC inspection reports in 2016, 2014 and 2004. The municipality is reminded that these materials do not meet the criteria for "clean wood and brush".
The definition of "municipal waste" taken from Regulation 347, is:
(a) **any waste**, whether or not it is owned, controlled or managed by a municipality, except,
(i) hazardous waste
(ii) liquid industrial waste
(iii) gaseous waste, or
(b) solid fuel, whether or not it is waste, that is derived in whole or in part from the waste included in clause (a)


Evidence of burning.

Mr. Sholdice stated that these plastic bags contained only weeds, ashes and pine tree needles, and that the burn pile in this picture are ashes dumped from barrels brought by residents.

2.7 GROUNDWATER/SURFACEWATER IMPACT:

Specifics:

At the time of the inspection, it was difficult to assess the condition of surface water due to the wet weather conditions and partially snow covered ground. No obvious leachate springs or ponding was observed. The pond on-site was reported to have garbage floating in the water at times, however this could not be visually confirmed during the time of inspection due to the wet/snow covered ground conditions, which limited walking access in certain areas of the site.

This landfill sits in a generally low-lying area, with a wetland and a creek nearby. The Fansher Creek is several metres north of the property, and eventually drains into the Sydenham River.

No groundwater monitoring has ever been conducted in this area, with the exception of a Preliminary Hydrogeological Assessment done in 1981. In August 2017, the municipality retained RWDI AIR Inc. to conduct a surface water characterization in the vicinity of the Limerick Landfill, which included an upstream and downstream sample of Fansher Creek, and the wetland area located in the central portion of the site. The sample results show concentrations of phosphorous and iron in both creek samples, with higher concentrations upstream than downstream, which RWDI did not attribute to landfill leachate. Phosphorous levels also exceeded limits in the wetland sampling location. The report recommends that a surface water quality monitoring program be established for the site with semi-annual monitoring in spring and fall, given the proximity of the wetland feature and creek. The full surface water report is attached to this inspection report.

During the inspection, Ms. Clayton stated that for now, further surface water sampling will be taking place annually.

2.8 LEACHATE CONTROL SYSTEM:

Specifics:

There is no leachate control system in place for this site.

2.9 METHANE GAS CONTROL SYSTEM:

Specifics:

There is no methane gas control system in place for this site.

2.10 OTHER WASTES:

Specifics:

The municipality has 2 bins for household recyclable materials, provided and picked up by Waste Management. Other noted recycled material accepted on-site includes used tires, leaf and yard waste, and construction and demolition waste (including shingles, carpeting, porcelain, and concrete).

Ms. Clayton said that composting does not take place on-site anymore, and she is not aware of any treated characteristic waste being accepted.

No subject waste was observed on-site during the inspection. There was a large pile of household appliances on-site, including but not limited to refrigerators and stoves. The municipality does not keep an accurate record of the number of refrigeration units accepted at the landfill, and does not keep a record confirming that they have been inspected prior to receiving to ensure that the refrigerator units are properly tagged. Section 41(1) of Regulation 463/10- Ozone Depleting Substances and Other Halocarbons, states "A person shall not dismantle, destroy, recycle, incinerate or dispose of by depositing in a dump or landfilling site refrigeration equipment or a container that has contained refrigerant unless a notice has been affixed to the equipment or container under section 32 and the equipment or

container is dismantled, destroying, recycled, incinerated or disposed of by depositing in a dump or landfilling site in a manner authorized under the Act O. Reg. 463/10, s. 41 (1)."

3.0 REVIEW OF PREVIOUS NON-COMPLIANCE ISSUES

The burning of waste other than clean wood and brush on-site has been an ongoing issue communicated in past MOECC inspection reports in 2016, 2014 and 2004.
MOECC inspection in 2014 identified 10 containers with what appeared to be used oil stored on-site. Jaime Francisco (Public Works Manager at the time) provided a receipt for soil removal contaminated by hydrocarbons, caused from spillage of the containers.

4.0 SUMMARY OF INSPECTION FINDINGS (HEALTH/ENVIRONMENTAL IMPACT)

Was there any indication of a known or anticipated human health impact during the inspection and/or review of relevant material, related to this Ministry's mandate?
No

Specifics:

Was there any indication of a known or anticipated environmental impact during the inspection and/or review of relevant material ?
No

Specifics:

Was there any indication of a known or suspected violation of a legal requirement during the inspection and/or review of relevant material which could cause a human health impact or environmental impairment ?
Yes

Specifics:
Evidence of waste other than clean wood and brush was observed to have been burned on-site, including:
-tables, doors and other wood furniture
-pressure treated wood
-cans and other unidentifiable debris

Was there any indication of a potential for environmental impairment during the inspection and/or the review of relevant material ?
No

Specifics:

Was there any indication of minor administrative non-compliance?
No

Specifics:

5.0 ACTION(S) REQUIRED

1. The Corporation of the Municipality of Southwest Middlesex must ensure that only clean wood and brush are burned at the Limerick Landfill. Confirmation of this must be sent to the undersigned Officer, with a signature from the Publics Works Manager as well as the Site Attendant, Mike Sholdice. Confirmation must be made by email or letter, no later than February 9, 2018.

2. The Corporation of the Municipality of Southwest Middlesex must keep John McGlynn (Area Environmental Officer) informed on all decisions regarding the operations the Limerick Landfill. This includes but is not limited to submitting the final Operations Review no later than 7 days after receiving it.

No

6.0 OTHER INSPECTION FINDINGS

The Limerick Landfill has been operating since 1971, with the same Certificate of Approval containing only two conditions. This Approval is in need of updates to reflect the Ministry's current standards of landfill operations and requirements.
There is very little information known about the Limerick Landfill. The municipality has not been required by the Ministry to do any ground or surface water monitoring, aside from a preliminary hydrogeological assessment in 1981. There are no records to be able to determine the current capacity and location of waste on-site.
The municipality has retained Archibald Consulting to complete an Operations Review of the Limerick Landfill, which will make recommendations for the future plans of the landfill. There is a possibility that the Limerick Landfill may close in the future if it is not economically viable to upgrade the site to current Ministry standards. In the case of closure, waste services from Limerick would be directed to the Trillium Road Landfill.
Ms. Clayton and Ms. Bellchamber-Glazier acknowledged that they would keep the Ministry posted on the municipality's decisions made for both landfills going forward. It was understood during the inspection that if the Limerick Landfill is to close, a completed Closure Plan must be submitted to the Ministry for approval. If the Limerick Landfill is to stay operational, the process of updating the existing Approval will be initiated.

7.0 INCIDENT REPORT

Applicable
1143-AUXSV2

8.0 ATTACHMENTS

170816_DRAFT RPT -Limerick LF SW Characterization_1703470 2000.pdf

PREPARED BY:
Environmental Officer:
Name: **Nicole Does**
District Office: **Southwestern Region**
Date: **2018/01/29**
Signature

REVIEWED BY:
District Supervisor:
Name: **Dan Cromp**
District Office: **London District Office**
Date: **2018/01/29**

Signature:

File Storage Number: -

Note:
"This inspection report does not in any way suggest that there is or has been compliance with applicable legislation and regulations as they may apply to this facility. It is, and remains, the responsibility of the owner and/or the operating authority to ensure compliance with all applicable legislative and regulatory requirements"

APPENDIX B

Provisional Certificate of Approval

Ministry of the Environment
Ontario

Provisional Certificate No. A 041902

PROVISIONAL CERTIFICATE OF APPROVAL
WASTE DISPOSAL SITE

Under The Environmental Protection Act, 1971 and the regulations and subject to the limitations thereof, this Provisional Certificate of Approval is issued to:

Township of Mosa
R.R. #2
Glencoe, Ontario
N0L 1M0

for the use and operation of a 6 hectare (15 acre) landfilling site

all in accordance with the following plans and specifications:

1. Application and supporting information
2. Location Plan entitled "Township of Mosa Landfilling Site".

Located: ✓ [redacted] Lot 23, Concession 3
Township of Mosa
County of Middlesex

which includes the use of the site only for the disposal of the following categories of waste (NOTE: Use of the site for additional categories of wastes requires a new application and amendments to the Provisional Certificate of Approval) Domestic, and non-hazardous solid industrial (limited to fencing etc., from agriculture) wastes.

and subject to the following conditions:

1. No operation shall be carried out at the site after sixty days from this condition becoming enforceable unless this Certificate including the reasons for this condition has been registered by the applicant as an instrument in the appropriate Land Registry Office against title to the site and a duplicate registered copy thereof has been returned by the applicant to the Director.
2. The burning of domestic wastes at the site is to be discontinued immediately.

Dated this 28th day of August, 1980

Director, Section 39
The Environmental Protection Act, 1971

MOE 1170 (10/79)

Ministry of the Environment

Ontario

NOTICE

TO: Township of Mosa
R.R. #2
Glencoe, Ontario
N0L 1M0

You are hereby notified that Provisional Certificate of Approval No. A 041902 has been issued to you subject to the conditions outlined therein.

The reasons for the imposition of these conditions are as follows:

1. The reason for the condition requiring registration of the Certificate is that Section 46 of The Environmental Protection Act, 1971 prohibits any use being made of the lands after they cease to be used for waste disposal purposes within a period of twenty-five years from the year in which such land ceased to be used unless the approval of the Minister for the proposed use has been given. The purpose of this prohibition is to protect future occupants of the site and the environment from any hazards which might occur as a result of waste being disposed of on the site. This prohibition and potential hazard should be drawn to the attention of future owners and occupants by the Certificate being registered on title.

2. Smoke from burning waste has created offensive odours and the continued practice of burning waste at the site may create a nuisance or cause a hazard to the health and safety of any person.

You may by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this Notice, require a hearing by the Board.

This Notice should be served upon:

The Secretary,
Environmental Appeal Board,
1 St. Clair Ave. West,
5th Floor,
Toronto, Ontario.
M4V 1K7

AND

The Director,
Section 3a E.P.A.
Ministry of the Environment,

DATED this 28th day of August , 1980 .

D P Caplice

Director,
Section 3a E.P.A.
Ministry of the Environment.

MOE 1844 6/78

APPENDIX C

Legal Survey

ASSOCIATION OF ONTARIO LAND SURVEYORS
PLAN SUBMISSION FORM
2074461

THIS PLAN IS NOT VALID UNLESS IT IS AN EMBOSSED ORIGINAL COPY ISSUED BY THE SURVEYOR
In accordance with Regulation 1026, Section 29(3).

PLAN OF SURVEY WITH TOPOGRAPHICAL DETAIL

OF ALL OF

LOT 23, CONCESSION 3
GEOGRAPHIC TOWNSHIP OF MOSA
IN THE
MUNICIPALITY OF SOUTHWEST MIDDLESEX
COUNTY OF MIDDLESEX

SCALE 1:750

15 10 5 0 15 30 45
SCALE IN METRES

2018
ARCHIBALD, GRAY & McKAY LTD.
ONTARIO LAND SURVEYORS

SURVEYOR'S CERTIFICATE:

I CERTIFY THAT:

1) THIS SURVEY AND PLAN ARE CORRECT AND IN ACCORDANCE WITH THE SURVEYS ACT, THE SURVEYORS ACT AND THE LAND TITLES ACT AND THE REGULATIONS MADE UNDER THEM.

2) THE SURVEY WAS COMPLETED ON THE

Dec 5/18

JASON WILBAND
ONTARIO LAND SURVEYOR

LEGAL LEGEND

■	DENOTES MONUMENT FOUND
□	DENOTES MONUMENT PLANTED
SIB	DENOTES STANDARD IRON BAR
IB	DENOTES IRON BAR
1335	DENOTES I.C. McLAREN, O.L.S.
OU	DENOTES ORIGIN UNKNOWN
MS	DENOTES MONTEITH & SUTHERLAND LTD., O.L.S
P1	DENOTES PLAN 25R-6694

TOPOGRAPHIC LEGEND

BM	DENOTES BENCHMARK
CSP	DENOTES CORRUGATED STEEL PIPE
DIA	DENOTES DIAMETER IN mm
INV	DENOTES INVERT
TP	DENOTES TEST PIT

UTM GRID NOTES

BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.

LINEAR VALUES SHOWN ON THIS PLAN ARE ADJUSTED GROUND LEVEL DISTANCES AND CAN BE CONVERTED TO GRID DISTANCES BY MULTIPLYING BY A COMBINED SCALE FACTOR OF 0.99630403

OBSERVED REFERENCE POINTS (ORPs) DERIVED FROM GPS OBSERVATIONS USING REAL TIME NETWORK (RTK). U.T.M. ZONE 17, NAD83 (ORIGINAL) COORDINATES TO URBAN ACCURACY PER SEC. 14(2) OF O.REG. 216/10

POINT ID	NORTHING	EASTING
ORP 1	4723831.104	431571.352
ORP 2	4724347.170	431572.770

COORDINATES CANNOT, IN THEMSELVES, BE USED TO RE-ESTABLISH CORNERS OR BOUNDARIES SHOWN ON THIS PLAN.

FOR BEARING COMPARISONS, A ROTATION OF 00°18'40" COUNTER CLOCKWISE WAS APPLIED TO BEARINGS ON PLAN 25R-6694

BENCHMARK

ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m

SITE BENCHMARKS

AS INDICATED ON THE FACE OF THIS PLAN.

METRIC

- DISTANCES AND COORDINATES AND ELEVATIONS SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048.

AGM PLAN • SURVEY • ENGINEER
ARCHIBALD, GRAY & McKAY LTD.
3514 WHITE OAK ROAD, LONDON, ON, N6E 2Z9
PHONE 519-685-5300 FAX 519-685-5303
EMAIL info@agm.on.ca WEB www.agm.on.ca

DRAWN BY: MPB	DIGITAL FILE: MO1802TP1_c13.dwg	PLAN No: L-5272
CHECKED BY: DH	OGO FILE: MO1802C1.COG	
Plot date: Dec 05, 2018	FILE No: MOS-03-23-1	

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APPENDIX D

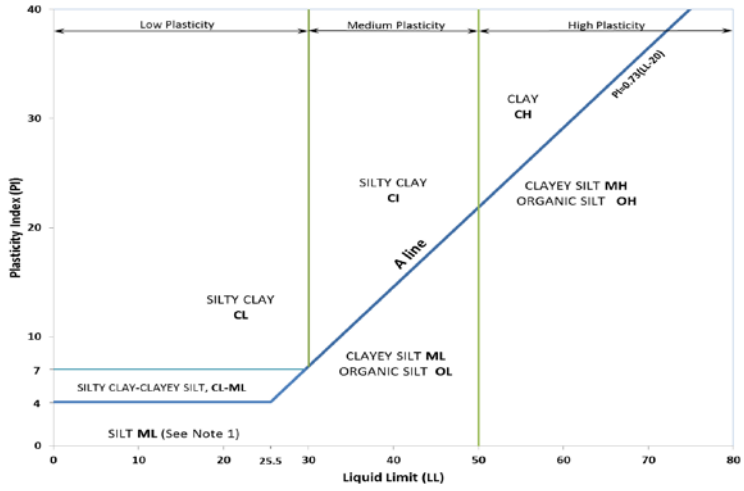
Borehole Logs

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil	Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
				Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)	Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
				Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
				Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
			Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
				None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)	Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
			Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
			Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures							30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat							75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to indicate a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.). Values reported are as recorded in the field and are uncorrected.

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DD	Diamond Drilling
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
GS	Grab Sample
MC	Modified California Samples
MS	Modified Shelby (for frozen soil)
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size (Shelby tube)
TP	Thin-walled, piston – note size (Shelby tube)
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

1. Tests anisotropically consolidated prior to shear are shown as CAD, CAU.

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for the effects of overburden pressure.
2. Definition of compactness terms are based on SPT 'N' ranges as provided in Terzaghi, Peck and Mesri (1996). Many factors affect the recorded SPT 'N' value, including hammer efficiency (which may be greater than 60% in automatic trip hammers), overburden pressure, groundwater conditions, and grainsize. As such, the recorded SPT 'N' value(s) should be considered only an approximate guide to the soil compactness. These factors need to be considered when evaluating the results, and the stated compactness terms should not be relied upon for design or construction.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1,2] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.
2. SPT 'N' values should be considered ONLY an approximate guide to consistency; for sensitive clays (e.g., Champlain Sea clays), the N-value approximation for consistency terms does NOT apply. Rely on direct measurement of undrained shear strength or other manual observations.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
NP	non-plastic
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c'	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

Notes: 1 $\tau = c' + \sigma' \tan \phi'$

2 shear strength = (compressive strength)/2

PROJECT: 18108934

LOCATION: N 4724155.65; E 431647.83

RECORD OF BOREHOLE: LW-101

BORING DATE: December 7, 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		209.17							
0		FILL - SILTY SAND; brown with garbage plastic bag material; moist		0.00	1A	AS					Concrete
1					1B						Bentonite
				207.65							
		WASTE mixed with Silty clay; black; wet - Dirty diaper - Rags - Clothes - Plastic lid - Garbage bag - Plastic bag		1.52							
2					2	AS					December 7, 2018
3					3	AS					Sand
4											
5					4A						Screen
				203.39							
6		SILTY CLAY, some sand, trace gravel; grey, wet		5.78	4B	AS					
7					5	AS					Bentonite
				201.55							
		END OF BOREHOLE		7.62							
8		NOTE: 1. Water level in open borehole at a depth of 2.13 m below ground surface (Elev. 207.04 m).									
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724319.27; E 431576.83

RECORD OF BOREHOLE: MW-101D

BORING DATE: December 4, 2018

SHEET 1 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.41							
0		TOPSOIL (180 mm)		0.00 / 208.23	1A						
		FILL -SILTY SAND, trace gravel; brown, odourless; loose with trace bits of plastic, moist		0.18 / 207.73	1B	SS	6				Concrete
1		SILTY SAND, some roots; brown/orange, odourless, oxidized; loose to compact, moist		0.68	2	SS	7				
		- Brown at a depth of 1.45 m to 1.8 m		206.61	3A						Bentonite
2		SILTY CLAY, some sand, trace gravel; brown, odourless; stiff, moist to wet		1.86	3B	SS	16				
		SILTY SAND; light brown, odourless; compact to stiff, wet - Grey and garbage odour at a depth of 2.21 m to 2.44 m		205.97	3C						
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet - Garbage odour at a depth of 2.44 m to 2.97 m		2.44	4A	SS	12				
3					4B						
					5	SS	18				
4					6	SS	13				
5	D50 50 mm Split Spoon / Hollow Stem Augers				7	SS	12				
6					8	SS	15				December 4, 2018
					9	SS	15				Grout
7											
8					10	SS	15				
9											
					11	SS	13				
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724319.27; E 431576.83

RECORD OF BOREHOLE: MW-101D

BORING DATE: December 4, 2018

SHEET 2 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	D50 50 mm Split Spoon / Hollow Stem Augers	SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet									
11					12	SS	13				
12											
13					13	SS	11				
14					14	SS	15				
15											Grout
16					15	SS	13				
17					16	SS	13				
18											
19					17	SS	15				
20		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724319.27; E 431576.83

RECORD OF BOREHOLE: MW-101D

BORING DATE: December 4, 2018

SHEET 3 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		*--- CONTINUED FROM PREVIOUS PAGE ---*											
20	D50 50 mm Split Spoon / Hollow Stem Augers	SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet											Grout
21					18	SS	16						Bentonite / Sand
22				186.46									
		GRAVEL with gas pocket, wet		21.95									Screen
23		END OF BOREHOLE		185.55 22.86									
		NOTE:											
		1. Water level in open borehole at a depth of 6.1 m below ground surface (Elev. 206.55 m).											
		2. Borehole terminated on inferred top of bedrock.											
24													
25													
26													
27													
28													
29													
30													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724318.34; E 431576.40

RECORD OF BOREHOLE: MW-101S

BORING DATE: December 4, 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.47							
0	D50 50 mm Split Spoon / Hollow Stem Augers	TOPSOIL (180 mm)		0.00 / 208.29	1A						Concrete
		FILL -SILTY SAND, trace gravel; brown, odourless; loose with trace bits of plastic, moist		0.18	1B	SS	6				Bentonite
				207.79							
		SILTY SAND, some roots; brown/orange, odourless, oxidized; loose to compact, moist		0.68	2	SS	7				Sand
1		- Brown at a depth of 1.45 m to 1.8 m			3A						
				206.67	3B	SS	16				
		SILTY CLAY, some sand, trace gravel; brown, odourless; stiff, moist to wet		1.86	3C						December 4, 2018
2		SILTY SAND; light brown, odourless; compact to stiff, wet - Grey and garbage odour at a depth of 2.21 m to 2.44 m		206.03	4A	SS	12				Screen
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet - Garbage odour at a depth of 2.44 m to 2.97 m		2.44	4B						
3					5	SS	18				
					6	SS	13				
4				204.05							
		END OF BOREHOLE		4.42							
		NOTE:									
5		1. Water level in open borehole at a depth of 1.86 m below ground surface (Elev. 206.61 m)									
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724216.23; E 431690.99

RECORD OF BOREHOLE: MW-102

BORING DATE: December 12, 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.63							
0	D50 50 mm Split Spoon / Hollow Stem Augers	TOPSOIL (270 mm)		0.00 / 208.36	1	SS	4				Concrete
		FILL - SILTY SAND; brown, rottlets; brown, odourless; very loose with plastic and glass pieces, moist		0.27 / 207.95	2	SS	9				
1		SILTY SAND; brown/orange, slightly oxidized, odourless; loose, moist		0.68 / 207.18							Bentonite
		SILTY SAND; grey, odourless; loose to compact, wet		1.45 / 206.38	3	SS	25				December 12, 2018 / Sand
2		SILTY CLAY, some sand, trace gravel; grey, odourless; firm to very stiff, wet		2.25	4A / 4B	SS	8				
3					5	SS	19				Screen
4				204.21	6	SS	15				
		END OF BOREHOLE		4.42							
5		NOTE: 1. Water level in open borehole at a depth of 1.86 m below ground surface (Elev. 206.61 m).									
6											
7											
8											
9											
10											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724085.87; E 431805.49

RECORD OF BOREHOLE: MW-103D

BORING DATE: December 11, 2018

SHEET 1 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		209.13									
0	D50 50 mm Split Spoon / Hollow Stem Augers	TOPSOIL (70 mm)		0.00	1A	SS	8						Concrete
		SILTY SAND; brown/orange, oxidized, odourless; loose, moist		0.09	1B								
1					2	SS	8						
		SILTY SAND; brown, odourless; compact, moist		207.73 1.40									
2					3	SS	24						December 11, 2018
					4A	SS	23						
		SILTY SAND; grey, odourless; compact, wet		206.43 2.70	4B								
3					5A	SS	16						
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff, wet		205.58 3.55	5B								
4					6	SS	10						
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet		204.56 4.57	7	SS	15						Bentonite
5													
6					8	SS	15						
7													
8					9	SS	15						
9													
10					10	SS	15						
		CONTINUED NEXT PAGE											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724085.87; E 431805.49

RECORD OF BOREHOLE: MW-103D

BORING DATE: December 11, 2018

SHEET 2 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○W WI; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	D50 50 mm Split Spoon / Hollow Stem Augers	SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet									
11					11	SS	16				
12					12	SS	16				
13											
14					13	SS	14				
15											Bentonite
16					14	SS	19				
17					15	SS	13				
18											
19					16	SS	19				
20		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724085.87; E 431805.49

RECORD OF BOREHOLE: MW-103D

BORING DATE: December 11, 2018

SHEET 3 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
20	D50 50 mm Split Spoon / Hollow Stem Augers	SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet									
21											
22					17	SS	26				Bentonite
23		Hard at 22.86 m			18	SS	50				
24											
25		Some gravel at 24.38 m			19	SS					Sand
26					20	SS					Screen
				182.61							
27		END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 2.03 m below ground surface (Elev. 207.10 m). 2. Borehole terminated on inferred top of bedrock.		26.52							
28											
29											
30											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724087.46; E 431806.00

RECORD OF BOREHOLE: MW-103S

BORING DATE: December 7, 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		209.27									
0	D50 50 mm Split Spoon Hollow Stem Augers	TOPSOIL (70 mm)		0.00	1A	SS	8						Concrete
		SILTY SAND; brown/orange, oxidized, odourless; loose, moist		0.09	1B								
1					2	SS	8						Bentonite
													Sand
				207.82									
		SILTY SAND; brown, odourless; compact, moist		1.45	3	SS	24						
2													December 7, 2018
					4A	SS	23						
				206.60	4B								
		SILTY SAND; grey, odourless; compact, wet		2.67									Screen
3					5A								
				205.92		SS	16						
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff, wet		3.35	5B								
4					6	SS	10						
				204.85									
		END OF BOREHOLE		4.42									
		NOTE:											
		1. Water level in open borehole at a depth of 2.07 m below ground surface (Elev. 207.20 m).											
5													
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4723900.71; E 431584.36

RECORD OF BOREHOLE: MW-104D

BORING DATE: December 10, 2018

SHEET 1 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.74							
0		Organics, leaves, sticks, moist		0.00	1A						
		TOPSOIL		0.08	1B						
		SILTY SAND, some roots; brown/orange, oxidized, odourless; loose, moist to wet		0.15	1C	SS	6				Concrete; Bentonite; December 10, 2018
1				207.60	2	SS	10				
		SILTY SAND, some clay; grey, odourless; loose to compact, wet		1.14							
2					3	SS	15				
				206.34	4A						
		SILTY SAND; grey, odourless; loose to compact, wet		2.40	4B	SS	9				
3						SS	12				
				205.04							
		SAND and GRAVEL, some silt; grey, odourless; compact, wet		3.70	5A	SS	15				
4				204.44							
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff, wet		4.30	5B						
				204.17							
		SILTY CLAY, trace to some sand, trace gravel; grey, odourless; stiff to very stiff, wet		4.57	7	SS	16				
5					8	SS	15				Grout
6					9	SS	18				
7					10	SS	18				
8					11	SS	20				
					12	SS	18				
9					13	SS	18				
10					14	SS	17				

D50 50 mm Split Spoon

Hollow Stem Augers

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

PROJECT: 18108934

LOCATION: N 4723900.71; E 431584.36

RECORD OF BOREHOLE: MW-104D

BORING DATE: December 10, 2018

SHEET 2 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	D50 50 mm Split Spoon / Hollow Stem Augers	SILTY CLAY, trace to some sand, trace gravel; grey, odourless; stiff to very stiff, wet			14	SS	17				
11					15	SS	15				
12					16	SS	17				
13					17	SS	16				
14					18	SS	15				
15					19	SS	16				Grout
16											
17					20	SS	20				
18					21	SS	18				
19											
20		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4723900.71; E 431584.36

RECORD OF BOREHOLE: MW-104D

BORING DATE: December 10, 2018

SHEET 3 OF 3

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---											
20	D50 50 mm Split Spoon / Hollow Stem Augers	SILTY CLAY, trace to some sand, trace gravel; grey, odourless; stiff to very stiff, wet											
21													
22					22	SS	14						
23													Grout
24					23	SS	14						
25													
26													
27		Hard at 27.43 m			24A								Bentonite / Sand
				180.94									
		Sandy SILTY CLAY, some gravel; grey, odourless; hard, wet		27.80	24B	SS							
28													Screen
				179.94									
		BEDROCK		28.80									
29		END OF BOREHOLE NOTE: 1. Water level in open borehole at a depth of 0.76 m below ground surface (Elev. 207.98 m).		28.96									
30													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4723901.88; E 431585.44

RECORD OF BOREHOLE: MW-104S

BORING DATE: December 7, 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		GROUND SURFACE		208.79									
	D50 50 mm Split Spoon / Hollow Stem Augers	Organics, leaves, sticks, moist		0.00	1A								Concrete
		TOPSOIL		0.08	1B								
		SILTY SAND, some roots; brown/orange, oxidized, odourless; loose, moist to wet		0.15	1C	SS	6						Bentonite
1				207.65	2	SS	10						December 7, 2018 / Sand
		SILTY SAND, some clay; grey, odourless; loose to compact, wet		1.14									
2					3	SS	15						
				206.39	4A								
		SILTY SAND; grey, odourless; loose to compact, wet		2.40	4B	SS	9						Screen
3						SS	12						
				205.09									
		SAND and GRAVEL, some silt; grey, odourless; compact, wet		3.70									
4					5A	SS	15						
				204.49									
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff, wet		4.30	5B								
				4.42									
		END OF BOREHOLE											
5													
6													
7													
8													
9													
10													

NOTE:

1. Water level in open borehole at a depth of 0.76 m below ground surface (Elev. 208.03 m).

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724044.41; E 431577.36

RECORD OF BOREHOLE: MW-105

BORING DATE: December 3 , 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		209.03									
0	D50 50 mm Split Spoon / Hollow Stem Augers	TOPSOIL (76 mm)		0.00									
		SILTY SAND; brown, odourless; loose to compact, moist		0.07	1	SS	8						Concrete
													Bentonite
1					2	SS	15						Sand
					3A	SS	6						
				207.05									
2		SILTY SAND; brown, odourless; loose to compact, wet		1.98	3B								December 3, 2018
					4	SS	24						Screen
3					5A	SS	13						
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff to very stiff, wet		3.43	5B								
4					6	SS	13						
				204.61									
		END OF BOREHOLE		4.42									
5		NOTE:											
		1. Water level in open borehole at a depth of 1.98 m below ground surface (Elev. 207.05 m).											
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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PROJECT: 18108934

LOCATION: N 4724196.36; E 431584.18

RECORD OF BOREHOLE: MW-106

BORING DATE: December 3 , 2018

SHEET 1 OF 1

DATUM:

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		208.94									
0	D50 50 mm Split Spoon / Hollow Stem Augers	ORGANICS		0.00									
		SILTY SAND, some rootlets; brown, odourless; loose to compact, moist		0.06 / 208.52	1A	SS	7						Concrete
		SILTY SAND, trace gravel; brown, odourless; loose, moist		0.42	1B								Bentonite
				207.97	2A	SS	8						Sand
1		SILTY SAND, trace clay, trace gravel; brown/orange, oxidized, odourless; compact, wet		0.97	2B								
					3A	SS	8						
2		SILTY SAND, trace gravel; grey, some garbage/organic odour; loose to compact, wet		1.98	3B								December 3, 2018
					4	SS	27						Screen
3				205.74	5A								
		SILTY CLAY, some sand, trace gravel; grey, odourless; stiff, wet		3.20	5B	SS	12						
4					6	SS	10						
				204.52									
		END OF BOREHOLE		4.42									
5		NOTE:											
		1. Water level in open borehole at a depth of 1.98 m below ground surface (Elev. 206.96 m).											
6													
7													
8													
9													
10													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MC

CHECKED: FRG

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APPENDIX E

Laboratory Certificate of Analysis

Maxxam
A Bureau Veritas Group Company

Your Project #: 18108934
Site Location: LIMERICK
Your C.O.C. #: 699019-01-01

Attention: Fabiano Gondim

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/01/28
Report #: R5573791
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B912368
Received: 2019/01/16, 16:10

Sample Matrix: Water
Samples Received: 10

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	10	N/A	2019/01/17	CAM SOP-00448	SM 23 2320 B m
Biochemical Oxygen Demand (BOD)	1	2019/01/17	2019/01/22	CAM SOP-00427	SM 23 5210B m
Chloride by Automated Colourimetry	10	N/A	2019/01/17	CAM SOP-00463	EPA 325.2 m
Chemical Oxygen Demand	10	N/A	2019/01/17	CAM SOP-00416	SM 23 5220 D m
Conductivity	1	N/A	2019/01/17	CAM SOP-00414	SM 23 2510 m
Conductivity	9	N/A	2019/01/18	CAM SOP-00414	SM 23 2510 m
Dissolved Organic Carbon (DOC) (1)	2	N/A	2019/01/16	CAM SOP-00446	SM 23 5310 B m
Dissolved Organic Carbon (DOC) (1)	8	N/A	2019/01/17	CAM SOP-00446	SM 23 5310 B m
Mercury in Water by CVAA	1	2019/01/18	2019/01/18	CAM SOP-00453	EPA 7470A m
Dissolved Metals by ICPMS	10	N/A	2019/01/21	CAM SOP-00447	EPA 6020B m
Total Ammonia-N	8	N/A	2019/01/17	CAM SOP-00441	EPA GS I-2522-90 m
Total Ammonia-N	2	N/A	2019/01/18	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (2)	10	N/A	2019/01/21	CAM SOP-00440	SM 23 4500-NO3I/NO2B
pH	10	N/A	2019/01/17	CAM SOP-00413	SM 4500H+ B m
Phenols (4AAP)	1	N/A	2019/01/17	CAM SOP-00444	OMOE E3179 m
Sulphate by Automated Colourimetry	10	N/A	2019/01/17	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	10	N/A	2019/01/24		
Total Dissolved Solids	6	2019/01/16	2019/01/17	CAM SOP-00428	SM 23 2540C m
Total Dissolved Solids	2	2019/01/17	2019/01/18	CAM SOP-00428	SM 23 2540C m
Total Dissolved Solids	1	2019/01/18	2019/01/21	CAM SOP-00428	SM 23 2540C m
Total Dissolved Solids	1	2019/01/23	2019/01/24	CAM SOP-00428	SM 23 2540C m
Total Kjeldahl Nitrogen in Water	1	2019/01/16	2019/01/17	CAM SOP-00938	OMOE E3516 m
Total Phosphorus (Colourimetric)	1	2019/01/16	2019/01/18	CAM SOP-00407	SM 23 4500 P B H m
Total Suspended Solids	1	2019/01/16	2019/01/17	CAM SOP-00428	SM 23 2540D m
Volatile Organic Compounds in Water	1	N/A	2019/01/17	CAM SOP-00226	EPA 8260C m

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam
A Bureau Veritas Group Company

Your Project #: 18108934
Site Location: LIMERICK
Your C.O.C. #: 699019-01-01

Attention: Fabiano Gondim

Golder Associates Ltd
6925 Century Ave
Suite 100
Mississauga, ON
CANADA L5N 7K2

Report Date: 2019/01/28
Report #: R5573791
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B912368
Received: 2019/01/16, 16:10

data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing. Maxxam is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Maxxam, results relate to the supplied samples tested.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Christine Gripton, Senior Project Manager
Email: CGripton@maxxam.ca
Phone# (800)268-7396 Ext:250
==========
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B912368
Report Date: 2019/01/28

Golder Associates Ltd
Client Project #: 18108934
Site Location: LIMERICK
Sampler Initials: MCK

RESULTS OF ANALYSES OF WATER

Maxxam ID		ITM507			ITM508	ITM509		
Sampling Date		2019/01/08 15:10			2019/01/14 10:45	2019/01/10 15:15		
COC Number		699019-01-01			699019-01-01	699019-01-01		
	UNITS	LW-101	RDL	QC Batch	MW-101D	MW-101S	RDL	QC Batch
Calculated Parameters								
Calculated TDS	mg/L	1800	1.0	5943854	880	990	1.0	5943854
Inorganics								
Total Ammonia-N	mg/L	150 (1)	0.50	5931202	0.46	0.17	0.050	5931202
Total BOD	mg/L	40	2	5932550				
Total Chemical Oxygen Demand (COD)	mg/L	130	4.0	5933018	5.8	12	4.0	5933018
Conductivity	umho/cm	3400	1.0	5931141	1800	1900	1.0	5931141
Total Dissolved Solids	mg/L	1390	10	5931067	915	1000	10	5931067
Total Kjeldahl Nitrogen (TKN)	mg/L	130 (1)	5.0	5931236				
Dissolved Organic Carbon	mg/L	45	0.50	5931497	2.3	4.3	0.50	5931497
pH	pH	7.29		5931143	8.25	8.04		5931143
Phenols-4AAP	mg/L	0.0070	0.0010	5932409				
Total Phosphorus	mg/L	0.11	0.020	5931250				
Total Suspended Solids	mg/L	100	10	5931144				
Dissolved Sulphate (SO4)	mg/L	<1.0	1.0	5931312	1.3	56	1.0	5931312
Alkalinity (Total as CaCO3)	mg/L	1300	1.0	5931129	190	290	1.0	5931129
Dissolved Chloride (Cl-)	mg/L	320	4.0	5931307	410	380	5.0	5931307
Nitrate (N)	mg/L				<0.10	<0.10	0.10	5931177
Nitrate + Nitrite (N)	mg/L	<0.10	0.10	5931177				

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
(1) TKN < NH4: Both values fall within acceptable RPD limits for duplicates and are likely equivalent.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B912368
Report Date: 2019/01/28

Golder Associates Ltd
Client Project #: 18108934
Site Location: LIMERICK
Sampler Initials: MCK

RESULTS OF ANALYSES OF WATER

Maxxam ID		ITM510			ITM511			ITM512		
Sampling Date		2019/01/08 13:50			2019/01/14 10:02			2019/01/08 11:25		
COC Number		699019-01-01			699019-01-01			699019-01-01		
	UNITS	MW102	RDL	QC Batch	MW-103D	RDL	QC Batch	MW-103S	RDL	QC Batch
Calculated Parameters										
Calculated TDS	mg/L	1100	1.0	5943854	500	1.0	5943854	380	1.0	5943854
Inorganics										
Total Ammonia-N	mg/L	34	0.25	5931211	0.35	0.050	5931202	0.44	0.050	5931202
Total Chemical Oxygen Demand (COD)	mg/L	58	4.0	5933018	70	4.0	5933018	18	4.0	5933018
Conductivity	umho/cm	1900	1.0	5931328	850	1.0	5931141	630	1.0	5931141
Total Dissolved Solids	mg/L	1010	10	5931067	570	10	5933371	1770	10	5942797
Dissolved Organic Carbon	mg/L	19	0.50	5931497	24	0.50	5931128	8.7	2.5	5931497
pH	pH	7.45		5931330	8.01		5931143	8.65		5931143
Dissolved Sulphate (SO4)	mg/L	44	1.0	5931312	200	1.0	5931312	33	1.0	5931312
Alkalinity (Total as CaCO3)	mg/L	910	1.0	5931324	130	1.0	5931129	260	1.0	5931129
Dissolved Chloride (Cl-)	mg/L	82	1.0	5931307	43	1.0	5931307	41	1.0	5931307
Nitrate (N)	mg/L	<0.10	0.10	5931177	<0.10	0.10	5931177	<0.10	0.10	5931177

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		ITM513			ITM514			ITM515		
Sampling Date		2019/01/08 12:50			2019/01/08 12:35			2019/01/08 14:50		
COC Number		699019-01-01			699019-01-01			699019-01-01		
	UNITS	MW-104D	RDL	QC Batch	MW-104S	RDL	QC Batch	MW-105	RDL	QC Batch
Calculated Parameters										
Calculated TDS	mg/L	320	1.0	5943854	900	1.0	5943854	1500	1.0	5943854
Inorganics										
Total Ammonia-N	mg/L	0.20	0.050	5931202	0.48	0.050	5931211	7.7	0.050	5931202
Total Chemical Oxygen Demand (COD)	mg/L	<4.0	4.0	5933018	6.9	4.0	5933018	48	4.0	5933018
Conductivity	umho/cm	600	1.0	5931141	1700	1.0	5931141	2400	1.0	5931141
Total Dissolved Solids	mg/L	350	10	5931067	1010	10	5933371	1560	10	5931067
Dissolved Organic Carbon	mg/L	1.5	0.50	5931497	20	0.50	5931497	20	0.50	5931497
pH	pH	8.17		5931143	7.79		5931143	7.54		5931143
Dissolved Sulphate (SO4)	mg/L	2.4	1.0	5931312	29	1.0	5931312	71	1.0	5931312
Alkalinity (Total as CaCO3)	mg/L	180	1.0	5931129	290	1.0	5931129	1100	1.0	5931129
Dissolved Chloride (Cl-)	mg/L	80	1.0	5931307	350	5.0	5931307	210	3.0	5931307
Nitrate (N)	mg/L	<0.10	0.10	5931177	<0.10	0.10	5931177	<0.10	0.10	5931297

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: B912368
Report Date: 2019/01/28

Golder Associates Ltd
Client Project #: 18108934
Site Location: LIMERICK
Sampler Initials: MCK

RESULTS OF ANALYSES OF WATER

Maxxam ID		ITM516		
Sampling Date		2019/01/08 14:00		
COC Number		699019-01-01		
	UNITS	**MW-106**	**RDL**	**QC Batch**
Calculated Parameters				
Calculated TDS	mg/L	840	1.0	5943854
Inorganics				
Total Ammonia-N	mg/L	7.5	0.050	5931202
Total Chemical Oxygen Demand (COD)	mg/L	20	4.0	5933018
Conductivity	umho/cm	1200	1.0	5931141
Total Dissolved Solids	mg/L	755	10	5935445
Dissolved Organic Carbon	mg/L	8.8	0.50	5931497
pH	pH	7.48		5931143
Dissolved Sulphate (SO4)	mg/L	49	1.0	5931312
Alkalinity (Total as CaCO3)	mg/L	610	1.0	5931129
Dissolved Chloride (Cl-)	mg/L	40	1.0	5931307
Nitrate (N)	mg/L	18.0	0.10	5931177

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		ITM507			ITM508	ITM509	ITM510	ITM511		
Sampling Date		2019/01/08 15:10			2019/01/14 10:45	2019/01/10 15:15	2019/01/08 13:50	2019/01/14 10:02		
COC Number		699019-01-01			699019-01-01	699019-01-01	699019-01-01	699019-01-01		
	UNITS	LW-101	RDL	QC Batch	MW-101D	MW-101S	MW102	MW-103D	RDL	QC Batch
Metals										
Mercury (Hg)	mg/L	<0.0001	0.0001	5934607						
Dissolved Arsenic (As)	ug/L	2.5	1.0	5931221						
Dissolved Barium (Ba)	ug/L	250	2.0	5931221	210	82	260	33	2.0	5931221
Dissolved Boron (B)	ug/L	1400	10	5931221	2000	1200	1200	310	10	5931221
Dissolved Cadmium (Cd)	ug/L	<0.10	0.10	5931221						
Dissolved Calcium (Ca)	ug/L	160000	200	5931221	22000	59000	200000	29000	200	5931221
Dissolved Chromium (Cr)	ug/L	<5.0	5.0	5931221						
Dissolved Copper (Cu)	ug/L	<1.0	1.0	5931221						
Dissolved Iron (Fe)	ug/L	43000	100	5931221	210	<100	3000	<100	100	5931221
Dissolved Lead (Pb)	ug/L	<0.50	0.50	5931221						
Dissolved Magnesium (Mg)	ug/L	78000	50	5931221	9900	47000	59000	9900	50	5931221
Dissolved Manganese (Mn)	ug/L	450	2.0	5931221						
Dissolved Potassium (K)	ug/L	89000	200	5931221						
Dissolved Sodium (Na)	ug/L	180000	100	5931221	310000	220000	69000	130000	100	5931221
Dissolved Zinc (Zn)	ug/L	<5.0	5.0	5931221						

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		ITM512	ITM513	ITM514	ITM515	ITM516		
Sampling Date		2019/01/08 11:25	2019/01/08 12:50	2019/01/08 12:35	2019/01/08 14:50	2019/01/08 14:00		
COC Number		699019-01-01	699019-01-01	699019-01-01	699019-01-01	699019-01-01		
	UNITS	MW-103S	MW-104D	MW-104S	MW-105	MW-106	RDL	QC Batch
Metals								
Dissolved Barium (Ba)	ug/L	17	190	210	410	150	2.0	5931221
Dissolved Boron (B)	ug/L	83	1000	49	260	360	10	5931221
Dissolved Calcium (Ca)	ug/L	11000	18000	180000	260000	210000	200	5931221
Dissolved Iron (Fe)	ug/L	150	<100	120	370	<100	100	5931221
Dissolved Magnesium (Mg)	ug/L	1400	6600	31000	51000	28000	50	5931221
Dissolved Sodium (Na)	ug/L	120000	95000	130000	230000	30000	100	5931221

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Report Date: 2019/01/28

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VOLATILE ORGANICS BY GC/MS (WATER)

Maxxam ID		ITM507		
Sampling Date		2019/01/08 15:10		
COC Number		699019-01-01		
	UNITS	LW-101	RDL	QC Batch
Volatile Organics				
Benzene	ug/L	3.7	0.50	5931260
1,4-Dichlorobenzene	ug/L	<1.0	1.0	5931260
Methylene Chloride(Dichloromethane)	ug/L	<2.5	2.5	5931260
Toluene	ug/L	<1.0	1.0	5931260
Vinyl Chloride	ug/L	<1.0	1.0	5931260
Surrogate Recovery (%)				
4-Bromofluorobenzene	%	104		5931260
D4-1,2-Dichloroethane	%	102		5931260
D8-Toluene	%	97		5931260

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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GENERAL COMMENTS

Some samples had visible sediment pass through the filter used for dissolved solids analysis. The results for these samples may be biased high.

Sample ITM507 [LW-101] : VOC Analysis: Due to high concentrations of target analytes, sample required dilution. Detection limits were adjusted accordingly.
TKN < Ammonia: Both values fall within the method uncertainty for duplicates and are likely equivalent.

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
5931067	MKX	QC Standard	Total Dissolved Solids	2019/01/17		98	%	90 - 110
5931067	MKX	Method Blank	Total Dissolved Solids	2019/01/17	<10		mg/L	
5931067	MKX	RPD	Total Dissolved Solids	2019/01/17	13		%	25
5931128	KRM	Matrix Spike	Dissolved Organic Carbon	2019/01/16		96	%	80 - 120
5931128	KRM	Spiked Blank	Dissolved Organic Carbon	2019/01/16		96	%	80 - 120
5931128	KRM	Method Blank	Dissolved Organic Carbon	2019/01/16	<0.50		mg/L	
5931128	KRM	RPD	Dissolved Organic Carbon	2019/01/16	1.5		%	20
5931129	SAU	Spiked Blank	Alkalinity (Total as CaCO3)	2019/01/17		98	%	85 - 115
5931129	SAU	Method Blank	Alkalinity (Total as CaCO3)	2019/01/17	<1.0		mg/L	
5931129	SAU	RPD	Alkalinity (Total as CaCO3)	2019/01/17	1.1		%	20
5931141	SAU	Spiked Blank	Conductivity	2019/01/18		100	%	85 - 115
5931141	SAU	Method Blank	Conductivity	2019/01/18	<1.0		umho/cm	
5931141	SAU	RPD	Conductivity	2019/01/18	0.69		%	25
5931143	SAU	Spiked Blank	pH	2019/01/17		101	%	98 - 103
5931143	SAU	RPD	pH	2019/01/17	0.57		%	N/A
5931144	MJ1	QC Standard	Total Suspended Solids	2019/01/17		97	%	85 - 115
5931144	MJ1	Method Blank	Total Suspended Solids	2019/01/17	<10		mg/L	
5931144	MJ1	RPD	Total Suspended Solids	2019/01/17	4.0		%	25
5931177	ASP	Matrix Spike	Nitrate (N)	2019/01/21		103	%	80 - 120
5931177	ASP	Spiked Blank	Nitrate (N)	2019/01/21		105	%	80 - 120
5931177	ASP	Method Blank	Nitrate (N)	2019/01/21	<0.10		mg/L	
5931177	ASP	RPD	Nitrate (N)	2019/01/21	NC		%	20
5931202	COP	Matrix Spike	Total Ammonia-N	2019/01/17		99	%	75 - 125
5931202	COP	Spiked Blank	Total Ammonia-N	2019/01/17		104	%	80 - 120
5931202	COP	Method Blank	Total Ammonia-N	2019/01/17	<0.050		mg/L	
5931202	COP	RPD	Total Ammonia-N	2019/01/17	NC		%	20
5931211	COP	Matrix Spike	Total Ammonia-N	2019/01/18		102	%	75 - 125
5931211	COP	Spiked Blank	Total Ammonia-N	2019/01/18		103	%	80 - 120
5931211	COP	Method Blank	Total Ammonia-N	2019/01/18	<0.050		mg/L	
5931211	COP	RPD	Total Ammonia-N	2019/01/18	NC		%	20
5931221	MRG	Matrix Spike [ITM507-05]	Dissolved Arsenic (As)	2019/01/21		100	%	80 - 120
			Dissolved Barium (Ba)	2019/01/21		96	%	80 - 120
			Dissolved Boron (B)	2019/01/21		NC	%	80 - 120
			Dissolved Cadmium (Cd)	2019/01/21		100	%	80 - 120
			Dissolved Calcium (Ca)	2019/01/21		NC	%	80 - 120
			Dissolved Chromium (Cr)	2019/01/21		97	%	80 - 120
			Dissolved Copper (Cu)	2019/01/21		99	%	80 - 120
			Dissolved Iron (Fe)	2019/01/21		NC	%	80 - 120
			Dissolved Lead (Pb)	2019/01/21		93	%	80 - 120
			Dissolved Magnesium (Mg)	2019/01/21		NC	%	80 - 120
			Dissolved Manganese (Mn)	2019/01/21		97	%	80 - 120
			Dissolved Potassium (K)	2019/01/21		NC	%	80 - 120
			Dissolved Sodium (Na)	2019/01/21		NC	%	80 - 120
			Dissolved Zinc (Zn)	2019/01/21		93	%	80 - 120
5931221	MRG	Spiked Blank	Dissolved Arsenic (As)	2019/01/21		101	%	80 - 120
			Dissolved Barium (Ba)	2019/01/21		98	%	80 - 120
			Dissolved Boron (B)	2019/01/21		101	%	80 - 120
			Dissolved Cadmium (Cd)	2019/01/21		100	%	80 - 120
			Dissolved Calcium (Ca)	2019/01/21		100	%	80 - 120
			Dissolved Chromium (Cr)	2019/01/21		100	%	80 - 120
			Dissolved Copper (Cu)	2019/01/21		99	%	80 - 120
			Dissolved Iron (Fe)	2019/01/21		100	%	80 - 120
			Dissolved Lead (Pb)	2019/01/21		95	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Dissolved Magnesium (Mg)	2019/01/21		100	%	80 - 120
			Dissolved Manganese (Mn)	2019/01/21		100	%	80 - 120
			Dissolved Potassium (K)	2019/01/21		100	%	80 - 120
			Dissolved Sodium (Na)	2019/01/21		98	%	80 - 120
			Dissolved Zinc (Zn)	2019/01/21		100	%	80 - 120
5931221	MRG	Method Blank	Dissolved Arsenic (As)	2019/01/21	<1.0		ug/L	
			Dissolved Barium (Ba)	2019/01/21	<2.0		ug/L	
			Dissolved Boron (B)	2019/01/21	<10		ug/L	
			Dissolved Cadmium (Cd)	2019/01/21	<0.10		ug/L	
			Dissolved Calcium (Ca)	2019/01/21	<200		ug/L	
			Dissolved Chromium (Cr)	2019/01/21	<5.0		ug/L	
			Dissolved Copper (Cu)	2019/01/21	<1.0		ug/L	
			Dissolved Iron (Fe)	2019/01/21	<100		ug/L	
			Dissolved Lead (Pb)	2019/01/21	<0.50		ug/L	
			Dissolved Magnesium (Mg)	2019/01/21	<50		ug/L	
			Dissolved Manganese (Mn)	2019/01/21	<2.0		ug/L	
			Dissolved Potassium (K)	2019/01/21	<200		ug/L	
			Dissolved Sodium (Na)	2019/01/21	<100		ug/L	
			Dissolved Zinc (Zn)	2019/01/21	<5.0		ug/L	
5931221	MRG	RPD [ITM507-05]	Dissolved Arsenic (As)	2019/01/21	1.5		%	20
			Dissolved Barium (Ba)	2019/01/21	0.41		%	20
			Dissolved Boron (B)	2019/01/21	2.9		%	20
			Dissolved Cadmium (Cd)	2019/01/21	NC		%	20
			Dissolved Calcium (Ca)	2019/01/21	0.026		%	20
			Dissolved Chromium (Cr)	2019/01/21	NC		%	20
			Dissolved Copper (Cu)	2019/01/21	NC		%	20
			Dissolved Iron (Fe)	2019/01/21	2.7		%	20
			Dissolved Lead (Pb)	2019/01/21	NC		%	20
			Dissolved Magnesium (Mg)	2019/01/21	2.5		%	20
			Dissolved Manganese (Mn)	2019/01/21	2.5		%	20
			Dissolved Potassium (K)	2019/01/21	3.0		%	20
			Dissolved Sodium (Na)	2019/01/21	2.4		%	20
			Dissolved Zinc (Zn)	2019/01/21	NC		%	20
5931236	SSV	Matrix Spike	Total Kjeldahl Nitrogen (TKN)	2019/01/17		91	%	80 - 120
5931236	SSV	QC Standard	Total Kjeldahl Nitrogen (TKN)	2019/01/17		101	%	80 - 120
5931236	SSV	Spiked Blank	Total Kjeldahl Nitrogen (TKN)	2019/01/17		102	%	80 - 120
5931236	SSV	Method Blank	Total Kjeldahl Nitrogen (TKN)	2019/01/17	<0.10		mg/L	
5931236	SSV	RPD	Total Kjeldahl Nitrogen (TKN)	2019/01/17	NC (1)		%	20
5931250	ASP	Matrix Spike	Total Phosphorus	2019/01/18		100	%	80 - 120
5931250	ASP	QC Standard	Total Phosphorus	2019/01/18		99	%	80 - 120
5931250	ASP	Spiked Blank	Total Phosphorus	2019/01/18		99	%	80 - 120
5931250	ASP	Method Blank	Total Phosphorus	2019/01/18	<0.020		mg/L	
5931250	ASP	RPD	Total Phosphorus	2019/01/18	0.071		%	20
5931260	GGU	Matrix Spike	4-Bromofluorobenzene	2019/01/17		101	%	70 - 130
			D4-1,2-Dichloroethane	2019/01/17		94	%	70 - 130
			D8-Toluene	2019/01/17		99	%	70 - 130
			Benzene	2019/01/17		95	%	70 - 130
			1,4-Dichlorobenzene	2019/01/17		93	%	70 - 130
			Methylene Chloride(Dichloromethane)	2019/01/17		90	%	70 - 130
			Toluene	2019/01/17		100	%	70 - 130
			Vinyl Chloride	2019/01/17		95	%	70 - 130
5931260	GGU	Spiked Blank	4-Bromofluorobenzene	2019/01/17		102	%	70 - 130
			D4-1,2-Dichloroethane	2019/01/17		98	%	70 - 130

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Report Date: 2019/01/28

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			D8-Toluene	2019/01/17		98	%	70 - 130
			Benzene	2019/01/17		97	%	70 - 130
			1,4-Dichlorobenzene	2019/01/17		96	%	70 - 130
			Methylene Chloride(Dichloromethane)	2019/01/17		92	%	70 - 130
			Toluene	2019/01/17		96	%	70 - 130
			Vinyl Chloride	2019/01/17		95	%	70 - 130
5931260	GGU	Method Blank	4-Bromofluorobenzene	2019/01/17		101	%	70 - 130
			D4-1,2-Dichloroethane	2019/01/17		96	%	70 - 130
			D8-Toluene	2019/01/17		99	%	70 - 130
			Benzene	2019/01/17	<0.10		ug/L	
			1,4-Dichlorobenzene	2019/01/17	<0.20		ug/L	
			Methylene Chloride(Dichloromethane)	2019/01/17	<0.50		ug/L	
			Toluene	2019/01/17	<0.20		ug/L	
			Vinyl Chloride	2019/01/17	<0.20		ug/L	
5931260	GGU	RPD	Benzene	2019/01/17	NC		%	30
			1,4-Dichlorobenzene	2019/01/17	NC		%	30
			Methylene Chloride(Dichloromethane)	2019/01/17	NC		%	30
			Toluene	2019/01/17	NC		%	30
			Vinyl Chloride	2019/01/17	NC		%	30
5931297	ASP	Matrix Spike [ITM515-01]	Nitrate (N)	2019/01/21		100	%	80 - 120
5931297	ASP	Spiked Blank	Nitrate (N)	2019/01/21		103	%	80 - 120
5931297	ASP	Method Blank	Nitrate (N)	2019/01/21	<0.10		mg/L	
5931297	ASP	RPD [ITM515-01]	Nitrate (N)	2019/01/21	NC		%	20
5931307	DRM	Matrix Spike [ITM516-01]	Dissolved Chloride (Cl-)	2019/01/17		NC	%	80 - 120
5931307	DRM	Spiked Blank	Dissolved Chloride (Cl-)	2019/01/17		102	%	80 - 120
5931307	DRM	Method Blank	Dissolved Chloride (Cl-)	2019/01/17	<1.0		mg/L	
5931307	DRM	RPD [ITM516-01]	Dissolved Chloride (Cl-)	2019/01/17	0.11		%	20
5931312	DRM	Matrix Spike [ITM516-01]	Dissolved Sulphate (SO4)	2019/01/17		NC	%	75 - 125
5931312	DRM	Spiked Blank	Dissolved Sulphate (SO4)	2019/01/17		103	%	80 - 120
5931312	DRM	Method Blank	Dissolved Sulphate (SO4)	2019/01/17	<1.0		mg/L	
5931312	DRM	RPD [ITM516-01]	Dissolved Sulphate (SO4)	2019/01/17	1.8		%	20
5931324	SAU	Spiked Blank	Alkalinity (Total as CaCO3)	2019/01/17		96	%	85 - 115
5931324	SAU	Method Blank	Alkalinity (Total as CaCO3)	2019/01/17	<1.0		mg/L	
5931324	SAU	RPD [ITM510-01]	Alkalinity (Total as CaCO3)	2019/01/17	0.38		%	20
5931328	SAU	Spiked Blank	Conductivity	2019/01/17		102	%	85 - 115
5931328	SAU	Method Blank	Conductivity	2019/01/17	<1.0		umho/cm	
5931328	SAU	RPD [ITM510-01]	Conductivity	2019/01/17	0.16		%	25
5931330	SAU	Spiked Blank	pH	2019/01/17		102	%	98 - 103
5931330	SAU	RPD [ITM510-01]	pH	2019/01/17	0.38		%	N/A
5931497	KRM	Matrix Spike [ITM509-02]	Dissolved Organic Carbon	2019/01/17		99	%	80 - 120
5931497	KRM	Spiked Blank	Dissolved Organic Carbon	2019/01/16		100	%	80 - 120
5931497	KRM	Method Blank	Dissolved Organic Carbon	2019/01/16	<0.50		mg/L	
5931497	KRM	RPD [ITM509-02]	Dissolved Organic Carbon	2019/01/16	0.74		%	20
5932409	BMO	Matrix Spike	Phenols-4AAP	2019/01/17		NC	%	80 - 120
5932409	BMO	Spiked Blank	Phenols-4AAP	2019/01/17		102	%	80 - 120
5932409	BMO	Method Blank	Phenols-4AAP	2019/01/17	<0.0010		mg/L	
5932409	BMO	RPD	Phenols-4AAP	2019/01/17	1.5		%	20
5932550	NNA	QC Standard	Total BOD	2019/01/22		107	%	80 - 120
5932550	NNA	Method Blank	Total BOD	2019/01/22	<2		mg/L	
5932550	NNA	RPD	Total BOD	2019/01/22	NC		%	30
5933018	NS3	Matrix Spike [ITM510-06]	Total Chemical Oxygen Demand (COD)	2019/01/17		86	%	80 - 120
5933018	NS3	Spiked Blank	Total Chemical Oxygen Demand (COD)	2019/01/17		94	%	80 - 120
5933018	NS3	Method Blank	Total Chemical Oxygen Demand (COD)	2019/01/17	<4.0		mg/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
5933018	NS3	RPD [ITM510-06]	Total Chemical Oxygen Demand (COD)	2019/01/17	0		%	20
5933371	NB3	QC Standard	Total Dissolved Solids	2019/01/18		98	%	90 - 110
5933371	NB3	Method Blank	Total Dissolved Solids	2019/01/18	<10		mg/L	
5933371	NB3	RPD	Total Dissolved Solids	2019/01/18	5.0		%	25
5934607	MEN	Matrix Spike	Mercury (Hg)	2019/01/18		90	%	75 - 125
5934607	MEN	Spiked Blank	Mercury (Hg)	2019/01/18		95	%	80 - 120
5934607	MEN	Method Blank	Mercury (Hg)	2019/01/18	<0.0001		mg/L	
5934607	MEN	RPD	Mercury (Hg)	2019/01/18	NC		%	20
5935445	NB3	QC Standard	Total Dissolved Solids	2019/01/21		97	%	90 - 110
5935445	NB3	Method Blank	Total Dissolved Solids	2019/01/21	<10		mg/L	
5935445	NB3	RPD	Total Dissolved Solids	2019/01/21	1.6		%	25
5942797	NB3	QC Standard	Total Dissolved Solids	2019/01/24		98	%	90 - 110
5942797	NB3	Method Blank	Total Dissolved Solids	2019/01/24	<10		mg/L	
5942797	NB3	RPD	Total Dissolved Solids	2019/01/24	7.4		%	25

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Due to a high concentration of NOx, the sample required dilution. The detection limit was adjusted accordingly.

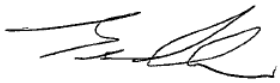
Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B912368
Report Date: 2019/01/28

Golder Associates Ltd
Client Project #: 18108934
Site Location: LIMERICK
Sampler Initials: MCK

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Brad Newman, Scientific Service Specialist

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

APPENDIX F

Limerick Landfill Stormwater Management Design Report

REPORT

Limerick Landfill Stormwater Management Design Report

724 Limerick Road, Bothwell, Municipality of Southwest Middlesex

Submitted to:

Greg Storms, Public Works Manager
The Municipality of Southwest Middlesex
153 McKellar Street
Glencoe, Ontario
N0L 1M0

Submitted by:

Golder Associates Ltd.
6925 Century Avenue, Suite #100, Mississauga, Ontario, L5N 7K2, Canada

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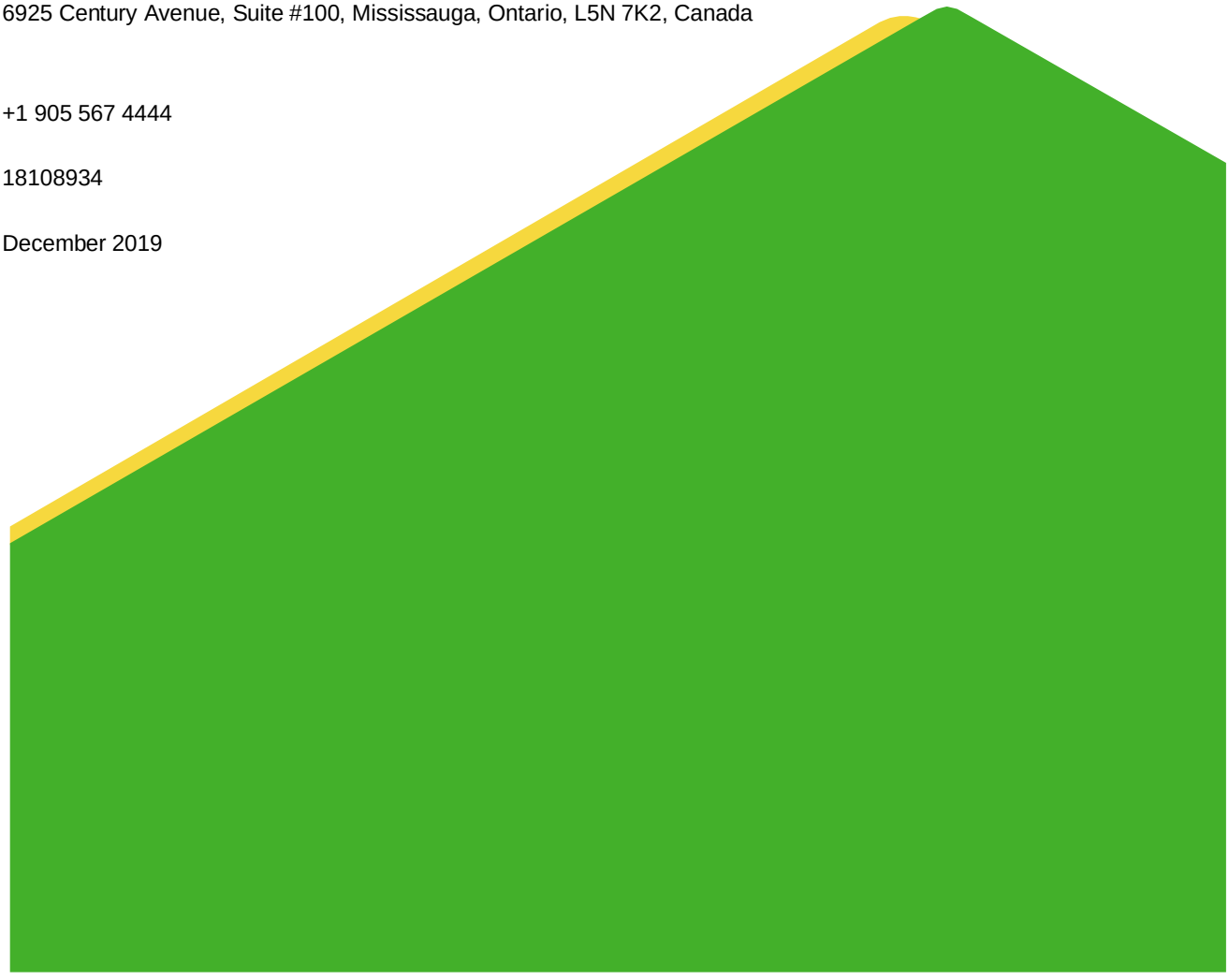
18108934

December 2019



Distribution List

Table of Contents

TABLES

DRAWINGS

1.0 INTRODUCTION

The Municipality of Southwest Middlesex (Municipality) owns the Limerick Landfill, located at 724 Limerick Road, Bothwell, Ontario (Site). The Site has been operational since 1971 and consists of a property with a triangular shape and area of 6.27 hectares. A provisional Certificate of Approval (C of A) for the Site was issued on August 28, 1980 for the operation of a waste disposal area of 6 hectares. The Site is bounded by Limerick Road to the west, Coltsfoot Drive to the southeast, and an agricultural field to the north/northeast. Stormwater runoff from the site currently discharges to the roadside ditches to the southeast and west, and ultimately to Fansher Creek (located immediately north of the Site).

Following a January 29, 2018 Inspection Report by the Ontario Ministry of Environment, Conservation, and Parks (MECP), the Municipality has been required to implement operational improvements and submit a Closure Plan in case the decision is made to close the Limerick Landfill. The final closure plan for the Site would include providing a final cover for the waste and a stormwater system to capture and convey runoff from the cover and the remaining Site.

Golder Associates Ltd. (Golder) was retained by the Municipality to prepare a Closure Plan for the Site. This includes preparation of a Stormwater Design Management Report (SWM Report) describing, at a conceptual level, the stormwater system proposed for the landfill closure and post-closure.

1.1 Objectives

The purpose of the SWM Report is to provide best management practices (BMP) for the Site to control the release of stormwater and associated water quality parameters to the natural environment. A SWM Plan has been completed in accordance with the MOE Stormwater Management Planning and Design Manual (MOE, 2003) and the Landfill Standards (MOE, 2012). The specific objectives of this study are to:

- Review all relevant background information;
- Propose BMPs to control stormwater runoff generated at the Site; and
- Recommend stormwater management measures, as needed.

2.0 EXISTING CONDITIONS

Site visits conducted on August 31, 2018 and a topographic survey for the Site was completed on December 6, 2018. Observations and photos from these Site visits, subsequent field work during the geotechnical investigations and the Site topographic survey were used to characterize existing on-site drainage areas and discharge locations. The following sections describe the existing drainage conditions at the Site.

2.1 Watershed

The Site is located within the Fansher Creek watershed. The drainage area to the creek at Limerick Road was estimated using the Ontario Ministry of Natural Resources and Forestry Ontario Flow Assessment Tool (OFAT), which suggested a drainage area of approximately 8.6 km^2. Return period peak flows estimated by the OFAT tool using the Index Flood Method are shown in Table 1 below. Fansher Creek discharges into the Sydenham River near Florence, ON and ultimately to Lake St. Claire.

Table 1: OFAT Peak Flows Using Index Flood Method

Catchment	Peak Runoff Rate (m^3/s)					
	1:2-year	1:5-year	1:10-year	1:20-year	1:50-year	1:100-year
Fansher Creek to Limerick Road	2.38	3.07	3.71	4.44	5.53	6.54

2.2 Site Drainage

The existing Site drainage areas are shown on Drawing 1. Runoff from the Site is currently uncontrolled to the roadside ditches along Limerick Road and Coltsfoot Road:

- Runoff collected in the Coltsfoot Road ditch and Limerick Road ditch south of the landfill entrance are conveyed via an existing 150 mm culvert to the west side Limerick Road and ultimately north to Fansher Creek; and
- Runoff collected in the Limerick Road east ditch north of the landfill entrance drains north to Fansher Creek.

The Site is characterized by relatively flat cleared spaces with some mounded waste and concrete rubble. The surficial soil at the Site is characterized by a thin sand veneer. Catchment areas are summarized in Table 2. Catchments 101 and 102 show the drainage from the Site, while Catchments 103 and 104 are the external drainage to the ditch on the west side of Limerick Road. The model also included the 150 mm culvert and the ditch on the west side of Limerick Road; the latter two catchments are included to model tailwater in the Limerick Road ditch.

Table 2: Existing Site Catchments

Catchment	Drainage Area (ha)
101	3.52
102	3.63
103 (External)	2.8
104 (External)	5.8

2.3 Existing Condition Hydrological Model

A hydrological model of the Site was prepared using EPA-SWMM5 to estimate peak runoff rates and volumes from the catchment areas. 24-hour Chicago design storm events were created using Intensity-Duration-Frequency (IDF) values derived from the rainfall data taken from the London Airport (1943-2003). Hydrologic simulations were conducted for 1:2-year through 1:100-year return period storm events.

Modelled peak flow results are summarized in Table 3. Catchments 103 and 104 were not included in these results as they are external to the Site. The modelled peak runoff rate from the entire Site for the 24-hour, 1:100-year storm event was 0.309 m^3/s, out of which approximately 0.051 m^3/s flowed out through the existing 150mm culvert, 0.155 m^3/s spilled over the road at the culvert and 0.184 m^3/s flowed north directly to the Fansher Creek. Limerick Road is shown to overtop at the 150 mm culvert in the 1:10-year through 1:100-year storms.

Table 3: Existing Site Peak Runoff Rates

Catchment	Peak Runoff Rate (m^3/s)					
	1:2-year	1:5-year	1:10-year	1:25-year	1:50-year	1:100-year
Through 150 mm Culvert	0.003	0.021	0.041	0.046	0.048	0.051
Flow over Limerick Road	N/A	N/A	0.007	0.053	0.099	0.155
To Fansher Creek along East Ditch	0.002	0.013	0.034	0.081	0.127	0.184
Site Total	0.005	0.034	0.082	0.180	0.274	0.390

3.0 PROPOSED STORMWATER MANAGEMENT PLAN

A SWM Plan was developed to convey runoff from the Site. Runoff from the landfill cover is not expected to generate water quality concerns. The target storm for safe conveyance from the Site is the 1:25-year storm event (MOE, 2012).

The proposed SWM Plan developed for the Site consists of:

- Proposed landfill cover to prevent waste migration offsite;
- Collect and convey Site runoff;
- Continue directing runoff towards Fansher Creek; and
- Housekeeping practices to reduce risks of sediment washoff.

Combining the above strategies will improve the quality of the Site runoff. The SWM Plan is discussed in detail in the following sections.

3.1 Changes to Existing Catchments

The proposed drainage plan is shown on Drawing 2. Approximately 3.16 ha of the Site (matching the inferred waste limit) will receive a landfill cover comprised of 600 mm of compacted clayey soil overlain with 150 mm of topsoil. The cover peaks along a north-south axis, with slopes falling away to either side at a 4.3% grade. Following construction, the cover will be revegetated with grass. The southern portion of the Site will remain undisturbed.

Drainage is generally the same as in the existing condition, with a portion of the Site drainage directed to the 150 mm culvert under Limerick Road and the remainder of the Site drainage directed north towards Fansher Creek. Proposed catchment areas are summarized in Table 4.

Table 4: Proposed Site Catchments

Catchment	Drainage Area (ha)
201	1.51
202	1.90
203	1.75
204	2.00
205 (External)	2.8
206 (External)	5.8

As indicated in Table 4 above, the area draining to the 150 mm culvert under Limerick Road is 1.51 ha (Catchment 201), down from 3.52 ha in the existing condition. This is matched by an increase in drainage areas to Fansher Creek, from 3.63 ha in the existing condition to a total of 5.65 ha (Catchment 202, 203, and 204) in the proposed condition.

3.2 Proposed Stormwater Management Controls

3.2.1 Proposed Perimeter Ditches

Runoff will be collected in vegetated V-shaped perimeter ditches between 0.6 m and 1.6 m deep located along the boundary of the Site. Ditch side slopes will be 3:1 to 4:1 with lateral grades along the ditch between 0.5% and 0.66%. The proposed SWM Plan is designed in such a way to avoid major changes to the drainage patterns. The ditches were design to convey the 1:25 year storm event as per the Landfill Standards (MOE, 2012).

At the north end of the Site, where the two perimeter ditches converge, a rock check dam is proposed to serve as a flow control. The check dam would follow OPSD 219.210, being a total of 0.7 m tall with a minimum 0.6 m wide spillway located 0.45 m above the ditch invert. In addition, since the OPSD is meant for temporary ditches and this installation would be permanent, a 0.3 m diameter culvert is proposed along the ditch invert through the check dam with a 0.1 m diameter orifice plate on the upstream end. The culvert will allow water stored above the check dam to drain should the check dam become silted.

Finally, recognizing that the existing 150 mm culvert resulted in flooding across the road in the existing condition during large storm events, the existing culvert is proposed to be replaced with a larger 300 mm diameter corrugated steel pipe culvert at the same inverts.

3.2.2 House Keeping

The proposed Site includes the following changes and house keeping measures to safeguard runoff water quality;

- The proposed closure of the landfill will mean no additional waste is deposited at the Site, and that existing exposed waste will be covered;
- The proposed closure will also result in significantly less vehicle traffic at the Site;
- On-going monitoring and maintenance of the landfill cover; and
- A routine inspection and maintenance program for the ditches should be developed for the Site.

3.3 Proposed Condition Hydrological Model

A SWMM5 hydrologic model was created for the proposed Site (following the method for the existing condition Site model), and simulations were conducted for 1:2-year through 1:100-year return period storm events.

Modelled peak flow results at are summarized in Table 5. The total peak runoff rate from the Site during the 24-hour, 1:100-year storm event is 0.331 m^3/s, out of which approximately 0.082 m^3/s flows through the proposed 300 mm culvert and 0.249 m^3/s flows north directly to the Fansher Creek. Unlike the existing condition, the larger 300 mm culvert under Limerick Road, combined with the storage in the upstream ditch, is sufficient to prevent the road overtopping in the 1:100 year storm. Additionally, all ditches where shown to have sufficient capacity to convey the 1:25 year peak flow.

Table 5: Proposed Site Peak Runoff Rates

Catchment	Peak Runoff Rate (m^3/s)					
	1:2-year	1:5-year	1:10-year	1:25-year	1:50-year	1:100-year
Through 300mm Culvert	0.006	0.024	0.044	0.056	0.069	0.082
To Fansher Creek along East Ditch	0.024	0.080	0.132	0.189	0.220	0.249
Site Total	*0.030*	*0.104*	*0.176*	*0.245*	*0.289*	*0.331*

Compared to the existing condition, the proposed final cover and stormwater management controls will result in a change in peak flows across Limerick Road through the culvert (between –0.124 m^3/s and +0.003 m^3/s compared to the existing condition flow through the 100 mm culvert and over the road), while the flows in the east ditch along Limerick Road will see an increase in peak flow (between +0.022 m^3/s and +0.108 m^3/s). Overall, the change in peak flow to Fansher Creek from the Site is between -0.059 m^3/s and +0.947 m^3/s. With respect to the estimated peak flows in Fansher Creek shown in Table 1, the changes are between -0.9% and +2.5% of the peak flow in the creek for the matching storm events. As noted, some improvement in water quality is expected from the closure of the site, the final cover construction and covering of exposed waste, and inspection and maintenance of the vegetated ditches.

4.0 CONCLUSIONS

Based on the preceding analysis, the following conclusions can be drawn:

- The existing Site drains to Fansher Creek indirectly via an existing 150 mm culvert across Limerick Road or directly to Fansher Creek. The existing culvert will be replaced by a 300 mm culvert;
- The proposed Site and stormwater features and drainage generally match the existing drainage;
- The proposed perimeter ditches and culvert upgrade have sufficient capacity to convey the 1:25 year peak flows;
- The proposed stormwater system results in changes in peak runoff of between -0.059 m^3/s and +0.094 m^3/s to Fansher Creek; and

- Changes to the site (including the closure, final cover, and perimeter ditches) are expected to result in some improvement in water quality.

5.0 REFERENCES

Ministry of Environment (MOE). 2003. *Stormwater Management Planning and Design Manual*.

Ministry of the Environment (MOE). 2012. *Landfill Standards – A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites*. Last updated: January 2012.

Ministry of Natural Resources and Forestry (MNRF), Ontario Flow Assessment Tool
https://www.gisapplication.lrc.gov.on.ca/OFAT/Index.html?site=OFAT&viewer=OFAT&locale=en-US

Signature Page

Golder Associates Ltd.

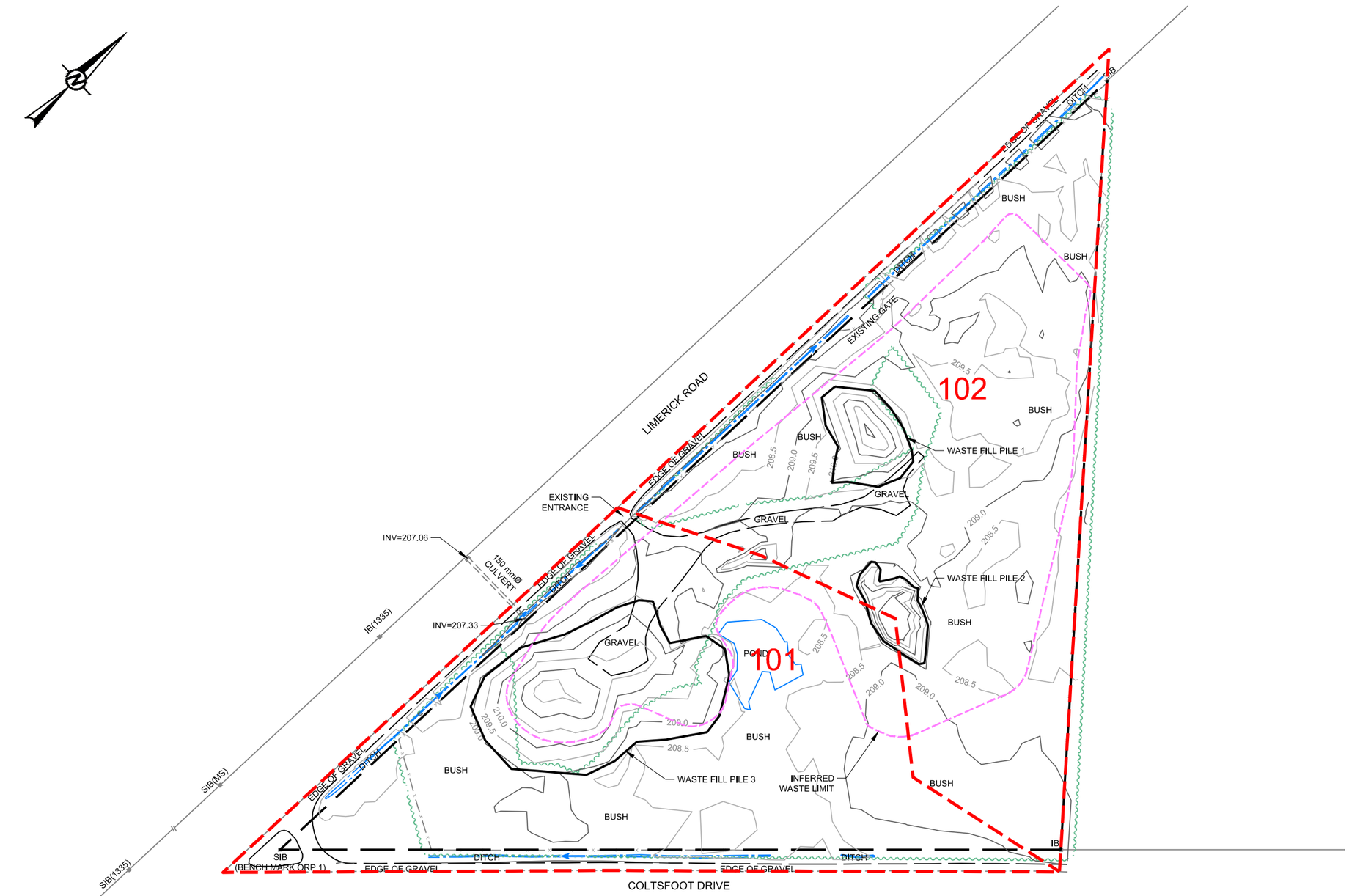
Christopher Davidson, PEng
Water Resources Engineer

Fabiano Gondim, MEng, PEng
Senior Waste Engineer

CD/FG/rb

https://golderassociates.sharepoint.com/sites/32886g/deliverables/limerick closure report/surface water/18108934 limerick swm report (2019-10-1).docx

Drawings



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- EXISTING CATCHMENT AREA
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- 209.0 EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- 208.5 EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- INFERRED WASTE LIMIT (3.16 ha)

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

CLIENT REVIEW

DRAFT

0 50 100
1:1,000 METRES

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

CONSULTANT
GOLDER

YYYY-MM-DD	2019-08-09
DESIGNED	CD
PREPARED	AZ
REVIEWED	CD
APPROVED	CD

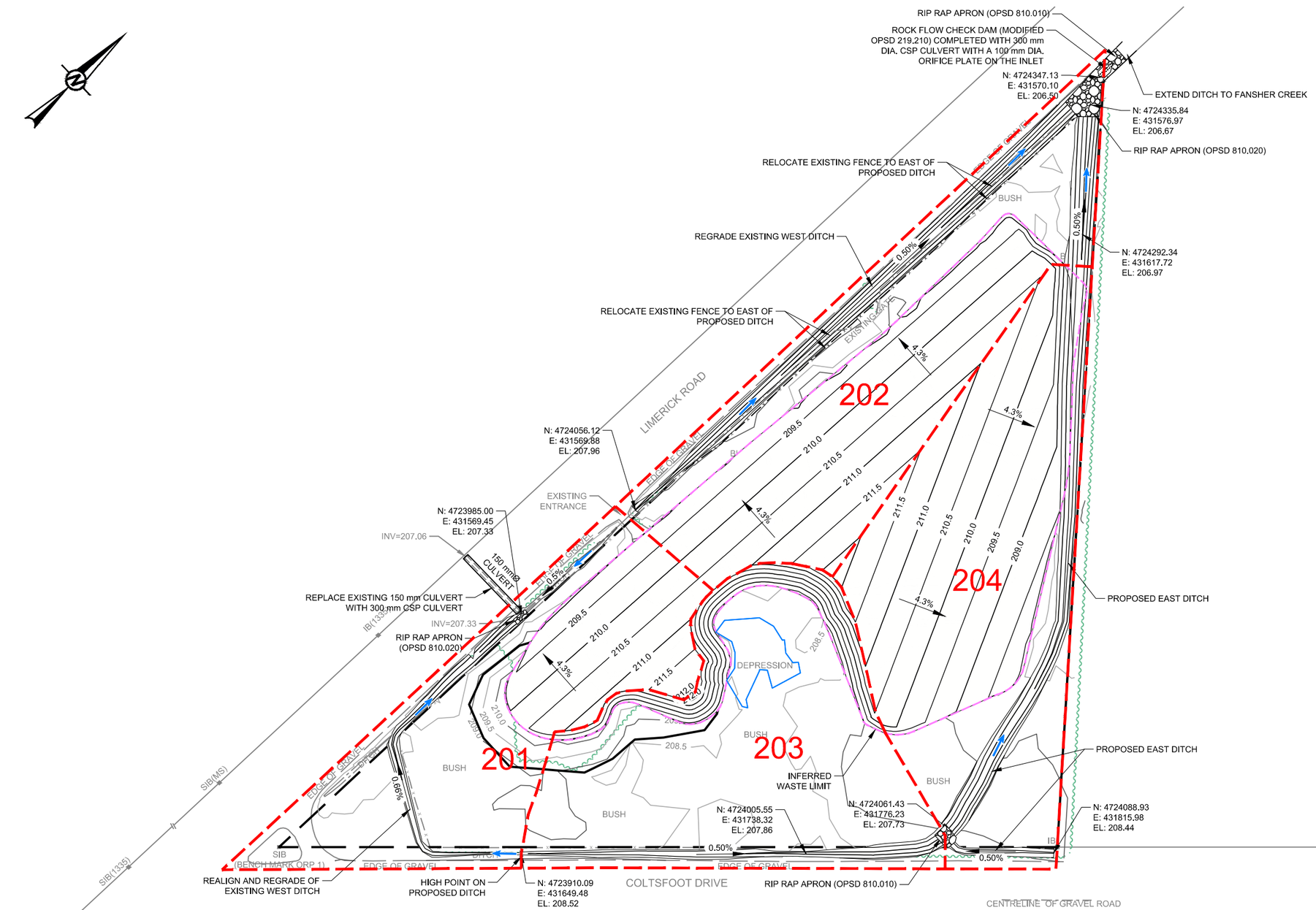
PROJECT
STORM WATER MANAGEMENT PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
EXISTING CONDITION

PROJECT NO.	CONTROL	REV.	DRAWING
18108934	0003	A	1

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

0 25 mm



LEGEND

- PROPERTY BOUNDARY (6.27 ha)
- PROPOSED CATCHMENT AREA
- EXISTING FENCE
- EXISTING DITCH
- EXISTING TREE LINE
- EXISTING MAJOR CONTOUR (INTERVAL 1 m)
- EXISTING MINOR CONTOUR (INTERVAL 0.5 m)
- PROPOSED MAJOR CONTOUR (TOP OF FINAL COVER)
- PROPOSED MINOR CONTOUR (TOP OF FINAL COVER)
- PROPOSED DITCH
- INFERRED WASTE LIMIT (3.16 ha)

NOTES(S)

1. BEARINGS ARE U.T.M. GRID, IN NAD83 (ORIGINAL) DERIVED FROM G.P.S. OBSERVATIONS AND THE LEICA SMART-NET AND ARE REFERRED TO THE CENTRAL MERIDIAN 81°00' WEST LONGITUDE, ZONE 17.
2. BENCHMARK: ELEVATIONS ARE GEODETIC CGVD28(HTV2.0) AND ARE DERIVED FROM LEICA G.P.S. SMART-NET REFERRED TO POINT NO. 1, BEING A SIB AS NOTED ON THE PLAN. ELEVATION = 208.82m.

POINT ID	NORTHING (m)	EASTING (m)	ELEVATION (masl.)
ORP 1	4723831.104	431571.352	208.82

REFERENCE(S)

1. TOPOGRAPHIC BASE PLAN, DATED DEC. 05, 2018 BY ARCHIBALD, GRAY & McKAY LTD.

CLIENT REVIEW

DRAFT

0 50 100

1:1,000 METRES

CLIENT
THE MUNICIPALITY OF SOUTHWEST MIDDLESEX

CONSULTANT
GOLDER

YYYY-MM-DD	2019-08-09
DESIGNED	CD
PREPARED	AZ
REVIEWED	CD
APPROVED	CD

PROJECT
STORM WATER MANAGEMENT PLAN
LIMERICK LANDFILL
SOUTHWEST MIDDLESEX, ONTARIO

TITLE
PROPOSED CONDITION

PROJECT NO.	CONTROL	REV.	DRAWING
18108934	0003	A	2

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

25 mm

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APPENDIX G

Monitoring Program

APPENDIX G: MONITORING PROGRAM

1.0 MONITORING FREQUENCY

- Groundwater, leachate and surface water monitoring should occur twice per year (Spring and Fall) for the first three years of post-closure monitoring and may be revised upon review of the analytical results against trigger mechanisms.
- Landfill gas monitoring should occur during the winter (January to February) under frozen ground conditions.

2.0 GROUNDWATER SAMPLING LOCATIONS

- Background (Upgradient) Groundwater Quality Monitoring Locations:
  - MW-103S and MW-104S.
- Leachate Monitoring Locations:
  - LW-101.
- Downgradient Groundwater Quality Monitoring Locations:
  - MW-101S, MW-102, MW-103D, MW-105 and MW-106.

Note: Monitoring wells MW-101D and MW-104D will not be monitored for groundwater quality; these wells will only be monitored for groundwater levels.

2.1 QA/QC

- Approximately one field blank and one field duplicate per sampling event.

3.0 SURFACE WATER SAMPLING LOCATIONS

- Lim-1 and Lim-2 as shown on Figure 9.

4.0 LANDFILL GAS SAMPLING LOCATIONS

- GP-101, GP-103 and GP-104 as shown on Figure 9.

5.0 FIELD MEASURED PARAMETERS

- Groundwater levels in all functional groundwater monitoring wells, including MW-101D and MW-104D;
- Groundwater temperature, conductivity and pH in all functional groundwater monitoring wells, except for MW-101D and MW-104D;
- Surface water visual assessment of flow;
- Surface water temperature, conductivity, dissolved oxygen and pH; and
- Landfill gas methane, carbon dioxide and oxygen.

6.0 LABORATORY MEASURED PARAMETERS

- As indicated in the Table G-1 below.

Table G-1: Monitoring Parameters

Parameter Group	Groundwater (Indicator List)	Leachate (Indicator List)	Surface Water (indicator List)
Inorganics	Alkalinity	Alkalinity	Alkalinity
Inorganics	Ammonia	Ammonia	Ammonia
Inorganics	Barium	Barium	
Inorganics	Boron	Boron	
Inorganics	Calcium	Calcium	
Inorganics	Chloride	Chloride	Chloride
Inorganics	Conductivity	Conductivity	Conductivity
Inorganics	Iron	Iron	Iron
Inorganics	Magnesium	Magnesium	
Inorganics	Nitrate	Nitrate	Nitrate
Inorganics	Nitrite	Nitrite	Nitrite
Inorganics			Total Kjeldahl Nitrogen
Inorganics	pH	pH	pH
Inorganics			Total Phosphorus
Inorganics		Potassium	
Inorganics	Sodium	Sodium	
Inorganics		Suspended Solids	Suspended Solids
Inorganics	Total Dissolved Solids	Total Dissolved Solids	Total Dissolved Solids
Inorganics	Sulphate	Sulphate	Sulphate
Other Organics		Biochemical Oxygen Demand (BOD_5)	Biochemical Oxygen Demand (BOD_5)
Other Organics	Chemical Oxygen Demand	Chemical Oxygen Demand	Chemical Oxygen Demand
Other Organics	Dissolved Organic Carbon	Dissolved Organic Carbon	
Other Organics			Phenol

6.1 Special Note for Parameters with Established Provincial Water Quality Criteria

All laboratory analyses of groundwater samples should be performed by a private analytical laboratory and the method detection limits (MDLs) for the specific analyses would be commensurate with the standards established in the Ontario Drinking Water Quality Standards, Objectives and Guidelines (MOE, 2003) or the Provincial Water Quality Objectives (MOEE, 1994a) whichever is lower.

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