D.13 Design and Operations Existing Conditions and Impact Assessment Report; completed by Golder Associates Ltd.

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Design and Operations Existing Conditions and Impact Assessment

W12A Landfill Expansion EA, City of London, Ontario

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Acronyms and Glossary of Terms

Term / Acronym	Definition
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
C of A	Certificate of Approval
CR&D	construction, renovation and demolition
EA	Environmental Assessment
EAA	Environmental Assessment Act
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
GHG	greenhouse gas
ha	Hectare
HELP	Hydraulic Evaluation of Landfill Performance
HSW	household special waste
IC&I	industrial, commercial and institutional
km	Kilometres
LCS	leachate collection system
LFG	landfill gas
m	Metres
m^2	square metres
m^3	cubic metres
masl	metres above sea level
MECP	Ministry of Environment, Conservation and Parks
MHSW	Municipal Hazardous or Special Waste
mm	Millimetres

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Term / Acronym	Definition
MRF	Material Recovery Facility
MSW	municipal solid waste
OMB	Ontario Municipal Board
O.Reg.	Ontario Regulation
scfm	standard cubic feet per minute
ToR	Terms of Reference
TSS	total suspended solids
WWTP	Wastewater Treatment Plant

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1.0 INTRODUCTION

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

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the landfill design and operation component existing conditions and impact assessment for the Environment Assessment (EA) of the proposed W12A Landfill expansion. This work has been conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR), dated February 2019.

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

The design and operation component relates only to activities associated with the landfill expansion itself and therefore the study area considered is the Site Study Area.

The preferred expansion alternative is a vertical expansion over the existing waste footprint.

2.0 SCOPE AND METHOD

This design and operations supporting document summarizes the history of approvals for the W12A Landfill and describes the existing conditions at the W12A site as related to the overall design of the landfill and its engineered control systems for leachate and landfill gas management. It also describes the performance of the currently approved landfill in terms of leachate effects on groundwater and surface water, as well as landfill gas migration in the subsurface, compared to MECP regulations, policies and guidelines. The description of current performance is based on the results of the 2019 site monitoring programs as reported in the 2019 W12A Landfill Annual Status Report, prepared by the City of London dated March 2020.

In terms of the proposed vertical expansion of the landfill, this report develops and provides the technical input (at an Environmental Assessment (EA) level of detail) related to the following specific items, as described in the approved ToR:

- The proposed phasing and development of the expanded landfill
- The projected leachate generation and projected landfill gas generation associated with the expansion
- The proposed approach to on-site management of leachate and landfill gas
- A geotechnical evaluation of the proposed expansion (stability and settlement)
- An overall soil balance for the expansion
- An estimate of probable costs associated with construction and operation of the expansion

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The methodologies used for each of these are described in the individual report sections and/or appendices.

Most of these items serve as inputs to the impact assessment of the preferred alternative by other technical disciplines, as well as to the overall description of project. For example, the proposed on-site leachate management approach relates to: 1) the prediction by the hydrogeological discipline of leachate impacts on groundwater and compliance with the Reasonable Use Guideline, as well as 2) the approach to design of stormwater management facilities to separate leachate-impacted water from stormwater runoff and the prediction of potential leachate impact on surface water quality. Some of these items also represent mitigation measures to be included in design of the expansion, i.e., management of leachate and landfill gas, intended for the purpose of the expanded landfill achieving long term compliance with relevant MECP requirements as set out in O.Reg. 232/98 Landfill Standards.

3.0 EXISTING CONDITIONS

The W12A Landfill, located at 3502 Manning Drive in the south end of the City of London, is currently approved to accept waste as follows:

- Solid non-hazardous waste, generated from only the following areas:
  - The geographic boundaries of the City of London
  - The geographic boundaries of the Municipality of Thames Centre
  - Lake Huron Water Treatment Plant located at 71155 Bluewater Highway, Municipality of South Huron
  - Elgin Area Water Treatment Plant located at 43665 Dexter Line, Municipality of Central Elgin
  - TRY Recycling Plants located at 21462 and 21463 Clarke Road, Municipality of Middlesex Centre
- Municipal Hazardous or Special Waste (MHSW) from residents and small quantity generators (businesses with limited amounts of MHSW) from the following areas:
  - The geographic boundaries of the City of London
  - The geographic boundaries of the County of Middlesex
  - The geographic boundaries of the County of Elgin

Solid, non-hazardous waste is disposed at the site while the MHSW is sent to a number of licensed facilities in Canada and USA for recycling, reuse or disposal.

The City owns a number of properties adjacent to and near the W12A Landfill as depicted in Figure 1. This figure also shows the boundary of the Waste Management Resource Recovery Area, which is an area identified in the City's Official Plan for future waste management facilities and activities including landfilling.

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3.1 Site Development History

In 1969, the City commissioned James F. MacLaren Limited to develop a long-term solid waste disposal plan. The results of the study are contained in the report entitled *Report on Solid Waste Disposal for the City of London* (October 1970). The report recommended that the City proceed with the necessary approvals, detailed design and land acquisition for the development of a new landfill (referred to as W12) to be located on part of Lots 18, 19 and 20 of Concession 5 in the former Township of Westminster.

During site investigations, it was determined that the geological setting of W12 was not suitable for a landfill because a spillway containing granular soils traversed the surficial silty clay soils that are generally predominant in the area. It was also determined that the area south of W12 had thick surficial deposits of silty clay. As a result, the location of the proposed landfill was changed to the area referred to as W12A located on part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster.

In April 1973, the City filed an application for a Certificate of Approval (C of A), (now referred to as an Environmental Compliance Approval (ECA)), for a Waste Disposal Site to the MECP for the W12A Landfill. Subsequently, the Environmental Hearing Board held a public hearing in the former Township of Westminster from July 30, 1973 to August 3, 1973 to review the application for the W12A Landfill. The Environmental Hearing approved the application.

On November 13, 1973, the MECP issued a Provisional C of A (#A042102) for the W12A Landfill. The C of A did not permit the disposal of waste until final design plans and specifications were submitted and approved by the MECP.

In 1974, the Ontario Municipal Board (OMB) held a public hearing to address planning issues related to the establishment of a new landfill. As a result of the hearing, the OMB issued an order in January 1975 authorizing the City to acquire the necessary lands to create the W12A Landfill and spend the necessary funds to construct the new landfill. The OMB also directed the former Township of Westminster to amend its zoning by-law and any other necessary by-laws to permit landfilling in the lands referred to as the W12A Landfill.

In 1976, the final design plans and specifications for the W12A Landfill were submitted to the MECP. The original site design consisted of 14 cells covering 107 hectares (ha), five stormwater management ponds, the use of berms and trees to provide screening, a perimeter leachate collection system and a surface water and groundwater monitoring program. On August 16, 1976 the MECP re-issued C of A #A042102 for the W12A Landfill to permit the disposal of waste in accordance with the submitted plans.

Since 1976, the C of A or ECA has been re-issued or amended sixteen times to permit changes in the operation of the landfill. These changes have included refinement of the environmental monitoring programs, requirement for an annual report, approval of a household special waste (HSW) facility, various design changes and infrastructure upgrades and an expansion of the service area from which waste can be received.

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Waste was first disposed of in the landfill during the summer of 1977. At this time, the landfill accepted non-hazardous waste generated from within the boundaries of London.

In 1999, the City received approval to establish a HSW depot at the landfill to accept MHSW from residents and small quantity generators from within the geographic boundaries of London and the County of Middlesex for transfer to appropriate recycling/processing facilities.

Several major engineering upgrades were approved in 2002 including approval for a full underdrain leachate collection system and a landfill gas collection system. The full underdrain leachate collection system was approved for the western portion of the landfill that had not already received waste (approximately 47 hectares) and is referred to as Phase 2 of the Landfill. The eastern portion of the landfill with the originally approved perimeter drain leachate collection system (approximately 60 hectares) is referred to as Phase 1 of the Landfill. The 2002 approval also reduced the number of stormwater management ponds from 5 to 4 by combining the flows of two ponds to be constructed in the future into one larger stormwater pond (referred to as pond 2/3).

In 2015, an Environmental Screening was completed as per *Ontario Regulation (O. Reg.) 101/07* (under the environmental Assessment Act (EAA)) to expand the service area of the site to include the following locations and types of waste:

- Lake Huron Water Treatment Plant (water treatment plant residuals)
- Elgin Area Water Treatment Plant (water treatment plant residuals)
- TRY Recycling's Clarke Road facility (construction, renovation and demolition (CR&D) recycling process residuals and residential garbage)
- Thames Centre (municipal non-hazardous waste)
- Elgin County (MHSW)

An Environmental Screening Report was submitted to the MECP and an amendment to the ECA for the landfill was obtained on May 16, 2016. The expanded service area did not change the approved fill rate (amount of waste the landfill can receive in a year) or the types of waste that can be accepted.

3.2 Landfill Site and Landfill Components

The W12A Landfill site has a 107 hectare (ha) fill area and is located on a 142 ha property. The landfill has buffers beyond the limit of the waste footprint area of 92 metres (m) to the south and west and 46 m to the north and east. The overall final designed shape of the landfill is generally rectangular. The design of the side slopes ranges from 4H:1V (horizontal to vertical) to 6H:1V and the top is sloped at approximately 1% from the south to a peak elevation of the final cover of 293 metres above sea level (masl) near the north end of the landfill. The final cover design consists of 0.85 m of compacted clay soil and 0.15 m of topsoil. The average height of the landfill above ground surface is about 9 m. In summary, the currently approved W12A Landfill can be described as having a large footprint area and a low height above grade.

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The W12A Landfill has an approved airspace of 12,500,000 cubic metres (m^3) for waste, daily cover and interim cover.

Over the first 25 years of operation between 1977 and 2002, approximately 5 million tonnes of waste were deposited at the W12A Landfill in the first six cells that comprise Phase 1. These Phase 1 cells cover 59.3 ha and occupy the eastern portion of the landfill footprint (see Figure 2). The Phase I cells are labelled Cells 1, 2, 3, 4, 5 East and 5 West, as shown on Figure 2. Landfilling in Phase 1 is complete. A soil final cover was constructed after completion of waste placement in Phase 1 to the approved final contours and a landfill gas extraction well system installed.

The remainder of the landfill covers 47.7 ha and has been designed to accommodate approximately another 5.5 million tonnes. The area is referred to as Phase 2 as shown on Figure 2. Phase 2 is divided into eight cells labelled on Figure 2 as Cells 6 South South Half, South North Half, North South Half and North North Half, and Cells 7 through 10. Cells 6, 7 and 8 have been filled and landfilling is currently ongoing in Cell 9; construction of Cell 10 is underway in 2020.

Phase 1 has six cells that were excavated to an average depth of 3 m below grade. The landfill design approach considered the low-permeability nature of the natural clay till soils below the landfill that hinder the potential downward migration of landfill leachate. The native clay till deposit provides a natural liner.

There are two approaches to leachate collection. Leachate within Phase 1 is collected by a perimeter leachate collection system consisting of 200 millimetre (mm) diameter perforated pipe placed in gravel around the perimeter of the waste footprint. There is a leachate mound within the Phase 1 landfill area.

Phase 2 of the landfill has eight cells, of which seven have been constructed. Phase 2 was designed with a full underdrain leachate collection system consisting of 200 mm diameter perforated pipes spaced 90 m apart within a clear stone blanket and covered with a geotextile filter and 0.2 m thick protective sand layer. The base of Phase 2 is graded to convey leachate into the perforated pipes and with an overall fall from north to south to a low point at an elevation of 270 m above sea level (masl). The collected leachate from both phases is stored in holding tanks before it is pumped via a pumping station located near the scalehouse through a forcemain along Manning Drive to the Dingman Creek Pumping Station and eventually to the Greenway Wastewater Treatment Plant for treatment.

The current waste disposal ECA for the site (#A042102) permits annual disposal of 650,000 tonnes of waste, noting that over the past 10 years the site typically receives between 200,000 and 320,000 tonnes of waste per year. Information on the types and quantities of waste that have historically been received at the W12A Landfill are presented in Volume III, Appendix C – 2019 Updated Residual Waste Projections and Landfill Capacity Assessment. The site is operated Monday through Friday from 8 a.m. to 4 p.m. and Saturday from 8 a.m. to 3 p.m.

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As of January 2020, the remaining approved airspace in Phase 2 is approximately 1.5 million m^3, which is equivalent to approximately 1.26 million tonnes of disposal capacity.

The landfill typically receives approximately 100 to 125 waste collection vehicles a day.

In summary, the existing landfill consists of the following major components (shown on Figure 2):

- **Fourteen landfill cells** divided into two waste disposal fill areas known as Phases 1 & 2.
- **Four stormwater management ponds** that provide flow control (to prevent flooding) and quality control (sediment removal) of drainage from the landfill received by a series of ditches located along the perimeter of the landfill as well as along the access road.
- A **perimeter leachate collection system** for Phase 1 of the landfill and an **underdrain leachate collection system** for Phase 2 of the landfill.
- A **LFG collection system and flare** consisting of 46 active LFG extraction wells and more than 5 kilometres (km) of piping that collect the LFG and carry it to the flare for combustion. This system reduces greenhouse gas (GHG) and odour emissions from the landfill.
- **HSW Depot** that accepts hazardous and special wastes from residents and small businesses for off-site recycling/disposal.
- **Public Drop-off Depot** that accepts household garbage, appliances, blue box recyclables (e.g., paper products, plastics, aluminum and steel containers, glass bottles and jars), yard waste, oversized cardboard, electronics, scrap metal, tires and wood for recycling.

In addition to the landfill and the diversion facilities noted above, facilities at the site are inbound and outbound weigh scales, a scalehouse, maintenance buildings and an administration building. Perimeter berms are present around the south, west and north sides of the site to visually screen the landfill from view along the adjacent roadways.

3.3 Current Landfill Performance

The W12A Landfill has had groundwater, surface water, leachate, water well and LFG monitoring programs since it opened in 1977. The following outlines the results from these monitoring programs for 2019 (City of London, 2020).

3.3.1 Groundwater Monitoring

There are two aquifers below the W12A Landfill - the Upper Aquifer and the White Oak Aquifer. The groundwater monitoring program includes sampling 25 monitoring wells both downgradient and upgradient of the landfill in the Upper Aquifer and the White Oak Aquifer for a wide range of parameters. The test results from 2019 indicate no impacts on the Upper Aquifer or White Oak Aquifer from the W12A Landfill.

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Chloride has been identified as the “critical” contaminant (i.e., the parameter that engineering controls and monitoring programs are based on) because it is the only parameter expected to be detected in the downgradient monitoring wells at elevated levels based on the contaminant transport modelling. For this reason, the trigger mechanism for implementation of contingency measures to prevent off-site groundwater impacts is based on chloride concentration levels. There has been no increase in downgradient chloride concentrations as a result of operation of the landfill.

3.3.2 Surface Water Monitoring

Surface water is monitored at six surface water sampling stations (located within the ditches surrounding the landfill). There are four critical contaminants with respect to surface water: un-ionized ammonia, biological oxygen demand, chloride and sulphate. In 2019, there were no exceedances of the trigger concentrations for the critical contaminants.

The City also undertakes sampling directly from the stormwater management ponds that receive runoff from areas that have been landfilled (Ponds 2/3, 4 and 5). In 2019, none of the samples collected from the stormwater management ponds exceeded trigger concentrations for the critical contaminants.

3.3.3 Water Well Monitoring

The two aquifers below the landfill (the Upper Aquifer and the White Oak Aquifer) are both used as sources of drinking water in the surrounding area. In 2019, sampling for the purpose of monitoring the off-site water wells was conducted at 1 water well in the Upper Aquifer and 13 water wells in the White Oak Aquifer (all wells are down-gradient or cross-gradient from the landfill). Indicator parameters are tested annually. Heavy metals are analyzed on a 3-year cycle with the latest testing completed in June 2020.

The results from 2019 indicated all wells had indicator parameter concentrations below the Reasonable Use Criteria (MECP, 1994). Most wells in the White Oak Aquifer continue to have high iron levels, which have been encountered in private water wells since monitoring began in 1977. Recent iron levels are similar to historical levels. The monitoring results show that the W12A Landfill is not affecting off-site water wells.

3.3.4 LFG Monitoring

The LFG monitoring program consists of:

- Continuous air quality monitoring for methane, oxygen and hydrogen sulphate in all on-site buildings
- Periodic testing of LFG to determine its composition
- Five monitoring events of two LFG monitoring wells installed in the buffer area of the landfill. These monitoring wells were installed at the property boundary opposite the two closest off-site buildings to the waste footprint.

Monitoring of the buildings has never encountered elevated levels of methane or hydrogen sulphate or low levels of oxygen.

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No testing of the LFG composition was completed in 2019. Historical testing of the LFG quality has found the LFG to be typical of other landfills with methane ranging from 55% to 60% and carbon dioxide between 40% and 45%, with trace amounts of a few non-methane organic compounds.

Testing of the LFG monitoring wells in 2019 found methane levels were always less than 250 parts per million in both monitoring wells for all sampling events, indicating that LFG is not migrating off-site through the subsurface.

In summary, the landfill monitoring programs indicate that the landfill is performing acceptably and in accordance with provincial requirements in terms of potential effects of leachate on groundwater and surface water, as well as in terms of LFG migration in the subsurface.

3.3.5 Leachate Collection

The amount of leachate that is captured has generally increased over the years as the size of the waste footprint has increased. Approximately 174,000 m^3 of leachate was captured and pumped for off-site treatment in 2019.

Leachate generation was estimated to be approximately 170,000 m^3 per year when the entire landfill footprint has been developed and capped as per the *Hydraulic Evaluation of Landfill Performance (HELP) Modeling* (London, November 2002).

3.3.6 LFG Collection

The amount of LFG that is captured has generally increased over the years as the waste footprint has increased, with new LFG wells and horizontal gas collection piping installed and connected to the gas extraction and flaring system. In 2019, an average of approximately 1,900 m^3 per hour of LFG was captured and flared.

4.0 DESCRIPTION OF THE PREFERRED ALTERNATIVE

This section of the report develops and describes the specific design and operations aspects of the proposed expansion listed in Section 2.

4.1 General Description

The landfill expansion consists of a vertical expansion over the existing landfill footprint to provide 13.8 million m^3 of airspace for waste and daily cover. To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be extended northward to Scotland Drive and a 100 m buffer width will be provided on the east side of the landfill footprint and some additional area in the southeast corner to tie into the adjacent Material Recovery Facility (MRF) property line. This results in a 106.3 ha landfill footprint within a 191.7 ha landfill property, with a highest ridge elevation of waste of 318.43 masl. The final design contours for the top of waste are shown on Figure 3, along with north-south and west-east oriented cross-sections to illustrate the configuration of the expanded landfill.

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4.2 Landfill Phasing and Development

The landfill expansion will be developed sequentially in eight Phases, 1E through 8E, as shown on Figure 4, progressing from the west side of the landfill towards the east. Landfilling in each Phase will be approximately 2.5 to 3.5 years based on an expected typical annual air space consumption of 500,000 m^3 per year, which corresponds to an average annual waste receipt of 370,000 tonnes per year over the 25 year planning period.

A separate cell dedicated for disposal of the non-decomposable portion of the waste stream will be provided in the southeastern area of the landfill expansion. Filling in this non-decomposable waste cell will take place in lifts over the 25 year expansion period, and will be blended in to meet the temporary sideslopes in the adjacent Phases 7E and 8E as they are developed. Because this waste is non-decomposable, it would not receive daily cover; however, if it is observed that specific materials are generating odours or are otherwise of concern if left uncovered, daily cover material would be placed. This fill area would receive final cover consistent with that on the remainder of the landfill, but it is not proposed to install a landfill gas collection system in this area as part of the final cover construction.

To commence filling in each Phase, the existing cover material would be progressively stripped from an area large enough to accommodate the year's disposal, which is estimated to average approximately 4 ha. The area of exposed waste would be limited to that needed to spread, compact and cover the waste received on a daily basis, and will range from about 40 m by 25 m typically (1,000 square metres (m^2)) to 50 m by 30 m (1,500 m^2). The waste will be spread and compacted in lifts of about 0.6 m to a height of approximately 3 m. All waste will be covered daily.

For the southern Phases 1E, 3E, 5E and 7E the waste would be placed initially to build a berm along the south side of the Phase and will be covered with final cover soil and seeded to establish vegetation; the berm will screen the view of subsequent filling operations north of the berm from off-Site vantage points to the south. The south side perimeter waste berm would be raised sequentially and filled in behind until the peak elevation is reached. The Phase boundaries have been designed (offset) such that the completed southern Phases (1E, 3E, 5E, 7E) will effectively screen the view of landfilling operations in the northern Phases (2E, 4E, 6E, 8E) from off-Site vantage points to the south.

Temporary soil berms, and if necessary shallow swales, would be provided to direct surface water runoff from existing covered upslope areas around the active fill areas / Phases to the stormwater management system since this runoff has not been in contact with waste.

On an annual or biannual basis, final cover would then be constructed over areas reaching final grade and permanent vertical LFG wells will be installed and connected to the LFG gas collection system. The landfill Phases will be progressively closed after the final waste contours have been reached in a Phase and landfill operations have proceeded into the next Phase(s). The final cover on the landfill will consist of a permeable cover design, comprised of 600 mm of soil topped with 150 mm of topsoil or similar and vegetated.

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4.3 Leachate Generation

Leachate is the contaminated liquid generated by precipitation infiltrating through the waste and dissolving constituents of the waste as the waste degrades over time. The estimated leachate generation associated with the proposed expansion, in terms of both quantity and quality, is provided below.

4.3.1 Leachate Quantity

The main factors governing the quantity of leachate generated are the landfill footprint area, type of cover and the amount of precipitation that infiltrates into the waste.

Data on the leachate quantity pumped from the main pump station (which receives the leachate collected from both Phase 1 and Phase 2 leachate collection system (LCS)) is provided in the City of London 2019 Annual W12A Status Report (City of London, 2020). The maximum leachate quantity has been 225,000 m^3/year; this was in 2013 when Cell 7 of Phase 2 was under construction and is considered to reflect the open cell base and LCS in Phase 7 and high precipitation. From 2013 to 2019 the total annual leachate volume has ranged from a low of 145,000 m^3 to a high of 225,000 m^3, averaging 185,000 m^3/year. It is noted that over this seven year time period additional landfill cell areas have been added in Phase 2. In 2018/2019 the area of the landfill generating leachate for collection is all but the northwestern cell 10 area, or about 90% of the whole landfill footprint.

The annual infiltration into the landfilled waste from precipitation for the expansion was estimated using the HELP model and the results are provided in Appendix A. The leachate generation is proportional to the landfill footprint area; it is noted that with the proposed vertical expansion the landfill footprint will remain approximately the same as the existing landfill. Under final closed conditions with all waste in place and the final cover constructed, the estimated long term steady state average infiltration through a permeable clayey soil cover is 235 mm/year. For the proposed (and approximately existing) 106.3 ha landfill footprint, this corresponds to an estimated total annual average leachate generation of approximately 250,000 m^3/year. This is also considered a reasonable estimate of the average annual leachate generation when the expansion is in operation, since the active area will be kept relatively small and there is little difference in the infiltration rate between having interim cover in place and having a permeable final cover in place. 250,000 m^3/year is the average volume of leachate from the expanded W12A Landfill expected to require conveyance by the forcemain and treatment at the Greenway Wastewater Treatment Plant (WWTP).

4.3.2 Leachate Quality

The characteristics of the leachate generated at the W12A Landfill is monitored as part of the Site's ongoing monitoring program. Current and historical data is provided in the City of London 2019 Annual W12A Status Report (City of London, 2020). Leachate quality is determined from monitoring wells installed at the base of the waste, and by analysis of the leachate at the main pump station; the latter represents the leachate that requires treatment at the Greenway WWTP. The leachate parameters that are relevant to the Greenway WWTP's effluent discharge criteria are ammonia, Biological Oxygen

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Demand (BOD), Chemical Oxygen Demand (COD) and phosphorus. At the main pump station, the 2019 range of concentration (and 2019 average) of these parameters were as follows: ammonia – 180 to 514 mg/L (average 315 mg/L); BOD – 21 to 434 mg/L (average 129 mg/L); COD – 304 to 538 mg/L (average 393 mg/L); and phosphorus – 0.5 to 2 mg/L (average 1 mg/L). The concentrations of COD and phosphorous are stable over time, whereas the concentrations of ammonia and BOD are more variable and depend on the sequence of construction of the Phase 2 cells and how much LCS area has been constructed and is open or only thinly covered with waste together with the amount of precipitation received. It is noted that during vertical expansion the Phase 2 cells will all have been constructed and covered with 12 m of waste, which can be expected to result in more stable parameter concentrations in combined leachate pumped from the Site in future.

The data also show that the combined leachate parameter concentrations are noticeably less than the leachate concentrations from monitoring wells at the base of the landfill waste. For example, chloride (which is a characteristic leachate parameter) had 2019 concentrations ranging from 1,500 to 2,200 mg/L in monitoring well samples compared to average 600 mg/L in the combined leachate at the main pump station. The O.Reg. 232/98 Landfill Standards provide leachate parameters and concentrations to be used for groundwater impact assessment; of the parameters, only the chloride concentration depends on the thickness of waste (which will increase with the W12A vertical expansion). The maximum chloride concentration that could be used is 2,500 mg/L, which is not much higher than is already being measured in the W12A monitoring well leachate. As such, it is reasonable to expect that the W12A expansion will result in only small to moderate increase in the concentrations of the leachate parameters relevant to treatment plant operation.

4.4 Leachate Control and Management

As previously described in Section 3.0, Phase 2 utilizes the clay till as a natural low permeability liner, and has a continuous granular drainage blanket and piping system over a shaped subgrade to collect leachate and direct it by gravity to the south end of the Phase 2 area where the collected leachate is pumped to the main pumping station located at the southeast corner of the Site for subsequent pumping off-site for treatment. The waste in the Phase 1 area rests directly on the underlying low permeability clay till and has a perimeter LCS around the north, east and south sides to intercept leachate seepage at the base of the waste. Collected leachate either drains into the Phase 2 collection system or to the storage tank for the main pumping station from where it is removed for subsequent off-site treatment.

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For the portion of the proposed vertical expansion that will involve placement of additional waste above the Phase 2 area, the existing LCS will continue to be used to collect and remove leachate from the area. For the vertical expansion above the Phase 1 area, it is proposed to replace the existing perimeter LCS with a new perimeter LCS that will more effectively serve the same functions as the existing system. To control the potential for leachate seeps along the perimeter sideslopes that could occur as a result of leachate mounding and/or perched leachate in Phase 1, it is proposed to construct granular finger drains around the north, east and south sides of the exterior perimeter of the Phase 1 area and connect them into the replacement Phase 1 perimeter LCS.

This conceptual design of the leachate control and management system will be advanced to an ECA level of design in support of the ECA amendment application to implement the expansion.

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

As part of the expansion operations it is proposed to consider options to provide temporary leachate storage on the W12A Landfill site during storm events of significant magnitude that could result in discharge of the mixed leachate/sewage to Dingman Creek or the Thames River if the WWTP is in a by-pass situation. Although the W12A leachate represents only a small percentage of the total flow within the sewer system (refer to Volume 1, Section 8), the objective is to minimize the discharge of untreated leachate to these water courses. The temporarily stored leachate would be pumped off-Site for treatment after the by-pass event is over. A conceptual approach to providing this temporary storage has been developed, as described below, and indicates that it should be feasible to design and implement. The detailed design of temporary leachate storage will be included in the Design and Operations Report as part of the subsequent ECA amendment application process.

From an assessment of the historical durations of overflow situations from the Dingman Pump Station and Greenway WWTP, as well as considering the potential of a power failure at the W12A Site, it is considered that accommodating four days of temporary leachate storage will be appropriate. Based on preliminary calculations, it is estimated that there is temporary storage available in the pore spaces of the granular drainage blanket and lower portion of the waste in the southern portion of Phase 2 to contain approximately 21,700 m3 of leachate (below elevation 272.4 masl, above which seepage at the perimeter could occur). Modelling (using the HELP model, see Appendix A) indicates that for the Phase 2 area and the western portion of the Phase 1 area that discharges leachate to the Phase 2 LCS, an estimated four days of temporary storage would correspond to a volume of approximately 7,750 m3. This is only about 1/3 of the storage volume available.

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Based on historical flow data for the Phase 1 perimeter LCS, the maximum estimated flow being conveyed is 7 m^3/ha/day; for the 24 ha area of Phase 1 that discharges leachate to the perimeter collector, this corresponds to approximately 1,000 m^3 for four days storage. Although this could readily be accommodated if pumped to storage within the base of the Phase 2 area, consideration is being given to the possibility of power being unavailable for pumping during all or part of the four day period. As such, temporary storage for the Phase 1 collected leachate could be provided in an enclosed structure (underground chamber(s) or tank) located at the southeast corner low point in the replacement Phase 1 perimeter LCS. Under a by-pass scenario when power is available, the Phase 1 perimeter LCS leachate would be pumped from the below ground storage chamber to temporary storage in Phase 2.

4.5 Landfill Gas Generation

The following subsections provide the estimated landfill gas (LFG) generation for the proposed expansion.

4.5.1 Methodology

LFG generation rates from materials to be landfilled in the W12A Landfill were estimated using the LandGEM model developed by the United States Environmental Protection Agency (US EPA). The LandGEM model is based on a first-order decay model of LFG generation. The LandGEM model was developed to estimate LFG generation rates for landfills accepting municipal solid waste (MSW) (US EPA, 2005). It should be noted that first order decay modelling of LFG without the benefit of actual measurement of LFG emissions is an inexact science, and that model results can vary, perhaps substantially, from actual LFG generation rates.

The key input parameters for the LandGEM model are the LFG production potential (L_o), the LFG generation rate factor (k), the annual tonnages of waste disposed of in the landfill cell footprint, and the methane content of the LFG. Based on the published data on typical LFG composition, LFG is typically composed of about 50% methane by volume; based on measurements from the LFG going to the W12A Landfill LFG flare between January 1, 2012 and March 30, 2020, LFG generated at the landfill site is comprised of approximately 50% methane by volume.

It should be noted that the LandGEM model provides an estimate of the maximum theoretical LFG generation. The amount of LFG that can be collected is estimated by applying a collection efficiency; a typical collection efficiency could range from 60-85%.

4.5.2 Ultimate Methane Yield and Methane Generation Rate Constant

L_o is a measure of the ultimate methane yield in cubic metres of methane per tonne of waste (m^3/tonne), and k is the methane generation rate constant in $year^{-1}$. Both L_o and k are highly influenced by moisture content, as well as waste composition, temperature, pH, particle size and availability of nutrients.

The values selected for L_o and k were the MECP specified values of 125 m^3/tonne of waste and 0.04 $years^{-1}$, respectively (MECP, 1992).

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4.5.3 Waste Tonnage and Waste Composition

Waste tonnages input to the LandGEM model included both historic waste tonnages and projected waste tonnages for the Site. Historic waste tonnages landfilled in the W12A Landfill between 1977 and 2019 were based on waste tonnages reported in the W12A Landfill Annual Status Report for 2019 (City of London, 2020). Projected waste tonnages to be landfilled in the W12A Landfill between 2020 and 2048 were based on 2019 Updated Residual Waste Projections and Landfill Capacity Assessment that is provided in Volume III Appendix C of the EASR.

Both the historic and projected waste tonnages were divided into waste types: residential; industrial, commercial and institutional (IC&I); CR&D residuals; sewage sludge ash; biosolids; “other municipal” (non-recyclable material from parks, City MRF residuals; and grit from pollution control plants); street sweepings/road waste, water treatment plant process residuals (soil-like suspended sediment from turbid lake water); and contaminated soil. Projected tonnages from the regional service area (i.e., municipalities outside of the existing service area) were also provided.

The LandGEM model assumes a waste composition similar to typical historical MSW in estimating LFG generation rates. The historic and projected waste tonnages were adjusted as discussed below based on the description of the different waste types provided in the 2019 Updated Residual Waste Projections and Landfill Capacity Assessment (refer to Volume IIII Appendix C of the EASR).

Residential, IC&I, “other municipal” waste and regional service area waste were assumed to have a waste composition similar to typical MSW, and so these historic and projected waste tonnages were not adjusted. As this model was run for EA purposes rather than for purposes such as collection system design or equipment sizing, projected tonnages of landfilled residential waste were not adjusted to reflect a reduction in organics following the implementation of the proposed residential green bin program in the City of London.

Sewage sludge ash, street sweepings/road waste, water treatment plant process residuals and contaminated soil are considered to be generally inert with respect to LFG generation, and therefore are assumed to produce negligible quantities of LFG. Historic and projected tonnages of these materials were therefore not included in the LandGEM model.

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Residuals from CR&D processing are described in the 2019 Updated Residual Waste Projections and Landfill Capacity Assessment as consisting of film plastic, insulation, flat roofing, and other materials that cannot be recycled for a variety of reasons. The City of London estimated that CR&D residuals are composed of about 33% organic material, including non-recyclable wood and old corrugated cardboard. It is understood that there are very low or negligible quantities of organic waste, such as food waste, in the CR&D residuals that are landfilled. The LFG generation potential of the CR&D residuals is therefore considered to be lower than typical MSW. As such, 75% of the reported historic and projected tonnages of CR&D residuals, which are projected to comprise about 20% of the overall residual wastes to be disposed, were used in the model to account for the reduced gas generation potential from this waste material.

Biosolids are described in the 2019 Updated Residual Waste Projections and Landfill Capacity Assessment as sewage sludge treated by lime stabilization. The process of lime stabilization began in 2007; prior to 2007 the tonnage of biosolids reported represents untreated raw sewage sludge that was landfilled when circumstances required (i.e., the sewage sludge incinerator was down for maintenance or repairs). Due to the high proportion of organic material composing biosolids, the gas generation potential of this material is likely higher than that of typical MSW. However, given the relatively small quantity of biosolids historically or projected to be landfilled (projected to be about 1 to 2% of the total residuals to be disposed) and since the model was run for EA purposes, the historical tonnages for biosolids have not been adjusted to reflect a potentially higher LFG generation rate.

4.5.4 LFG Generation Estimates

The resulting theoretical maximum total LFG and methane generation rate estimates obtained from the LandGEM model are presented in Appendix B, Attachment A and illustrated in Figure 5. Table 4.5-1 presents a summary of the estimated LFG and methane theoretical maximum generation.

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Figure 5: Estimated Total Landfill Gas and Methane Generation for the W12A Landfill Expansion

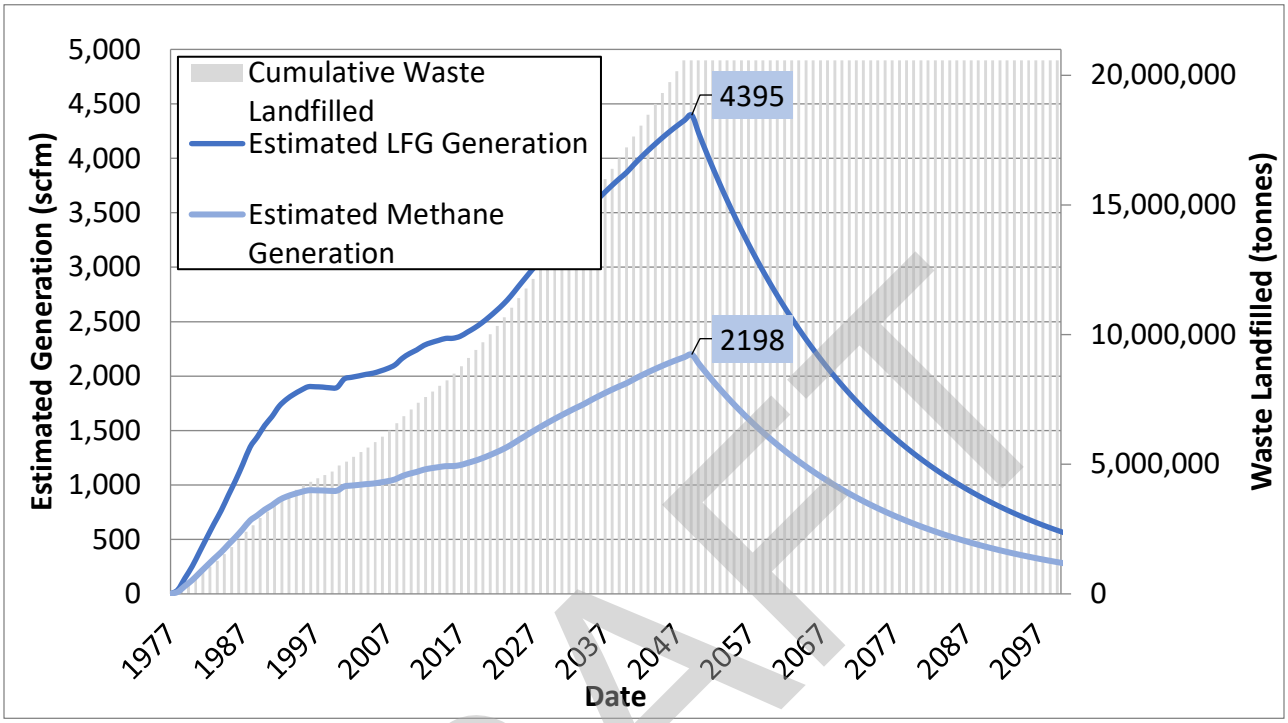

Table 4.5-1: Summary of Total Estimated Landfill Gas and Methane Generation for the W12A Landfill Expansion

Year	Landfill Gas Generation Estimate		Methane Generation Estimate*	
	scfm	m^3/hr	scfm	m^3/hr
2020	2,489	4,229	1,244	2,114
2035	3,552	6,035	1,776	3,017
2048 (landfill closure)	4,349	7,389	2,175	3,695
2049 (peak LFG generation)	4,395	7,468	2,198	3,734
2065	2,318	3,938	1,159	1,969
2080	1,272	2,161	636	1,081

Notes:
* Assumes LFG is comprised of 50% methane
m^3 = cubic metres
scfm = standard cubic feet per minute

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4.5.5 Assessment of Existing Flare Capacity

The W12A Landfill operates an enclosed LFG flare system that is sized to combust a maximum of approximately 1,700 standard cubic feet per minute (scfm) of LFG. The LFG collection system and flare are approved under ECA #. A042102.

In the Ontario Regulation 347 Exemption and Design Report (Comcor, 2009), included as item 30 in Schedule A of ECA # A042102, it was stated that collecting LFG from Cells 1 and 2 and the southern portion of Cell 3, landfilled between 1977 and 1983, may not be practical or effective due to the age of the waste and due to leachate mounding in that area. The report indicated that LFG pump tests conducted in 2003 and actual LFG production in a number of vertical gas extraction wells that were installed in this area of the site in 2005 were found not to produce significant amounts of LFG. Therefore, the approved design of the LFG collection system does not include Cells 1, 2 and 3.

Given the exclusion of Cells 1, 2 and 3 from the LFG collection system, a second LandGEM model was completed to estimate the LFG for comparison with the current flare capacity. This LandGEM model used the same values for L_o and k as described above and the same assumptions about waste composition, but excluded historic landfilled waste tonnages from 1977 to 1983 that were landfilled in Cells 1, 2 and 3. The resulting theoretical total LFG generation rate estimates obtained from this LandGEM model are presented in Appendix B- Attachment B. Figure 6 and Table 4.5-2 present the results and a summary, respectively of the estimated LFG theoretical generation with assumed collection efficiency rates of 60% and 85% applied.

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Figure 6: Estimated Landfill Gas Generation and Collection, Excluding Cells 1, 2, and 3

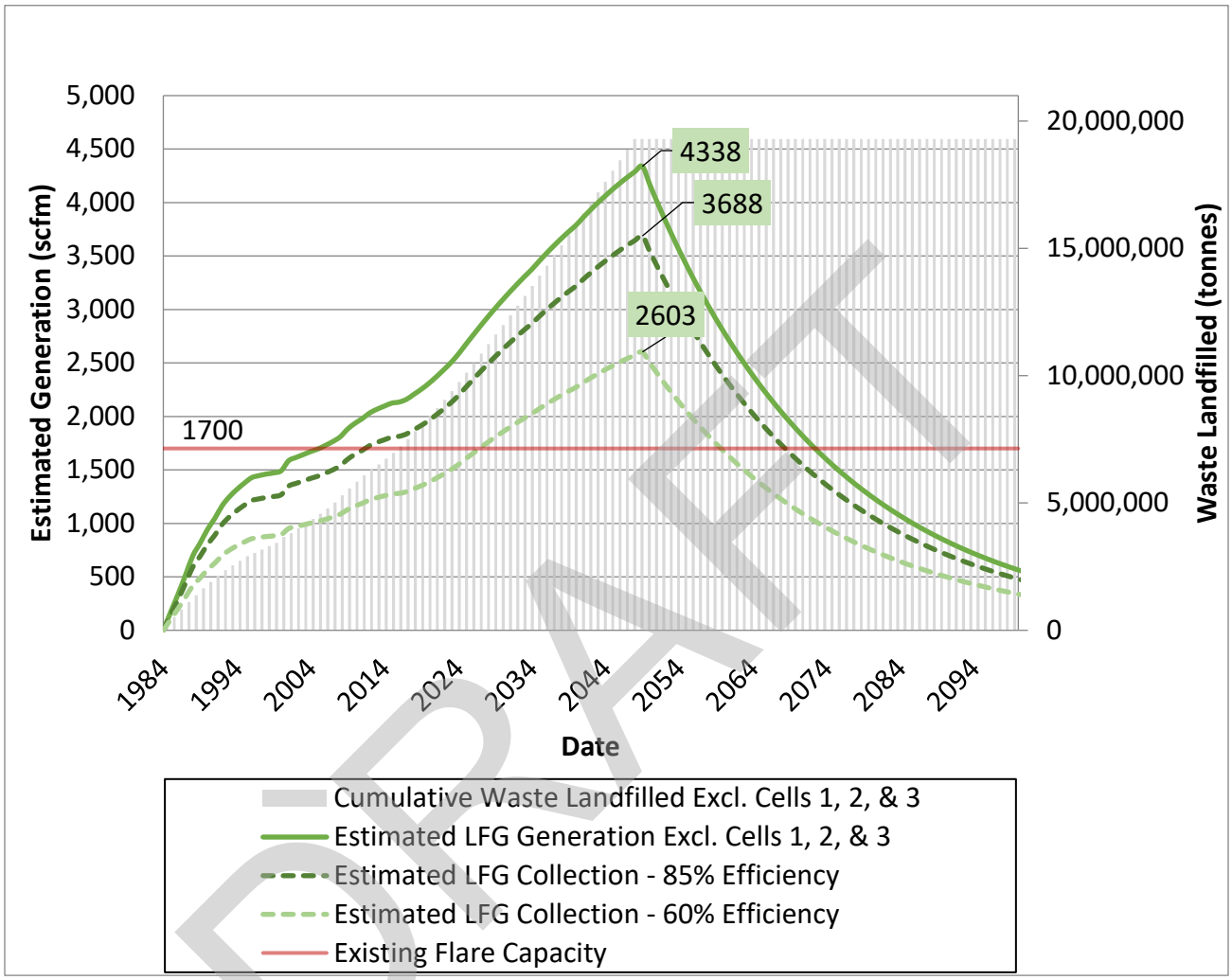

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Table 4.5-2: Summary of Estimated Landfill Gas Generation and Collection, Excluding Cells 1, 2, and 3

Year	Landfill Gas Generation Estimate - Excluding Cells 1-3		60% Collection Efficiency		85% Collection Efficiency	
	scfm	m^3/hour	scfm	m^3/hour	scfm	m^3/hour
2020	2,307	3,920	1,384	2,352	1,961	3,332
2027	2,844	4,831	1,706	2,899	2,417	4,107
2035	3,452	5,866	2,071	3,519	2,935	4,986
2048 (landfill closure)	4,290	7,288	2,574	4,373	3,646	6,195
2049 (peak LFG generation)	4,338	7,371	2,603	4,423	3,688	6,265
2065	2,288	3,887	1,373	2,332	1,944	3,304
2080	1,255	2,133	753	1,280	1,067	1,813

Notes:
scfm = standard cubic feet per minute
m^3 = cubic metres

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The MECP's current requirement is that a collection efficiency of 85% should be considered and is therefore presented above. Based on the LFG generation modelling and a collection efficiency of 85%, the capacity of the flare would be currently exceeded. However, in 2019 the flare operated at an average flow of 1,193 scfm compared to a flare capacity of about 1,700 scfm, recognizing that the LFG collection system will be expanded progressively as development and landfilling of the Site and placement of final cover continues. It is reasonable to conclude a collection efficiency of around 60% is more suitable for the landfill design and existing conditions on the currently approved landfill; using this collection efficiency, the analysis indicates that the capacity of the flare may be exceeded around year 2027. The timing for installation of additional flare capacity will depend on the actual operation of the existing flare and its ability to handle the collected gas flow rate. The year 2027 would approximately coincide with the installation of the LFG collection system in the completed first expansion Phase 1E, but additional flare capacity may not be required until after the LFG collection system is installed after completion of Phase 2E.

4.6 Landfill Gas Control and Management

It is estimated that the total expanded landfill will theoretically generate a maximum of 4,395 scfm of LFG in 2049 (the year following completion of filling of the expansion), of which typically 50% is methane. LFG is collected from completed areas of the landfill

using a vertical well system that is connected to an enclosed flare; the existing flare is sized to combust a maximum of approximately 1,700 scfm of LFG. As described above, considering the actual extent of the LFG well extraction system and its collection efficiency, analysis indicates that the capacity of the existing flare may be exceeded around year 2027.

For the proposed expansion, it is proposed to utilize vertical LFG extraction wells to be progressively installed with the construction of final cover following placement of waste to final contours in each Phase. To reduce air emissions (for odour control purposes during landfilling operations and to increase the overall collection of landfill gases), it is proposed that a number of horizontal landfill gas collection pipes will also be installed progressively as waste is placed. The combined LFG collection system, consisting of vertical wells and horizontal collector pipes, connected to the extraction blower and flares by a network of lateral and header piping will provide LFG control for the proposed expansion. This conceptual design of the LFG control system will be advanced to an ECA level of design in support of the ECA amendment application to implement the expansion.

4.7 Geotechnical Evaluation

A geotechnical evaluation of the vertical landfill expansion was undertaken to assess the stability of the proposed expansion supported on the underlying clay till deposit, as well as to estimate the consolidation settlement of the clay till under the waste loading to assist in assessing potential impacts to the existing LCS beneath the Phase 2 landfill area. The details of the assessment are provided in Appendix C and the results are summarized below.

At the time of the geotechnical assessment the final geometry of the preferred landfill expansion had not yet been finalized but the height of waste evaluated was very similar to the preferred landfill expansion and hence the previous geotechnical assessment is directly applicable to the proposed landfill expansion.

Stability is evaluated based on the factor of safety, which is defined as the ratio of the forces tending to resist failure (the strength of the clay till soils and the waste) to the forces tending to cause instability (the weight of the waste). Stability was evaluated for two cases: 1) a translational slide of the waste and cover soil, where the slip surface does not extend into the underlying clay till, and 2) a deeper seated rotational slope failure involving a larger mass of the waste and extending into the underlying clay till.

For the proposed expansion, the results of the analyses indicate a factor of safety in excess of about 2.0 for a half-height slide (i.e., top of slide scarp at the mid-height ground surface along the waste slope) and in excess of 2.5 for a full height, deeper seated slide. These factors of safety are considered appropriate from a geotechnical perspective and are greater than target factors of safety for cut and fill slopes in urban environments.

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The waste in Phase 1 of the landfill was placed directly on the silty clay till and does not have a leachate collection system beneath the landfill. There is a perimeter leachate collection system around the exterior of Phase 1; it is to be replaced with a new perimeter leachate collection system that will continue to provide control of lateral migration of leachate in the shallow subsurface for the proposed expansion. As such, the estimated settlements will not adversely affect any engineered components beneath the Phase 1 area.

The waste in Phase 2 of the landfill is underlain by a LCS consisting of a continuous granular drainage blanket and a series of perforated collection pipes. The base grades and the pipes slope upwards from south to north at a grade of 0.5%; the southern 120 m of the piping is sloped at 2.5% towards the header and collection manhole. The drainage and collection of leachate rely on gravity flow in a series of peaks and valleys laterally towards the piping and longitudinally from north to south. An assessment of the effects of the above estimated settlements on the existing base and pipe grades and slopes/drainage pattern was carried out. For the preferred expansion alternative, and as illustrated on cross section A-A' on Figure 3 in Appendix C, the settlements are quite uniform across much of the width of Phase 2 and will vary with the height of waste (which varies parallel to cross section A-'A'). Cross section B-B' on Figure 3 in Appendix C shows that the settlement will be greatest under the peak of the waste and decrease to both the north and south, with estimated differential settlement of about 10 mm for every 100 m of length. Although there will be an overall lowering of the base of the landfill by up to about an estimated 155 mm, the differential settlements along the length are small and will not change the base and pipe design grade of 0.5 % except for a small reduction of about 0.01 to 0.02 % in the 100 m long section below and just south of the waste peak. This will not adversely affect the performance or service life of the existing LCS below Phase 2.

An assessment was also carried out on the ability of the strength of the existing LCS piping beneath Phase 2 to withstand the increased loading associated with the proposed vertical expansion. The assessment included pipe wall crushing, ring deflection and pipe wall buckling, and confirmed that the high density polyethylene piping, which is DR11, is capable of withstanding the increased loading.

Based on this geotechnical assessment, it is concluded that the overall stability of the preferred landfill expansion is acceptable and that the settlement of the clay till subgrade beneath the existing footprint will not adversely affect the performance or service life of the existing LCS beneath the Phase 2 area.

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4.8 Soil Balance for the Proposed Expansion

A soil balance was prepared for the proposed landfill expansion and is provided below. A soil balance estimates the volume of soil materials available on site for potential use in constructing various components of the expansion compared to the types and volumes of soil materials required for their construction. If the volume available exceeds the requirements, then the site has a net soil surplus. Conversely, the site could have a net soil deficit and there will be a need to import soil materials from off-site sources.

The City has completed a soil balance for the existing landfill site and reported the results in the 2019 W12A Landfill Annual Status Report, prepared by the City of London dated March 2020. The soil balance concludes that at the end of the currently approved landfill operations the site will have a soil surplus of an estimated 361,000 m^3 of topsoil and clay soil. This material is and will be stockpiled at the site and available for future uses associated with the expansion.

Because the proposed expansion involves a vertical expansion above the existing waste footprint, there will be no excavation of new landfill cells to provide a volume of additional soil. There will be small volumes of soil generated from excavations associated with upgrading and replacement of site infrastructure, but these will not be significant amounts and have not been included in the soil balance.

The soil volumes associated with landfill operations and closure are provided in Table 4.8-1 below.

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Table 4.8-1: Soil Balance

Item #	Item Name	Description	Volume (m^3)	
			Soil	Topsoil
A	Soil Excavation	Vertical expansion, so no excavation.	0	0
B	Existing Final Cover to be removed prior to vertical expansion	All of the landfill will have received final cover. Corresponding area above existing sideslopes is 77 ha. Existing final cover consists of 0.85 m clay soil and 0.15 m topsoil. Assumes all this material can be stripped off prior to placing additional waste, and topsoil is separated for re-use in final cover.	+654,500	+115,500
C	Estimated Soil Surplus at end of current approved landfill operations	Estimated Soil Surplus at end of current approved landfill operations. Existing soil stockpiles plus soil remaining to be excavated less remaining soil needed for existing approved W12A Landfill.	+335,300	+25,700
D	Soil Surplus available for use in the expansion	Use mainly for daily and final cover: Items B + C	+989,800	+141,200
E	Soil Required for final cover of the expansion	Surface area of expanded landfill above existing sideslopes is 78 ha. Proposed final cover consists of 0.6 m of soil and 0.15 m of topsoil.	-468,000	-117,000
F	Daily Soil Cover Requirements	Airspace for waste and daily cover (less the 1 million m^3 in the Dedicated Non-decomposable Waste Cell) is 12.8 millionm^3. Assumes 4:1 waste:daily cover ratio and that alternative cover materials are not used.	-2,560,000	0
G	Soil requirements for expansion	Items E + F	-3,028,000	-117,000
H	Soil Balance	Items D - G	-2,038,200 (Deficit)	+24,200 (surplus)

Notes: + indicates soil available for use; - indicates soil required for the expansion

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Over the 25 year operational planning period for the expansion, approximately 2,000,000 m^3 of fill material will be required to be imported to the site from off-site sources. This represents approximately 80% of the daily cover material requirements for the expansion. Imported daily cover will continue to consist of clean street sweepings (primarily sand), clean water treatment plant residuals (primarily sand), select contaminated soil (e.g., no adverse odours) and wood chip residuals from local CR&D recycling facilities. In 2019, these off-site sources provided 85% (by volume) of the cover material used, with only about 15% coming from on-site stockpiles. As such, during the 25 year expansion period, about 15,350 m^3 per year, or 384,000 m^3 total will be required from the soil stockpiles, leaving approximately 605,800 m^3 of surplus. Therefore, there is expected to be enough on-site stockpiled soil to construct the final cover, leaving a surplus of approximately 137,800 m^3 of soil and 24,200 m^3 of topsoil, or a total soil surplus of approximately 162,000 m^3, which can readily be accommodated within the expanded landfill site property limits.

4.9 Estimate of Probable Costs of the Expansion

As described in Section 8.0 of the EASR, there are components of the existing site infrastructure that are to be replaced or upgraded / modified, and some new components to be added.

An estimate of capital costs for implementation of the expansion was prepared. It is considered appropriate to consider a range of probable costs, including contingency allowances, to account for components that may or may not be required as the result of the approvals process, the final engineering design and potential variations in both construction materials and contractor costs over time. There will also be costs associated with the approvals process and engineering services during design and construction.

It is estimated that the capital costs of implementing the expansion (including engineering and contingencies) are in the range of $55 to $90 million, with a midpoint estimate of approximately $72 million (in 2020 dollars). The main components of the capital costs can be broken down as follows:

- Replacement of the Phase 1 LCS and installation of finger drains; other possible leachate controls; installation of component to manage leachate during large storm events; replacement of the main leachate pump station; stormwater management system modifications; site roads, landscaping and fencing – range of $11.6 to $25.6 million, midpoint estimate of $18 million to be carried out in 2023/2024 during initial expansion period.
- Replacement/upgrading of ancillary facilities – range of $10.8 to $16 million, likely to be carried out during the first half of the expansion period.
- Additional LFG flare – $1.5 to $2 million, anticipated to be required around 2027.
- Annual costs of stripping and management of existing final cover soil; progressive placement of final cover and installation of LFG collection system – approximately $1.2 to $1.8 million per year over a 25 year period, total estimated cost in the range of $31 to $46 million.

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The current annual operating cost, including both staff and the operations, is approximately $4.5 million (in 2020 dollars). It is estimated that with the additional infrastructure operations associated with the expansion, the annual operating cost could increase to $5 million.

5.0 IMPACT ASSESSMENT

The proposed W12A expansion incorporates many mitigation measures in its design and operational procedures to control emissions of leachate and LFG to the natural environment, control potential off-site nuisance effects and operate in compliance with provincial regulations and standards. A discussion of potential impacts associated with site design and operations is provided below.

Phasing and Development: The design of the expansion phasing and the approach to development of each phase will reduce potential visual impacts (i.e., view of ongoing site landfilling operations) from off-Site vantage points to the south, from where the site operations are most visible for the greatest number of existing residences. In terms of landfilling, the area from which the existing final cover will be stripped in advance of placement of waste, as well as the active area used for waste disposal will be kept as small as practical to minimize the potential for odours and blowing litter.

Management of Leachate: The management of leachate will continue to rely on the same LCS approaches that have proven effective in preventing impacts on groundwater and surface water quality. These provide control on leachate migration away from the waste footprint in the shallow subsurface and, together with the natural hydrogeological setting, prevent adverse effects on off-Site groundwater resources (aquifers) used by water supply wells. The current Phase 2 LCS below the waste will continue to be used below the portion of the expansion above the Phase 2 landfill area. For the Phase 1 area, it is proposed to improve the effectiveness of the current perimeter LCS by replacing it with a new perimeter system, and control potential perimeter leachate seeps associated with the leachate mound in Phase 1 by installing finger drains connected into the replacement perimeter LCS. In addition, the proposed leachate management system design will provide sufficient temporary leachate storage to minimize the potential for untreated leachate release due to storm events that are sufficiently large to cause overflows from the off-Site pumping station and WWTP.

Management of LFG: The expansion will continue to utilize an active LFG collection system (installed progressively with the final cover as expansion phases are completed) to capture and flare LFG and thereby control odour and greenhouse gas releases. The expansion will also utilize horizontal LFG collectors installed in the waste to further control LFG (including odour) release during the landfilling operations.

Geotechnical Considerations: Geotechnical analysis demonstrate that the proposed expansion will be stable in terms of overall stability of the waste, and that settlement of the underlying clay till deposit due to the weight of the vertical expansion of waste will not adversely affect the operation and performance of the underdrain LCS below the Phase 2 area.

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Soil Balance: To satisfy its need for soils for daily and final cover purposes, the expansion is expected to use a combination of available on-Site stockpiled soil and alternative daily cover consisting of off-Site waste materials. It is anticipated that there will be an overall soil surplus at the end of the expansion period. The expansion will require aggregates and asphalt for infrastructure construction and maintenance. However, besides these imported materials, the expansion is not expected to consume off-Site soil resources from licensed pits or other borrow sources.

Capital and Operational Costs: The capital costs associated with the expansion can be planned within the municipality's annual capital expenditures budgeting process. The operating costs are comparable to but somewhat higher than the current operating costs. These cost components are not expected to impact municipal finances.

6.0 MITIGATION AND MONITORING

There are no additional mitigation measures associated with the design and operations of the W12A Landfill expansion.

The City will undertake continuous monitoring of all permanent on-site buildings for concentrations of methane, oxygen, and hydrogen sulphide. In addition, two dedicated perimeter landfill gas monitoring wells were installed on June 22, 2011 and will be sampled three times per year (April, June and October). The results from the aforementioned monitoring locations (i.e. on-site buildings and perimeter wells) will be reviewed and compared to the concentration limits outlined in O.Reg 232/98. Monitoring programs associated with other potential effects are provided under the specific environmental component, i.e., groundwater and surface water. For example, the monitoring of the leachate mound height in the Phase 1 area of the existing landfill (Phases 5E through 8E of the expansion) is part of the groundwater and leachate monitoring program.

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7.0 LIMITATIONS

This report was prepared for the exclusive use of the City of London. The report, which specifically includes all tables, figures and attachments, is based on data and information collected by Golder Associates Ltd. 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 Associates Ltd. as described in this report.

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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.

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

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8.0 REFERENCES

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City of London. November 2002. Hydraulic Evaluation of Landfill Performance (HELP) Modeling.

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9.0 SIGNATURE PAGE

Golder Associates Ltd.

Paul Smolkin, P.Eng.
Principal, Senior Geo-environmental Engineer

https://golderassociates.sharepoint.com/sites/114635/project files/5 technical work/1.0 - technical components/08 - d&o/8.6 existing conditions & impact assessment report/1648176-6700-rev a oct2020 d&o assessment.docx

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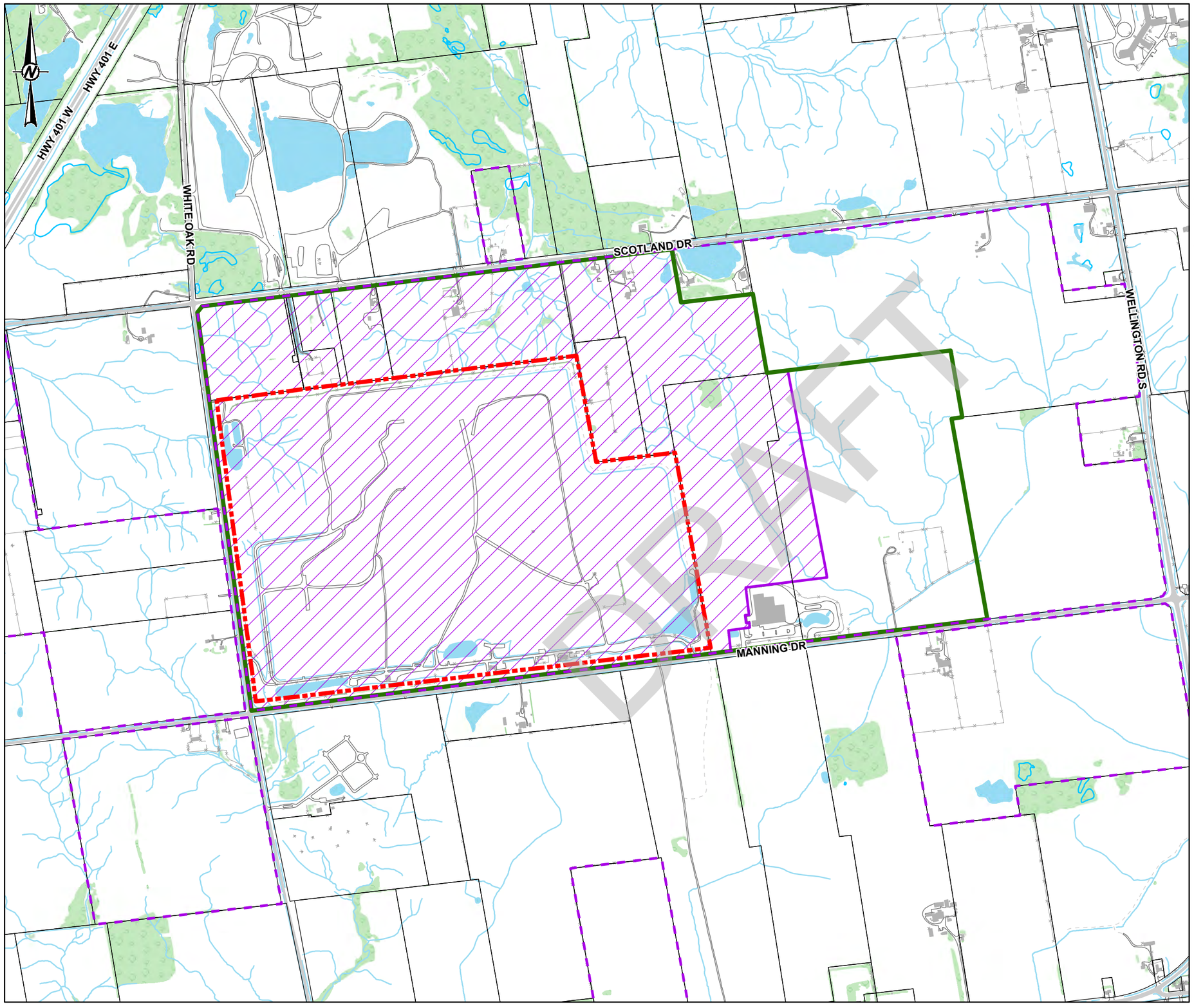

LEGEND

- WATERCOURSE
- DRIVEWAY
- FENCELINE
- TRAIL
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- CITY OWNED PROPERTY
- WASTE MANAGEMENT RESOURCE RECOVERY AREA BOUNDARY
- SITE STUDY AREA
- EXISTING W12A LANDFILL SITE BOUNDARY

REFERENCE(S)

1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

0 125 250 500

1:12,500 METRES

CLIENT
CITY OF LONDON

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION

TITLE
SITE PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2020-07-30
DESIGNED	----
PREPARED	JEM
REVIEWED	PLE
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
1648176	0019	0	1

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

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SCOTLAND DR

Drainage Ditch No. 10

Drainage Ditch No. 7

Pond Forebay

Stormwater Pond No. 1

CELL 10

CELL 6 NORTH NORTH HALF

CELL 4

CELL 9

CELL 6 NORTH SOUTH HALF

WHITE OAK RD

PHASE 2 WASTE DISPOSAL FILL AREA

PHASE 1 WASTE DISPOSAL FILL AREA

CELL 8

CELL 6 SOUTH NORTH HALF

CELL 5 WEST

CELL 5 EAST

CELL 3

CELL 2

CELL 1

CELL 7

CELL 6 SOUTH SOUTH HALF

Back-up Leachate Loading Station #2

Back-up Leachate Loading Station #1

Pond Forebay

Stormwater Pond No. 4

Stormwater Pond No. 5

Stormwater Pond No. 2/3

MANNING DR

Drainage Ditch No. 5

Drainage Ditch No. 4

Drainage Ditch No. 3

Flare Station

City Maintenance Building

Drainage Ditch No. 1

Contractor Maintenance Building

Administrative Building

Household Special Waste Building

Weigh Scale & Scale House

Drainage Ditch No. 2

Main Pumping Station/ Standby Generator

LEGEND

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

PROPERTY INFORMATION

- EXISTING W12A LANDFILL
- STORMWATER PONDS/FOREBAY
- BUILDINGS

REFERENCE(S)

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

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1:6,000 METRES

CLIENT
CITY OF LONDON

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION

TITLE
W12A LANDFILL EXISTING CONDITIONS PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2018-01-04
DESIGNED	---
PREPARED	JEM
REVIEWED	PLE
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
1648176	0019	0	2

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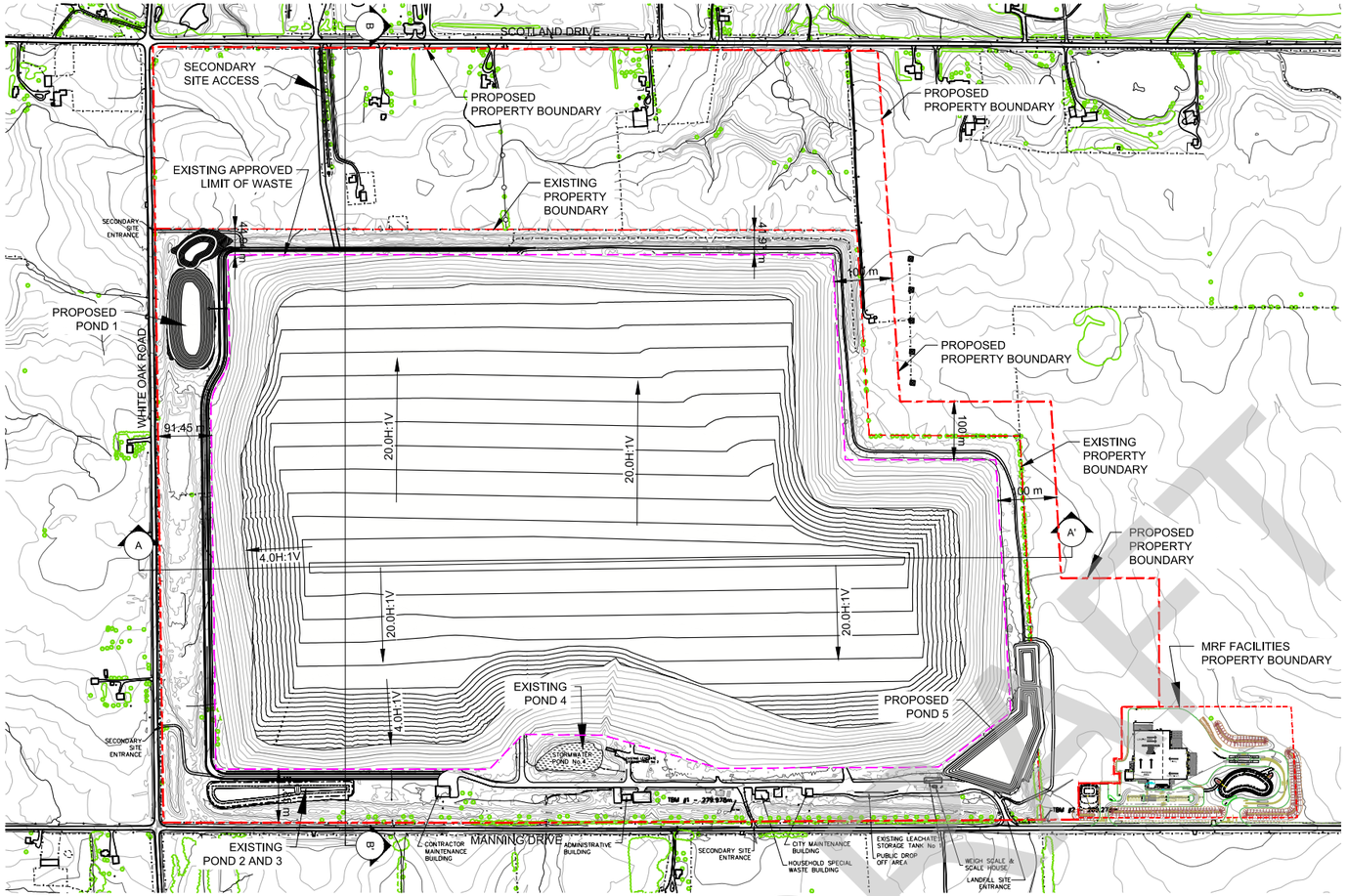

SITE PLAN
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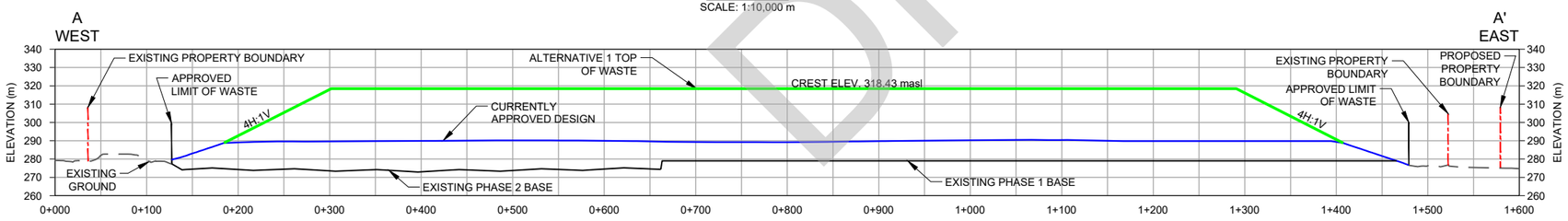

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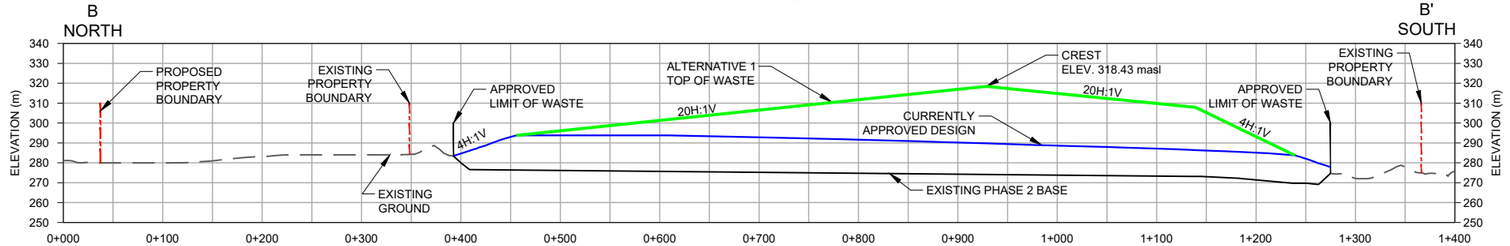
VERT. SCALE: 1:3,000 m
A-A' CROSS-SECTION



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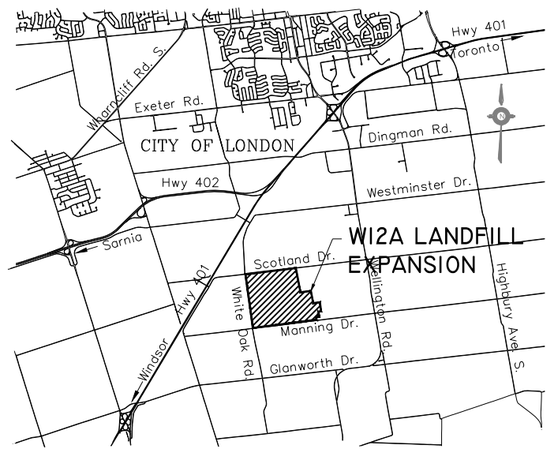
VERT. SCALE: 1:3,000 m
B-B' CROSS-SECTION

KEY MAP



NOTE(S)

1. ELEVATION CONTOURS SHOWN ARE TOP OF WASTE, masl.

REFERENCE(S)

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

NOT FOR CONSTRUCTION

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0 100 200
1:6,000 METRES

0 250 500
1:10,000 METRES

CLIENT
CITY OF LONDON
LONDON, ONTARIO
CANADA

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION

TITLE
LANDFILL EXPANSION FINAL CONTOUR PLAN AND CROSS-SECTIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	MLF
PREPARED	MLF
REVIEWED	PAS
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
1648176	0019	1	3

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

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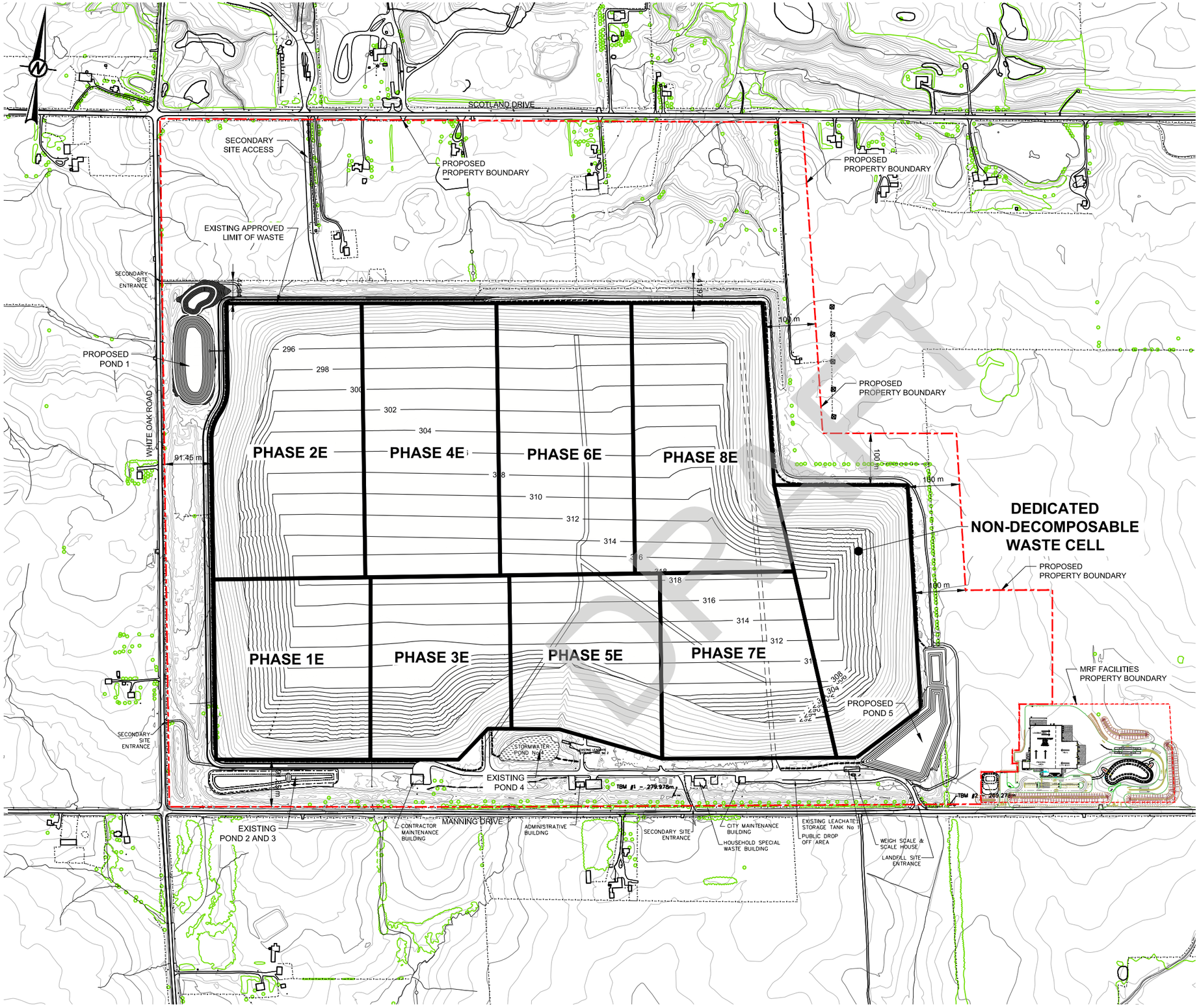
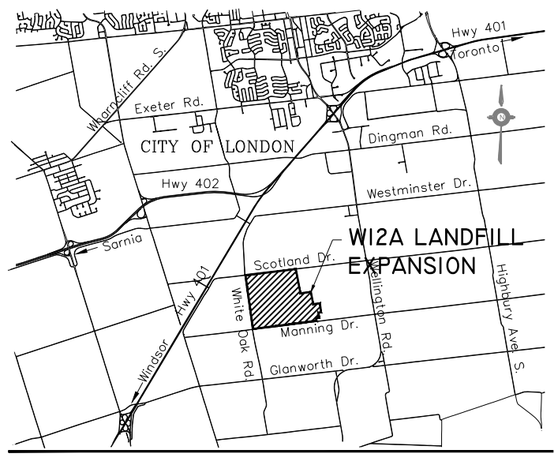


KEY MAP



LEGEND

LANDFILL ROAD THAT CAN HANDLE HEAVY TRAFFIC WITHOUT FURTHER UPGRADE

LANDFILL ROAD THAT NEEDS TO BE UPGRADED TO HANDLE HEAVY TRAFFIC

NOTE(S)

1. ELEVATION CONTOURS SHOWN ARE TOP OF WASTE, masl.
2. REVISED WASTE FOOTPRINT AREA = 106.26 ha.

REFERENCE(S)

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

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

NOT FOR CONSTRUCTION

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0 125 250

1:7,500 METRES

CLIENT
CITY OF LONDON
LONDON, ONTARIO
CANADA

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION

TITLE
LANDFILL EXPANSION PHASING PLAN

CONSULTANT
GOLDER

YYYY-MM-DD	2020-10-22
DESIGNED	MLF
PREPARED	MLF
REVIEWED	PAS
APPROVED	PAS

PROJECT NO.	CONTROL	REV.	FIGURE
1648176	0019	1	4

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

25 mm

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APPENDIX A

HELP Modelling Results

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Calculation for Percolation Rates Through Daily and Final Cover W12A Landfill Expansion, London, Ontario		
Project No.: 1648176	Prepared by: S. Rimal Reviewed by: F. Barone / P. Smolkin	Date: April 2020

Reference:

Ref. 1 - The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07 (1 November 1997), Developed by Environmental Laboratory, USAE Waterways Experiment Station for U.S. Environmental Protection Agency Risk Reduction Engineering Laboratory, Cincinnati, OH.

Ref 2. – Schroeder, P.R., Dozier, T.S., Zappi, P.A., McEnroe, B.M., Sjostrom, J.W., and Peyton, R.L. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, September 1994, U.S. Environmental Protection Agency, Office of Research and Development, Washington DC.

Ref 3. – Sharma, H.P. and Lewis, S.P. (1994). Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley and Sons, Inc. New York, 588p.

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The potential percolation rate of atmospheric water through the daily and final cover of the W12A Landfill was estimated using the Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 (Ref.-1).

The HELP model is a quasi-two-dimensional water-balance model for water movement in the landfill (Ref-2.). The model accepts the weather data and landfill design data and uses solution techniques that account for the effect of different processes such as surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetation growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage and leakage through liners (Ref-2. and Ref-3). The site-specific runoff, evapotranspiration, infiltration, drainage, leachate collection and liner leakage can be determined using the HELP model.

Climatological Input Parameters:

Daily precipitation and temperature input data for the W12A Landfill Site were synthetically generated using the HELP model (Ref. 1). This involved taking 30 years of continuous precipitation and temperature data for Detroit, Michigan, USA (nearest reference station included in the HELP model database) and then adjusting the data with

mean monthly precipitation and temperature values based on the average values for the London Airport meteorological station as shown in the attached Table 1.

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

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

Daily Cover, Final Cover and Waste Layer Input Parameters:

The HELP model input parameters for the daily cover, final cover and waste are summarized in Table 3. The values used in the HELP model on total porosity, field capacity and wilting point are according to the HELP model default values as shown in the attached Table 3. For the daily cover, final cover and waste layers the initial water content was taken as equal to or greater than the field capacity water content, which is the water content at which the soil can no longer absorb/retain additional moisture under free drainage. With respect to modelling the leachate generation rate, this is a conservative assumption as it reduces the time to reach peak leachate generation.

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

Vegetation Input Parameters:

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

For the filling period an evaporative zone depth of 15 cm i.e. the full thickness of the daily cover was assumed. The evaporative zone depth is defined as the maximum depth from which water may be removed by evapotranspiration. For the post closure period an

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evaporative zone depth of 55 cm was assumed for loam / clayey loam soil with good stand of grass.

Result:

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

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TABLE 1: NORMAL MEAN MONTHLY PRECIPITATION AND TEMPERATURE AT LONDON AIRPORT METEOROLOGICAL STATION

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

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

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

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TABLE 2: NORMAL RELATIVE HUMIDITY AND WINDSPEED AT LONDON AIRPORT METEOROLOGICAL STATION

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

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

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

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TABLE 3: HELP MODEL INPUT PARAMETERS†

Input Parameters	**Units**	***Daily Cover***	***Final Cover***		***Waste***
			Topsoil	***Cover Soil***	
HELP Model Soil Texture Class†	[-]	8	8	11	18
USDA Soil Texture Class	[-]	Loam (L)	Loam (L)	Clayey Loam (CL)	Municipal Waste
Thickness	m	0.15	0.15	0.60	10
Total porosity	[-]	0.463	0.463	0.464	0.67
Field capacity	[-]	0.232	0.232	0.310	0.29
Wilting point	[-]	0.116	0.116	0.187	0.08
Initial volumetric water content	[-]	0.232	0.232	0.310	0.29
Hydraulic Conductivity*	cm/s	3.7E-4	3.7E-4	6.4E-5	1.0E-3

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

* Effective saturated hydraulic conductivity.

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TABLE 4: HELP MODEL OUTPUT
(Average Annual Water Balance and Peak Daily Percolation Rate)

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

APPENDIX B

Landfill Gas Generation Estimates

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Summary Report

Landfill Name or Identifier: W12A - Total LFG Generation

Date: April 24, 2020

Description/Comments:
Uses MECP Values for Lo and k. Reduce the tonnage of CR&D residuals to 75% to account for low organic content of residuals. All Phases of W12A Landfill.

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About LandGEM:

First-Order Decomposition Rate Equation: $$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation ($m^3/year$)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate ($year^{-1}$)
L_o = potential methane generation capacity (m^3/Mg)
M_i = mass of waste accepted in the i^{th} year (Mg)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1977**	
Landfill Closure Year (with 80-year limit)	**2048**	
Actual Closure Year (without limit)	***2048***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.040**	$year^{-1}$
Potential Methane Generation Capacity, L_o	**125**	m^3/Mg
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1977	56,022	61,624	0	0
1978	166,925	183,618	56,022	61,624
1979	172,690	189,959	222,947	245,242
1980	212,799	234,079	395,637	435,201
1981	220,149	242,164	608,436	669,280
1982	225,789	248,368	828,585	911,444
1983	223,704	246,074	1,054,374	1,159,811
1984	259,652	285,617	1,278,078	1,405,886
1985	261,658	287,824	1,537,730	1,691,503
1986	288,278	317,106	1,799,388	1,979,327
1987	306,644	337,308	2,087,666	2,296,433
1988	222,214	244,435	2,394,310	2,633,741
1989	242,313	266,544	2,616,524	2,878,176
1990	214,344	235,778	2,858,837	3,144,721
1991	242,087	266,296	3,073,181	3,380,499
1992	197,185	216,904	3,315,268	3,646,795
1993	175,900	193,490	3,512,453	3,863,698
1994	166,681	183,349	3,688,353	4,057,188
1995	159,278	175,206	3,855,034	4,240,537
1996	113,160	124,476	4,014,312	4,415,743
1997	108,734	119,607	4,127,472	4,540,219
1998	103,031	113,334	4,236,206	4,659,827
1999	117,600	129,360	4,339,237	4,773,161
2000	230,240	253,264	4,456,837	4,902,521
2001	140,628	154,691	4,687,077	5,155,785
2002	137,232	150,955	4,827,705	5,310,476
2003	140,549	154,604	4,964,937	5,461,431
2004	136,368	150,005	5,105,486	5,616,035
2005	151,146	166,261	5,241,854	5,766,039
2006	156,941	172,635	5,393,000	5,932,300
2007	171,734	188,907	5,549,941	6,104,935
2008	216,407	238,048	5,721,675	6,293,843
2009	194,369	213,806	5,938,082	6,531,890
2010	182,006	200,207	6,132,451	6,745,696
2011	197,032	216,735	6,314,457	6,945,903
2012	174,005	191,406	6,511,489	7,162,638
2013	166,948	183,643	6,685,494	7,354,044
2014	166,504	183,155	6,852,443	7,537,687
2015	141,576	155,734	7,018,947	7,720,841
2016	165,925	182,518	7,160,523	7,876,575

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WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2017	198,907	218,797	7,326,448	8,059,093
2018	202,323	222,555	7,525,355	8,277,890
2019	215,312	236,843	7,727,677	8,500,445
2020	229,050	251,955	7,942,989	8,737,288
2021	238,750	262,625	8,172,039	8,989,243
2022	248,625	273,488	8,410,789	9,251,868
2023	268,100	294,910	8,659,414	9,525,355
2024	288,775	317,653	8,927,514	9,820,265
2025	290,975	320,073	9,216,289	10,137,918
2026	294,850	324,335	9,507,264	10,457,990
2027	296,275	325,903	9,802,114	10,782,325
2028	297,100	326,810	10,098,389	11,108,228
2029	297,650	327,415	10,395,489	11,435,038
2030	298,375	328,213	10,693,139	11,762,453
2031	298,800	328,680	10,991,514	12,090,665
2032	299,850	329,835	11,290,314	12,419,345
2033	299,525	329,478	11,590,164	12,749,180
2034	317,300	349,030	11,889,689	13,078,658
2035	316,750	348,425	12,206,989	13,427,688
2036	316,225	347,848	12,523,739	13,776,113
2037	315,425	346,968	12,839,964	14,123,960
2038	314,500	345,950	13,155,389	14,470,928
2039	313,850	345,235	13,469,889	14,816,878
2040	338,125	371,938	13,783,739	15,162,113
2041	336,900	370,590	14,121,864	15,534,050
2042	335,375	368,913	14,458,764	15,904,640
2043	333,925	367,318	14,794,139	16,273,553
2044	334,525	367,978	15,128,064	16,640,870
2045	332,875	366,163	15,462,589	17,008,848
2046	331,150	364,265	15,795,464	17,375,010
2047	329,800	362,780	16,126,614	17,739,275
2048	328,475	361,323	16,456,414	18,102,055
2049	0	0	16,784,889	18,463,378
2050	0	0	16,784,889	18,463,378
2051	0	0	16,784,889	18,463,378
2052	0	0	16,784,889	18,463,378
2053	0	0	16,784,889	18,463,378
2054	0	0	16,784,889	18,463,378
2055	0	0	16,784,889	18,463,378
2056	0	0	16,784,889	18,463,378

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Pollutant Parameters

		Gas / Pollutant Default Parameters:		*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

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Pollutant Parameters (Continued)

		Gas / Pollutant Default Parameters:		*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

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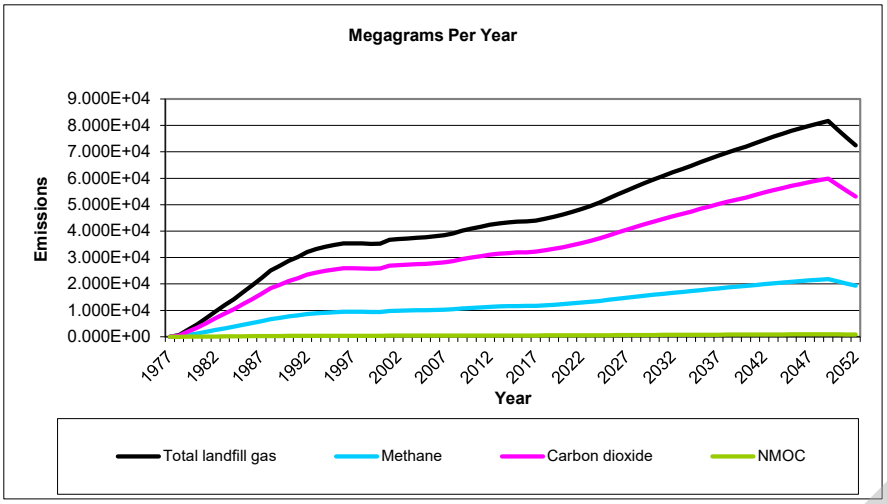
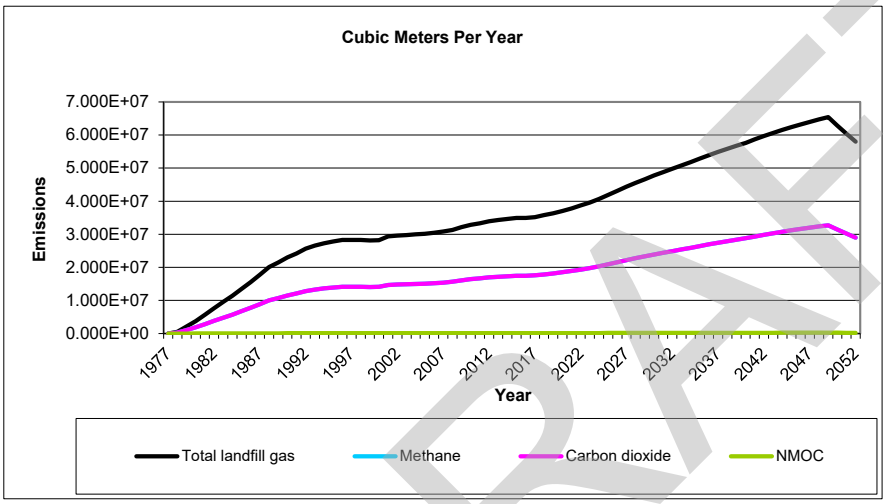
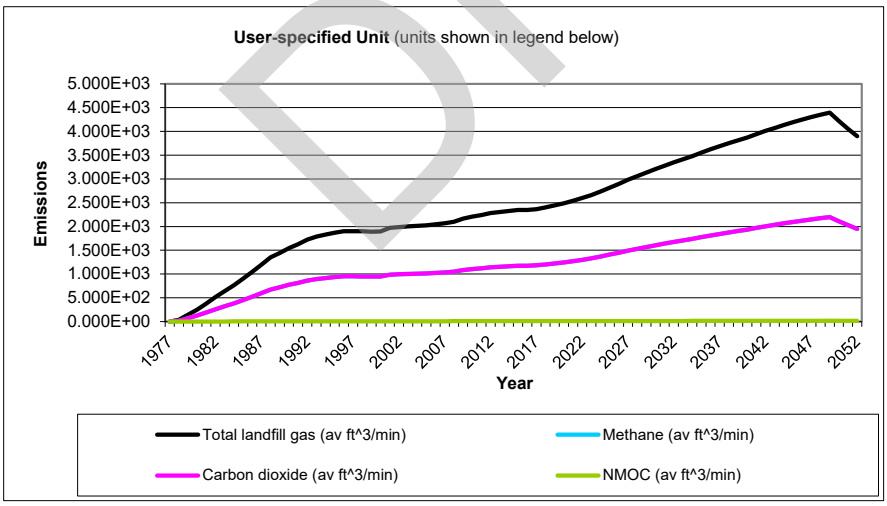
Graphs







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Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1977	0	0	0	0	0	0
1978	6.872E+02	5.503E+05	3.697E+01	1.836E+02	2.751E+05	1.849E+01
1979	2.708E+03	2.168E+06	1.457E+02	7.233E+02	1.084E+06	7.284E+01
1980	4.720E+03	3.779E+06	2.539E+02	1.261E+03	1.890E+06	1.270E+02
1981	7.145E+03	5.721E+06	3.844E+02	1.909E+03	2.861E+06	1.922E+02
1982	9.565E+03	7.659E+06	5.146E+02	2.555E+03	3.830E+06	2.573E+02
1983	1.196E+04	9.577E+06	6.435E+02	3.195E+03	4.788E+06	3.217E+02
1984	1.423E+04	1.140E+07	7.659E+02	3.802E+03	5.699E+06	3.829E+02
1985	1.686E+04	1.350E+07	9.072E+02	4.504E+03	6.751E+06	4.536E+02
1986	1.941E+04	1.554E+07	1.044E+03	5.185E+03	7.771E+06	5.222E+02
1987	2.219E+04	1.776E+07	1.194E+03	5.926E+03	8.882E+06	5.968E+02
1988	2.508E+04	2.008E+07	1.349E+03	6.698E+03	1.004E+07	6.746E+02
1989	2.682E+04	2.148E+07	1.443E+03	7.164E+03	1.074E+07	7.215E+02
1990	2.874E+04	2.301E+07	1.546E+03	7.677E+03	1.151E+07	7.731E+02
1991	3.024E+04	2.422E+07	1.627E+03	8.078E+03	1.211E+07	8.135E+02
1992	3.203E+04	2.564E+07	1.723E+03	8.554E+03	1.282E+07	8.615E+02
1993	3.319E+04	2.658E+07	1.786E+03	8.865E+03	1.329E+07	8.928E+02
1994	3.405E+04	2.726E+07	1.832E+03	9.094E+03	1.363E+07	9.159E+02
1995	3.475E+04	2.783E+07	1.870E+03	9.283E+03	1.391E+07	9.349E+02
1996	3.535E+04	2.830E+07	1.902E+03	9.441E+03	1.415E+07	9.508E+02
1997	3.535E+04	2.830E+07	1.902E+03	9.442E+03	1.415E+07	9.509E+02
1998	3.530E+04	2.826E+07	1.899E+03	9.428E+03	1.413E+07	9.495E+02
1999	3.518E+04	2.817E+07	1.893E+03	9.396E+03	1.408E+07	9.463E+02
2000	3.524E+04	2.822E+07	1.896E+03	9.413E+03	1.411E+07	9.480E+02
2001	3.668E+04	2.937E+07	1.974E+03	9.798E+03	1.469E+07	9.868E+02
2002	3.697E+04	2.960E+07	1.989E+03	9.874E+03	1.480E+07	9.945E+02
2003	3.720E+04	2.979E+07	2.002E+03	9.937E+03	1.489E+07	1.001E+03
2004	3.747E+04	3.000E+07	2.016E+03	1.001E+04	1.500E+07	1.008E+03
2005	3.767E+04	3.016E+07	2.027E+03	1.006E+04	1.508E+07	1.013E+03
2006	3.805E+04	3.047E+07	2.047E+03	1.016E+04	1.523E+07	1.024E+03
2007	3.848E+04	3.081E+07	2.070E+03	1.028E+04	1.541E+07	1.035E+03
2008	3.908E+04	3.129E+07	2.103E+03	1.044E+04	1.565E+07	1.051E+03
2009	4.020E+04	3.219E+07	2.163E+03	1.074E+04	1.610E+07	1.081E+03
2010	4.101E+04	3.284E+07	2.206E+03	1.095E+04	1.642E+07	1.103E+03
2011	4.163E+04	3.334E+07	2.240E+03	1.112E+04	1.667E+07	1.120E+03
2012	4.242E+04	3.397E+07	2.282E+03	1.133E+04	1.698E+07	1.141E+03
2013	4.289E+04	3.434E+07	2.308E+03	1.146E+04	1.717E+07	1.154E+03
2014	4.325E+04	3.464E+07	2.327E+03	1.155E+04	1.732E+07	1.164E+03
2015	4.360E+04	3.491E+07	2.346E+03	1.165E+04	1.746E+07	1.173E+03
2016	4.363E+04	3.494E+07	2.347E+03	1.165E+04	1.747E+07	1.174E+03
2017	4.395E+04	3.520E+07	2.365E+03	1.174E+04	1.760E+07	1.182E+03
2018	4.467E+04	3.577E+07	2.403E+03	1.193E+04	1.788E+07	1.202E+03
2019	4.540E+04	3.635E+07	2.443E+03	1.213E+04	1.818E+07	1.221E+03
2020	4.626E+04	3.704E+07	2.489E+03	1.236E+04	1.852E+07	1.244E+03
2021	4.726E+04	3.784E+07	2.542E+03	1.262E+04	1.892E+07	1.271E+03
2022	4.833E+04	3.870E+07	2.600E+03	1.291E+04	1.935E+07	1.300E+03
2023	4.949E+04	3.963E+07	2.662E+03	1.322E+04	1.981E+07	1.331E+03
2024	5.083E+04	4.071E+07	2.735E+03	1.358E+04	2.035E+07	1.368E+03
2025	5.238E+04	4.195E+07	2.818E+03	1.399E+04	2.097E+07	1.409E+03
2026	5.390E+04	4.316E+07	2.900E+03	1.440E+04	2.158E+07	1.450E+03

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Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2027	5.540E+04	4.436E+07	2.981E+03	1.480E+04	2.218E+07	1.490E+03
2028	5.686E+04	4.553E+07	3.059E+03	1.519E+04	2.277E+07	1.530E+03
2029	5.828E+04	4.667E+07	3.136E+03	1.557E+04	2.333E+07	1.568E+03
2030	5.964E+04	4.776E+07	3.209E+03	1.593E+04	2.388E+07	1.605E+03
2031	6.097E+04	4.882E+07	3.280E+03	1.628E+04	2.441E+07	1.640E+03
2032	6.224E+04	4.984E+07	3.349E+03	1.663E+04	2.492E+07	1.674E+03
2033	6.348E+04	5.083E+07	3.415E+03	1.696E+04	2.542E+07	1.708E+03
2034	6.466E+04	5.178E+07	3.479E+03	1.727E+04	2.589E+07	1.740E+03
2035	6.602E+04	5.287E+07	3.552E+03	1.763E+04	2.643E+07	1.776E+03
2036	6.732E+04	5.390E+07	3.622E+03	1.798E+04	2.695E+07	1.811E+03
2037	6.856E+04	5.490E+07	3.688E+03	1.831E+04	2.745E+07	1.844E+03
2038	6.974E+04	5.584E+07	3.752E+03	1.863E+04	2.792E+07	1.876E+03
2039	7.086E+04	5.674E+07	3.812E+03	1.893E+04	2.837E+07	1.906E+03
2040	7.193E+04	5.760E+07	3.870E+03	1.921E+04	2.880E+07	1.935E+03
2041	7.326E+04	5.866E+07	3.941E+03	1.957E+04	2.933E+07	1.971E+03
2042	7.452E+04	5.967E+07	4.009E+03	1.990E+04	2.984E+07	2.005E+03
2043	7.571E+04	6.063E+07	4.073E+03	2.022E+04	3.031E+07	2.037E+03
2044	7.684E+04	6.153E+07	4.134E+03	2.052E+04	3.076E+07	2.067E+03
2045	7.793E+04	6.240E+07	4.193E+03	2.082E+04	3.120E+07	2.096E+03
2046	7.896E+04	6.322E+07	4.248E+03	2.109E+04	3.161E+07	2.124E+03
2047	7.992E+04	6.400E+07	4.300E+03	2.135E+04	3.200E+07	2.150E+03
2048	8.083E+04	6.473E+07	4.349E+03	2.159E+04	3.236E+07	2.175E+03
2049	8.169E+04	6.542E+07	4.395E+03	2.182E+04	3.271E+07	2.198E+03
2050	7.849E+04	6.285E+07	4.223E+03	2.097E+04	3.143E+07	2.111E+03
2051	7.541E+04	6.039E+07	4.057E+03	2.014E+04	3.019E+07	2.029E+03
2052	7.246E+04	5.802E+07	3.898E+03	1.935E+04	2.901E+07	1.949E+03
2053	6.961E+04	5.574E+07	3.745E+03	1.859E+04	2.787E+07	1.873E+03
2054	6.688E+04	5.356E+07	3.599E+03	1.787E+04	2.678E+07	1.799E+03
2055	6.426E+04	5.146E+07	3.457E+03	1.717E+04	2.573E+07	1.729E+03
2056	6.174E+04	4.944E+07	3.322E+03	1.649E+04	2.472E+07	1.661E+03
2057	5.932E+04	4.750E+07	3.192E+03	1.585E+04	2.375E+07	1.596E+03
2058	5.700E+04	4.564E+07	3.066E+03	1.522E+04	2.282E+07	1.533E+03
2059	5.476E+04	4.385E+07	2.946E+03	1.463E+04	2.192E+07	1.473E+03
2060	5.261E+04	4.213E+07	2.831E+03	1.405E+04	2.107E+07	1.415E+03
2061	5.055E+04	4.048E+07	2.720E+03	1.350E+04	2.024E+07	1.360E+03
2062	4.857E+04	3.889E+07	2.613E+03	1.297E+04	1.945E+07	1.307E+03
2063	4.666E+04	3.737E+07	2.511E+03	1.246E+04	1.868E+07	1.255E+03
2064	4.483E+04	3.590E+07	2.412E+03	1.198E+04	1.795E+07	1.206E+03
2065	4.308E+04	3.449E+07	2.318E+03	1.151E+04	1.725E+07	1.159E+03
2066	4.139E+04	3.314E+07	2.227E+03	1.105E+04	1.657E+07	1.113E+03
2067	3.976E+04	3.184E+07	2.139E+03	1.062E+04	1.592E+07	1.070E+03
2068	3.821E+04	3.059E+07	2.056E+03	1.020E+04	1.530E+07	1.028E+03
2069	3.671E+04	2.939E+07	1.975E+03	9.805E+03	1.470E+07	9.875E+02
2070	3.527E+04	2.824E+07	1.897E+03	9.420E+03	1.412E+07	9.487E+02
2071	3.388E+04	2.713E+07	1.823E+03	9.051E+03	1.357E+07	9.115E+02
2072	3.256E+04	2.607E+07	1.752E+03	8.696E+03	1.303E+07	8.758E+02
2073	3.128E+04	2.505E+07	1.683E+03	8.355E+03	1.252E+07	8.415E+02
2074	3.005E+04	2.407E+07	1.617E+03	8.028E+03	1.203E+07	8.085E+02
2075	2.887E+04	2.312E+07	1.554E+03	7.713E+03	1.156E+07	7.768E+02
2076	2.774E+04	2.221E+07	1.493E+03	7.410E+03	1.111E+07	7.463E+02
2077	2.665E+04	2.134E+07	1.434E+03	7.120E+03	1.067E+07	7.170E+02

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Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2078	2.561E+04	2.051E+07	1.378E+03	6.841E+03	1.025E+07	6.889E+02
2079	2.461E+04	1.970E+07	1.324E+03	6.572E+03	9.851E+06	6.619E+02
2080	2.364E+04	1.893E+07	1.272E+03	6.315E+03	9.465E+06	6.360E+02
2081	2.271E+04	1.819E+07	1.222E+03	6.067E+03	9.094E+06	6.110E+02
2082	2.182E+04	1.747E+07	1.174E+03	5.829E+03	8.737E+06	5.871E+02
2083	2.097E+04	1.679E+07	1.128E+03	5.601E+03	8.395E+06	5.640E+02
2084	2.015E+04	1.613E+07	1.084E+03	5.381E+03	8.066E+06	5.419E+02
2085	1.936E+04	1.550E+07	1.041E+03	5.170E+03	7.749E+06	5.207E+02
2086	1.860E+04	1.489E+07	1.001E+03	4.967E+03	7.446E+06	5.003E+02
2087	1.787E+04	1.431E+07	9.613E+02	4.773E+03	7.154E+06	4.807E+02
2088	1.717E+04	1.375E+07	9.236E+02	4.585E+03	6.873E+06	4.618E+02
2089	1.649E+04	1.321E+07	8.874E+02	4.406E+03	6.604E+06	4.437E+02
2090	1.585E+04	1.269E+07	8.526E+02	4.233E+03	6.345E+06	4.263E+02
2091	1.523E+04	1.219E+07	8.192E+02	4.067E+03	6.096E+06	4.096E+02
2092	1.463E+04	1.171E+07	7.870E+02	3.907E+03	5.857E+06	3.935E+02
2093	1.405E+04	1.125E+07	7.562E+02	3.754E+03	5.627E+06	3.781E+02
2094	1.350E+04	1.081E+07	7.265E+02	3.607E+03	5.407E+06	3.633E+02
2095	1.297E+04	1.039E+07	6.980E+02	3.466E+03	5.195E+06	3.490E+02
2096	1.247E+04	9.982E+06	6.707E+02	3.330E+03	4.991E+06	3.353E+02
2097	1.198E+04	9.590E+06	6.444E+02	3.199E+03	4.795E+06	3.222E+02
2098	1.151E+04	9.214E+06	6.191E+02	3.074E+03	4.607E+06	3.096E+02
2099	1.106E+04	8.853E+06	5.948E+02	2.953E+03	4.427E+06	2.974E+02
2100	1.062E+04	8.506E+06	5.715E+02	2.837E+03	4.253E+06	2.858E+02
2101	1.021E+04	8.172E+06	5.491E+02	2.726E+03	4.086E+06	2.746E+02
2102	9.806E+03	7.852E+06	5.276E+02	2.619E+03	3.926E+06	2.638E+02
2103	9.421E+03	7.544E+06	5.069E+02	2.517E+03	3.772E+06	2.534E+02
2104	9.052E+03	7.248E+06	4.870E+02	2.418E+03	3.624E+06	2.435E+02
2105	8.697E+03	6.964E+06	4.679E+02	2.323E+03	3.482E+06	2.340E+02
2106	8.356E+03	6.691E+06	4.496E+02	2.232E+03	3.346E+06	2.248E+02
2107	8.028E+03	6.429E+06	4.319E+02	2.144E+03	3.214E+06	2.160E+02
2108	7.713E+03	6.177E+06	4.150E+02	2.060E+03	3.088E+06	2.075E+02
2109	7.411E+03	5.934E+06	3.987E+02	1.980E+03	2.967E+06	1.994E+02
2110	7.120E+03	5.702E+06	3.831E+02	1.902E+03	2.851E+06	1.915E+02
2111	6.841E+03	5.478E+06	3.681E+02	1.827E+03	2.739E+06	1.840E+02
2112	6.573E+03	5.263E+06	3.536E+02	1.756E+03	2.632E+06	1.768E+02
2113	6.315E+03	5.057E+06	3.398E+02	1.687E+03	2.528E+06	1.699E+02
2114	6.068E+03	4.859E+06	3.265E+02	1.621E+03	2.429E+06	1.632E+02
2115	5.830E+03	4.668E+06	3.137E+02	1.557E+03	2.334E+06	1.568E+02
2116	5.601E+03	4.485E+06	3.014E+02	1.496E+03	2.243E+06	1.507E+02
2117	5.382E+03	4.309E+06	2.895E+02	1.437E+03	2.155E+06	1.448E+02

DRAFT

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1977	0	0	0	0	0	0
1978	5.036E+02	2.751E+05	1.849E+01	7.890E+00	2.201E+03	1.479E-01
1979	1.985E+03	1.084E+06	7.284E+01	3.109E+01	8.673E+03	5.827E-01
1980	3.459E+03	1.890E+06	1.270E+02	5.419E+01	1.512E+04	1.016E+00
1981	5.237E+03	2.861E+06	1.922E+02	8.203E+01	2.289E+04	1.538E+00
1982	7.010E+03	3.830E+06	2.573E+02	1.098E+02	3.064E+04	2.059E+00
1983	8.765E+03	4.788E+06	3.217E+02	1.373E+02	3.831E+04	2.574E+00
1984	1.043E+04	5.699E+06	3.829E+02	1.634E+02	4.559E+04	3.063E+00
1985	1.236E+04	6.751E+06	4.536E+02	1.936E+02	5.401E+04	3.629E+00
1986	1.423E+04	7.771E+06	5.222E+02	2.228E+02	6.217E+04	4.177E+00
1987	1.626E+04	8.882E+06	5.968E+02	2.547E+02	7.106E+04	4.774E+00
1988	1.838E+04	1.004E+07	6.746E+02	2.879E+02	8.032E+04	5.397E+00
1989	1.966E+04	1.074E+07	7.215E+02	3.079E+02	8.590E+04	5.772E+00
1990	2.106E+04	1.151E+07	7.731E+02	3.300E+02	9.205E+04	6.185E+00
1991	2.216E+04	1.211E+07	8.135E+02	3.472E+02	9.687E+04	6.508E+00
1992	2.347E+04	1.282E+07	8.615E+02	3.677E+02	1.026E+05	6.892E+00
1993	2.432E+04	1.329E+07	8.928E+02	3.810E+02	1.063E+05	7.143E+00
1994	2.495E+04	1.363E+07	9.159E+02	3.909E+02	1.090E+05	7.327E+00
1995	2.547E+04	1.391E+07	9.349E+02	3.990E+02	1.113E+05	7.480E+00
1996	2.590E+04	1.415E+07	9.508E+02	4.058E+02	1.132E+05	7.607E+00
1997	2.591E+04	1.415E+07	9.509E+02	4.058E+02	1.132E+05	7.607E+00
1998	2.587E+04	1.413E+07	9.495E+02	4.052E+02	1.131E+05	7.596E+00
1999	2.578E+04	1.408E+07	9.463E+02	4.039E+02	1.127E+05	7.570E+00
2000	2.583E+04	1.411E+07	9.480E+02	4.046E+02	1.129E+05	7.584E+00
2001	2.688E+04	1.469E+07	9.868E+02	4.211E+02	1.175E+05	7.894E+00
2002	2.709E+04	1.480E+07	9.945E+02	4.244E+02	1.184E+05	7.956E+00
2003	2.726E+04	1.489E+07	1.001E+03	4.271E+02	1.192E+05	8.006E+00
2004	2.746E+04	1.500E+07	1.008E+03	4.302E+02	1.200E+05	8.063E+00
2005	2.761E+04	1.508E+07	1.013E+03	4.325E+02	1.207E+05	8.107E+00
2006	2.788E+04	1.523E+07	1.024E+03	4.368E+02	1.219E+05	8.188E+00
2007	2.820E+04	1.541E+07	1.035E+03	4.418E+02	1.233E+05	8.281E+00
2008	2.864E+04	1.565E+07	1.051E+03	4.487E+02	1.252E+05	8.410E+00
2009	2.946E+04	1.610E+07	1.081E+03	4.615E+02	1.288E+05	8.652E+00
2010	3.005E+04	1.642E+07	1.103E+03	4.708E+02	1.314E+05	8.825E+00
2011	3.051E+04	1.667E+07	1.120E+03	4.780E+02	1.334E+05	8.960E+00
2012	3.109E+04	1.698E+07	1.141E+03	4.870E+02	1.359E+05	9.129E+00
2013	3.143E+04	1.717E+07	1.154E+03	4.924E+02	1.374E+05	9.230E+00
2014	3.170E+04	1.732E+07	1.164E+03	4.966E+02	1.385E+05	9.309E+00
2015	3.195E+04	1.746E+07	1.173E+03	5.006E+02	1.397E+05	9.383E+00
2016	3.197E+04	1.747E+07	1.174E+03	5.009E+02	1.397E+05	9.389E+00
2017	3.221E+04	1.760E+07	1.182E+03	5.046E+02	1.408E+05	9.459E+00
2018	3.274E+04	1.788E+07	1.202E+03	5.129E+02	1.431E+05	9.613E+00
2019	3.327E+04	1.818E+07	1.221E+03	5.212E+02	1.454E+05	9.770E+00
2020	3.390E+04	1.852E+07	1.244E+03	5.311E+02	1.482E+05	9.956E+00
2021	3.463E+04	1.892E+07	1.271E+03	5.426E+02	1.514E+05	1.017E+01
2022	3.542E+04	1.935E+07	1.300E+03	5.549E+02	1.548E+05	1.040E+01
2023	3.627E+04	1.981E+07	1.331E+03	5.682E+02	1.585E+05	1.065E+01
2024	3.726E+04	2.035E+07	1.368E+03	5.836E+02	1.628E+05	1.094E+01
2025	3.839E+04	2.097E+07	1.409E+03	6.014E+02	1.678E+05	1.127E+01
2026	3.950E+04	2.158E+07	1.450E+03	6.188E+02	1.726E+05	1.160E+01

DRAFT

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2027	4.060E+04	2.218E+07	1.490E+03	6.361E+02	1.775E+05	1.192E+01
2028	4.167E+04	2.277E+07	1.530E+03	6.529E+02	1.821E+05	1.224E+01
2029	4.271E+04	2.333E+07	1.568E+03	6.691E+02	1.867E+05	1.254E+01
2030	4.371E+04	2.388E+07	1.605E+03	6.848E+02	1.910E+05	1.284E+01
2031	4.468E+04	2.441E+07	1.640E+03	7.000E+02	1.953E+05	1.312E+01
2032	4.562E+04	2.492E+07	1.674E+03	7.146E+02	1.994E+05	1.339E+01
2033	4.652E+04	2.542E+07	1.708E+03	7.288E+02	2.033E+05	1.366E+01
2034	4.739E+04	2.589E+07	1.740E+03	7.424E+02	2.071E+05	1.392E+01
2035	4.838E+04	2.643E+07	1.776E+03	7.580E+02	2.115E+05	1.421E+01
2036	4.934E+04	2.695E+07	1.811E+03	7.729E+02	2.156E+05	1.449E+01
2037	5.024E+04	2.745E+07	1.844E+03	7.871E+02	2.196E+05	1.475E+01
2038	5.111E+04	2.792E+07	1.876E+03	8.007E+02	2.234E+05	1.501E+01
2039	5.193E+04	2.837E+07	1.906E+03	8.135E+02	2.270E+05	1.525E+01
2040	5.272E+04	2.880E+07	1.935E+03	8.258E+02	2.304E+05	1.548E+01
2041	5.369E+04	2.933E+07	1.971E+03	8.411E+02	2.346E+05	1.577E+01
2042	5.461E+04	2.984E+07	2.005E+03	8.556E+02	2.387E+05	1.604E+01
2043	5.549E+04	3.031E+07	2.037E+03	8.692E+02	2.425E+05	1.629E+01
2044	5.631E+04	3.076E+07	2.067E+03	8.822E+02	2.461E+05	1.654E+01
2045	5.711E+04	3.120E+07	2.096E+03	8.947E+02	2.496E+05	1.677E+01
2046	5.787E+04	3.161E+07	2.124E+03	9.065E+02	2.529E+05	1.699E+01
2047	5.857E+04	3.200E+07	2.150E+03	9.176E+02	2.560E+05	1.720E+01
2048	5.924E+04	3.236E+07	2.175E+03	9.281E+02	2.589E+05	1.740E+01
2049	5.987E+04	3.271E+07	2.198E+03	9.379E+02	2.617E+05	1.758E+01
2050	5.752E+04	3.143E+07	2.111E+03	9.011E+02	2.514E+05	1.689E+01
2051	5.527E+04	3.019E+07	2.029E+03	8.658E+02	2.415E+05	1.623E+01
2052	5.310E+04	2.901E+07	1.949E+03	8.319E+02	2.321E+05	1.559E+01
2053	5.102E+04	2.787E+07	1.873E+03	7.992E+02	2.230E+05	1.498E+01
2054	4.902E+04	2.678E+07	1.799E+03	7.679E+02	2.142E+05	1.439E+01
2055	4.710E+04	2.573E+07	1.729E+03	7.378E+02	2.058E+05	1.383E+01
2056	4.525E+04	2.472E+07	1.661E+03	7.089E+02	1.978E+05	1.329E+01
2057	4.348E+04	2.375E+07	1.596E+03	6.811E+02	1.900E+05	1.277E+01
2058	4.177E+04	2.282E+07	1.533E+03	6.544E+02	1.826E+05	1.227E+01
2059	4.013E+04	2.192E+07	1.473E+03	6.287E+02	1.754E+05	1.179E+01
2060	3.856E+04	2.107E+07	1.415E+03	6.041E+02	1.685E+05	1.132E+01
2061	3.705E+04	2.024E+07	1.360E+03	5.804E+02	1.619E+05	1.088E+01
2062	3.560E+04	1.945E+07	1.307E+03	5.576E+02	1.556E+05	1.045E+01
2063	3.420E+04	1.868E+07	1.255E+03	5.358E+02	1.495E+05	1.004E+01
2064	3.286E+04	1.795E+07	1.206E+03	5.147E+02	1.436E+05	9.649E+00
2065	3.157E+04	1.725E+07	1.159E+03	4.946E+02	1.380E+05	9.270E+00
2066	3.033E+04	1.657E+07	1.113E+03	4.752E+02	1.326E+05	8.907E+00
2067	2.914E+04	1.592E+07	1.070E+03	4.565E+02	1.274E+05	8.558E+00
2068	2.800E+04	1.530E+07	1.028E+03	4.386E+02	1.224E+05	8.222E+00
2069	2.690E+04	1.470E+07	9.875E+02	4.214E+02	1.176E+05	7.900E+00
2070	2.585E+04	1.412E+07	9.487E+02	4.049E+02	1.130E+05	7.590E+00
2071	2.483E+04	1.357E+07	9.115E+02	3.890E+02	1.085E+05	7.292E+00
2072	2.386E+04	1.303E+07	8.758E+02	3.738E+02	1.043E+05	7.006E+00
2073	2.292E+04	1.252E+07	8.415E+02	3.591E+02	1.002E+05	6.732E+00
2074	2.203E+04	1.203E+07	8.085E+02	3.450E+02	9.626E+04	6.468E+00
2075	2.116E+04	1.156E+07	7.768E+02	3.315E+02	9.249E+04	6.214E+00
2076	2.033E+04	1.111E+07	7.463E+02	3.185E+02	8.886E+04	5.970E+00
2077	1.953E+04	1.067E+07	7.170E+02	3.060E+02	8.538E+04	5.736E+00

DRAFT

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2078	1.877E+04	1.025E+07	6.889E+02	2.940E+02	8.203E+04	5.511E+00
2079	1.803E+04	9.851E+06	6.619E+02	2.825E+02	7.881E+04	5.295E+00
2080	1.733E+04	9.465E+06	6.360E+02	2.714E+02	7.572E+04	5.088E+00
2081	1.665E+04	9.094E+06	6.110E+02	2.608E+02	7.275E+04	4.888E+00
2082	1.599E+04	8.737E+06	5.871E+02	2.506E+02	6.990E+04	4.697E+00
2083	1.537E+04	8.395E+06	5.640E+02	2.407E+02	6.716E+04	4.512E+00
2084	1.476E+04	8.066E+06	5.419E+02	2.313E+02	6.453E+04	4.335E+00
2085	1.419E+04	7.749E+06	5.207E+02	2.222E+02	6.200E+04	4.165E+00
2086	1.363E+04	7.446E+06	5.003E+02	2.135E+02	5.956E+04	4.002E+00
2087	1.309E+04	7.154E+06	4.807E+02	2.051E+02	5.723E+04	3.845E+00
2088	1.258E+04	6.873E+06	4.618E+02	1.971E+02	5.498E+04	3.694E+00
2089	1.209E+04	6.604E+06	4.437E+02	1.894E+02	5.283E+04	3.550E+00
2090	1.161E+04	6.345E+06	4.263E+02	1.819E+02	5.076E+04	3.410E+00
2091	1.116E+04	6.096E+06	4.096E+02	1.748E+02	4.877E+04	3.277E+00
2092	1.072E+04	5.857E+06	3.935E+02	1.680E+02	4.686E+04	3.148E+00
2093	1.030E+04	5.627E+06	3.781E+02	1.614E+02	4.502E+04	3.025E+00
2094	9.897E+03	5.407E+06	3.633E+02	1.550E+02	4.325E+04	2.906E+00
2095	9.509E+03	5.195E+06	3.490E+02	1.490E+02	4.156E+04	2.792E+00
2096	9.136E+03	4.991E+06	3.353E+02	1.431E+02	3.993E+04	2.683E+00
2097	8.778E+03	4.795E+06	3.222E+02	1.375E+02	3.836E+04	2.578E+00
2098	8.433E+03	4.607E+06	3.096E+02	1.321E+02	3.686E+04	2.476E+00
2099	8.103E+03	4.427E+06	2.974E+02	1.269E+02	3.541E+04	2.379E+00
2100	7.785E+03	4.253E+06	2.858E+02	1.220E+02	3.402E+04	2.286E+00
2101	7.480E+03	4.086E+06	2.746E+02	1.172E+02	3.269E+04	2.196E+00
2102	7.187E+03	3.926E+06	2.638E+02	1.126E+02	3.141E+04	2.110E+00
2103	6.905E+03	3.772E+06	2.534E+02	1.082E+02	3.018E+04	2.028E+00
2104	6.634E+03	3.624E+06	2.435E+02	1.039E+02	2.899E+04	1.948E+00
2105	6.374E+03	3.482E+06	2.340E+02	9.985E+01	2.786E+04	1.872E+00
2106	6.124E+03	3.346E+06	2.248E+02	9.593E+01	2.676E+04	1.798E+00
2107	5.884E+03	3.214E+06	2.160E+02	9.217E+01	2.571E+04	1.728E+00
2108	5.653E+03	3.088E+06	2.075E+02	8.856E+01	2.471E+04	1.660E+00
2109	5.431E+03	2.967E+06	1.994E+02	8.509E+01	2.374E+04	1.595E+00
2110	5.218E+03	2.851E+06	1.915E+02	8.175E+01	2.281E+04	1.532E+00
2111	5.014E+03	2.739E+06	1.840E+02	7.854E+01	2.191E+04	1.472E+00
2112	4.817E+03	2.632E+06	1.768E+02	7.547E+01	2.105E+04	1.415E+00
2113	4.628E+03	2.528E+06	1.699E+02	7.251E+01	2.023E+04	1.359E+00
2114	4.447E+03	2.429E+06	1.632E+02	6.966E+01	1.943E+04	1.306E+00
2115	4.273E+03	2.334E+06	1.568E+02	6.693E+01	1.867E+04	1.255E+00
2116	4.105E+03	2.243E+06	1.507E+02	6.431E+01	1.794E+04	1.205E+00
2117	3.944E+03	2.155E+06	1.448E+02	6.179E+01	1.724E+04	1.158E+00

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Summary Report

Landfill Name or Identifier: W12A Landfill - LFG Collection Model

Date: April 24, 2020

Description/Comments:
Uses MECP Values for Lo and k. Reduce the tonnage of CR&D residuals to 75% to account for low organic content of residuals. Excludes Cells 1, 2, and 3 where gas collection infrastructure is not installed.

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About LandGEM:

First-Order Decomposition Rate Equation: $$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation ($m^3/year$)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate ($year^{-1}$)
L_o = potential methane generation capacity (m^3/Mg)
M_i = mass of waste accepted in the i^{th} year (Mg)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1984**	
Landfill Closure Year (with 80-year limit)	**2048**	
Actual Closure Year (without limit)	***2048***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.040**	$year^{-1}$
Potential Methane Generation Capacity, L_o	**125**	m^3/Mg
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1984	259,652	285,617	0	0
1985	261,658	287,824	259,652	285,617
1986	288,278	317,106	521,310	573,441
1987	306,644	337,308	809,588	890,547
1988	222,214	244,435	1,116,232	1,227,855
1989	242,313	266,544	1,338,446	1,472,291
1990	214,344	235,778	1,580,759	1,738,835
1991	242,087	266,296	1,795,103	1,974,613
1992	197,185	216,904	2,037,190	2,240,909
1993	175,900	193,490	2,234,375	2,457,813
1994	166,681	183,349	2,410,275	2,651,303
1995	159,278	175,206	2,576,956	2,834,652
1996	113,160	124,476	2,736,234	3,009,857
1997	108,734	119,607	2,849,394	3,134,333
1998	103,031	113,334	2,958,128	3,253,941
1999	117,600	129,360	3,061,159	3,367,275
2000	230,240	253,264	3,178,759	3,496,635
2001	140,628	154,691	3,408,999	3,749,899
2002	137,232	150,955	3,549,627	3,904,590
2003	140,549	154,604	3,686,859	4,055,545
2004	136,368	150,005	3,827,408	4,210,149
2005	151,146	166,261	3,963,776	4,360,154
2006	156,941	172,635	4,114,922	4,526,414
2007	171,734	188,907	4,271,863	4,699,049
2008	216,407	238,048	4,443,597	4,887,957
2009	194,369	213,806	4,660,004	5,126,004
2010	182,006	200,207	4,854,373	5,339,810
2011	197,032	216,735	5,036,379	5,540,017
2012	174,005	191,406	5,233,411	5,756,752
2013	166,948	183,643	5,407,416	5,948,158
2014	166,504	183,155	5,574,365	6,131,801
2015	141,576	155,734	5,740,869	6,314,956
2016	165,925	182,518	5,882,445	6,470,689
2017	198,907	218,797	6,048,370	6,653,207
2018	202,323	222,555	6,247,277	6,872,004
2019	215,312	236,843	6,449,599	7,094,559
2020	229,050	251,955	6,664,911	7,331,402
2021	238,750	262,625	6,893,961	7,583,357
2022	248,625	273,488	7,132,711	7,845,982
2023	268,100	294,910	7,381,336	8,119,469

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WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
2024	288,775	317,653	7,649,436	8,414,379
2025	290,975	320,073	7,938,211	8,732,032
2026	294,850	324,335	8,229,186	9,052,104
2027	296,275	325,903	8,524,036	9,376,439
2028	297,100	326,810	8,820,311	9,702,342
2029	297,650	327,415	9,117,411	10,029,152
2030	298,375	328,213	9,415,061	10,356,567
2031	298,800	328,680	9,713,436	10,684,779
2032	299,850	329,835	10,012,236	11,013,459
2033	299,525	329,478	10,312,086	11,343,294
2034	317,300	349,030	10,611,611	11,672,772
2035	316,750	348,425	10,928,911	12,021,802
2036	316,225	347,848	11,245,661	12,370,227
2037	315,425	346,968	11,561,886	12,718,074
2038	314,500	345,950	11,877,311	13,065,042
2039	313,850	345,235	12,191,811	13,410,992
2040	338,125	371,938	12,505,661	13,756,227
2041	336,900	370,590	12,843,786	14,128,164
2042	335,375	368,913	13,180,686	14,498,754
2043	333,925	367,318	13,516,061	14,867,667
2044	334,525	367,978	13,849,986	15,234,984
2045	332,875	366,163	14,184,511	15,602,962
2046	331,150	364,265	14,517,386	15,969,124
2047	329,800	362,780	14,848,536	16,333,389
2048	328,475	361,323	15,178,336	16,696,169
2049	0	0	15,506,811	17,057,492
2050	0	0	15,506,811	17,057,492
2051	0	0	15,506,811	17,057,492
2052	0	0	15,506,811	17,057,492
2053	0	0	15,506,811	17,057,492
2054	0	0	15,506,811	17,057,492
2055	0	0	15,506,811	17,057,492
2056	0	0	15,506,811	17,057,492
2057	0	0	15,506,811	17,057,492
2058	0	0	15,506,811	17,057,492
2059	0	0	15,506,811	17,057,492
2060	0	0	15,506,811	17,057,492
2061	0	0	15,506,811	17,057,492
2062	0	0	15,506,811	17,057,492
2063	0	0	15,506,811	17,057,492

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Pollutant Parameters

		Gas / Pollutant Default Parameters:		*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Gases	Total landfill gas		0.00		
	Methane		16.04		
	Carbon dioxide		44.01		
	NMOC	4,000	86.18		
Pollutants	1,1,1-Trichloroethane (methyl chloroform) - HAP	0.48	133.41		
	1,1,2,2-Tetrachloroethane - HAP/VOC	1.1	167.85		
	1,1-Dichloroethane (ethylidene dichloride) - HAP/VOC	2.4	98.97		
	1,1-Dichloroethene (vinylidene chloride) - HAP/VOC	0.20	96.94		
	1,2-Dichloroethane (ethylene dichloride) - HAP/VOC	0.41	98.96		
	1,2-Dichloropropane (propylene dichloride) - HAP/VOC	0.18	112.99		
	2-Propanol (isopropyl alcohol) - VOC	50	60.11		
	Acetone	7.0	58.08		
	Acrylonitrile - HAP/VOC	6.3	53.06		
	Benzene - No or Unknown Co-disposal - HAP/VOC	1.9	78.11		
	Benzene - Co-disposal - HAP/VOC	11	78.11		
	Bromodichloromethane - VOC	3.1	163.83		
	Butane - VOC	5.0	58.12		
	Carbon disulfide - HAP/VOC	0.58	76.13		
	Carbon monoxide	140	28.01		
	Carbon tetrachloride - HAP/VOC	4.0E-03	153.84		
	Carbonyl sulfide - HAP/VOC	0.49	60.07		
	Chlorobenzene - HAP/VOC	0.25	112.56		
	Chlorodifluoromethane	1.3	86.47		
	Chloroethane (ethyl chloride) - HAP/VOC	1.3	64.52		
	Chloroform - HAP/VOC	0.03	119.39		
	Chloromethane - VOC	1.2	50.49		
	Dichlorobenzene - (HAP for para isomer/VOC)	0.21	147		
	Dichlorodifluoromethane	16	120.91		
	Dichlorofluoromethane - VOC	2.6	102.92		
	Dichloromethane (methylene chloride) - HAP	14	84.94		
	Dimethyl sulfide (methyl sulfide) - VOC	7.8	62.13		
	Ethane	890	30.07		
	Ethanol - VOC	27	46.08		

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Pollutant Parameters (Continued)

		Gas / Pollutant Default Parameters:		*User-specified Pollutant Parameters:*	
	Compound	Concentration (*ppmv*)	Molecular Weight	Concentration (*ppmv*)	Molecular Weight
Pollutants	Ethyl mercaptan (ethanethiol) - VOC	2.3	62.13		
	Ethylbenzene - HAP/VOC	4.6	106.16		
	Ethylene dibromide - HAP/VOC	1.0E-03	187.88		
	Fluorotrichloromethane - VOC	0.76	137.38		
	Hexane - HAP/VOC	6.6	86.18		
	Hydrogen sulfide	36	34.08		
	Mercury (total) - HAP	2.9E-04	200.61		
	Methyl ethyl ketone - HAP/VOC	7.1	72.11		
	Methyl isobutyl ketone - HAP/VOC	1.9	100.16		
	Methyl mercaptan - VOC	2.5	48.11		
	Pentane - VOC	3.3	72.15		
	Perchloroethylene (tetrachloroethylene) - HAP	3.7	165.83		
	Propane - VOC	11	44.09		
	t-1,2-Dichloroethene - VOC	2.8	96.94		
	Toluene - No or Unknown Co-disposal - HAP/VOC	39	92.13		
	Toluene - Co-disposal - HAP/VOC	170	92.13		
	Trichloroethylene (trichloroethene) - HAP/VOC	2.8	131.40		
	Vinyl chloride - HAP/VOC	7.3	62.50		
	Xylenes - HAP/VOC	12	106.16		

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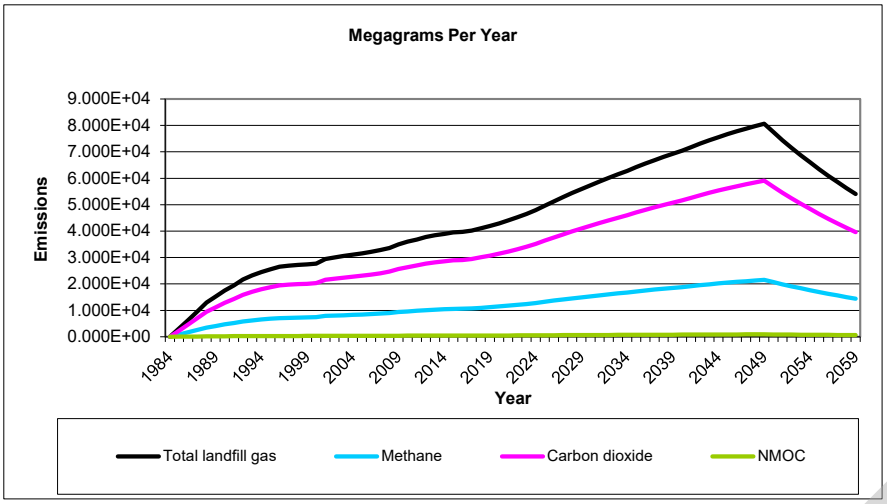
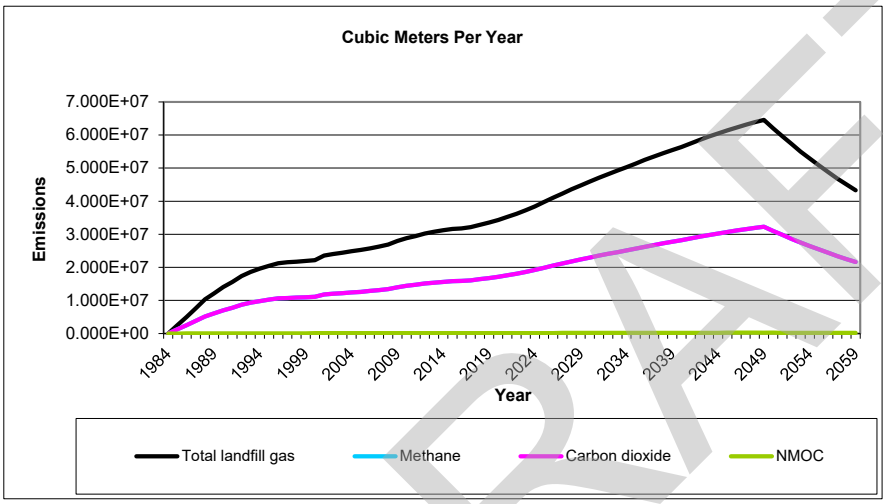
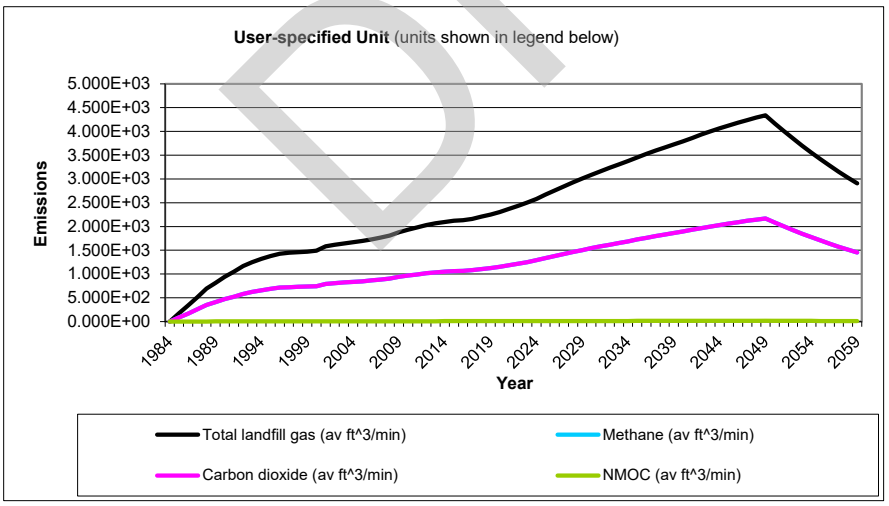
Graphs







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Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1984	0	0	0	0	0	0
1985	3.185E+03	2.550E+06	1.714E+02	8.507E+02	1.275E+06	8.568E+01
1986	6.270E+03	5.020E+06	3.373E+02	1.675E+03	2.510E+06	1.687E+02
1987	9.560E+03	7.655E+06	5.143E+02	2.554E+03	3.828E+06	2.572E+02
1988	1.295E+04	1.037E+07	6.966E+02	3.458E+03	5.183E+06	3.483E+02
1989	1.516E+04	1.214E+07	8.159E+02	4.051E+03	6.072E+06	4.079E+02
1990	1.754E+04	1.405E+07	9.438E+02	4.686E+03	7.023E+06	4.719E+02
1991	1.948E+04	1.560E+07	1.048E+03	5.204E+03	7.801E+06	5.241E+02
1992	2.169E+04	1.737E+07	1.167E+03	5.793E+03	8.684E+06	5.835E+02
1993	2.326E+04	1.862E+07	1.251E+03	6.212E+03	9.312E+06	6.257E+02
1994	2.450E+04	1.962E+07	1.318E+03	6.545E+03	9.810E+06	6.592E+02
1995	2.559E+04	2.049E+07	1.377E+03	6.835E+03	1.024E+07	6.883E+02
1996	2.654E+04	2.125E+07	1.428E+03	7.088E+03	1.062E+07	7.139E+02
1997	2.688E+04	2.153E+07	1.446E+03	7.181E+03	1.076E+07	7.232E+02
1998	2.716E+04	2.175E+07	1.462E+03	7.256E+03	1.088E+07	7.308E+02
1999	2.736E+04	2.191E+07	1.472E+03	7.309E+03	1.096E+07	7.361E+02
2000	2.773E+04	2.221E+07	1.492E+03	7.408E+03	1.110E+07	7.460E+02
2001	2.947E+04	2.360E+07	1.586E+03	7.872E+03	1.180E+07	7.928E+02
2002	3.004E+04	2.405E+07	1.616E+03	8.024E+03	1.203E+07	8.081E+02
2003	3.054E+04	2.446E+07	1.643E+03	8.159E+03	1.223E+07	8.217E+02
2004	3.107E+04	2.488E+07	1.672E+03	8.299E+03	1.244E+07	8.358E+02
2005	3.153E+04	2.524E+07	1.696E+03	8.421E+03	1.262E+07	8.481E+02
2006	3.214E+04	2.574E+07	1.729E+03	8.586E+03	1.287E+07	8.647E+02
2007	3.281E+04	2.627E+07	1.765E+03	8.763E+03	1.314E+07	8.826E+02
2008	3.363E+04	2.693E+07	1.809E+03	8.982E+03	1.346E+07	9.046E+02
2009	3.496E+04	2.800E+07	1.881E+03	9.339E+03	1.400E+07	9.406E+02
2010	3.598E+04	2.881E+07	1.936E+03	9.610E+03	1.440E+07	9.678E+02
2011	3.680E+04	2.947E+07	1.980E+03	9.829E+03	1.473E+07	9.899E+02
2012	3.777E+04	3.025E+07	2.032E+03	1.009E+04	1.512E+07	1.016E+03
2013	3.843E+04	3.077E+07	2.067E+03	1.026E+04	1.538E+07	1.034E+03
2014	3.897E+04	3.120E+07	2.097E+03	1.041E+04	1.560E+07	1.048E+03
2015	3.948E+04	3.162E+07	2.124E+03	1.055E+04	1.581E+07	1.062E+03
2016	3.967E+04	3.177E+07	2.134E+03	1.060E+04	1.588E+07	1.067E+03
2017	4.015E+04	3.215E+07	2.160E+03	1.072E+04	1.608E+07	1.080E+03
2018	4.102E+04	3.284E+07	2.207E+03	1.096E+04	1.642E+07	1.103E+03
2019	4.189E+04	3.354E+07	2.254E+03	1.119E+04	1.677E+07	1.127E+03
2020	4.289E+04	3.434E+07	2.307E+03	1.146E+04	1.717E+07	1.154E+03
2021	4.402E+04	3.525E+07	2.368E+03	1.176E+04	1.762E+07	1.184E+03
2022	4.522E+04	3.621E+07	2.433E+03	1.208E+04	1.810E+07	1.216E+03
2023	4.649E+04	3.723E+07	2.502E+03	1.242E+04	1.862E+07	1.251E+03
2024	4.796E+04	3.840E+07	2.580E+03	1.281E+04	1.920E+07	1.290E+03
2025	4.962E+04	3.974E+07	2.670E+03	1.325E+04	1.987E+07	1.335E+03
2026	5.125E+04	4.104E+07	2.757E+03	1.369E+04	2.052E+07	1.379E+03
2027	5.285E+04	4.232E+07	2.844E+03	1.412E+04	2.116E+07	1.422E+03
2028	5.441E+04	4.357E+07	2.928E+03	1.453E+04	2.179E+07	1.464E+03
2029	5.593E+04	4.478E+07	3.009E+03	1.494E+04	2.239E+07	1.504E+03
2030	5.738E+04	4.595E+07	3.087E+03	1.533E+04	2.298E+07	1.544E+03
2031	5.879E+04	4.708E+07	3.163E+03	1.570E+04	2.354E+07	1.582E+03
2032	6.015E+04	4.817E+07	3.236E+03	1.607E+04	2.408E+07	1.618E+03
2033	6.147E+04	4.922E+07	3.307E+03	1.642E+04	2.461E+07	1.654E+03

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Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2034	6.274E+04	5.024E+07	3.375E+03	1.676E+04	2.512E+07	1.688E+03
2035	6.417E+04	5.138E+07	3.452E+03	1.714E+04	2.569E+07	1.726E+03
2036	6.554E+04	5.248E+07	3.526E+03	1.751E+04	2.624E+07	1.763E+03
2037	6.685E+04	5.353E+07	3.597E+03	1.786E+04	2.676E+07	1.798E+03
2038	6.809E+04	5.453E+07	3.664E+03	1.819E+04	2.726E+07	1.832E+03
2039	6.928E+04	5.548E+07	3.728E+03	1.851E+04	2.774E+07	1.864E+03
2040	7.042E+04	5.639E+07	3.789E+03	1.881E+04	2.819E+07	1.894E+03
2041	7.180E+04	5.750E+07	3.863E+03	1.918E+04	2.875E+07	1.932E+03
2042	7.312E+04	5.855E+07	3.934E+03	1.953E+04	2.928E+07	1.967E+03
2043	7.437E+04	5.955E+07	4.001E+03	1.986E+04	2.977E+07	2.001E+03
2044	7.555E+04	6.049E+07	4.065E+03	2.018E+04	3.025E+07	2.032E+03
2045	7.669E+04	6.141E+07	4.126E+03	2.048E+04	3.070E+07	2.063E+03
2046	7.776E+04	6.227E+07	4.184E+03	2.077E+04	3.113E+07	2.092E+03
2047	7.878E+04	6.308E+07	4.238E+03	2.104E+04	3.154E+07	2.119E+03
2048	7.973E+04	6.385E+07	4.290E+03	2.130E+04	3.192E+07	2.145E+03
2049	8.064E+04	6.457E+07	4.338E+03	2.154E+04	3.228E+07	2.169E+03
2050	7.747E+04	6.204E+07	4.168E+03	2.069E+04	3.102E+07	2.084E+03
2051	7.444E+04	5.960E+07	4.005E+03	1.988E+04	2.980E+07	2.002E+03
2052	7.152E+04	5.727E+07	3.848E+03	1.910E+04	2.863E+07	1.924E+03
2053	6.871E+04	5.502E+07	3.697E+03	1.835E+04	2.751E+07	1.848E+03
2054	6.602E+04	5.286E+07	3.552E+03	1.763E+04	2.643E+07	1.776E+03
2055	6.343E+04	5.079E+07	3.413E+03	1.694E+04	2.540E+07	1.706E+03
2056	6.094E+04	4.880E+07	3.279E+03	1.628E+04	2.440E+07	1.639E+03
2057	5.855E+04	4.689E+07	3.150E+03	1.564E+04	2.344E+07	1.575E+03
2058	5.626E+04	4.505E+07	3.027E+03	1.503E+04	2.252E+07	1.513E+03
2059	5.405E+04	4.328E+07	2.908E+03	1.444E+04	2.164E+07	1.454E+03
2060	5.193E+04	4.158E+07	2.794E+03	1.387E+04	2.079E+07	1.397E+03
2061	4.990E+04	3.995E+07	2.685E+03	1.333E+04	1.998E+07	1.342E+03
2062	4.794E+04	3.839E+07	2.579E+03	1.281E+04	1.919E+07	1.290E+03
2063	4.606E+04	3.688E+07	2.478E+03	1.230E+04	1.844E+07	1.239E+03
2064	4.425E+04	3.544E+07	2.381E+03	1.182E+04	1.772E+07	1.190E+03
2065	4.252E+04	3.405E+07	2.288E+03	1.136E+04	1.702E+07	1.144E+03
2066	4.085E+04	3.271E+07	2.198E+03	1.091E+04	1.636E+07	1.099E+03
2067	3.925E+04	3.143E+07	2.112E+03	1.048E+04	1.571E+07	1.056E+03
2068	3.771E+04	3.020E+07	2.029E+03	1.007E+04	1.510E+07	1.014E+03
2069	3.623E+04	2.901E+07	1.949E+03	9.678E+03	1.451E+07	9.747E+02
2070	3.481E+04	2.788E+07	1.873E+03	9.298E+03	1.394E+07	9.365E+02
2071	3.345E+04	2.678E+07	1.799E+03	8.934E+03	1.339E+07	8.997E+02
2072	3.213E+04	2.573E+07	1.729E+03	8.584E+03	1.287E+07	8.645E+02
2073	3.087E+04	2.472E+07	1.661E+03	8.247E+03	1.236E+07	8.306E+02
2074	2.966E+04	2.375E+07	1.596E+03	7.924E+03	1.188E+07	7.980E+02
2075	2.850E+04	2.282E+07	1.533E+03	7.613E+03	1.141E+07	7.667E+02
2076	2.738E+04	2.193E+07	1.473E+03	7.314E+03	1.096E+07	7.367E+02
2077	2.631E+04	2.107E+07	1.416E+03	7.028E+03	1.053E+07	7.078E+02
2078	2.528E+04	2.024E+07	1.360E+03	6.752E+03	1.012E+07	6.800E+02
2079	2.429E+04	1.945E+07	1.307E+03	6.487E+03	9.724E+06	6.534E+02
2080	2.333E+04	1.869E+07	1.255E+03	6.233E+03	9.343E+06	6.277E+02
2081	2.242E+04	1.795E+07	1.206E+03	5.989E+03	8.976E+06	6.031E+02
2082	2.154E+04	1.725E+07	1.159E+03	5.754E+03	8.624E+06	5.795E+02
2083	2.070E+04	1.657E+07	1.113E+03	5.528E+03	8.286E+06	5.567E+02
2084	1.988E+04	1.592E+07	1.070E+03	5.311E+03	7.961E+06	5.349E+02

DRAFT

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2085	1.910E+04	1.530E+07	1.028E+03	5.103E+03	7.649E+06	5.139E+02
2086	1.836E+04	1.470E+07	9.876E+02	4.903E+03	7.349E+06	4.938E+02
2087	1.764E+04	1.412E+07	9.489E+02	4.711E+03	7.061E+06	4.744E+02
2088	1.694E+04	1.357E+07	9.117E+02	4.526E+03	6.784E+06	4.558E+02
2089	1.628E+04	1.304E+07	8.759E+02	4.349E+03	6.518E+06	4.380E+02
2090	1.564E+04	1.253E+07	8.416E+02	4.178E+03	6.263E+06	4.208E+02
2091	1.503E+04	1.203E+07	8.086E+02	4.014E+03	6.017E+06	4.043E+02
2092	1.444E+04	1.156E+07	7.769E+02	3.857E+03	5.781E+06	3.884E+02
2093	1.387E+04	1.111E+07	7.464E+02	3.706E+03	5.554E+06	3.732E+02
2094	1.333E+04	1.067E+07	7.171E+02	3.560E+03	5.337E+06	3.586E+02
2095	1.281E+04	1.025E+07	6.890E+02	3.421E+03	5.127E+06	3.445E+02
2096	1.230E+04	9.853E+06	6.620E+02	3.287E+03	4.926E+06	3.310E+02
2097	1.182E+04	9.466E+06	6.360E+02	3.158E+03	4.733E+06	3.180E+02
2098	1.136E+04	9.095E+06	6.111E+02	3.034E+03	4.548E+06	3.056E+02
2099	1.091E+04	8.739E+06	5.871E+02	2.915E+03	4.369E+06	2.936E+02
2100	1.048E+04	8.396E+06	5.641E+02	2.801E+03	4.198E+06	2.821E+02
2101	1.007E+04	8.067E+06	5.420E+02	2.691E+03	4.033E+06	2.710E+02
2102	9.679E+03	7.750E+06	5.207E+02	2.585E+03	3.875E+06	2.604E+02
2103	9.299E+03	7.446E+06	5.003E+02	2.484E+03	3.723E+06	2.502E+02
2104	8.935E+03	7.154E+06	4.807E+02	2.387E+03	3.577E+06	2.404E+02
2105	8.584E+03	6.874E+06	4.619E+02	2.293E+03	3.437E+06	2.309E+02
2106	8.248E+03	6.604E+06	4.438E+02	2.203E+03	3.302E+06	2.219E+02
2107	7.924E+03	6.345E+06	4.264E+02	2.117E+03	3.173E+06	2.132E+02
2108	7.614E+03	6.097E+06	4.096E+02	2.034E+03	3.048E+06	2.048E+02
2109	7.315E+03	5.858E+06	3.936E+02	1.954E+03	2.929E+06	1.968E+02
2110	7.028E+03	5.628E+06	3.781E+02	1.877E+03	2.814E+06	1.891E+02
2111	6.753E+03	5.407E+06	3.633E+02	1.804E+03	2.704E+06	1.817E+02
2112	6.488E+03	5.195E+06	3.491E+02	1.733E+03	2.598E+06	1.745E+02
2113	6.234E+03	4.992E+06	3.354E+02	1.665E+03	2.496E+06	1.677E+02
2114	5.989E+03	4.796E+06	3.222E+02	1.600E+03	2.398E+06	1.611E+02
2115	5.754E+03	4.608E+06	3.096E+02	1.537E+03	2.304E+06	1.548E+02
2116	5.529E+03	4.427E+06	2.975E+02	1.477E+03	2.214E+06	1.487E+02
2117	5.312E+03	4.253E+06	2.858E+02	1.419E+03	2.127E+06	1.429E+02
2118	5.104E+03	4.087E+06	2.746E+02	1.363E+03	2.043E+06	1.373E+02
2119	4.903E+03	3.926E+06	2.638E+02	1.310E+03	1.963E+06	1.319E+02
2120	4.711E+03	3.773E+06	2.535E+02	1.258E+03	1.886E+06	1.267E+02
2121	4.526E+03	3.625E+06	2.435E+02	1.209E+03	1.812E+06	1.218E+02
2122	4.349E+03	3.482E+06	2.340E+02	1.162E+03	1.741E+06	1.170E+02
2123	4.178E+03	3.346E+06	2.248E+02	1.116E+03	1.673E+06	1.124E+02
2124	4.015E+03	3.215E+06	2.160E+02	1.072E+03	1.607E+06	1.080E+02

DRAFT

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1984	0	0	0	0	0	0
1985	2.334E+03	1.275E+06	8.568E+01	3.657E+01	1.020E+04	6.854E-01
1986	4.595E+03	2.510E+06	1.687E+02	7.198E+01	2.008E+04	1.349E+00
1987	7.006E+03	3.828E+06	2.572E+02	1.098E+02	3.062E+04	2.057E+00
1988	9.488E+03	5.183E+06	3.483E+02	1.486E+02	4.147E+04	2.786E+00
1989	1.111E+04	6.072E+06	4.079E+02	1.741E+02	4.857E+04	3.264E+00
1990	1.286E+04	7.023E+06	4.719E+02	2.014E+02	5.619E+04	3.775E+00
1991	1.428E+04	7.801E+06	5.241E+02	2.237E+02	6.241E+04	4.193E+00
1992	1.590E+04	8.684E+06	5.835E+02	2.490E+02	6.947E+04	4.668E+00
1993	1.705E+04	9.312E+06	6.257E+02	2.670E+02	7.449E+04	5.005E+00
1994	1.796E+04	9.810E+06	6.592E+02	2.813E+02	7.848E+04	5.273E+00
1995	1.875E+04	1.024E+07	6.883E+02	2.938E+02	8.196E+04	5.507E+00
1996	1.945E+04	1.062E+07	7.139E+02	3.047E+02	8.500E+04	5.711E+00
1997	1.970E+04	1.076E+07	7.232E+02	3.087E+02	8.611E+04	5.786E+00
1998	1.991E+04	1.088E+07	7.308E+02	3.119E+02	8.701E+04	5.846E+00
1999	2.005E+04	1.096E+07	7.361E+02	3.142E+02	8.764E+04	5.889E+00
2000	2.032E+04	1.110E+07	7.460E+02	3.184E+02	8.883E+04	5.968E+00
2001	2.160E+04	1.180E+07	7.928E+02	3.383E+02	9.439E+04	6.342E+00
2002	2.202E+04	1.203E+07	8.081E+02	3.449E+02	9.622E+04	6.465E+00
2003	2.239E+04	1.223E+07	8.217E+02	3.507E+02	9.783E+04	6.573E+00
2004	2.277E+04	1.244E+07	8.358E+02	3.567E+02	9.952E+04	6.687E+00
2005	2.310E+04	1.262E+07	8.481E+02	3.619E+02	1.010E+05	6.785E+00
2006	2.356E+04	1.287E+07	8.647E+02	3.690E+02	1.030E+05	6.918E+00
2007	2.404E+04	1.314E+07	8.826E+02	3.767E+02	1.051E+05	7.061E+00
2008	2.465E+04	1.346E+07	9.046E+02	3.861E+02	1.077E+05	7.237E+00
2009	2.562E+04	1.400E+07	9.406E+02	4.014E+02	1.120E+05	7.525E+00
2010	2.637E+04	1.440E+07	9.678E+02	4.131E+02	1.152E+05	7.743E+00
2011	2.697E+04	1.473E+07	9.899E+02	4.225E+02	1.179E+05	7.920E+00
2012	2.768E+04	1.512E+07	1.016E+03	4.337E+02	1.210E+05	8.129E+00
2013	2.816E+04	1.538E+07	1.034E+03	4.412E+02	1.231E+05	8.270E+00
2014	2.856E+04	1.560E+07	1.048E+03	4.474E+02	1.248E+05	8.386E+00
2015	2.894E+04	1.581E+07	1.062E+03	4.533E+02	1.265E+05	8.497E+00
2016	2.907E+04	1.588E+07	1.067E+03	4.555E+02	1.271E+05	8.537E+00
2017	2.943E+04	1.608E+07	1.080E+03	4.610E+02	1.286E+05	8.641E+00
2018	3.006E+04	1.642E+07	1.103E+03	4.709E+02	1.314E+05	8.827E+00
2019	3.070E+04	1.677E+07	1.127E+03	4.809E+02	1.342E+05	9.015E+00
2020	3.143E+04	1.717E+07	1.154E+03	4.924E+02	1.374E+05	9.230E+00
2021	3.226E+04	1.762E+07	1.184E+03	5.053E+02	1.410E+05	9.473E+00
2022	3.314E+04	1.810E+07	1.216E+03	5.192E+02	1.448E+05	9.731E+00
2023	3.408E+04	1.862E+07	1.251E+03	5.338E+02	1.489E+05	1.001E+01
2024	3.515E+04	1.920E+07	1.290E+03	5.506E+02	1.536E+05	1.032E+01
2025	3.637E+04	1.987E+07	1.335E+03	5.697E+02	1.589E+05	1.068E+01
2026	3.756E+04	2.052E+07	1.379E+03	5.884E+02	1.641E+05	1.103E+01
2027	3.874E+04	2.116E+07	1.422E+03	6.068E+02	1.693E+05	1.137E+01
2028	3.988E+04	2.179E+07	1.464E+03	6.247E+02	1.743E+05	1.171E+01
2029	4.099E+04	2.239E+07	1.504E+03	6.421E+02	1.791E+05	1.204E+01
2030	4.206E+04	2.298E+07	1.544E+03	6.588E+02	1.838E+05	1.235E+01
2031	4.309E+04	2.354E+07	1.582E+03	6.750E+02	1.883E+05	1.265E+01
2032	4.409E+04	2.408E+07	1.618E+03	6.906E+02	1.927E+05	1.295E+01
2033	4.505E+04	2.461E+07	1.654E+03	7.058E+02	1.969E+05	1.323E+01

DRAFT

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2034	4.598E+04	2.512E+07	1.688E+03	7.203E+02	2.009E+05	1.350E+01
2035	4.703E+04	2.569E+07	1.726E+03	7.367E+02	2.055E+05	1.381E+01
2036	4.803E+04	2.624E+07	1.763E+03	7.524E+02	2.099E+05	1.410E+01
2037	4.899E+04	2.676E+07	1.798E+03	7.675E+02	2.141E+05	1.439E+01
2038	4.991E+04	2.726E+07	1.832E+03	7.818E+02	2.181E+05	1.465E+01
2039	5.078E+04	2.774E+07	1.864E+03	7.954E+02	2.219E+05	1.491E+01
2040	5.161E+04	2.819E+07	1.894E+03	8.085E+02	2.255E+05	1.515E+01
2041	5.262E+04	2.875E+07	1.932E+03	8.244E+02	2.300E+05	1.545E+01
2042	5.359E+04	2.928E+07	1.967E+03	8.395E+02	2.342E+05	1.574E+01
2043	5.450E+04	2.977E+07	2.001E+03	8.538E+02	2.382E+05	1.600E+01
2044	5.537E+04	3.025E+07	2.032E+03	8.674E+02	2.420E+05	1.626E+01
2045	5.620E+04	3.070E+07	2.063E+03	8.805E+02	2.456E+05	1.650E+01
2046	5.699E+04	3.113E+07	2.092E+03	8.928E+02	2.491E+05	1.674E+01
2047	5.773E+04	3.154E+07	2.119E+03	9.044E+02	2.523E+05	1.695E+01
2048	5.844E+04	3.192E+07	2.145E+03	9.154E+02	2.554E+05	1.716E+01
2049	5.910E+04	3.228E+07	2.169E+03	9.258E+02	2.583E+05	1.735E+01
2050	5.678E+04	3.102E+07	2.084E+03	8.895E+02	2.482E+05	1.667E+01
2051	5.455E+04	2.980E+07	2.002E+03	8.546E+02	2.384E+05	1.602E+01
2052	5.241E+04	2.863E+07	1.924E+03	8.211E+02	2.291E+05	1.539E+01
2053	5.036E+04	2.751E+07	1.848E+03	7.889E+02	2.201E+05	1.479E+01
2054	4.838E+04	2.643E+07	1.776E+03	7.580E+02	2.115E+05	1.421E+01
2055	4.649E+04	2.540E+07	1.706E+03	7.282E+02	2.032E+05	1.365E+01
2056	4.466E+04	2.440E+07	1.639E+03	6.997E+02	1.952E+05	1.312E+01
2057	4.291E+04	2.344E+07	1.575E+03	6.723E+02	1.875E+05	1.260E+01
2058	4.123E+04	2.252E+07	1.513E+03	6.459E+02	1.802E+05	1.211E+01
2059	3.961E+04	2.164E+07	1.454E+03	6.206E+02	1.731E+05	1.163E+01
2060	3.806E+04	2.079E+07	1.397E+03	5.962E+02	1.663E+05	1.118E+01
2061	3.657E+04	1.998E+07	1.342E+03	5.729E+02	1.598E+05	1.074E+01
2062	3.513E+04	1.919E+07	1.290E+03	5.504E+02	1.536E+05	1.032E+01
2063	3.376E+04	1.844E+07	1.239E+03	5.288E+02	1.475E+05	9.913E+00
2064	3.243E+04	1.772E+07	1.190E+03	5.081E+02	1.417E+05	9.524E+00
2065	3.116E+04	1.702E+07	1.144E+03	4.882E+02	1.362E+05	9.150E+00
2066	2.994E+04	1.636E+07	1.099E+03	4.690E+02	1.308E+05	8.792E+00
2067	2.877E+04	1.571E+07	1.056E+03	4.506E+02	1.257E+05	8.447E+00
2068	2.764E+04	1.510E+07	1.014E+03	4.330E+02	1.208E+05	8.116E+00
2069	2.655E+04	1.451E+07	9.747E+02	4.160E+02	1.161E+05	7.797E+00
2070	2.551E+04	1.394E+07	9.365E+02	3.997E+02	1.115E+05	7.492E+00
2071	2.451E+04	1.339E+07	8.997E+02	3.840E+02	1.071E+05	7.198E+00
2072	2.355E+04	1.287E+07	8.645E+02	3.689E+02	1.029E+05	6.916E+00
2073	2.263E+04	1.236E+07	8.306E+02	3.545E+02	9.889E+04	6.645E+00
2074	2.174E+04	1.188E+07	7.980E+02	3.406E+02	9.501E+04	6.384E+00
2075	2.089E+04	1.141E+07	7.667E+02	3.272E+02	9.129E+04	6.134E+00
2076	2.007E+04	1.096E+07	7.367E+02	3.144E+02	8.771E+04	5.893E+00
2077	1.928E+04	1.053E+07	7.078E+02	3.021E+02	8.427E+04	5.662E+00
2078	1.853E+04	1.012E+07	6.800E+02	2.902E+02	8.097E+04	5.440E+00
2079	1.780E+04	9.724E+06	6.534E+02	2.788E+02	7.779E+04	5.227E+00
2080	1.710E+04	9.343E+06	6.277E+02	2.679E+02	7.474E+04	5.022E+00
2081	1.643E+04	8.976E+06	6.031E+02	2.574E+02	7.181E+04	4.825E+00
2082	1.579E+04	8.624E+06	5.795E+02	2.473E+02	6.899E+04	4.636E+00
2083	1.517E+04	8.286E+06	5.567E+02	2.376E+02	6.629E+04	4.454E+00
2084	1.457E+04	7.961E+06	5.349E+02	2.283E+02	6.369E+04	4.279E+00

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Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2085	1.400E+04	7.649E+06	5.139E+02	2.193E+02	6.119E+04	4.112E+00
2086	1.345E+04	7.349E+06	4.938E+02	2.107E+02	5.879E+04	3.950E+00
2087	1.293E+04	7.061E+06	4.744E+02	2.025E+02	5.649E+04	3.795E+00
2088	1.242E+04	6.784E+06	4.558E+02	1.945E+02	5.427E+04	3.647E+00
2089	1.193E+04	6.518E+06	4.380E+02	1.869E+02	5.215E+04	3.504E+00
2090	1.146E+04	6.263E+06	4.208E+02	1.796E+02	5.010E+04	3.366E+00
2091	1.101E+04	6.017E+06	4.043E+02	1.725E+02	4.814E+04	3.234E+00
2092	1.058E+04	5.781E+06	3.884E+02	1.658E+02	4.625E+04	3.107E+00
2093	1.017E+04	5.554E+06	3.732E+02	1.593E+02	4.444E+04	2.986E+00
2094	9.769E+03	5.337E+06	3.586E+02	1.530E+02	4.269E+04	2.869E+00
2095	9.386E+03	5.127E+06	3.445E+02	1.470E+02	4.102E+04	2.756E+00
2096	9.018E+03	4.926E+06	3.310E+02	1.413E+02	3.941E+04	2.648E+00
2097	8.664E+03	4.733E+06	3.180E+02	1.357E+02	3.787E+04	2.544E+00
2098	8.324E+03	4.548E+06	3.056E+02	1.304E+02	3.638E+04	2.444E+00
2099	7.998E+03	4.369E+06	2.936E+02	1.253E+02	3.495E+04	2.349E+00
2100	7.684E+03	4.198E+06	2.821E+02	1.204E+02	3.358E+04	2.256E+00
2101	7.383E+03	4.033E+06	2.710E+02	1.157E+02	3.227E+04	2.168E+00
2102	7.094E+03	3.875E+06	2.604E+02	1.111E+02	3.100E+04	2.083E+00
2103	6.815E+03	3.723E+06	2.502E+02	1.068E+02	2.979E+04	2.001E+00
2104	6.548E+03	3.577E+06	2.404E+02	1.026E+02	2.862E+04	1.923E+00
2105	6.291E+03	3.437E+06	2.309E+02	9.856E+01	2.750E+04	1.847E+00
2106	6.045E+03	3.302E+06	2.219E+02	9.469E+01	2.642E+04	1.775E+00
2107	5.808E+03	3.173E+06	2.132E+02	9.098E+01	2.538E+04	1.705E+00
2108	5.580E+03	3.048E+06	2.048E+02	8.741E+01	2.439E+04	1.639E+00
2109	5.361E+03	2.929E+06	1.968E+02	8.399E+01	2.343E+04	1.574E+00
2110	5.151E+03	2.814E+06	1.891E+02	8.069E+01	2.251E+04	1.513E+00
2111	4.949E+03	2.704E+06	1.817E+02	7.753E+01	2.163E+04	1.453E+00
2112	4.755E+03	2.598E+06	1.745E+02	7.449E+01	2.078E+04	1.396E+00
2113	4.568E+03	2.496E+06	1.677E+02	7.157E+01	1.997E+04	1.342E+00
2114	4.389E+03	2.398E+06	1.611E+02	6.876E+01	1.918E+04	1.289E+00
2115	4.217E+03	2.304E+06	1.548E+02	6.607E+01	1.843E+04	1.238E+00
2116	4.052E+03	2.214E+06	1.487E+02	6.347E+01	1.771E+04	1.190E+00
2117	3.893E+03	2.127E+06	1.429E+02	6.099E+01	1.701E+04	1.143E+00
2118	3.740E+03	2.043E+06	1.373E+02	5.859E+01	1.635E+04	1.098E+00
2119	3.594E+03	1.963E+06	1.319E+02	5.630E+01	1.571E+04	1.055E+00
2120	3.453E+03	1.886E+06	1.267E+02	5.409E+01	1.509E+04	1.014E+00
2121	3.317E+03	1.812E+06	1.218E+02	5.197E+01	1.450E+04	9.741E-01
2122	3.187E+03	1.741E+06	1.170E+02	4.993E+01	1.393E+04	9.359E-01
2123	3.062E+03	1.673E+06	1.124E+02	4.797E+01	1.338E+04	8.992E-01
2124	2.942E+03	1.607E+06	1.080E+02	4.609E+01	1.286E+04	8.640E-01

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APPENDIX C

Geotechnical Evaluation of Alternative Methods of Landfill Expansion

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TECHNICAL MEMORANDUM

DATE November 18, 2019 **Project No.** 1648176-6000-M01-Rev0

TO Mr. Mike Losee, Division Manager - Solid Waste Management
The Corporation of the City of London

FROM Mr. Michael E. Beadle, P. Eng. **EMAIL mbeadle@golder.com**

GEOTECHNICAL EVALUATION
ALTERNATIVE METHODS OF LANDFILL EXPANSION
W12A LANDFILL EXPANSION ENVIRONMENTAL ASSESSMENT
CITY OF LONDON, ONTARIO

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This technical memorandum provides geotechnical engineering input to the Environmental Assessment (EA) related to the W12A landfill expansion in London, Ontario. The location of the site is shown on the Location Plan, Figure 1.

Of the three expansion 'Alternative Methods' developed for comparative evaluation, Alternative 1 – Vertical Expansion Over Existing Landfill Footprint involves the greatest total thickness of waste. It is therefore the expansion alternative that has the highest slopes and applies the highest load to the underlying clay till subgrade. As such, it has been subjected to a geotechnical evaluation in regard to: 1) stability of the landfill and 2) estimation of post-landfilling settlement due to consolidation of the underlying clay till deposit and potential effects on leachate collection system performance. If the evaluation indicates expansion Alternative 1 is stable and post-landfilling settlements do not have adverse effects, then this will also be valid for Alternatives 2 and 3.

Alternative 1 provides additional waste disposal capacity within the existing landfill footprint. The existing ground surface adjacent to the landfill gently slopes from about elevation 285 metres above sea level (masl) in the northwest to about elevation 275 masl in the southeast. The currently approved landfill design incorporates waste material being deposited to a maximum of about elevation 295 masl in the north portion of the landfill sloping down to about elevation 285 masl in the southern portion. Alternative 1 will result in a maximum waste elevation of about 317.7 masl. The top surface of the waste will be sloped downward from the peak to the north and to the south at inclinations of about 20 horizontal to 1 vertical (20H:1V) and then transition to perimeter side slopes constructed at inclinations of 4H:1V.

This technical memorandum summarizes the subsurface soil and groundwater conditions expected to be present within the footprint of the landfill together with an assessment of the potential settlements of the native soils related to the placement of the waste to assist in assessing potential impacts to the existing leachate collection system beneath the Phase 2 landfill area, as well as an assessment of the stability of the landfill.

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SUBSURFACE CONDITIONS

The subsurface conditions at the site have been established based on the results of boreholes drilled previously at the site by Golder Associates Ltd. (Golder). These are:

- Golder Report 72483 entitled "Subsurface Investigation, Proposed White Oaks Landfill Site, London, Ontario" dated November 1972 – Borehole 101
- Golder Report 72483-1 entitled "Additional Subsurface Investigation, Proposed White Oaks Landfill Site, London, Ontario" dated December 1972 – Boreholes 102 to 104
- Golder Report 72483-2 entitled "Additional Subsurface Investigation, Proposed White Oaks Landfill Site, London, Ontario" dated June 1973 – Borehole 201
- Golder Report 753227 entitled "Groundwater Monitoring Well Installations, Proposed Sanitary Landfill W-12A, Township of Westminster, County of Middlesex, Ontario" dated May 1976 – Boreholes 1 to 5
- Golder Report 811-3089 entitled "Subsurface Investigation, Proposed Cells 3 and 4, City of London Sanitary Landfill W12A, Concession VI, Township of Westminster, County of Middlesex, Ontario" dated July 1981 – Boreholes 1 to 4
- Golder Report 001-3225 entitled "Preliminary Foundation Investigation, Proposed Wonderland Road Underpass, Highway 401, GWP 476-89-00" dated February 2002

The locations of the relevant previous boreholes are shown on the Location Plan, Figure 1, and the Records of Previous Boreholes are attached in Appendix A.

In addition, the Records of Boreholes for BH19-1 through BH19-8 drilled recently (late 2019) by Dillon Consulting Limited as part of the overall project were reviewed. These recent boreholes indicated reasonable agreement with the previously drilled holes.

Soil Conditions

The subsurface conditions at the landfill site generally consist of a layer of stiff to hard silty clay glacial till (Surficial Aquitard) generally about 15 to 20 metres thick that is underlain by about 10 metres of compact to very dense fine grained granular deposits of sand, silty sand and sandy silt (Upper Aquifer). Beneath these deposits, additional layers of silty clay and sandy silt glacial till are present and are, in turn, underlain by sand and gravel deposits.

The upper silty clay till extends to about elevation 257.5 to 269 masl, but is generally at approximately elevation 260 masl below much of the existing landfill footprint. The silty clay glacial till typically exhibits "N" values, as determined by standard penetration testing, of 10 to greater than 100 blows per 0.3 metres with a representative N value of about 30 blows per 0.3 metres. Samples of the silty clay till have water contents ranging from about 10 to 28 per cent with an average of about 19 per cent. The silty clay till has average plastic and liquid limits of about 19 and 33 per cent, respectively, based on two Atterberg limits determinations. Beneath the upper silty clay glacial till, the subsurface soils are generally hard/very dense (generally with N values in excess of 100 blows per 0.3 metres). A graphical summary of the standard penetration test N values and water contents is provided on Figure 2.

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Compression Characteristics

The initial void ratio and compression indices for the upper silty clay till were estimated using published correlations with index properties (natural water content, Atterberg limits results) and these are shown on Figure 2. The averages of these estimated compression characteristics were compared to the results of oedometer test data from the Wonderland Road/Highway 401 interchange immediately west of the site and indicated relatively good agreement. Figure 2 illustrates estimated compressibility characteristics (void ratio and compression index) as compared to the Wonderland Road data (shown as a dashed vertical line) where the estimated values are typically greater than the locally-measured values.

	W12A Average	Wonderland Road
Initial void ratio	0.51	0.53
Compression index	0.19	0.154
Recompression index	0.02	0.016

Based on our experience in the London area, glacial history, the results of the odometer testing and the N values, the upper silty clay till is considered to be moderately overconsolidated. Based on the anticipated loads from the waste and cover material, it is expected that the recompression characteristics will govern the settlements.

Groundwater Conditions

From the ongoing groundwater monitoring programs, the piezometric level in the granular layer (Upper Aquifer) beneath the upper silty clay till is typically at about elevation 258 to 259 masl. It is known that a leachate mound has formed within the waste in Phase 1 to some 5 to 10 metres above the silty clay till surface; in Phase 2, the leachate level is controlled to near the base of the cell by the underdrain leachate collection system.

DISCUSSION

Settlement Estimates

Settlement calculations were completed using the compression characteristics noted above for the silty clay till and the following engineering parameters:

Unit weight of silty clay till – 21 kN/m^3

Unit weight of final cover material – 21 kN/m^3

Combined unit weight of waste and daily/intermediate cover materials – 12 kN/m^3

Thickness of final cover material – 0.75 to 1.0 m

Thickness of waste - varies

Estimated settlements as provided in this memorandum represent only the compression of the native soils beneath the landfill under the anticipated total load caused by placing waste to the proposed design top elevations. These settlement estimates do not include overall displacements of the waste mass surface associated with internal consolidation/decomposition of the waste. The materials below the upper silty clay till are generally very dense/hard and were neglected in the analyses since they are not expected to contribute measurably to the calculated settlements. The elevation of the bottom of the silty clay till layer is variable; thus, the settlement calculations were carried out for two scenarios in which the bottom of the silty clay till were taken

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as elevation 262 masl and elevation 258 masl. The estimated settlements of the native soils under the total loads are expected to be within the ranges provided below. The cross sections and estimated settlements along the cross sections are shown graphically on Figure 3 and the estimated settlements are summarized below. The location of cross-sections A-A' (west to east) and B-B' (north to south) are the same sections as shown on the plan and cross section views for Alternative 1 and are shown on the attached Figure 1.

Location	Estimated Settlement (mm)	
	Lower Bound	Upper Bound
Cross Section A-A'		
0+200	95	110
0+300 to 1+300	135	155
1+400	95	110
Cross Section B-B'		
0+200	95	110
0+300	105	120
0+400	115	130
0+500	125	140
0+600	130	150
0+670	135	155
0+700	130	150
0+800	120	140
0+900	105	125
1+000	50	65

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The cross sections and estimated settlements are shown graphically on Figure 3.

It is estimated that these maximum total settlements will take place over a period of approximately 10 to 12 years after the final waste contours are reached and final cover placed.

Effects of Estimated Settlements

The waste in Phase 1 of the landfill was placed directly on the silty clay till and does not have a leachate collection system beneath the landfill. There is a perimeter leachate collection system around the exterior of Phase 1 that will continue to provide control of lateral migration of leachate in the shallow subsurface for the proposed expansion, coupled with a proposed underdrain leachate collection system in the horizontal expansion areas of Alternatives 2 and 3. As such, the estimated settlements will not adversely affect any engineered components beneath the Phase 1 area for Alternative 1, and can be accommodated in design of the leachate collection system for the horizontal expansion areas for Alternatives 2 and 3.

The waste in Phase 2 of the landfill is underlain by a leachate collection system consisting of a continuous granular drainage blanket and a series of perforated collection pipes. The base grades and the pipes slope upwards from south to north at a grade of 0.5 per cent; the southern 120 metres of the piping is sloped at 2.5 per cent towards the header and collection manhole. The drainage and collection of leachate rely on gravity flow in a series of peaks and valleys laterally towards the piping and longitudinally from north to south. This same leachate collection system will also serve to collect and convey leachate beneath the portion of the Alternative 1 vertical expansion above the Phase 2 area. An assessment of the effects of the above estimated settlements on the existing base and pipe grades and slopes/drainage pattern was carried out. For Alternative 1, and as illustrated on cross section A-A' on Figure 3, the settlements are quite uniform across much of the width of Phase 2 and will vary with the height of waste (which varies parallel to cross section A'A'). Cross section B-B' on Figure 3 shows that the settlement will be greatest under the peak of the waste and decrease to both the north and south, with estimated differential settlement of about 10 mm for every 100 metres of length. Although there will be an overall lowering of the base of the landfill by up to about an estimated 155 mm, the differential settlements along the length are small and will not change the base and pipe design grade of 0.5 per cent except for a small reduction of about 0.01 to 0.02 per cent in the 100 metre long section below and just south of the waste peak. This will not adversely affect the performance or service life of the existing leachate collection system below the Phase 2 area of the Alternative 1 vertical expansion. Because the total settlements beneath Alternatives 2 and 3 (smaller thickness of waste) will be less than those corresponding to Alternative 1, post-landfilling settlements will also not adversely affect the Phase 2 leachate collection system beneath the vertically expanded Alternative 2 or 3.

The total and differential settlement of the clay till, and the proposed leachate collection system, under the horizontal expansion areas of Alternative 2 (northward) and Alternative 3 (eastward) will be less than calculated for Alternative 1 because of the lesser thickness of waste above these areas. If one of Alternative 2 or 3 is identified as the preferred expansion alternative, the estimated settlements under the horizontal expansion areas will be calculated and used in the design of the underdrain leachate collection system.

Stability Assessment

Specific shear strength parameters for the municipal solid waste at this site are not available. Therefore, a literature review was completed to assess typical shear strength parameters. The literature suggests that the effective stress cohesion intercept and angle of internal friction, used within conventional Mohr-Coulomb strength analyses, varies considerably depending on the constituents that make up the bulk of the waste. However, it is clear that typical municipal solid waste exhibits some mass cohesion and that effective strength friction angles in excess of 30 degrees are not uncommon for use in landfill stability analyses. For these analyses, the cohesion intercept was taken as nil and the angle of internal friction taken as 30 degrees, consistent with the lower bound based on the literature review.

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Two cases were considered:

- A translational slide of the waste and cover material (linear slip surfaces assumed), where the slip surface does not penetrate into the underlying native soils; and
- A deeper seated rotational global movement (curved slip surfaces assumed).

The translational slide was assessed using conventional manual calculations. Based on the shear strength parameters summarized above and a maximum side slope inclination of 4H:1V, the estimated factor of safety was excess of about 2.0, where a factor of safety of one indicates incipient failure. The rotational slip surface analyses were completed using Slope /W, a commercially available computer program developed for such analyses. Based on the Alternative 1 design, the "critical" location for the slope stability assessment corresponds to the western slope where the upper silty clay is thickest, the waste highest and the slope steepest (inclined at 4H:1V). Within the analyses, an effective stress cohesion intercept of nil and an internal angle of friction of 30 degrees was used for the upper silty clay till, consistent with our experience in this portion of the City of London and fine-grained glacial till soils in southwestern Ontario. The results of the analyses indicate a factor of safety of about 2.0 for a half-height slide (i.e., top of slide scarp at the mid-height ground surface along the waste slope) and in excess of 2.5 for a full height slide. These factors of safety are considered appropriate from a geotechnical perspective and are consistent with to greater than target factors of safety for cut and fill slopes in urban environments.

The factors of safety for Alternatives 2 and 3, which have a maximum thickness of waste approximately 8 to 9 metres less than Alternative 1, will be higher than the above values.

SUMMARY

Based on this geotechnical assessment, it is concluded that the overall stability of the proposed expansion 'Alternative Methods' is acceptable and that the settlement of the silty clay till subgrade beneath the existing footprint under the waste loading associated with the vertical expansion in the Phase 2 area will not adversely affect the performance or service life of the existing leachate collection system beneath the Phase 2 area. Similarly, the leachate collection system beneath the proposed horizontal expansion areas can be designed such that they will perform acceptably.

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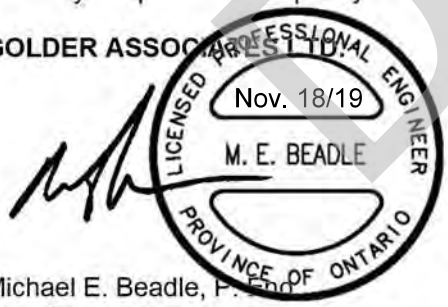

Michael E. Beadle, P. Eng.
Associate

MEB/SJB/PAS/cr

Attachments: Figure 1 – Location Plan
Figure 2 – Summary of Field and Laboratory Testing and Compression Characteristics
Figure 3 – Cross Sections and Estimated Settlements
Appendix A – Previous Records of Boreholes

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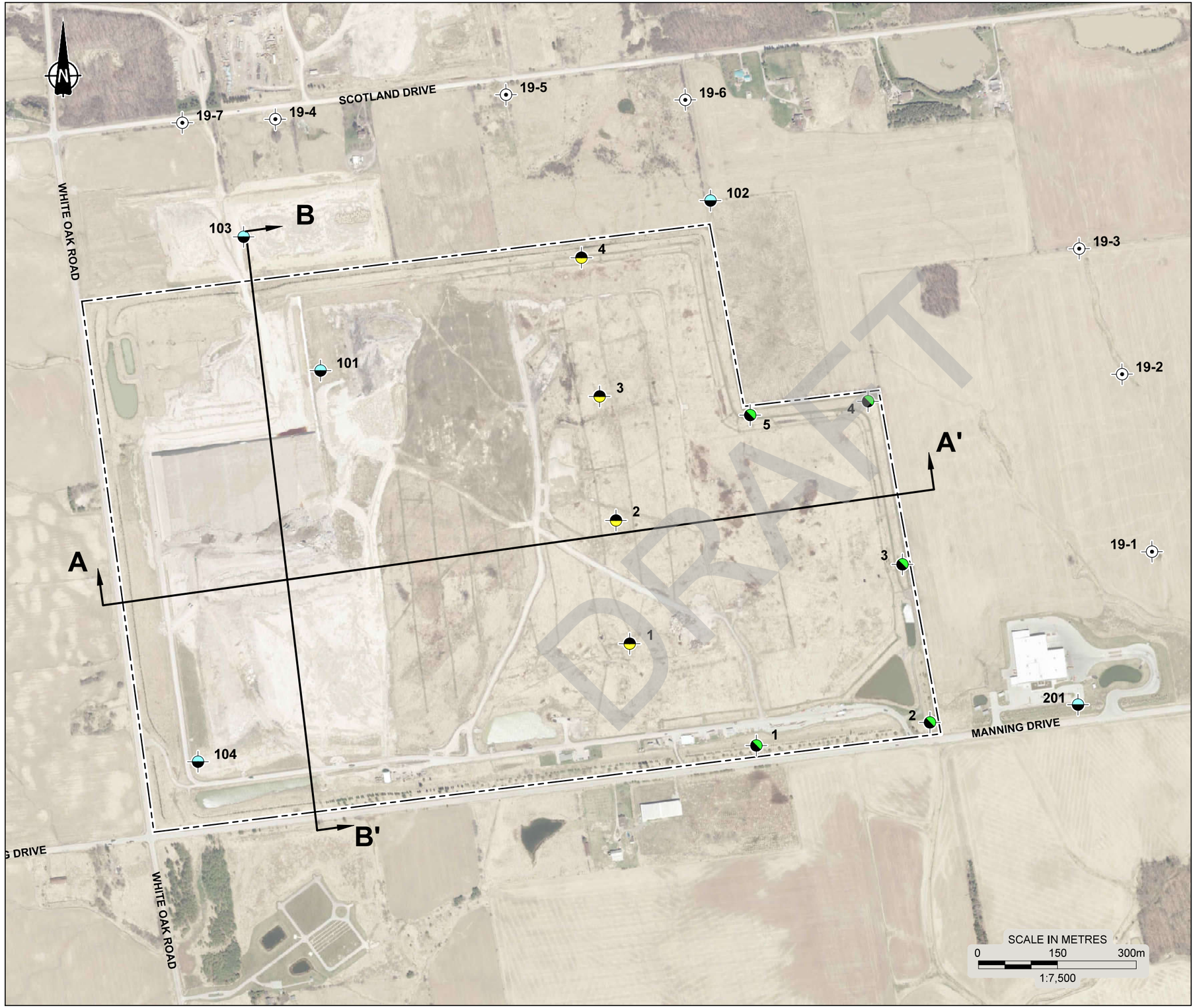

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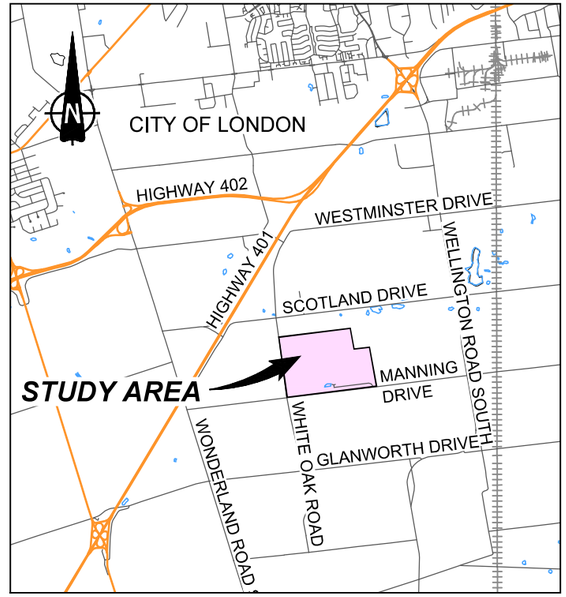

KEY PLAN

LEGEND

- APPROXIMATE LOCATION OF SITE STUDY AREA
- SECTION LINE (REFER TO FIGURE 3 FOR SECTIONS)
- BOREHOLE (DILLON, 2019)

PREVIOUS GOLDER BOREHOLES

- REPORT: 811-3089
- REPORT: 753227
- REPORTS: 72483-2, 72483-1, and 72483

REFERENCE

DRAWING BASED ON CITY OF LONDON, 2019 OPEN DATASET; PDF FILE FIGURE 1 SITE PLAN, EXISTING GROUNDWATER CONDITIONS, PROJECT No. 19-1230, PROVIDED BY DILLON CONSULTING, JULY 2020;
AND CANMAP STREETFILES V2008.4.

NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT

INDIVIDUAL EA, RESIDUAL WASTE DISPOSAL STRATEGY
W12A LANDFILL WASTE MOUND CONCEPT DESIGN
LONDON, ONTARIO

TITLE

LOCATION PLAN

GOLDER

PROJECT No.			1648176	FILE No. 1648176-6000-M01001
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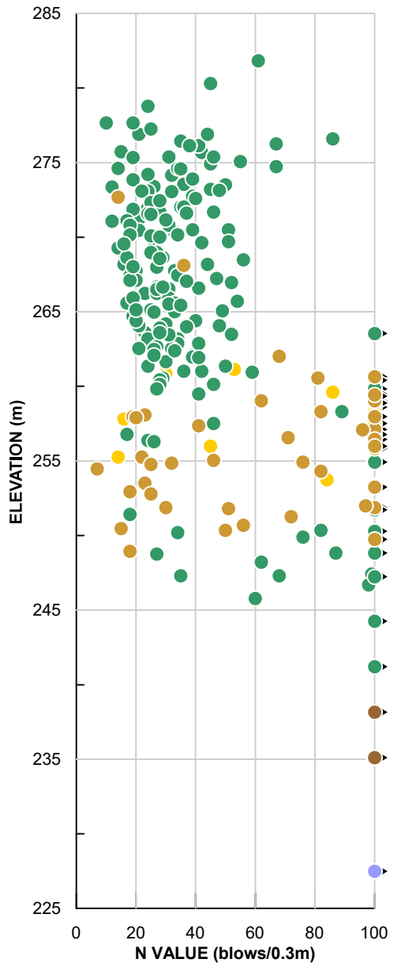
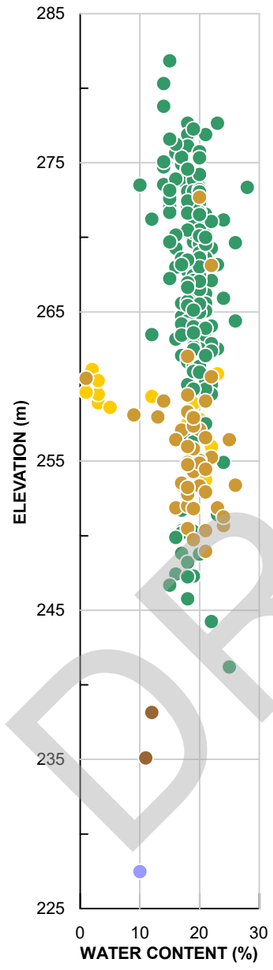
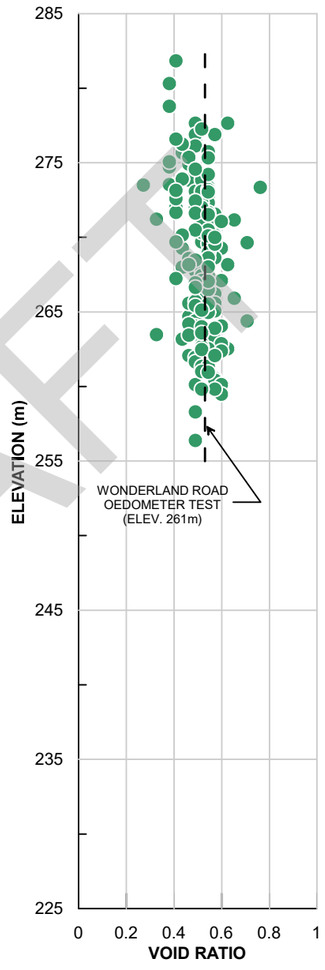
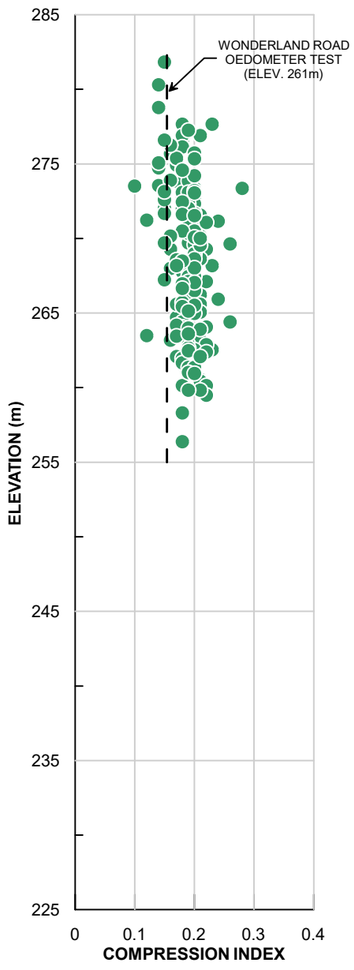
CHECK	PS			

FIGURE 1









- SILTY CLAY, CLAYEY SILT, SILTY CLAY TILL
- SAND
- SANDY SILT, SILTY SAND, SILT
- SANDY SILT TILL
- SAND & GRAVEL

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PROJECT

INDIVIDUAL EA, RESIDUAL WASTE DISPOSAL STRATEGY
W12A LANDFILL WASTE MOUND CONCEPT DESIGN

TITLE

SUMMARY OF FIELD AND LABORATORY TESTING AND COMPRESSION CHARACTERISTICS

GOLDER

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DRAWN	MEB	NOV 14-19		
CHECK				

FIGURE 2

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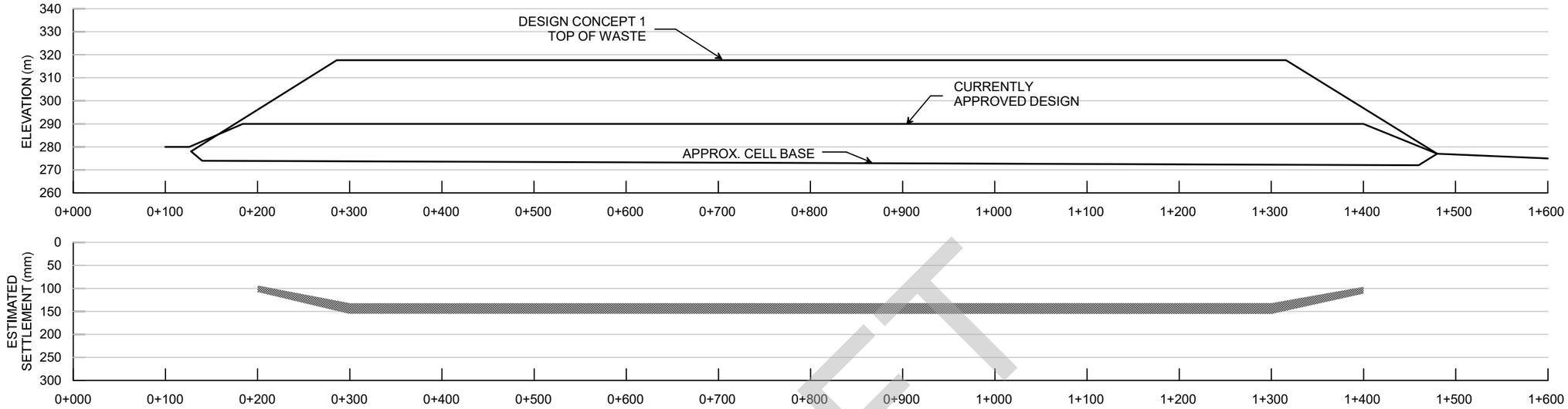
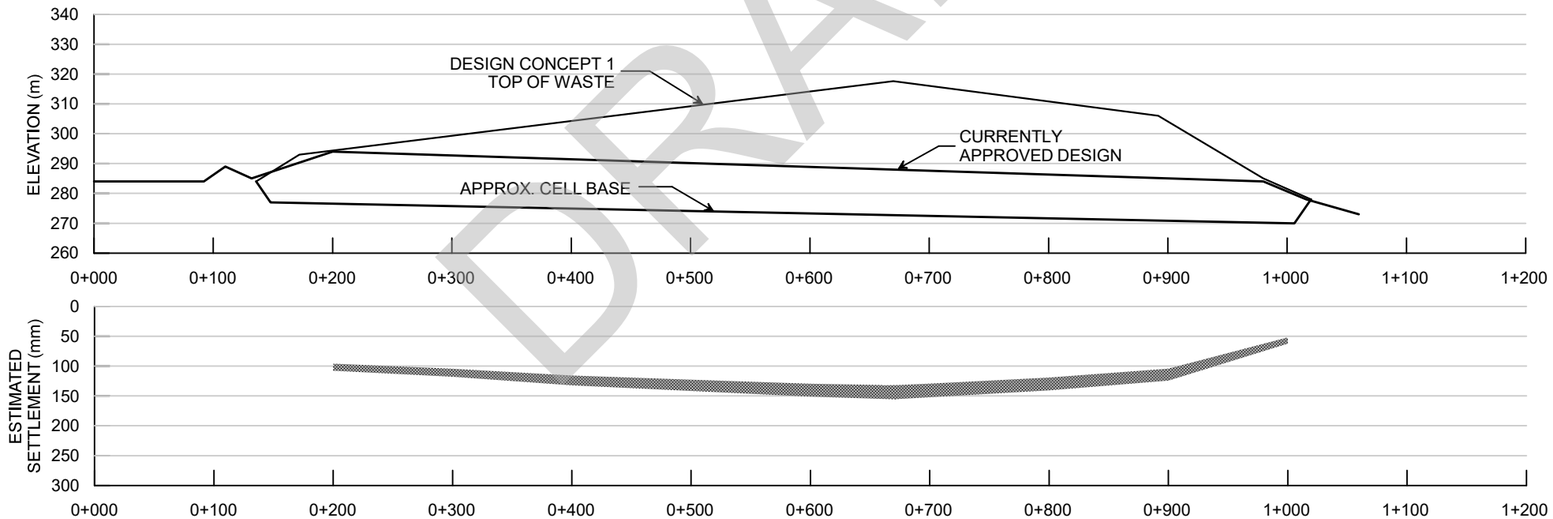
CROSS-SECTION A-A'



CROSS-SECTION B-B'



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PROJECT

INDIVIDUAL EA, RESIDUAL WASTE DISPOSAL STRATEGY
W12A LANDFILL WASTE MOUND CONCEPT DESIGN

TITLE

CROSS SECTIONS AND ESTIMATED SETTLEMENTS

GOLDER

PROJECT No.	1648176-1001		FILE No.	F
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DRAWN	MEB	NOV 14-19		
CHECK				

FIGURE 3

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