



WASTE CONNECTIONS OF CANADA
**Ridge Landfill Expansion:
Other Supporting Documents**

Appendix F

January 2020





Errata Sheet

Ridge Landfill Environmental Assessment Report: Appendix F – Other Supporting Documents

The Draft Ridge Landfill Environmental Assessment (EA) Report and supporting documentation (appendices) were provided for review and comment to the MECP, Stakeholders, Indigenous Communities and Organizations on July 22, 2019. The final version of the Ridge Landfill Environmental Assessment was revised where appropriate, to address the comments received. All revised versions of the final environmental assessment report and supporting documentation are posted on the website for the Ridge Landfill, www.ridgelandfill.com/our-future-plans.

Changes made as a result of the review for this particular document have been included in the final version. The changes to the document as described below, have been incorporated into the on-line and DVD versions.

Revisions to Appendix Appendix F – Other Supporting Documents:

Errata No.	Section	Revision
1	All	Date changed – from July 2019 to January 2020
2	All	Report name changed - Draft Ridge Landfill EA to Ridge Landfill EA
3	Appendix F	Revised the opportunity assessment document - now dated October 7, 2019.

Appendix F1

Problem/Opportunity Assessment Supporting Document #1



MEMO

TO: Cathy Smith, Project Manager
FROM: Betsy Varghese, P.Eng. and Jack Carr, Ph.D., Economist
DATE: January 14, 2020
SUBJECT: Update to Purpose/Opportunity Assessment Supporting Document #1
OUR FILE: 15-2456

The Amended Terms of Reference (ToR) was approved by the Ministry of Environment, Conservation and Parks (MECP) in May 2018. As per the Ridge Landfill Expansion Environmental Assessment (EA) Commitments Table, this memo is intended to fulfil the following two commitments:

1. As outlined in the Code of Practice, Waste Connections will reconfirm the data used to develop the rationale for the undertaking that is outlined in the ToR. The rationale for the project and opportunity will be revisited during the EA.
2. Waste Connections will revisit the purpose and opportunity outlined in the Terms of Reference. Waste Connections will reconfirm the data and methods used to develop the rationale for the undertaking that considers the available disposal volume at existing landfill sites, anticipated capacity from proposed landfill facilities, and waste export to the United States. Waste Connections will prepare a comprehensive market analysis to quantify the industrial, commercial and institutional waste that the Ridge Landfill can reasonably expect to receive over the 20-year planning period to support the identified opportunity.

The ToR included Supporting Document #1: Purpose/Opportunity Assessment (SD #1) which was supplemented by An Economic Analysis of the Market for IC&I Waste in Central and Southwestern Ontario (Jack Carr, November, 2017). The purpose of SD#1 was to illustrate the opportunity for Waste Connections to continue operating the Ridge Landfill beyond 2021. Waste generation data was taken from Statistics Canada's Waste Management Industry Survey. Waste projections were compiled to estimate the quantity of residual waste remaining after diversion during the future period of the Ridge Landfill operation. Estimated available capacity at central and southern Ontario landfills over the 20-year planning period was estimated based on waste disposal capacity data received from MECP in December 2017. It was assumed that private sector disposal facilities within the service area (existing and planned facilities) would reserve 100% of their capacity for IC&I waste (even though it is documented that some of these sites receive residential waste). Since municipal disposal facilities typically reserve capacity to meet future residential waste disposal needs, it was assumed that 15% of the waste received at municipal disposal facilities would come from the IC&I sector. This was based on information provided by the largest municipal landfill sites (Waterloo, Toronto and London which represent almost 70% of the total municipal disposal capacity) who were contacted to determine the proportion of IC&I waste received at their sites. Using a weighted average based on reported fill rates, an average percentage of IC&I waste landfilled at municipal sites was calculated to be 15%. This percentage was applied to the approved fill rates for all municipal sites and included in the available capacity during the planning period. These assumptions are carried forward in this update. The projections had also assumed that

Ontario will not be able to continue exporting waste to out of province landfills throughout the planning period since there is no guarantee that export will still be permitted by the US and uncertainty about the annual quantity that could be sent to US landfills as well as other border issues. This assumption has not been carried forward in this update and export of a significant volume of waste to the US is included in the market projections for the Ridge Landfill expansion planning period.

The conclusion in SD#1 was that there is a business opportunity for the Ridge Landfill to continue to provide an annual waste disposal rate of 1.3 million tonnes for the management of residual IC&I waste during the planning period of the EA.

In order to revisit the purpose and opportunity per the ToR commitments, the data that was previously used was reviewed to confirm if any changes occurred, the regulatory regime was researched to identify any changes since 2017 and observations about current market conditions were made. In addition, the Economic Analysis of the Market for IC&I Waste in Central and Southwestern Ontario, which was prepared in 2017 and attached to SD#1, was reviewed to determine if anything had changed between 2017 and 2019. The 2017 economic analysis was undertaken to update a 1997 Browning Ferris Industries (BFI) EA waste opportunity study to define the current waste opportunity from 2021 to 2041. The 2017 study examined the supply and demand for IC&I waste for the market in Central and South Western Ontario and also examined the economic impact on the Ontario economy of maintaining the annual fill rate of 1.3 million tonnes. This 2019 examination re-confirms the waste opportunity identified originally in 1997 and then again in the 2017 study.

The following provides our observations:

Assumptions Made in the Preparation of SD#1 to Support the EA Terms of Reference

MECP provided 2014-2016 data on existing and approved large waste disposal facilities within the proposed service area to assist Waste Connections in projecting remaining waste disposal capacity over the planning period. MECP confirmed that no updated data set was available. The estimated population growth from the Ministry of Finance of nearly 1% per year has not been changed.

It is noted that Statistics Canada waste generation estimates do not account for land clearing activities on areas not previously developed, as well as materials such as concrete, asphalt, bricks, clean sand, gravel that are reused and likely does not include all of the waste exported to the US. This means that the waste generation estimates in SD#1 are lower than what the actual generation rates have been in the province therefore the remaining available disposal capacity is only further consumed than what was estimated in SD#1.

Canadian waste quantities historically exported to the US for disposal was available for the State of Michigan until 2018, for the State of New York up to 2014 and for State of Ohio from 2011 to 2015. Based on this information, within the last 10 years, the total quantities of Canadian waste disposed annually in the US has been as high as 4 million tonnes (2008).

In addition, waste generation, particularly in the IC&I sector, can be linked to patterns in economic activity. There is a boom of economic activity with the Greater Toronto and Hamilton Area and with the province's Open for Business mandate, economic activity and the resulting waste generation is anticipated to increase.

SD#1 did not account for waste generated from natural disasters and climate change related events (e.g., ice storms, flooding) although there have been more occurrences of these incidents resulting in additional and unplanned disposal capacity being consumed (e.g., recent flooding in Chatham-Kent).

SD#1 assumed that no municipal waste is landfilled at private sector landfills within the proposed service area even though it is known this is not the case (e.g., Peel Region and City of Guelph send their residual waste to private sector landfills within the proposed service area). The assumption was made to be conservative (e.g., capacity could be consumed only by IC&I waste in the future) and because the proportions of residential to IC&I waste in these landfills was not known due to lack of available data. Accounting for municipal waste being landfilled in private sector disposal sites increases the need and opportunity for the Ridge Landfill expansion as it would consume the capacity of private sector sites at a greater rate than what was projected in SD#1 thereby reducing the capacity available for IC&I waste within the proposed service area. This assumption has been carried forward in this update (no municipal waste going to private landfill sites).

Similarly, it was previously assumed that all currently planned capacity via current EA projects for new or expanded landfill capacity will be approved. The Stoney Creek Regional Facility Landfill EA has recently been approved which will provide 750,000 tonnes per year of disposal capacity over approximately 13 years. The W12A landfill has received approval for their Terms of Reference which, if approved, would provide 500,000 tonnes of disposal capacity annually. The W12A landfill site has been included in the analysis using the same methodology as other municipal disposal sites (see below).

Regulatory Regime

The Provincial guidance document (Strategy for a Waste-Free Ontario) provided interim diversion goals of 30% by 2020, 50% by 2030 and 80% by 2050 (for residential and non-residential, combined) that was developed to mark progress towards the visionary zero waste goals in Ontario. The projections that were done in SD#1 assumed that the residual waste remaining for disposal would be after 80% diversion was achieved in 2050. Statistics Canada IC&I diversion rates were used as a starting point for the projections and then increased to 80% by 2050. Two sensitivity analyses were done that looked at the quantities of residual waste if only 75% and 50% of the target is achieved (i.e., 60% and 40% diversion by 2050). However, the available disposal capacity in the Province over the 20-year planning period was estimated assuming the 80% diversion goal. Even with using this aggressive diversion target, an opportunity for the Ridge Landfill to continue operations until 2041 was still demonstrated.

Currently, the main Provincial regulations/guidelines related to this work are the *Waste-Free Ontario Act* (comprised of the *Resource Recovery and Circular Economy Act* and the *Waste Diversion Transition Act*), the Made-in-Ontario Environment Plan, the discussion paper Reducing Litter and Waste in our Communities and the Food and Organic Waste Policy Statement. The discussion paper includes the same diversion targets mentioned above (i.e., overall targets of 30% by 2020, 50% by 2030 and 80% by 2050) and steps to meet the target such as addressing IC&I regulations, consider designating additional materials and developing a proposal to ban food waste from landfills. The Policy Statement has set recovery targets for food and organic waste by different entities including reducing and recovering 50% to 70% of food and organic waste generated by certain IC&I facilities by 2025.

The 80% waste diversion by 2050 target in the discussion paper is an overall goal for residential and IC&I waste combined. While the residential sector has seen steady increases in diversion performance over recent years, which is anticipated to continue into the future, the IC&I sectors' historic diversion rates has remained relatively stagnant, hovering between 11% and 17% between 2006 and 2018. This has resulted in a combined current diversion rate in Ontario of 30%. As 98% of the waste received at the Ridge Landfill comes from the IC&I sector, it was decided for the purpose of this update that a diversion target reflective of this sector should be considered. In revisiting the need and opportunity, the diversion goal for IC&I waste of 40% by 2050 has been carried forward. It is assumed that achieving the diversion target of 40% will be made possible by the efforts to be undertaken as a result of current and future Provincial and federal regulations/guidelines.

The federal government recently announced a proposal to ban single-use plastics (e.g., straws, stir sticks) as early as 2021. Consultation with provinces and territories will occur to determine the extent and timing of the ban. Once the ban is in full effect, along with the other measures the provincial government is intending to implement (discussed above), it will impact the quantity of waste generated and could contribute to the future diversion achieved in the proposed service area (i.e., 40% IC&I diversion by 2050).

Review of Market Conditions

SD#1 included an assumption that the Ridge Landfill would receive 1.3 million tonnes in 2017 when the ToR was submitted in December 2017. The actual waste disposed at the Ridge Landfill in 2017 was just under that amount at 1.294 million tonnes. In 2018, there was an increased need for waste disposal capacity at the Ridge to avoid a potential accumulation of waste at generating sites and transfer stations over the holiday period. The MECP approved an emergency ECA amendment to temporarily increase the maximum annual disposal rate by 20,000 tonnes for 2018. Waste Connections managed this such that by year end, the Ridge received 1,302,199 tonnes of waste (i.e., only approximately 2,200 tonnes more than originally permitted annual capacity).

In 2019 an unforecasted issue arose with demands to dispose of a significant amount of excess soil. A temporary increase in the amount of a 100,000 tonne allowance was approved by MECP enabling the landfill to meet this demand for capacity from existing contracted customers. Waste Connections worked to minimize the need for this 100,000 tonne allowance and at year end received about 1,374,870 tonnes (i.e., approximately 75,000 tonnes more than originally permitted annual capacity and less than the requested 100,000 allowance). This issue is not expected to arise in 2020 or during the EA planning horizon (2021 to 2022). It is anticipated that pending excess soil legislation, *O.Reg. 406/19: On-site and Excess Soil Management* (filed on December 4, 2019 under the EPA) will be enacted and will serve to mitigate the problem.

In both cases, these were pro-active steps taken by Waste Connections to ensure sufficient disposal capacity would be available at year-end to avoid the potential accumulation of waste at transfer stations in excess of ECA waste storage compliance levels.

There has recently been significant media attention related to the issues with the quality of materials being placed in Blue Boxes and finding markets for Blue Box recyclable materials. Current market conditions have resulted in an increased need for disposal capacity for Blue Box materials with the advent of overseas markets placing greater restrictions on imported waste. While the hope is that these

restrictions will drive innovation towards a circular economy and redesign of products, at present, this has reduced viable markets for previously recycled materials thereby increasing the quantity of residual waste disposal needs.

Waste generated in Ontario continues to be exported for disposal to the United States. In 2018, Michigan landfills received over 2.95 million tonnes of Canadian waste which accounted for almost 19% of the total airspace consumed at Michigan landfills¹. Waste Connections' Brent Run landfill in Michigan received almost 685,000 tonnes of waste generated in Ontario in addition to waste normally taken locally. The quantities of Ontario waste that were sent to New York and Ohio landfills in 2018 is unknown.

It is challenging to estimate or predict how long Ontario can rely on disposal capacity in the United States. Recent news articles suggest that the politicians in the State of Michigan are once again considering imposing disposal taxes on international wastes² which, depending on the level of tax, has the potential to make the Ontario disposal facilities more competitive. However, given the projected shortfall in Ontario waste disposal capacity, this will only exacerbate the problem. In revisiting the need and opportunity for the Ridge Landfill to continue operations, consideration of Canadian waste exported to the US was accounted for by calculating the 10-year historical average quantities sent to Michigan, New York and Ohio disposal facilities based on available data.

Based on the above, there remains a strong demand for IC&I waste disposal in Ontario which presents an opportunity for Waste Connections to continue operations at the Ridge Landfill after 2021 until 2041 at the same fill rate of 1.3 million tonnes per year. This is further demonstrated by the attached flow chart prepared in response to our discussions with the MECP on May 24, 2019 and an email received on July 10, 2019. **Figure 1** illustrates the opportunity for Waste Connections to continue to provide disposal capacity over the planning period and is based primarily on the same data used in SD#1 with the noted exceptions of the future waste diversion assumption changing from an overall rate of 80% to an IC&I sector specific rate of 40% by 2050 (given how the majority of waste received at the Ridge Landfill is from the IC&I sector) and including an estimated quantity of Ontario waste exported to US disposal sites. An explanation of how the flow chart was developed is provided following **Figure 1**.

Ridge Landfill Market Rationalization

SD#1 included Attachment #3: *An Economic Analysis of the Market for IC&I Waste in Central and Southwestern Ontario (2017)*. The purpose of the analysis was to examine the supply and demand for IC&I waste for the market in central and southwestern Ontario and to examine the economic impact on the Ontario economy of maintaining the annual fill rate of 1.3 million tonnes. The analysis relied on the results of a previous study completed for the Ridge Landfill: *BFI Ridge Landfill Expansion EA Impact Assessment – Appendix Q – The Waste Management Opportunity (1996)*.³ The independent analysis was completed by economist, Dr. Jack Carr.

¹ Michigan Department of Environmental Quality, *Report of Solid Waste Landfilled in Michigan (Oct. 2017-Sept. 2018)*, January 2019.

² https://www.mlive.com/news/2018/01/snyder_renew_michigan_trash_ta.html, Accessed June 2019.

³ Dillon Consulting Limited, *BFI Ridge Landfill Expansion Environmental Assessment Report*, January 1997.

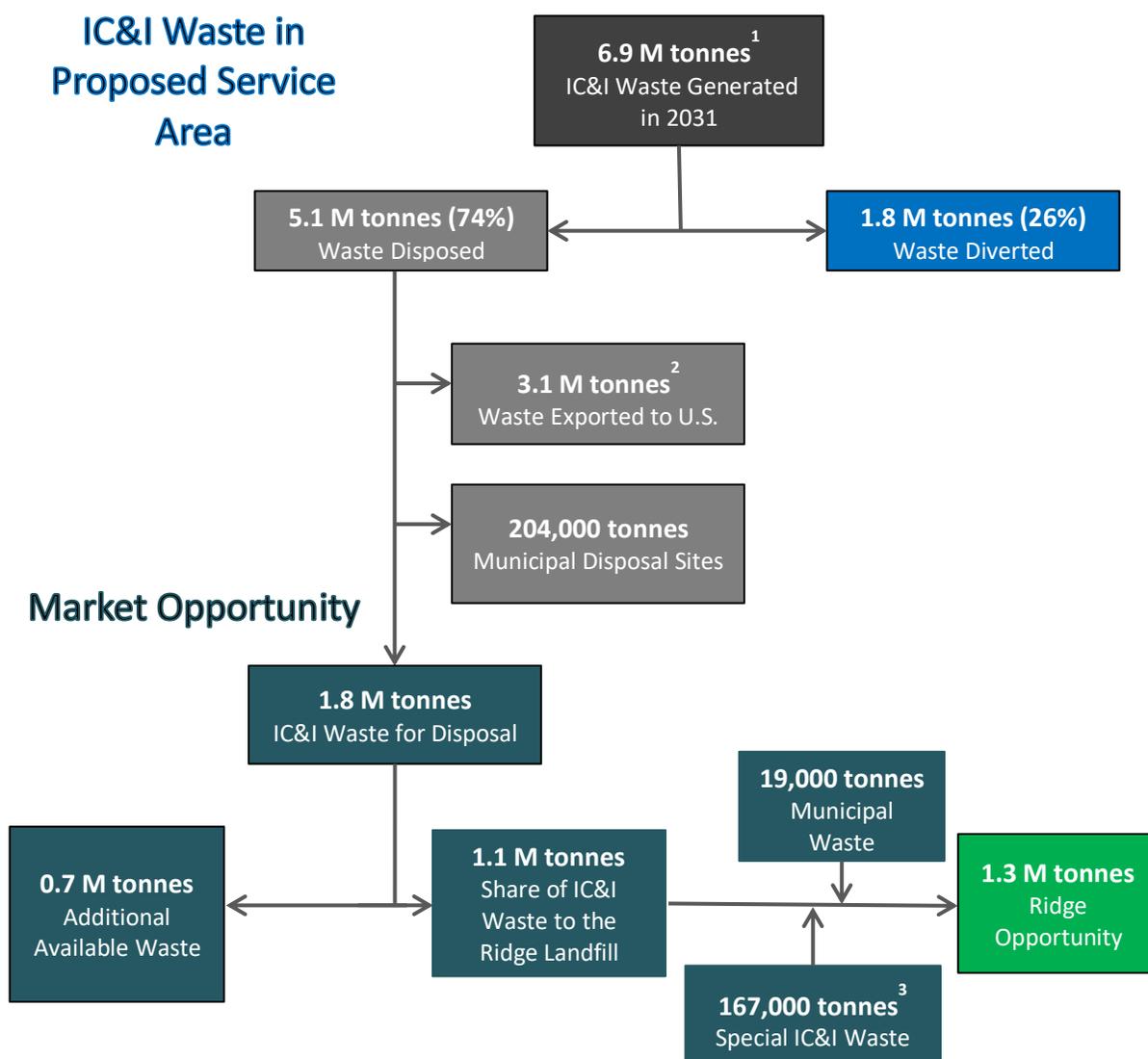
The 2017 Economic Analysis concluded that "... the data shows that the relative cost of hauling and disposing of waste at the Ridge versus the cost of hauling and disposing of waste at Ridge's competitor is approximately the same today and it was when the 1996 study was completed. As such, in my opinion, the data shows that the 'least cost approach' in Appendix Q is valid today."

The main conclusion of the 2017 Economic Analysis is still valid today. Currently the price of gasoline in the Toronto area is about 116 cents per litre and the real increase in gasoline prices from 1996 to 2019 is about 34.9%. There is no new data on fuel efficiency. If it is assumed that fuel efficiency of light trucks has increased from 2014 to 2019 at the same rate that it increased from 1996 to 2014, then fuel efficiency of light trucks has increased at 34.9 % from 1996 to 2019. With fuel efficiency increasing by the same rate as the increase in the price of gasoline, the real fuel cost per kilometre of hauling waste is approximately the same today as it was in 1996. This analysis indicates that the main results of the least cost analysis in Appendix Q is as valid today as it was in 1996.

Summary

This memo reconfirms that there remains a substantial, sustained opportunity for Waste Connections to continue operations at the Ridge Landfill beyond 2021 until 2041 which justifies the request for the Ridge to expand its capacity by 26 million tonnes of waste disposal over the 20-year planning period.

FIGURE 1: OPPORTUNITY FOR THE RIDGE LANDFILL (2031)

**Legend**

1. All quantities in metric tonnes and forecasted quantities in 2031.
2. Based on 10-year historical average of waste actually exported (2008 to 2018).
3. Based on a 5-year average of special waste received at the Ridge Landfill (2014 to 2018).

Explanation of Flow Chart

The flow chart was prepared to illustrate the proposed opportunity for the Ridge Landfill to continue operations beyond 2021. The midpoint of the planning period, 2031, was used. The following provides the approach and supporting data/data sources used to provide the estimates in the flow chart. The bolded text below refers to the titles in the flow chart boxes. The **IC&I Waste Generated in 2031** quantity of 6.9 million tonnes was estimated in SD#1 and is based on Statistics Canada Waste

Management Industry Survey data and Ministry of Finance employment projections for the proposed service area. An average per employee annual waste generation rate was estimated from these data sources and used to project the total waste generated.

The **Waste Diverted** quantity in the flow chart (1.8 million tonnes in 2031) is based on the still applicable sensitivity analysis previously completed in SD#1 where 40% diversion is achieved by the IC&I sector in 2050 and reflects an IC&I diversion rate of 26% in 2031. This is a realistic target based on Statistics Canada historical quantities diverted in this sector. The **Waste Disposed** quantity of 5.1 million tonnes is calculated by subtracting Waste Diverted from Total IC&I Waste Generated in 2031.

The potential quantity of Ontario waste being exported to the United States (**US Export**) is estimated by calculating the 10-year annual average (2008 to 2018) quantity of Canadian waste exported to US disposal sites in Michigan, New York and Ohio. This is based on available data from published Michigan and New York State reports and from data gathered by the Ontario Waste Management Association. Given that there are no breakdowns on specific Canadian locations where waste was exported from, it is assumed that because of geographic proximity that the majority of Canadian waste exported to these three states is generated within the proposed service area.

At the start of planning period, there are an estimated 14 major municipal disposal sites that were projected to have waste disposal capacity remaining. It is forecasted that six of the 14 would still have waste disposal capacity remaining in 2031. These disposal sites include Durham York Energy Centre, City of Hamilton's Glanbrook Landfill, City of Brantford's Mohawk Street Landfill, Oxford County's Salford Landfill, City of Stratford Landfill and the Essex Windsor Solid Waste Authority Regional Landfill. As W12A has now received approval for their Terms of Reference (requested annual capacity of 500,000 tonnes per year), they have been added to the list of municipal landfills that could receive IC&I waste. It was assumed that these facilities will reserve an average of 15% of their capacity for IC&I waste which was based on data received from municipal landfill operators. This results in approximately 204,000 tonnes of available permitted annual capacity in 2031 from **Municipal Disposal Sites** for IC&I waste. The Durham York Energy Centre has not committed to an expansion to their facility, it is anticipated that it would not be required until the mid 2030s with the majority (if not all) capacity being allocated for residential waste.

The Market Opportunity for **IC&I Waste for Disposal** was calculated by subtracting US Export and Municipal Landfill Sites quantities from Waste Disposed which equates to 1.9 million tonnes.

The Ridge Landfill receives specific wastes including residual solid non-hazardous waste from Chatham-Kent and special IC&I waste. Residential waste projections for Chatham-Kent were developed in SD#1 where the residential population was projected using data from the Ministry of Finance Ontario Population Projections (2013 – 2041) and residential waste generation was projected based on data from Statistics Canada's Waste Management Industry Survey. An average per capita annual waste generation rate was estimated from these data sources and used to project the total waste generated for Chatham-Kent. Given the residential sector has historically achieved higher diversion rates than the IC&I sector, the previous Provincial diversion goal of 80% by 2050 was maintained for the residential waste projections in SD#1. With this, the estimated post-diversion residual **Municipal Waste (Chatham-Kent)** quantity in 2031 is 19,000 tonnes.

The Ridge Landfill receives specific waste types such as auto manufacturing and construction and demolition wastes and contaminated soils. Based on a 5-year average of actual quantities of these waste types received at the Ridge Landfill between 2014 and 2018, the estimated quantity of **Special IC&I Waste** to be received in 2031 is 167,000 tonnes.

With Waste Connections seeking to continue maintaining their annual waste disposal rate of 1.3 million tonnes per year (**Ridge Opportunity**), the remaining **Additional Available Waste** for other waste disposal sites is estimated by subtracting the Ridge Opportunity, Municipal Waste (Chatham-Kent) and Special IC&I Waste from the Market Opportunity IC&I Waste for Disposal which equals approximately 0.7 million tonnes. Of the estimated 1.8 million tonnes of IC&I waste available for waste disposal, it is projected that 1.1 million tonnes will be available for the Ridge Landfill (**Share of IC&I Waste for Disposal**).

**AN ECONOMIC ANALYSIS OF THE MARKET FOR
IC&I WASTE IN CENTRAL AND SOUTHWESTERN ONTARIO**

**By:
Jack L. Carr***

December 14, 2017

***Professor Emeritus of Economics, University of Toronto**

Table of Contents

1. INTRODUCTION.....	1
2. DEMAND FOR WASTE DISPOSAL SERVICES FOR NEXT 20 OR 25 YEARS.....	1
2.1 Scenario 1 - Achievement of 50% of Strategy for a Waste-Free Ontario Targets.....	2
2.2 Scenario 2 - 100% Achievement of Strategy for a Waste- Free Ontario Targets	2
3. DEMAND FOR DISPOSAL SERVICES AT THE RIDGE.....	3
3.1 Results of Appendix Q in the 1996 Study	3
3.2 Implications of Current Data	4
4. ECONOMIC BENEFITS OF MAINTAINING THE RIDGE AT ITS CURRENT PERMITTED WASTE DISPOSAL RATE	5
5. CONCLUSIONS	7

TABLES

TABLE 1: FORECAST OF WASTE GENERATED IN THE IC&I SECTOR OF CENTRAL AND SOUTHWESTERN ONTARIO (MILLIONS OF TONNES).....	1
---	---

1. INTRODUCTION

Waste Connections is proposing to maintain the current annual fill rate of 1.3 million tonnes over a 20-year planning period for Ridge Landfill (the Ridge). This study examines the supply and demand for IC&I waste for the market in Central and South Western Ontario and also examines the economic impact on the Ontario economy of maintaining this annual fill rate of 1.3 million tonnes. This study relies on the results of a previous study of the Ridge: *BFI Ridge Landfill Expansion EA Impact Assessment -Appendix Q -The Waste Management Opportunity* dated December 1996. It should be noted that any forecast over the next 20 or 25 years is bound to be speculative.

2. DEMAND FOR WASTE DISPOSAL SERVICES FOR NEXT 20 OR 25 YEARS

Waste generation is a by-product of economic activity, and as the Ontario economy grows faster than Canada's and those of all other G7 nations for the past three years according to the 2017 Ontario Outlook and Fiscal Review, so will Ontario's waste generation. Before taking into account diversion, I assume waste volumes will grow in line with the Ontario's economy, and for simplicity, I assume that the growth in real GDP in Central and Southwestern Ontario will be equal to the growth in real GDP for the entire Ontario economy. The waste generated for the IC&I sector for Southern and Central Ontario was 5.641 million tonnes in 2010.¹ In Table 1, I start with the actual waste generated in 2010 and assume that the waste generated will increase to 2016 at the same rate of increase as the actual rate of increase of real GDP in the Ontario economy from 2010 to 2016 of 11.6%. For 2016, I assume a diversion rate of 15%. The Ministry of Finance of the Ontario Government forecasts an annual real GDP growth of 2.1 percent between 2016 and 2040. I use this estimate of future growth to project the volume of waste generated for 2030 and 2040.

TABLE 1: FORECAST OF WASTE GENERATED IN THE IC&I SECTOR OF CENTRAL AND SOUTHWESTERN ONTARIO (MILLIONS OF TONNES)

YEAR	WASTE	DIVERSION RATE SCENARIO 1	DIVERSION RATE SCENARIO 2	RESIDUAL WASTE SCENARIO 1	RESIDUAL WASTE SCENARIO 2
2010	5.641				
2016	6.295			5.351	5.351
2030	8.421	25%	50%	6.316	4.211
2040	10.366	32.5%	65%	6.997	3.628

The most difficult variable to estimate for the next 25 years is the diversion rate for the IC&I sector. The diversion rate for the IC&I sector is about 15% for 2014. Given the proprietary nature of data for the IC&I sector, it is difficult for Statistics Canada to obtain reliable estimates of diversion rates in the IC&I sector. Statistics Canada estimates for 2014, a 37% residential diversion rate and a 15% non-residential diversion rates; for a total diversion rate of 25%. The

¹This number is derived from Statistics Canada, *2010 Waste Management Industry Survey: Business and Government Sectors*.

Strategy for a Waste-Free Ontario diversion targets are 50% for 2030 and 80% for 2050. From these targets, I would estimate a *Waste-Free Ontario* target of 65% ($\frac{1}{2} \times (50\% + 80\%)$) for 2040. I consider two diversion rate scenarios.

2.1 Scenario 1 - Achievement of 50% of Strategy for a Waste-Free Ontario Targets

In this Scenario, I assume a target diversion rate of 25% ($50\% \times 50\%$) for 2030 and 32.5% ($50\% \times 65\%$) for 2040. Given the much higher actual diversion rates for the residential sector over the IC&I sector, it will be more difficult for the IC&I sector to reach the Strategy for a Waste Free Ontario goals. Based on the performance of various past programs aimed at the sector, Appendix Q of the 1996 EA study noted various government programs and forces which would lead to an increase in diversion rates. On page 14 of Appendix Q it is stated that "...[b]oth these factors leading to reductions in the IC&I waste being produced were identified and discussed in detail in the GTA Reports. Therefore for the purposes of this study, a 40% diversion rate is believed to be a reasonable estimate for planning purposes. As with the disposable opportunity analysis, the 40% diversion rate is estimated for the year 2011". The actual diversion rate for the IC&I sector for 2011 was 12%. In 1996, Appendix Q overestimated the future diversion rates and by extension underestimated the future disposal rates at the time. The results of Appendix Q would have changed dramatically if a lower (12%) diversion rate were used instead of a 40% diversion rate.

With the diversion rate of 25% for 2030 (which is more than double the actual diversion rate in 2012), the total residual IC&I waste market is 6.316 million tonnes for 2030 and with a diversion rate of 32.5% for 2040, the total residual IC&I waste market is 6.997 million tonnes. Given the 2016 residual IC&I waste landfill disposal rate to handle 5.351 million tonnes a year (see Table 1), under Scenario 1, there is an excess demand for disposal capacity in the IC&I sector. It should be noted that the 5.351 figure is a status quo figure. It assumes no reduction and no additions to available landfill capacities.

2.2 Scenario 2 - 100% Achievement of Strategy for a Waste- Free Ontario Targets

In this scenario, I assume a target diversion rate of 50% for 2030 and 65% for 2040. This scenario assumes that the Strategy for a Waste Free Ontario targets are fully achieved. In this scenario, there will be a demand for residual IC&I waste landfill services of 4.211 million tonnes per year in 2030 and 3.628 million tonnes per year in 2040. With the addition of all proposed expanded or new facilities and MOECC's diversion targets are achieved, the estimated annual waste disposal rate rises to approximately 6 million tonnes in 2022, decreasing to 2.5 million tonnes in 2036 until the end of the planning period.¹

Taking into account the estimated changes in supply of landfill facilities, also under Scenario 2 there is still an excess demand for disposal facilities. In Scenario 2, there is still an excess demand for disposal facilities even with 100% achievement in *Waste-Free Ontario* diversion

¹ Data as of 2015 was obtained from MOECC received through email to Waste Connections in December 2017. It should be noted that there are three landfills in the service area that are undergoing an EA process (W12A London, Southwestern Landfill - Walker, Terrapure Stoney Creek). My estimates were based on the MOECC 2015 data plus the 3 expansions/new sites underway.

targets.

3. DEMAND FOR DISPOSAL SERVICES AT THE RIDGE

The previous section provided the macro analysis, which showed that over the next 20 or 25 years there will be a situation where total demand for waste disposal services will exceed the total supply of landfill services to dispose of the available waste. This section examines the microeconomic situation of whether the Ridge is sufficiently competitive to be able to supply its ask of 1.3 million tonnes per year. I believe that there is overwhelming evidence that the Ridge will be able to successfully compete in the IC&I waste market of Central and Southwestern Ontario and fulfill and maintain its annual waste disposal rate of 1.3 million tonnes.

3.1 Results of Appendix Q in the 1996 Study

The question of the ability of the Ridge to compete in the waste market by fulfilling and maintaining all of its permitted annual waste disposal rate was first addressed in the 1996 study. This comprehensive study completed a “least cost” approach and estimated “the tonnage of waste that should be attracted to the Ridge site based solely on the estimated costs to existing and potential IC&I customers from Southern Ontario of hauling and disposing of their waste at Ridge, versus hauling and disposing of their waste at Ridge’s competitors.” On page 31 of the report it is concluded that “[b]ased on least cost analysis alone, it appears approximately 1,215,000 tonnes of IC&I waste will be the maximum reasonable amount available for disposal at the Ridge Landfill site.”

In my opinion, the data shows that the relative cost of hauling and disposing of waste at the Ridge versus the cost of hauling and disposing of waste at Ridge’s competitor is approximately the same today and it was when the 1996 study was completed.² As such, in my opinion, the data shows that the ‘least cost approach’ in Appendix Q is valid today. Of the 16 sites listed in Appendix Q, 7 are now closed leaving 9 sites from the Appendix Q’s list. Currently the Ridge competes successfully with the disposal sites in its market area, and does so at an intake of 1.3 million tonnes annually.

When Appendix Q was written the Ridge operated on a relatively small scale of approximately 220,000 tonnes. Today the Ridge has an annual waste disposal rate of 1.3 million tonnes and almost 98% of these 1.3 million tonnes of residual waste disposed of annually comes from the IC&I sector. The relevant market for the Ridge is residual waste from the IC&I sector. Today there are only five landfill sites with an annual fill rate of 100,000 tonnes or more that compete in the market for IC&I waste and these landfill sites are Walker Environmental-South Landfill, Terrapure-Stoney Creek Landfill, Waste Management-Petrolia, Waste Management-Twin

²I assume in my analysis that the relative costs of operating the landfill site at the Ridge versus operating the landfill sites at the competitors of the Ridge has not changed since 1996. Given the substantial increase in capacity at the Ridge that has taken place since 1996 and given the economies of scale in operating landfill sites, then it is likely that the competitiveness of the Ridge may have increased since 1996. This increase in competitiveness will only apply with respect to competitors who have not experienced a similar increase in annual capacity.

Creeks and the Ridge. All five sites existed when Appendix Q was written. Of the five sites, two are estimated to be near or at currently approved capacity; Terrapure-Stoney Creek and Petrolia.

From the original sites that competed with the Ridge in 1996, there are now only two private sector sites other than the Ridge permitted to accept putrescible waste from the IC&I sector; Walker South Landfill and Twin Creeks operated by Waste Management.³

These two major competitors to the Ridge existed in 1996 when Appendix Q was written. The prime cost of hauling waste is the cost of trucks/transportation, the cost of labour and the cost of fuel. Since the competitors of today existed in 1996, then the basic geographical distances from the collection from these waste sites to the disposal at the major landfills has not significantly changed. The major change is the price of fuel. Statistics Canada shows a price of gasoline of 56.1 cents a litre in Toronto in 1996.⁴ Today the price of fuel is about 105 cents a litre in Toronto. After adjusting for inflation the real price of fuel has increased by about 27.5%. Counteracting this increase in the price of fuel, has been an increase in fuel efficiency for motor vehicles. It is difficult to get fuel efficiency data for the type of trucks used in the waste disposal industry however the U.S. Department of Transportation estimated that fuel efficiency of light trucks increased by 26.4% from 1996 to 2014.⁵ With fuel efficiency increasing by approximately the same rate as the increase in the price of gasoline, the real fuel cost per kilometre of hauling waste is approximately the same today as it was in 1996. This analysis indicates that the main results of the least cost analysis in Appendix Q are as valid today as it was in 1996.

The main results of this comprehensive analysis are valid today. As such, the maximum reasonable amount of 1.215 million tonnes will simply have to be adjusted by the growth in the size of the market that has taken place since 2011.⁶ The growth of the market from 2011 to 2030 (the mid-point of the planning period) will take this 1.215 million tonnes figures well over the 1.3 million tonnes figure that Waste Connections is proposing for the Ridge.

The 1996 study showed that the Ridge was in a favorable geographical location to successfully compete with the competitors of the Ridge. The 1996 study supports the proposition that the Ridge will in the planning period be able to fulfill and maintain all of its proposed intake waste disposal rate of 1.3 million tonnes per year.

3.2 Implications of Current Data

In 2012 the permitted annual waste disposal rate of the Ridge was increased to 1.3 million tonnes. In 2014, 2015 and 2016 the Ridge was successful in accepting 1.3 million tonnes in each year and is on target to do the same in 2017. During my research it was revealed that in the fourth quarter of each year since 2014, Waste Connections has had to re-direct IC&I waste away from the Ridge in order to avoid exceeding the site's annual waste fill limits. The 1996 study by its very nature had to be speculative in forecasting the future. That study was done for a business

³It is estimated that about 15% of waste received by public sector sites is from the IC&I sector.

⁴See Statistics Canada, CANSIM TABLE #326-0009.

⁵See US Department of Transportation, Highway Statistics

⁶It should be noted that this 1.215 million tonnes figure was estimated assuming a diversion rate of 40%.

that did not exist at the time. To a large extent we know what happened in that future. The actual historical data shows that the Ridge was a very successful competitor and could have supplied even more than the 1.3 million tonnes annual waste disposal rate.

In 2017 about 375,000 tonnes of Ontario's IC&I waste will be disposed of at the Brent Run facility in Michigan operated by Waste Connections. This waste could and would likely have been disposed of at the Ridge but for the current annual waste disposal rate restrictions at that site. In addition to Brent Run there are approximately 2.625 million tonnes of Ontario waste being disposed of at other US landfills annually (for a total of about 3 million tonnes annually). This waste should/would also be disposed of in Ontario if sufficient capacity existed. It also should be noted that it has become more costly to get across the Canada-US border. In addition, the actual experience for the last four years shows that there is an excess demand for waste disposal at the Ridge and that but for the current annual waste disposal rate restrictions, the Ridge could have disposed of IC&I waste significantly above the current annual waste disposal rate of 1.3 million tonnes.

If the commercial waste diversion initiatives of the *Strategy for a Waste-Free Ontario* becomes more successful over time then there is the possibility of the repatriation of some or all of the approximate 3 million tonnes of Ontario IC&I waste currently going to the US. This fact alone almost guarantees that the Ridge will be able to fulfill and maintain all of the 1.3 million tonnes annual waste disposal rate.

The geographical advantage and management efficiency at the Ridge shows that the Ridge has been a successful competitor and will continue to be a successful competitor over the planning period and will be able to supply all of its 1.3 million tonnes of the annual waste disposal rate.

4. ECONOMIC BENEFITS OF MAINTAINING THE RIDGE AT ITS CURRENT PERMITTED WASTE DISPOSAL RATE

Waste Connections employs 1400 people in Ontario and currently spends about \$84 million dollars in labour expenses and about \$154 million in other vendor expenses annually. Additionally, Waste Connections reinvests substantial amounts of capital into its business on an annual basis to purchase trucks and other investment equipment to construct and expand facilities it owns and operates in the Province. The Ridge is an important landfill site for Waste Connections representing about 25% of the market in Central and Southwestern Ontario with over 200 trucks per day are inbound to the Ridge site. These trucks use local restaurants, purchase fuel locally, employ Ontarians and the facility contributes significantly in taxes and royalties to local governments and communities.

If the Ridge's annual waste disposal rate is maintained at the current level of 1.3 million tonnes, the Ridge's contribution to the Ontario economy will continue. If the Ridge's annual waste disposal rate is maintained Waste Connections has plans to build a gas plant and become a reliable source of renewable gas for decades to come. The gas plant also plays an important role in meeting the objectives of the Province's *Climate Change Action Plan* in the generation of renewable natural gas at the Ridge. The gas plant will cost about \$40 million dollars to build. If the Ridge's capacity is eliminated, this gas plant could possibly be built but it would have to be

built on a smaller scale. With economies of scale in the operation of gas plants, a smaller scale plant will have higher per unit costs. Elimination of the Ridge's annual capacity will change the economics of building a gas plant and as such, decrease the likelihood that this gas plant will be built.

Waste Connections has experience in building and operating gas plants. Waste Connections invested over \$40 million at the Lachenaie landfill site in Quebec, creating Canada's largest biogas-to-vehicle-fuel-quality project. That site produces enough renewable natural gas to fuel 1,500 trucks over 20 years, offsetting nearly 100,000 tonnes CO₂e annually. The site has a similar annual waste disposal rate as the Ridge receiving over 1.2 million tonnes of waste, including food waste, from MSW and IC&I sources. To capture the methane produced from this waste Lachenaie invests over \$2 million per year, and has achieved an impressive landfill gas capture efficiency rate above 93%. Lachenaie's 50 or more employees also oversee a variety of yard waste recovery operations while having a positive effect on the local economy. If the Ridge's capacity is maintained and if the gas plant is built, there should be additional positive economic effects on the local Southwestern and Central Ontario.

A gas plant at the Ridge will pay an additional \$85,000 a year in local taxes. Currently the Ridge pays just under \$350,000 in local taxes. The Ridge paid an annual royalty payment to Chatham-Kent of \$2.6 million in 2016 in addition to significant contributions that are made to the Ridge Landfill Trust, which in 2016 were approximately \$1.1 million dollars. Waste Connections also provides incentives to Chatham-Kent to reduce the amount of waste residuals delivered to the Ridge with payments averaging over \$1.2 million per year. In total, the Ridge contributes over \$5 million a year to the local government.

In addition to the above payments, The Ridge also generates direct and indirect benefits to the local community; salaries, goods and services, purchased services, local roads maintenance etc., which amounts to \$9 million per year. Furthermore, the expansion of the Ridge capacity and the building of a gas plant will help stimulate the local economy and provide additional environmental benefits to Ontario by recapturing of gas that is currently flared off.

The Ridge services 25% of the disposal capacity of the Southwestern and Central Ontario market. If the Ridge is closed then competition in this market will be significantly reduced. The only other fully integrated provider is Waste Management and if Waste Connections no longer accepted waste at the Ridge, Waste Management will become a monopolist in this market.⁷ Monopoly almost always results in higher prices and eliminating the competition from the Ridge will increase the costs of waste disposal in the IC&I sector in Central and Southwestern Ontario. Increasing the cost of doing business will result in a reduction in economic activity in the IC&I sector throughout Central and Southwestern Ontario.

⁷Even if competition from Walker South Landfill is considered the elimination of the Ridge will leave only two competitors for IC&I waste resulting in a duopoly. Reduction in the number of competitors from 3 to 2 also represents a substantial reduction in competition.

5. CONCLUSIONS

The data shows that if all of the *Strategy for a Waste Free Ontario* diversion rates for the Ontario IC&I sector are achieved then the Ridge will still be able to successfully supply all of its annual waste disposal rate (i.e., 1.3 million tonnes). If any of the assumptions used in this report turn out to be incorrect, I believe the main conclusions of this report will still hold. Due to the fact that currently around 375,000 tonnes of waste go annually from Ontario to the Brent Run facility in Michigan, as well as about 2.625 million tonnes of Ontario waste being disposed annually at other US landfills (for a total of about 3 million tonnes annually), this provides robustness to the conclusion. For example, if the government is even more successful in diverting IC&I waste, the Ridge will still be able to fulfill and maintain its annual waste disposal rate of 1.3 million tonnes by the diversion to the Ridge, of waste that now goes to the US. This would result in a reduction of trucks to the US further reducing GHG emissions.

If the annual waste disposal rate of the Ridge is renewed the Ridge will continue to be a positive influence on the Ontario economy and if the gas plant is built at the Ridge, this landfill site will have an even more stimulating impact on the Ontario economy.

Appendix F2

Landfill Mining Report



DILLON
CONSULTING

WASTE CONNECTIONS OF CANADA

Landfill Mining Assessment Report

Ridge Landfill Expansion EA

Table of Contents

Executive Summary

1.0	Introduction	1
1.1	Purpose of Report	1
2.0	Background	1
3.0	Old Landfill Design	2
3.1	Leachate Management System at the Old Landfill	3
4.0	Old Landfill Operations	3
4.1	Filling Sequence.....	3
4.2	Filling Method	5
4.3	Types and Quantities of Waste	5
4.4	Daily Cover	6
4.5	Landfill Densities	6
5.0	Leachate Levels Monitoring	8
6.0	Literature Review	9
7.0	Site Specific Mining Assessment	10
7.1	Process Description	10
7.2	Operational Requirements	11
7.3	Potential Volume Recovery Rates in Air Space	11
7.4	Air Quality Assessment	11
7.5	Odour Impact Assessment	12
7.5.1	Surface Monitoring of Emissions.....	12
7.5.2	Potential for Odour Emissions	13
7.5.3	Odour Management	13
7.6	Other Nuisances Effects	14
7.6.1	Dust and Airborne Contaminant Management	14
7.6.2	Litter Control	14

7.6.3	Noise Control	15
7.7	Surface Water and Leachate Management	15
7.8	Health and Safety Considerations	15
7.9	Cost Estimate	16
7.10	Evaluation Criteria	16
7.11	Opportunities and Risks with Mining the Old Landfill	17
7.11.1	Site-Specific Opportunities	17
7.11.2	Site-Specific Risks	18
8.0	Summary and Conclusions	19

Tables

Table 1: Location of Active Landfilling Area	4
Table 2: Annual Waste Tonnage, Depleted Capacity and Density	6
Table 3: Site Compactors	8
Table 4: Summary of Key Findings and Mining Reasons	9
Table 5: Criteria and Evaluation of Mining Potential	16

Figures

Figure 1: Site Plan
Figure 2: Cross Sections
Figure 3: Process Flow Diagram for Landfill Mining

Appendices

A	Leachate Well Borehole Logs
B	Leachate Well Photographs
C	Literature Review

References

Executive Summary

Waste Connections of Canada Inc. (WCC) is proposing to expand the Ridge Landfill and one of the contemplated options is to mine the existing portion of the site known as the Old Landfill to gain additional landfill capacity. Landfill mining (or landfill reclamation) consists of excavating existing disposed waste and cover material, attempt to recover typically 1-2% by volume of recyclables, separate earthen material or “fines”, and return the waste to an engineered disposal area.

The purpose of this report is to assess the site-specific advantages and disadvantages associated with landfill mining. To support this mining assessment report, we reviewed available background documents, completed a literature review and interviews with landfill managers that have completed mining projects, conducted a site investigation at the Old Landfill (i.e. drilled boreholes, observed the type of waste materials and measured leachate levels).

Landfill mining has been completed in Ontario and elsewhere in North America under favourable conditions when combined with significant drivers such as remediating groundwater impacts, gaining landfill capacity or accessing soil for future needs.

As discussed in this report, the Old Landfill does not have favourable conditions for landfill mining and none of the typical main drivers apply. Therefore, the potential advantages associated with landfill mining are limited and are by far outweighed by the various challenges and concerns specific to the Old Landfill.

The Ridge Landfill future capacity needs can be achieved by expanding the waste footprint horizontally and vertically expanding the Old Landfill without the contemplated mining component.

Page intentionally left blank

1.0 Introduction

1.1 Purpose of Report

Waste Connections of Canada (WCC) is currently undertaking an Environmental Assessment (EA) to expand the Ridge Landfill to fulfill a need for additional waste disposal capacity in Ontario. The proposed expansion would maintain the annual fill rate and extend the operating life of the facility for an additional 20 years. The EA will consider site development alternatives to physically expand the waste disposal capacity of the site. The primary purpose of this report is to examine the technical and economic feasibility, benefits and challenges related to undertaking landfill mining activities at the Old Landfill as a way to gain landfill capacity. Landfill mining has been discussed with the Ministry of the Environment and Climate Change (MOECC) and was described as a potential component of a site development alternative in the Terms of Reference (ToR) for the EA.

This report documents a desktop assessment for the potential to mine a portion of the Ridge Landfill. In preparing this report, we reviewed background documents available in our files for the Ridge Landfill, conducted interviews with WCC personnel, reviewed notes of previous site visits at the City of Barrie Landfill in Ontario and Ocean County Landfill mining project in New Jersey, interviewed landfill operators that have completed or are completing other mining (reclamation) projects in Ontario, and completed a literature review for landfill mining projects in Ontario and the USA.

2.0 Background

The Ridge Landfill started operations at the area currently known as the Old Landfill. The Old Landfill started operations in 1963 (Garter Lee, 1981) and received a Certificate of Approval (now called Environmental Compliance Approval) No. A021601, which was dated July 25, 1983.

The Waste Certificate of Approval changed its name to Environmental Compliance Approval No. A021601 (Waste ECA) and was consolidated in May 1, 2013. The Old Landfill is referred to in the consolidated Waste ECA as the Existing Fill Area with a 48.2 hectare waste fill area.

The Old Landfill did not have a weigh scale until 1992. Prior to 1992, waste records were tracked using truck load counts or ground survey methods.

Maps, aerial photos and plans are available from 1981 (Dillon, 1981 and Garter Lee, 1981).

The Old Landfill has 3 Mounds as shown on *Figure 1*. The landfill operations first started in Mound 2 and subsequently Mounds 1 and 3 were developed. The Old Landfill operated until December 31, 1999 and has not received waste since then.

Old Landfill Design

The development of the Old Landfill started in Mound 2 in 1963 (Garter Lee, 1981). A dozer was the only equipment on-site to excavate trenches, spread the waste and fill (trench and fill method) at Mound 2. The majority of Mound 2 was developed using the trench and fill method. According to Tim Kozlof (former Landfill Manager), the Mound 2 trenches had depths between 3 and 4.5 m (10 and 15 ft.) below the original ground. The filling method changed at later stages of Mound 2 with the introduction of a cell filling method (i.e. excavation of a wide area with rectangular or square shape excavated below the ground surface and filled to a final grade above the ground level) with base excavations up to 8.2 m (27 ft.) below original ground (Dillon, 1981).

Mound 1 was developed using a cell landfilling method. Dillon prepared excavation plans for Mound 1 from 1981, which consisted of generally rectangular cells up to 120 m long and with variable widths. Each individual cell was designed with a sloped base, a low point/sump to allow temporary pumping as needed, cut-off ditches at the edges, separation berms and access roads (Dillon, 1981). *Figure 2* illustrates a general representation of the base of Mound 1 without identification of individual cells.

An excavation plan was prepared for Mound 3 in 1985 (Dillon, 1985a). The base excavation of Mound 3 was initiated in 1985 and its filling started in 1992 and continued until the end of 1999. The cross-sections shown on *Figure 2* provide a visualization of the Mound 3 base. Note that the base of Mound 2 is not shown on *Figure 2* because we could not find records to confirm its depth.

The Old Landfill had an original approved capacity of 4,483,000 m³ (5,864,000 yd³) for waste and daily/intermediate cover (Dillon, 1985a, pg. C-8). An additional 689,000 m³ of landfill capacity was approved as part of the late 1990s EA to horizontally expand the Old Landfill footprint. The approved horizontal expansion is located west of Mounds 1 and 2 in the area identified as Infill (shown on *Figure 1*).

Six leachate wells were drilled at the Old Landfill in January 2017 (refer to *Appendix A – Leachate Well Borehole Logs* and *Appendix B – Leachate Well Photographs*). The key information found in the borehole logs was added to *Figures 1* and *2*. The base depths determined in the drilling program and shown on the borehole logs suggest a reasonable correlation with the base design for Mounds 1 and 3.

Figure 2 indicates that waste was buried at Mound 2 at 3.2 m below original ground (M2W1 - from elevation 194.8 to 198 m above sea level) and 9.8 m (M2W2 - from elevation 188.2 to 198 m above sea level). The shallow landfill base at M2W1 location confirms the trench and fill method used at the majority of Mound 2 of the Old Landfill. The deeper base at M2W2 location confirms the cell fill method applied at later stages of the Mound 2 development.

3.1 Leachate Management System at the Old Landfill

During the operational period of the Old Landfill, a series of leachate collection ditches at the edges of the active cells of Mounds 1 and 3 were drained by gravity to low points/sumps. Leachate was pumped from the low points/sumps to leachate recharge trenches in the landfill waste cells. This leachate recharge practice was used from 1988 until the closure of the Old Landfill in 1999, i.e. for approximately 11 years.

Mounds 1 to 3 have a perimeter leachate collection system (toe drain). The perimeter leachate collection system was approved by MOECC in 1994 (Dillon, 1995, pg. 15&16) and constructed in three phases:

- Phase 1 - Mounds 1 and 2 perimeter completed in 1995.
- Phase 2 – Mound 3 perimeter initial phase completed in 1997.
- Phase 3 – Mound 3 perimeter final phase completed in 2000.

Leachate is collected at the perimeter of the Old Landfill by perforated pipes with finger drains spaced 60 m apart and drained by gravity to manholes and pumping stations, which pump to an above ground storage tank with a capacity of 600 m³ (160,000 U.S. gallons). Leachate is pumped from the above ground storage tank through an off-site forcemain to the Blenheim Sewage Treatment Plant for treatment.

There is a low permeability wall (recompacted clay cut-off wall) constructed with native clay soil at the perimeter of the Old Landfill and outside the perimeter toe drain to enhance horizontal containment.

4.0 Old Landfill Operations

4.1 Filling Sequence

The available reports were reviewed to define the filling sequence determined by the location of the active landfilling area.

Table 1 below provides the annual location of the active landfilling area for the Old Landfill relative to each Mound.

Table 1: Location of Active Landfilling Area

Year	Mound		
	1	2	3
Initial Operations of Mound 2		ü	
Later Operations of Mound 2/Initial Operations of Mound 1	ü	ü	
1981	ü	ü	
1982	ü	ü	
1983	ü	ü	
1984	ü	ü	
1985	ü	ü	
1986	ü	Not filled	
1987	ü	Not filled	
1988	ü	Not filled	
1989	ü	ü	
1990	ü	ü	
1991	Closed	ü	
1992	Closed	ü	ü
1993	Closed	Not filled	ü
1994	Closed	Not filled	ü
1995	Closed	Not filled	ü
1997	Closed	Not filled	ü
1998	Closed	Not filled	ü
1999	Closed	ü	ü

Notes:

- The 1981 Dillon and Gartner Lee reports show aerial photographs and maps with the majority of the waste footprint on Mound 2 and a small waste footprint area on Mound 1. Since there are no records prior to 1981, the exact year when operations started in Mound 1 is unknown.
- The 1996 annual report was not available at the time of this report preparation.

In general, the filling operations proceeded in the following fashion:

- Mound 2 operations first started in 1963;
- Mound 1 operations started before 1981 (historical maps show small areas filled in Mound 1 in 1980);
- Mound 1 closed in 1991;
- Mound 3 landfilling started in 1992;
- Mound 2 operations resumed in 1999 to fill localized settlement areas before closure in 1999; and
- Mound 3 closed in December 31, 1999.

The filling sequence is relevant to the mining assessment because it gives an indication of the age of the waste.

4.2 Filling Method

The majority of Mound 2 was developed using the trench and fill method with depths between 3 and 4.5 m (10 and 15 ft.) below original ground, while Mounds 1 and 3 were developed using a cell filling method with deep cell excavations. Mound 2 therefore has soils between the trenches that were completed at earlier stages of Mound 2 operation, which could increase airspace gain if waste is excavated or mined. Further excavation can potentially be completed at soils under the trenches of Mound 2 to gain additional airspace.

4.3 Types and Quantities of Waste

From November 1972 to September 1981, the Ridge Landfill received approximately 1,400,000 m³ of municipal waste from the City of Chatham, the Town of Blenheim and the Town of Tilbury, approximately 580,000 m³ of industrial, commercial and institutional (IC&I) solid waste, and approximately 74,000 m³ (20,000,000 gal) of liquid industrial waste (which included municipal and industrial sludge). The municipal and IC&I sector wastes included grit from wastewater treatment facilities, wastes from street cleaning and other municipal activities, sludge from municipal sewage works, sludge from industrial wastewater treatment facilities and demolition debris (Dillon, 1981).

Based on the 1981 Design and Operations Report, on average, about 4,500 tonnes (5,000 tons) of waste per month was received at the site and it was anticipated that this amount would increase to 18,100 tonnes (20,000 tons) per month by 1991 (Dillon, 1981). The Old Landfill operated until December 31, 1999. During the operational period, the maximum annual tonnage received was 261,800 tonnes in 1999 (Dillon, 2000).

The following wastes were prohibited from 1981 (Dillon, 1981):

- Pathological wastes from hospitals or laboratories;
- Industrial liquid wastes;
- Hazardous or toxic substances;
- Radioactive wastes; and
- Septic tank pumpings.

Sludges from municipal sewage works and industrial wastewater treatment facilities continued to be accepted at the Old Landfill (Dillon, 1981).

There used to be a liquid waste lagoon at the east corner of Mound 1 with an interceptor trench in between the lagoon and the adjacent property (Dillon As-Built Drawing, Drawing 9 - Interceptor Trench,

December 9, 1983). The liquid waste lagoon was later excavated, had its contents removed and was filled with clean soil (Dillon, 1987, Drawings 1 and 9, August, 1985).

The Existing Site Conditions map (Dillon, 1983, Drawing 1) shows that at different locations in Mounds 1 and 2 there were areas where liquid wastes had been co-disposed with solid waste and in Mound 2 there were also locations of industrial sludge and municipal sewage sludge co-disposed with solid waste in 1983.

The available reports indicate that Mounds 1 and 2 received sludge and liquid wastes. The available borehole logs and photographs (Appendix A and B) indicate the presence of sludges with strong odours. Mining wet wastes or sludges is not practical and is usually avoided based on our literature review.

4.4 Daily Cover

Based on the background information reviewed, a 4:1 waste to daily/intermediate soil cover was estimated, which equates to 20% by volume. Since no alternative daily cover was used at the Old Landfill, approximately 20% of the Old Landfill volume is comprised of local soils that were used as daily/intermediate cover and buried with waste.

The local soils, used as daily cover, are cohesive due to high clay content. Since cohesive soils holds moisture and tends to attach to waste, the mining process in this case would be less efficient, would possibly require additional equipment and as a consequence it would be more time consuming, which in turn would increase the potential for odour concerns.

4.5 Landfill Densities

Landfill densities are reviewed in this report to assist with the assessment of potential air space gain if landfill mining was done in the Old Landfill. Landfill mining is often conducted on closed landfill sites that have low compaction rates because the airspace gained through the mining operations offsets some or all of the mining costs.

Waste records were kept at the Ridge Landfill until February 1992 by volume. A weigh scale was installed in February 1992, with waste tonnages being recorded since then. Since tonnage information prior to 1992 is not available, density calculations were not completed for that period of time. For 1983 and 1984, the uncompacted and compacted waste densities were assumed to be 267 kg/m³ (450 lb/yd³) and 593 kg/m³ (1000 lb/yd³), respectively (Dillon, 1984, pg. 4; Dillon, 1985b, pg. 5).

From 1992 to 1999, waste/soil volume, waste weight, and apparent density were reported every year in annual reports, which are summarized on *Table 2* below.

Table 2: Annual Waste Tonnage, Depleted Capacity and Density

Reporting Period	Waste Weight (Jan – Dec) (tonnes)	Depleted Capacity Between Two Mappings (m ³)	Apparent Density (kg/m ³)
1992	183,300	304,000	603
1993	216,500	244,800	743
1994	214,500	256,400	878
1995	201,700	239,300	882
1997	209,900	282,400	924
1998	215,500	285,100	623
1999	261,800	525,800	564

Notes:

- Values rounded to the next 100 for Waste Weight and Depleted Capacity.
- The 1996 annual report was not available at the time of writing.

The apparent density reported in *Table 2* is defined as the weight of waste divided by the volume of waste and daily/intermediate cover. The volume change due to landfilling between two subsequent surveys was calculated for each annual report and the waste weight for the exact same period of time was used to calculate the waste apparent density.

For additional context, we also reviewed the landfill compaction equipment for the Old Landfill. In 1990, a CAT 826C landfill compactor was purchased by the Ridge Landfill (Dillon, 1991, pg. 8). Prior to 1990, there was no "Equipment List" in the annual reports so it is unclear what compaction equipment was available on site. According to Tim Kozlof (former Landfill Manager), there was no landfill compactor during the earlier stages of Mound 2 operations. *Table 3* summarizes the type of compactors available on site from 1990.

Table 3: Site Compactors

Annual Report Date	CAT 826C Landfill Compactor	CAT 836 Landfill Compactor	Trashmaster Rex 3-70 Landfill Compactor
1990-1993	ü		
1994	ü		ü
1995	ü	ü	
1997- 1999		ü	

Note

- The 1996 annual report was not available at the time of writing.

The overall density for the Old Landfill was not calculated because waste tonnages are not available for the entire site history. The apparent density summarized on *Table 2* is considered high, with a maximum value of 924 kg/m³ and an average of 745 kg/m³ from 1992 to 1999. Also, large size compactors were used on site from 1990 to 1999. The 2016 annual mapping indicates that there have been some settlements, which contributes to a further increase to the apparent density.

Based on the data above, Mound 3 was filled with a high compaction rate, which limits the opportunity to gain landfill capacity through mining operations.

5.0 Leachate Levels Monitoring

Leachate levels were measured on February 24, 2017 at the six new leachate wells installed at the Old Landfill. Since an accurate base is not available for Mound 2, we will refer to leachate depth from the existing top of the landfill surveyed in March 2017.

The following leachate levels were measured from the existing ground on February 24, 2017 (refer to Figure 2):

- Mound 1: 5.3 m below top of landfill surface (mbgs) measured at both leachate wells M1W1 and M1W2;
- Mound 2: 7.1 to 9.2 mbgs measured at M2W1 and M2W2 respectively; and
- Mound 3: 14.2 to 15.2 mbgs measured at M3W1 and M3W2 respectively.

The leachate levels at Mound 1 and 2 are higher than the leachate levels at Mound 3. Higher leachate levels can indicate isolated perched leachate conditions or some leachate mounding, which add significant challenges to mining operations in Mounds 1 and 2 as described later in this report. The higher leachate levels at Mounds 1 and 2 could be attributed to liquids/sludge disposal and since these Mounds are older they had more opportunity for more infiltration and associated leachate generation.

6.0 Literature Review

A literature review was conducted of four Canadian and two American landfill sites that are pursuing or have completed landfill mining operations. The literature review is provided in *Appendix C* for each landfill followed by a discussion on problems and mitigation measures implemented during the mining operations.

Based on our literature review and site visits to the City of Barrie Landfill and Ocean County Landfill Corporation Site, landfill mining is only considered or completed when its benefits outweigh the associated high costs, and odour and health and safety concerns. *Table 4* below summarizes the reasons to consider landfill mining.

Table 4: Summary of Key Findings and Mining Reasons

Landfill Site	Key Findings	Reasons to Consider Landfill Mining
Trail Landfill, Ottawa	<ul style="list-style-type: none"> Unlined existing site on sand setting. Site with existing groundwater impacts. No leachate mounding because the landfill base would not offer natural containment. 	<ul style="list-style-type: none"> Groundwater impacts mitigation. Landfill capacity gain.
Sault Ste. Marie Municipal Landfill	<ul style="list-style-type: none"> Unlined existing site on sand and gravel setting. Site with existing groundwater impacts. No leachate mounding because the landfill base would not offer natural containment. 	<ul style="list-style-type: none"> Groundwater impacts mitigation. Landfill capacity gain.
City of Barrie Landfill	<ul style="list-style-type: none"> Unlined existing site on sand setting. Site with existing groundwater impacts. No leachate mounding because the landfill base would not offer natural containment. 	<ul style="list-style-type: none"> Groundwater impacts mitigation. Landfill capacity gain.
Blue Mountains Landfill	<ul style="list-style-type: none"> Unlined existing site on sand and gravel setting. Site with existing groundwater impacts. Existing site was filled using trench and fill method, providing higher potential for landfill capacity gain. No leachate mounding because the landfill base would not offer natural containment. 	<ul style="list-style-type: none"> Groundwater impacts mitigation. Landfill capacity gain.
Perdido Landfill	<ul style="list-style-type: none"> Unlined existing site on sand setting. Site with existing groundwater impacts. Existing site had leachate seeps. Existing site had differential settlement. Existing site was filled using trench and fill method, providing higher potential for landfill capacity gain. 	<ul style="list-style-type: none"> Groundwater impacts mitigation. Landfill capacity gain.
Ocean County Landfill Corporation Site	<ul style="list-style-type: none"> The site did not have enough soils for regular landfill operations. There were limited vertical and horizontal options. 	<ul style="list-style-type: none"> Fines recovery supplemented soils deficit for landfill operations. Landfill capacity gain.

Most of the mining drivers above do not apply to the Ridge Landfill as will be discussed in details as follows.

7.0 Site Specific Mining Assessment

This section provides discussions for the Old Landfill mining option at the Ridge Landfill.

7.1 Process Description

The typical mining process that would be followed at the Ridge Landfill should, in general, be completed according to the following sequence (for a process flow diagram, refer to *Figure 3*):

- *Planning* - Prepare and implement a health and safety plan, air quality monitoring plan, odour mitigation plan, dust and erosion and sedimentation control plans.
- *Mobilization* – Mobilize waste excavation, processing and transport equipment.
- *Site preparation* – Strip existing soil cover within the area to be mined for each day. Soil would be stockpiled for future cover use.
- *Waste excavation and pre-separation* – Excavate waste in lifts of approximately 3 m thick using an excavator and/or dozer. Materials that could be reused, recycled or cause damage to screening equipment (typically large size, bulky items) would be pre-separated. During waste excavations, large size materials (e.g. tires, long metal rebars, concrete rubble and boulders) could be pre-separated and stockpiled or stored for reuse or recycling, which may include mechanical processing such as shredding, grinding or crushing. However, it is expected that amount of waste that would be recyclable from the Old Landfill would be extremely low; the recovery rate at the Barrie Landfill mining operations was about 1-2% of the waste processed volume.
- *Waste screening* - Excavated waste materials that are not pre-separated would be loaded by an excavator into screening equipment (e.g. trommel screen). The screening process would mechanically separate fine parts (mainly soil), from the residual materials typically referred to as waste overs. In the case of the Ridge Landfill (unlike other reviewed landfills), additional efforts would be required to separate the fines fraction from the previously landfilled waste material because the soil applied as daily/intermediate cover at the Ridge Landfill would have been cohesive due to high clay content, and would require a shredder to break the material or as a minimum longer or more screening (e.g., two screens placed in series).
- *Fines* – Typically, the fines fraction would be hauled to the working face of the active cell for use as daily/intermediate cover, or temporarily stockpiled on the existing landfill footprint. The stockpiled fines would be used to offset the need for virgin soils in future daily/interim cover needs. However, the Ridge Landfill has a soil surplus and therefore additional soils for cover material is not expected to be needed. Because the natural soils are clayey, the successful recovery of fines in any significant amount is unlikely.

- *Waste overs* - The waste overs would be hauled to the working face of the active cell and immediately re-landfilled along with the regular incoming solid waste materials.
- *Compaction and cover* - Mined waste that is re-landfilled would be treated as regular waste, would be compacted and/or mixed with other waste and would be covered with daily cover at the end of each operating day.

7.2 Operational Requirements

The following are the minimum key operational requirements for mining of the Old Landfill:

- Prepare and implement an effective air quality and odour control plan.
- Prepare and implement an effective health and safety plan.
- Plan for an efficient layout and excavation sequence.
- Plan for the introduction of an additional shredder to break the cohesive soils prior to screening. Expect low recovery rate of recyclable materials (approximately 1-2% was achieved in Barrie).
- Have an active working face at the expansion area ready to receive wastes from the mining operations.
- Construct low points (sumps) to pump leachate out of the mining area.
- Construct stormwater separation berms as needed to minimize leachate volumes.

7.3 Potential Volume Recovery Rates in Air Space

The recovered air space (landfill capacity) rates ranged from 20% to 70% at the reviewed mining projects (*Appendix C*). Considering that Mound 3 was filled with a high waste density, and the presence of sludges and high moisture in Mounds 1 and 2, and the presence of cohesive soils in all Mounds, a realistic recovery rate of recyclables is expected to be extremely low.

A potential air space recovery volume for the Old Landfill is likely close to 20% of the mined volume. In addition, since the majority of the bottom of Mound 2 was filled with shallow trenches, its base could be excavated 6 m below the existing trenches following mining. The soil excavation volume below existing waste at Mound 2 is estimated at 0.8 million m³.

It should be noted that the estimated 1 to 2% maximum volume of recycling materials potentially recoverable is included in the likely 20% airspace recovery volume.

7.4 Air Quality Assessment

An initial review of potential landfill mining impacts on air quality was completed. In 2010, the City of Barrie completed an air quality assessment to determine if mining and routine landfill operations could pose a human and environmental health concern. Air samples were collected and analyzed for target parameters of concern. The conclusions of the health assessment indicated that there were no unacceptable health risks to off-site residents resulting from the landfilling or mining activities at the City of Barrie Landfill.

A desktop screening assessment was completed for the Town of Blue Mountain's proposed landfill during the Environmental Assessment approvals process to assess potential air quality impacts associated with landfill mining operations. This screening assessment concluded that there would be no health risks related to landfill mining operations.

Based on the City of Barrie and the Town of Blue Mountain's mining experience, landfill mining operations are typically not expected to pose health risks at municipal landfills. However, health risks would be monitored during mining operations at the Old Landfill since its waste composition is different than a typical municipal landfill waste composition. Also, residents at the vicinity of the Ridge Landfill may raise concerns that could delay the Ridge Landfill Environmental Assessment approval.

Odours and dust generated during landfill mining operations may impact the air quality if not properly managed. Separate odour and dust assessments are presented as follows.

7.5 Odour Impact Assessment

7.5.1 Surface Monitoring of Emissions

Surface monitoring scans were completed at the Ridge Landfill in 2012 and 2013 by RWDI with the purpose to determine areas of elevated Total Hydrocarbon (THC) concentrations. Walkover surveys were conducted at the entire area of the Old Landfill using a handheld THC analyser.

Higher measurements of THC (as methane) were measured at the following locations in 2012 (RWDI, 2012):

- 7 spots at the final cover;
- 16 leachate manholes; and
- 1 red pipe.

Higher measurements of THC (as methane) were measured at the following locations in 2013 (RWDI, 2013):

- 48 spots at the final cover;
- 4 leachate manholes; and
- 1 red pipe, with leak near the cap.

The 2012 and 2013 findings indicate that landfill gas emissions, and therefore active decomposition of materials within the Mounds, are present.

The final cover design for the Old Landfill has a minimum of 1 metre of uncompacted soil including topsoil with no geomembrane. A review of the borehole logs (*Appendix A*) indicate that the final cover may be thinner than the minimum design at some locations, i.e. the final cover thickness ranges from 0.3 m to 0.7 m plus some mixed soil/waste.

7.5.2 Potential for Odour Emissions

Based on the records from site condition in 1983, at various locations in Mounds 1 and 2, liquid industrial waste and sewage sludge were co-disposed with solid waste. The borehole log records for Mounds 1 and 2 from January 2017 (two boreholes in each mound), show that below soil cover, there is a mixture of soil and domestic household waste (the depth varies between 4.6 m to 15.2 m) (*Appendix A*) and below that there is wet black sludge with no distinguishable waste and with “heavy waste” smell (with thickness between 3.7 m to 10 m) (*Appendix A*). In three out of four boreholes, the sludge begins at least 3.2 m below the leachate level and in the fourth borehole (M1W2), it is slightly above the leachate level (0.6m). In Mound 3, there is no record of sludge and it is just soil mixed with domestic, household waste (*Appendix A*).

Based on the recent boreholes in the 3 Mounds of the Old Landfill, Mounds 1 and 2 have odourous sludge beneath the mixture of soil and domestic waste. The household waste is at least 17 years old so it is expected to be mostly decomposed.

Old wastes generally have less odour potential; however, the type of waste also influences odour potential. Mound 3 is 17-25 years old and did not receive high quantities of sludges, while Mounds 1 and 2 are older and received higher quantities of liquid wastes and sludges. The borehole logs indicate that strong odours were observed at Mounds 1 and 2 when sludges were encountered (*Appendix A*).

Based on the experience of other sites, odour management measures would be required at mining in any of the Mounds with Mounds 1 and 2 having higher potentials for odour generation. Although Mound 3 waste is relatively younger, it is at least 17 years old in advanced stage of decomposition and based on the field observations recorded in the borehole logs, no strong odours were observed during Mound 3 drilling (*Appendix A*).

7.5.3 Odour Management

For odour management, different site-specific practices were employed in other landfill mining operations at other landfills. These practices include:

- Minimizing the active excavation area during the operation;
- Conducting the waste excavation during the cool and cold months and when there is little precipitation is often advantageous for drier sites. However, in the case of the Ridge Landfill, which is a wet and clayey site, waste excavation and mining operations during winter or colder months will likely not be feasible and can actually be problematic to screening equipment, causing poor recyclables recovery and mechanical issues;
- Increasing the slope of excavation to decrease the exposed area of waste;
- Monitoring meteorological conditions such as wind speed and direction and manage the operations based on the climatic conditions and location of sensitive receptors;
- Proactive and ongoing communication with neighbours and nearby residents;
- By-passing processing of highly odourous and/or young waste;

- Covering the waste with soil at the end of each work day; and
- Applying a foam control agent/masking agent/odour neutralizing agent to exposed waste surfaces and surfaces of coarse and fine-screened stockpiled materials to suppress odour if problems arise. This may require an understanding of the types of compounds that are being emitted, so that appropriate odour control agents could be selected and made available at the site.

In most cases, odour management entailed on-going monitoring of operations and the application of a combination of measures at any given time.

7.6 Other Nuisances Effects

Dust, litter and noise are other typical nuisances that require mitigation during landfill mining operations. Although the Ridge Landfill is located in a remote and rural setting and dust, litter and noise are still important, and the general mitigation approaches for those nuisances are described in this section.

7.6.1 Dust and Airborne Contaminant Management

Mining operations have the potential to generate dust during dry periods (usually in the summer when the ground is dried up by higher temperatures). Dust can be generated by typical mining operations such as cover stripping, waste and soil excavation, screening and heavy equipment and truck traffic.

Dust is a concern because it may reduce visibility, generate airborne contaminants and potentially may become a nuisance to off-site receptors if not controlled at the source. Airborne contaminants should be controlled because they represent a safety hazard to site personnel and should be addressed in the health and safety plan.

A dust and airborne contaminant management plan should be prepared and implemented for mining operations. The dust and airborne contaminant management plan should include equipment used to control dust and describe the liquid and rate that will be applied as a minimum. Monitoring procedures should also be included in the dust and airborne contaminant management plan.

7.6.2 Litter Control

Several measures should be taken to minimize the amount of wind-blown debris leaving the landfill mining operations area.

Similar to regular landfilling operations, litter control measures to be applied during mining operations can be divided into two groups: preventative measures to limit the generation of litter and regular maintenance measures to collect and prevent litter from leaving the site. Those measures include covering loose waste, keeping the size of the exposed mining face to a minimum and using portable litter control fences.

7.6.3 Noise Control

Potential noise impacts may result from waste mining operations equipment. The operation of this equipment should be conducted in such a manner as to minimize noise impacts, whenever possible. All operation equipment used during waste mining activities should comply with the noise level limits outlined in the *"Noise Guidelines for Landfill Sites"* (MOECC, 1997) and the Municipal Noise By-Law.

7.7 Surface Water and Leachate Management

Clean surface water, originating from non-operating areas of the landfill (i.e., undeveloped areas or areas completed with final cover) will continue to be collected in a ditch inside the perimeter road and conveyed to one of the surface water management ponds that serves the existing Old Landfill. Berms or ditching will be used to divert any non-contaminated storm water away from landfill mining operations where it may cause operational problems and from operating areas where it may come in contact with waste.

Potentially contaminated surface water, such as that originating from mining operation areas where drainage may come in contact with waste or leachate, will not be discharged to the surface drainage system. This isolation of drainage from operating areas will be accomplished by grading of waste and daily/intermediate cover surfaces (i.e. interim separation berms, slopes and diversion ditches will be constructed as part of the landfill mining operations). All drainage from operating areas that may come in contact with waste or leachate will be collected and managed as leachate, i.e. allow infiltration within the open waste areas.

If perched leachate is encountered during waste excavations, low points (sumps) will be constructed to allow temporary pumping to drain the waste and to pump leachate out of the mining area. Surface water separation berms can also be constructed as needed to minimize leachate volumes.

7.8 Health and Safety Considerations

Prior to landfill mining operations, a site-specific health and safety plan should be prepared and implemented.

The health and safety plan should consider different potential hazards (physical, chemical and biological) associated with mining operations, such as gases (methane, hydrogen sulphide). Sharps, liquid waste and sludge, asbestos and equipment traffic will be identified and mitigated. The health and safety plan should include specific operating procedures to address air quality for on-site personnel, dust monitoring, airborne contaminant management, suspect wastes/liquids, personal protective equipment (PPE), decontamination procedures and emergency procedures.

The health and safety plan should include procedures to manage anticipated or confirmed hazardous materials. It should also address potential presence of any material of concern and include material-specific procedures such as asbestos handling or other materials or chemicals of concern.

The health and safety plan should include procedures to operate heavy equipment, processing equipment and tools. Heavy equipment and processing equipment should be provided with engineering controls.

7.9 Cost Estimate

Costing information for various landfill mining projects were collected as summarized below.

- City of Barrie Landfill mining: \$10 to \$15 per m³ (information received from Chris Visser, Waste Connections).
- Blue Mountains Landfill mining: \$10 to \$20 per m³ (information received from Chris Visser, Waste Connections).
- Ocean County Landfill Corporation Site: \$24 per m³ (\$13.69 USD per yd³) using union labour (Dillon Consulting, 2017b).

The mining cost for the Ridge Landfill is estimated at \$25 per m³. The mining cost for the Ridge Landfill is expected to be higher due to the nature of the waste, soils and other site-specific conditions.

All costs per cubic meter above are for the mining component, i.e. it includes waste excavation, screening, loading, hauling and unloading at the working face and excludes liner and leachate collection system construction.

7.10 Evaluation Criteria

The following table provides a summary of our evaluation criteria prepared for each Mound of the Old Landfill.

Table 5: Criteria and Evaluation of Mining Potential

Criteria	Mound 1	Mound 2	Mound 3
Odour Potential (based on observations recorded on the leachate wells borehole logs and photographs)	• High	• High	• Medium
Leachate Levels	• High (5.3 m below top of landfill surface)	• High (7.3-9.1 m below top of landfill surface)	• Low (14.2-15.2 m below top of landfill surface)
H&S Concerns for On-Site Staff	• Lower than Mound 2, higher than Mound 3 • High leachate level • Types of waste • Odourous sludges	• Highest • High leachate level • Types of waste • Odourous sludges	• Lowest
Air Quality	• No health risks related to	• Same as Mound 1	• Same as Mound 1

Criteria	Mound 1	Mound 2	Mound 3
	landfill mining operations <ul style="list-style-type: none"> No health related to airborne emissions are anticipated based on Barrie and Blue Mountains mining projects (to be confirmed by air quality monitoring during mining operations) 		
Estimated Capacity Gain	<ul style="list-style-type: none"> 0.4 million m³ 	<ul style="list-style-type: none"> 1.3 million m³ (0.5 million m³ mining and 0.8 million m³ excavation under existing waste) 	<ul style="list-style-type: none"> 0.5 million m³
Costs	<ul style="list-style-type: none"> Relatively higher than Mound 3 due to intense liquid management Probably equivalent to Mound 2 	<ul style="list-style-type: none"> Relatively higher than Mound 3 due to intense liquid management Probably equivalent to Mound 1 	<ul style="list-style-type: none"> Lower than Mounds 1 and 2 Comparable to the mining costs for the Ocean County Landfill Corporation Site

7.11 Opportunities and Risks with Mining the Old Landfill

Since landfill mining has high cost implications, mining projects usually have multiple benefits to offset the mining costs. As described in the literature review, the most common benefits are improvement of groundwater conditions, reduction of potential liabilities as a risk management strategy, gain landfill capacity, and supply soils for sites that have soil deficiency. We will discuss and test each opportunity and identify constraints applicable to the Old Landfill as follows.

7.11.1 Site-Specific Opportunities

The following are the typical opportunities associated with a landfill mining project and how they might apply to the Old Landfill:

- Remediation of groundwater impacts. This is the usually the main driver to complete landfill mining projects and typically occurs at sites with unfavourable hydrogeological conditions (i.e. high permeability soils such as sandy soil or gravel at the base of the landfill, or high groundwater levels). In the case of the Old Landfill, there are no groundwater impacts and the site meets regulatory requirements. The Ridge Landfill is located in a thick natural clay plain that serves as an in-situ clay liner, i.e. approximately 30 m thick till (clayey silt/silty clay).
- The trench and fill method used in the Old Landfill area represents an opportunity to gain airspace as the soils between existing trenches are excavated. This is applicable to most of Mound 2.

- Mining can typically address a shortage of soil for future landfill operations. The Ridge Landfill is in a soil surplus situation and therefore mining to access more soils or fines for future cover needs does not provide an opportunity in this instance.
- Mining can provide limited opportunity to extend landfill site life if there is no opportunity to complete a horizontal or vertical expansion. This does not apply to the Ridge Landfill since there are opportunities for horizontal and vertical expansions.

7.11.2 Site-Specific Risks

There are site-specific risks that on balance do not support mining operations at the Ridge Landfill as discussed below.

- The landfills that have been mined in Ontario (included in the literature review section) are located in sand/gravel deposits, which allow leachate to drain downwards while keeping the waste dry. The deep, low permeability in-situ clay base at the Old Landfill does not promote leachate subsurface infiltration, rendering mining of saturated (wet) wastes not practical below the leachate levels.
- The soils at the Ridge Landfill have a high clay content, which would make screening and separation of materials very challenging due to the soil cohesion nature and moisture holding capacity. A pre-screening process would likely be needed with the introduction of a shredder to break the cohesive materials or alternatively potentially increased processing time in the screener.
- Mounds 1 and 2 have a history of liquid co-disposal.
- The combination of the three site-specific factors above would require an intense level of moisture and liquid management, making mining more problematic. The mining operations may become even more difficult during winter or cold months as the moisture in the waste and soil cover freezes and attaches with the processing equipment. High leachate levels would delay mining operations and could cause more odours.

Summary and Conclusions

Based on the background and literature review, field investigations and assessment described in this report, there are limited advantages and strong reasons to not consider mining the Old Landfill as summarized below.

- Remediation is not a driver for mining the Old Landfill because there are no groundwater impacts and the site meets regulatory requirements.
- The thick in-situ clay liner (i.e. approximately 30 m thick clayey silt/silty clay till) that forms the base of the Old Landfill does not promote moisture drainage, creating leachate pockets within the waste that would make mining operations problematic.
- The cohesive nature of the local soil that was used as daily cover at the Old Landfill holds moisture and tends to attach with waste and processing equipment, making materials separation more challenging during mining operations.
- The amount of recyclables recovered is not anticipated to be significant (estimated between 1 and 2% based on the Barrie Landfill experience and the Old Landfill boreholes).
- Mining to gain airspace is not the only available option to expand the Ridge Landfill. Since the site has available land for horizontal expansion and there are opportunities to vertically expand the Old Landfill and the South Landfill, the limited volume achieved with landfill mining is actually not needed for the proposed landfill expansion.
- The amount of soils or fines that are generated through mining operations would not help the site soil management as the site has enough soil material for operations and closure needs.

In summary, unlike other landfills that are considering or have completed mining, the Ridge Landfill does not have the compelling benefits to mine versus the associated disadvantages of mining, i.e. cost, operational challenges, potential nuisances, site constraints, and health and safety concerns. The potential benefits associated with landfill mining are limited and are by far outweighed by the various concerns mentioned above.

As an option, the Old Landfill could be vertically expanded without mining considerations, since the existing ground contours are much lower than the maximum elevation allowed by the airport regulation.

References

- Cornerstone Environmental (2014). Overliner of Landfill mining? Best Approach for a Landfill Expansion for an unlined Landfill, SWANA LF Symposium, March 26, 2014
- Dewaele, P., and Brunet, S. (2017) Reclamation & Re-Engineering, Environmental Remediation, June/July 2017, www.canadianconsultingengineer.com
- Dillon Consulting Limited (1981). Ridge Landfill Site Design and Operations Report, File No. 8935-01, August 1981
- Dillon Consulting Limited (1983). Ridge Landfill Site Design and Operations Final Report, File No. 8935-03, December 1983
- Dillon Consulting Limited (1984). Site Development and Operations, 1983 Annual Report, Ridge Landfill, File No. 8935-03, March 1984
- Dillon Consulting Limited (1985a). Ridge Landfill Site, Design and Operations Final Report, File No. 8935-03, August 1985
- Dillon Consulting Limited (1985b). Ridge Landfill Site, Site Development and Operations, 1984 Annual Report, File No. 8935-03, March 1985
- Dillon Consulting Limited (1986). Ridge Landfill Site, Site Development and Operations, 1985 Annual Report, File No. 8935-05, March 1986
- Dillon Consulting Limited (1987). Ridge Landfill Site, Site Development and Operations, 1986 Annual Report, File No. 1317-03-1, March 1987
- Dillon Consulting Limited (1988). Ridge Landfill Site, Site Development and Operations, 1987 Annual Report, File No. 1317-04-1, March 1988
- Dillon Consulting Limited (1989). Ridge Landfill Site, Site Development and Operations, 1988 Annual Report, File No. 1317-05-1, March 1989
- Dillon Consulting Limited (1990). Ridge Landfill Site, Site Development and Operations, 1989 Annual Report, File No. 1317-06-1, April 1990
- Dillon Consulting Limited (1991). Ridge Landfill Site, Site Development and Operations, 1990 Annual Report, File No. 1317-07-1, March 1991
- Dillon Consulting Limited (1992). Ridge Landfill Site, Site Development and Operations, 1991 Annual Report, File No. 1317-08-0, March 1992
- Dillon Consulting Limited (1993). Ridge Landfill Site, Site Development and Operations, 1992 Annual Report, File No. 92-1317-09-00, March 1993
- Dillon Consulting Limited (1994). Ridge Landfill Site, Site Development and Operations, 1993 Annual Report, File No. 92-1317-10-01, March 1994
- Dillon Consulting Limited (1995). Ridge Landfill Site, Site Development and Operations, 1994 Annual Operations Report, File No. 92-1317-11-01, March 1995
- Dillon Consulting Limited (1996). Ridge Landfill Site, Site Development and Operations, 1995 Annual Operations Report, File No. 92-1317-12-01, March 1996

- Dillon Consulting Limited (1998). Ridge Landfill Site, Site Development and Operations, 1997 Annual Operations Report, File No. 92-1317-14-01, March 1998
- Dillon Consulting Limited (1999). Ridge Landfill Site, Site Development and Operations, 1998 Annual Report, File No. 92-1317-15-01, March 1999
- Dillon Consulting Limited (2000). Ridge Landfill Site, Site Development and Operations, 1999 Annual Report, File No. 92-1317-16, April 2000
- Dillon Consulting Limited (2002). Ridge Landfill Site Development, Operations and Monitoring, 2001 Annual Report, File No. 02-0079, April 2002
- Dillon Consulting Limited (2011). Telephone Discussion Between Betsy Varghese (Dillon) and Sandy Coulter (City of Barrie) regarding City of Barrie Landfill mining, File No. 06-6988, June 2, 2011
- Dillon Consulting Limited (2013a). Telephone Discussion Between Betsy Varghese (Dillon) and Sandy Coulter (City of Barrie) regarding City of Barrie Landfill mining, Project No. 06-6988, October 21, 2013
- Dillon Consulting Limited (2013b). Telephone Discussion Between Stephen Betts (Dillon) and Jim Wraith (Tervita, Area Manager, Ontario, Environmental Services) regarding asbestos, hazardous materials and odour at the Barrie Landfill due to landfill mining, Project No. 06-6988, November 26, 2013
- Dillon Consulting Limited (2014). Memo of Barrie Landfill site visit by Fabiano Gondim, Project No. 06-6988, October 28, 2014
- Dillon Consulting Limited (2015). Visit to the Ocean County Landfill Corporation Site (OCLC) by Fabiano Gondim, Project No. 15-2456, December 7, 2015
- Dillon Consulting Limited (2017a). Sault Ste. Marie Municipal Landfill Design and Operations Report, Project No. 06-6988, March 2017
- Dillon Consulting Limited (2017b). Telephone Discussion between Fabiano Gondim (Dillon) and Martin Ryan, P.Eng. (VP Engineering, Ocean County Landfill), April 27, 2017
- Dillon Consulting Limited (2017c). Telephone Discussion between Fabiano Gondim (Dillon) and Daren Kirby (Operator/Lead head, Tervita, Barrie Landfill), April 28, 2017
- Dillon Consulting Limited (2017d). Telephone Discussion between Fabiano Gondim (Dillon) and Jeff Fletcher (Manager of Solid Water and Environmental initiatives, Town of Blue Mountains), April 28, 2017
- Food and Drug Directorate (Windsor, Ontario) letter to Kent County Health Unit (Chatham, Ontario), June 1971.
- Garter Lee Associates Ltd. (1981) Ridge Landfill Site Hydrogeological Study, July 1981
- Garter Lee Associates Ltd. (1991) Ridge Landfill Site Geotechnical Investigation of New BFI Properties, File No. GLL 91-421, December 1991
- Golder Associates Ltd. (2014). The Blue Mountains Landfill Design and Operation Plan (Revision #3), Report Number 12-1188-0045, February 2014
- J.L. Richards & Associates Ltd. (2001). Appendix O, Landfill Reclamation Pilot Program, Trail Waste Facility Landfill Optimization/Expansion Project, Confirmation of alternative Methods, Project, No. 17546-02, July 2001

- Jain, P., Townsend, T.G., Johnson, P. (2013). Case study of landfill reclamation at a Florida landfill site, *Waste Management*, 33, pg. 109–116
- Ocean County Landfill Corporation Site (OCLC) Fact sheet, 2015
- Ridge Landfill Corporation Limited letter to Kent-Chatham Heath Unit, October 1970.
- RWDI Air Inc. (2012). Report – Total Hydrocarbon Survey – March 20, 2012, BFI Ridge Landfill, April 2012
- RWDI Air Inc. (2013). Report – Total Hydrocarbon Survey – September 9, 2013, BFI Ridge Landfill, September 2013
- Waste Connections (2004). Phase I Waste Excavation & Relocation Plan, Area F Expansion, Meadow Branch Landfill, July 2003, Revised July 2004

Figures

RIDGE LANDFILL

OLD LANDFILL MINING ASSESSMENT REPORT

Figure 1 - Site Plan

-  PROPERTY BOUNDARY
-  APPROVED SITE BOUNDARY
-  CELL LIMITS
-  STORM WATER POND
-  MONITORING WELL
-  MANHOLE CLEANOUT AND IDENTIFICATION
-  LEACHATE COLLECTION PIPE
-  APPROVED LIMIT OF FILL FOR EXISTING LANDFILL
-  APPROVED LIMIT OF FILL FOR EXPANSION

TRUE NORTH



PLAN NORTH



SCALE 1:8,000



Base Mapping Data from The Base Mapping Co. Ltd, May 16, 2016.

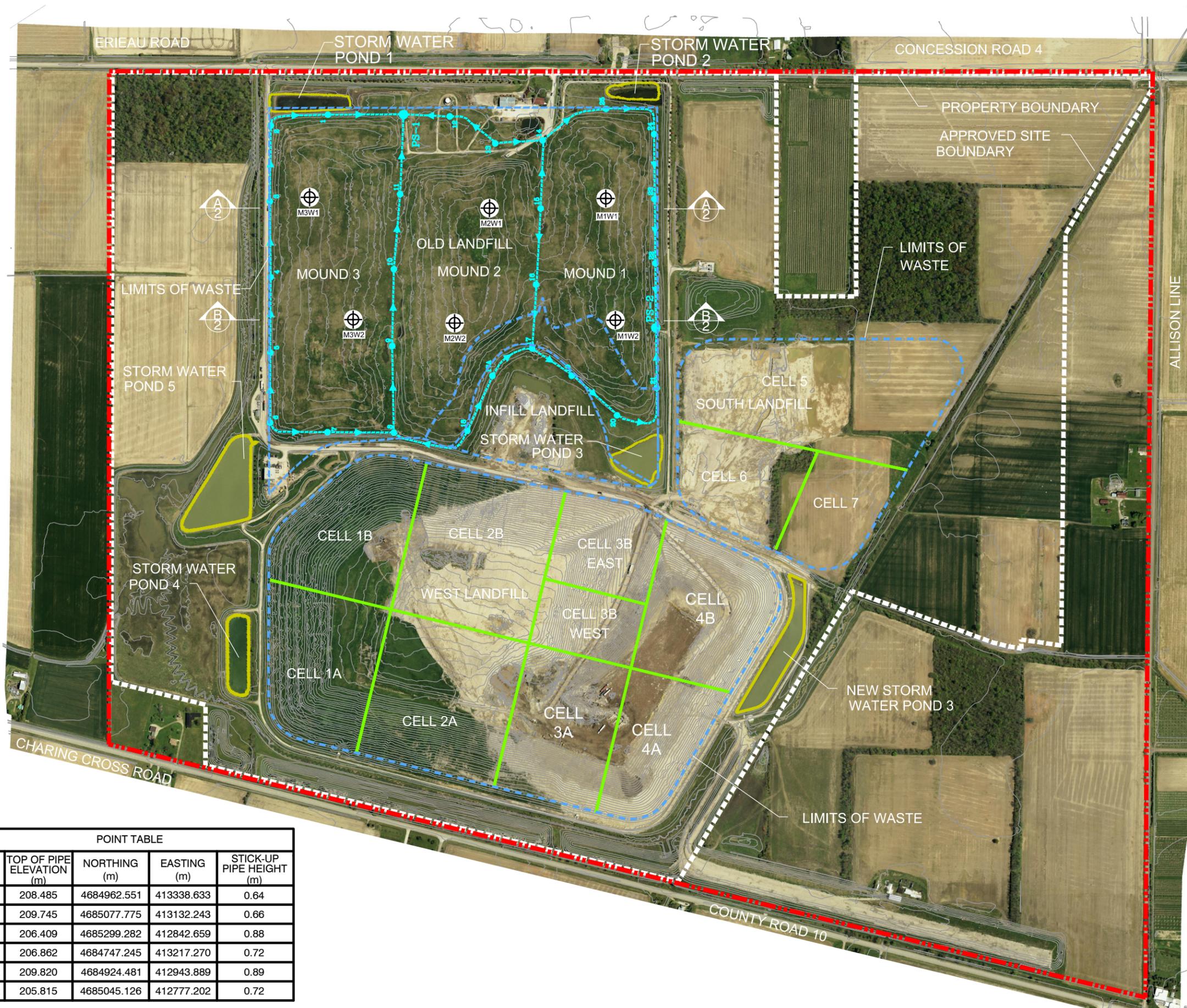
Ground elevations/co-ordinates and pipe stick-up heights for leachate wells obtained by Lance Tavener, Dillon Consulting, on March 21, 2017, using Trimble R10 GNSS GPS system.

CREATED BY: AZ
CHECKED BY: FG

File Location:
c:\projectwise\working\directory\active\34axz\d0469912\figure 1 - site plan.dwg June, 09, 2017 9:17 AM



PROJECT: 152456
STATUS: DRAFT
DATE: 03/28/17



POINT TABLE				
No.	TOP OF PIPE ELEVATION (m)	NORTHING (m)	EASTING (m)	STICK-UP PIPE HEIGHT (m)
M1W1	208.485	4684962.551	413338.633	0.64
M2W1	209.745	4685077.775	413132.243	0.66
M3W1	206.409	4685299.282	412842.659	0.88
M1W2	206.862	4684747.245	413217.270	0.72
M2W2	209.820	4684924.481	412943.889	0.89
M3W2	205.815	4685045.126	412777.202	0.72

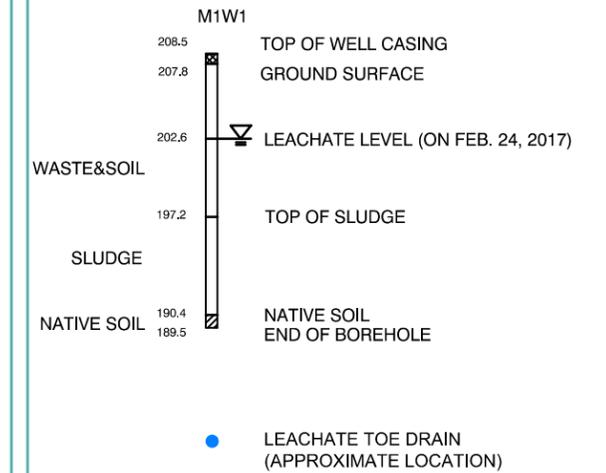


RIDGE LANDFILL

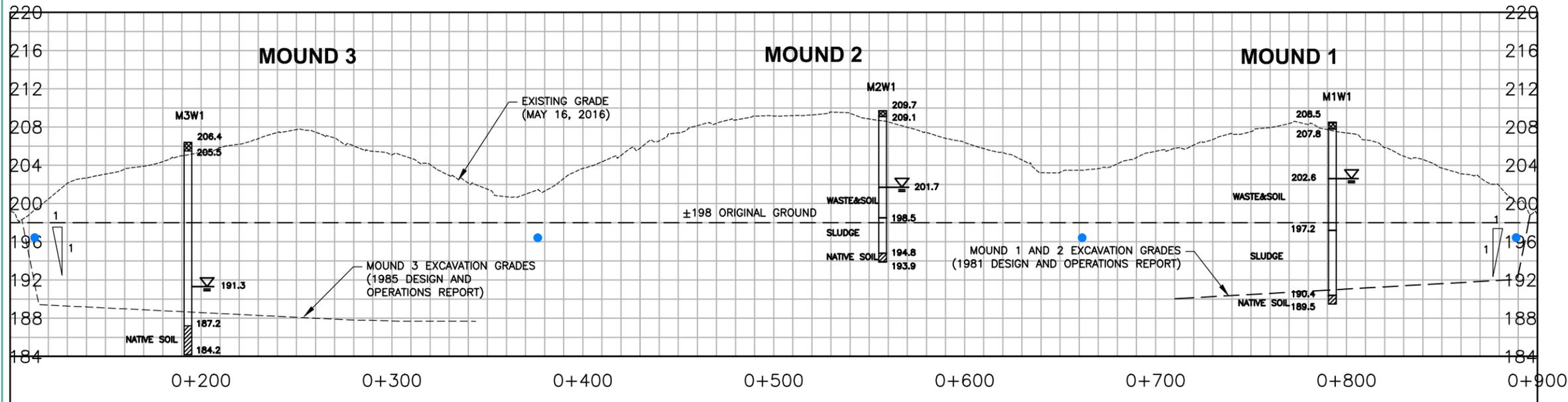
OLD LANDFILL MINING ASSESSMENT REPORT

Figure 2 - Cross Sections

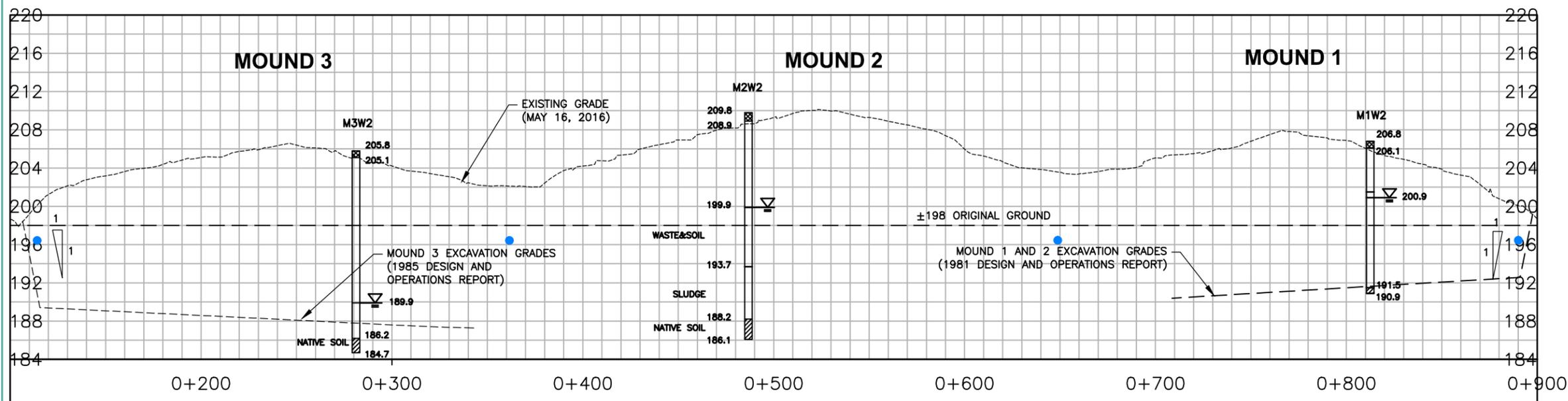
LEGEND



A-A
HORIZ: 1:2500
VERT: 1:500



B-B
HORIZ: 1:2500
VERT: 1:500



Base Mapping Data from The Base Mapping Co. Ltd, May 16, 2016.

Ground elevations/co-ordinates and pipe stick-up heights for leachate wells obtained by Lance Tavener, Dillon Consulting, on March 21, 2017, using Trimble R10 GNSS GPS system.

CREATED BY: AZ
DESIGN BY: PS
CHECKED BY: FG

File Location:
c:\projectwise\working directory\active\34axz\d0469912\figure 2 - cross sections.dwg June, 09, 2017 9:20 AM



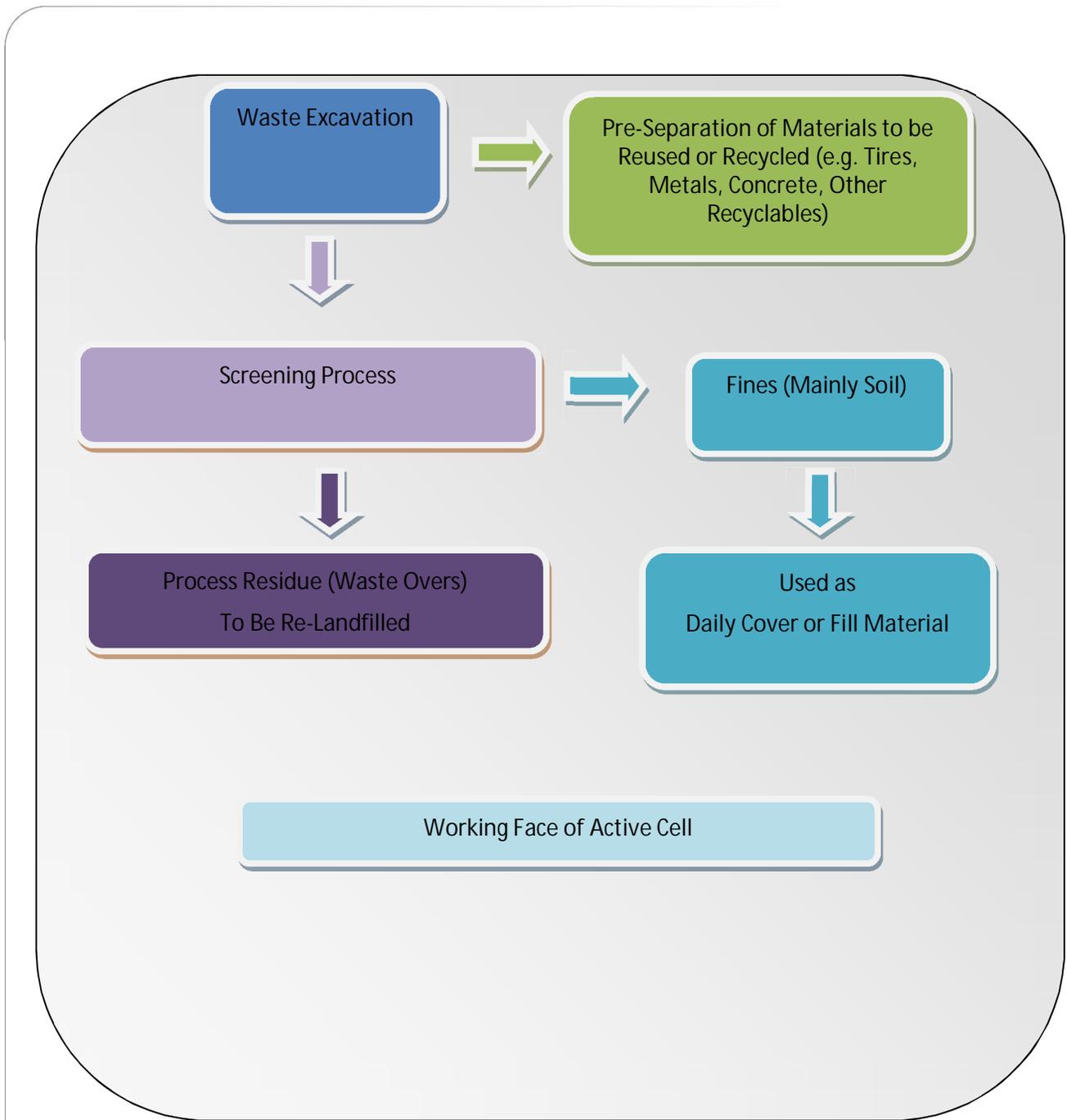
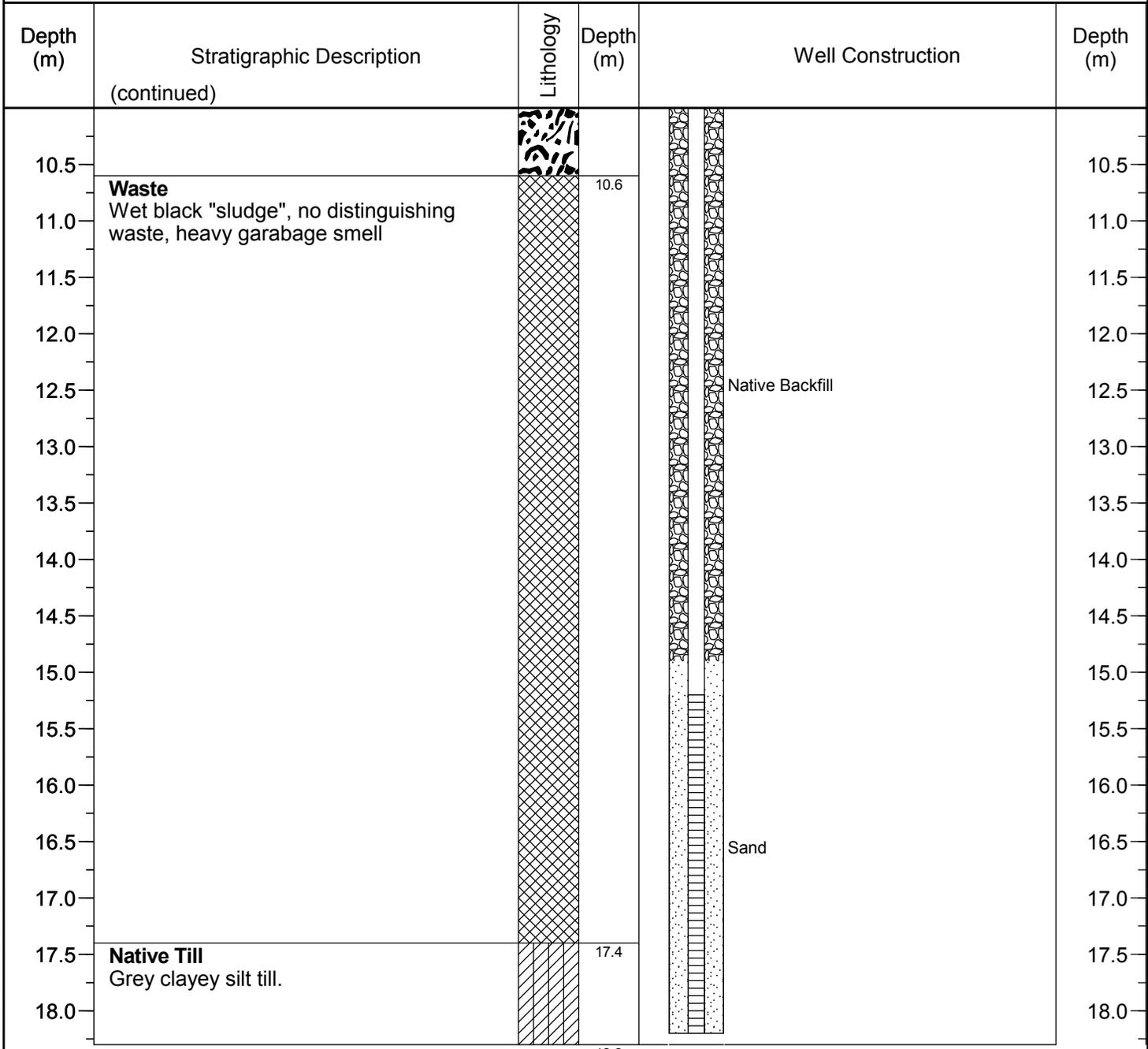


Figure 3 - Process Flow Diagram for Landfill Mining

Appendix A

Leachate Well Borehole Logs

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/23/17</u> Date Completed: <u>1/23/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

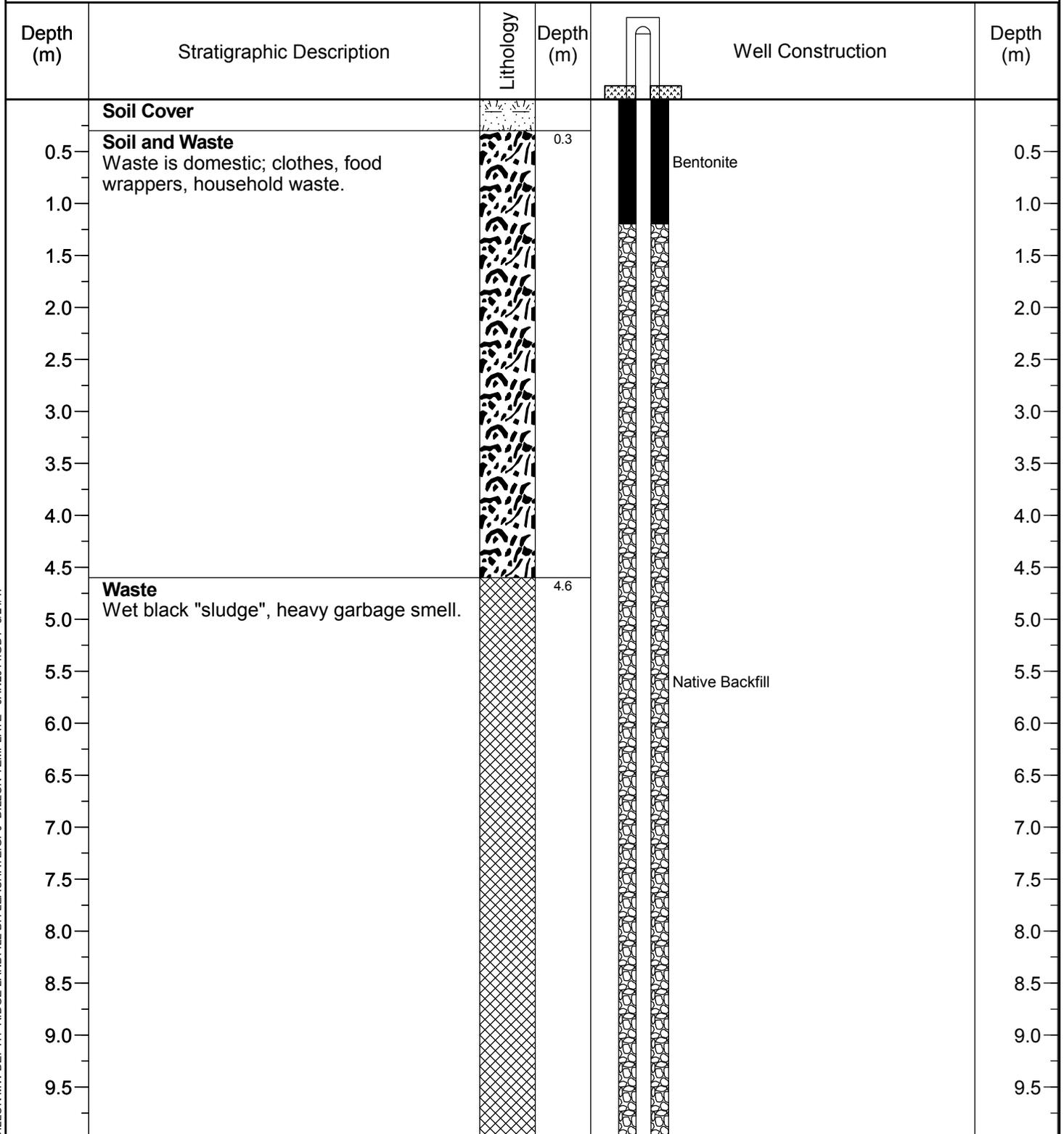
LITHOLOGY SYMBOLS

-  Organics
-  Fill

-  Misc. Debris
-  Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/23/17</u> Date Completed: <u>1/24/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

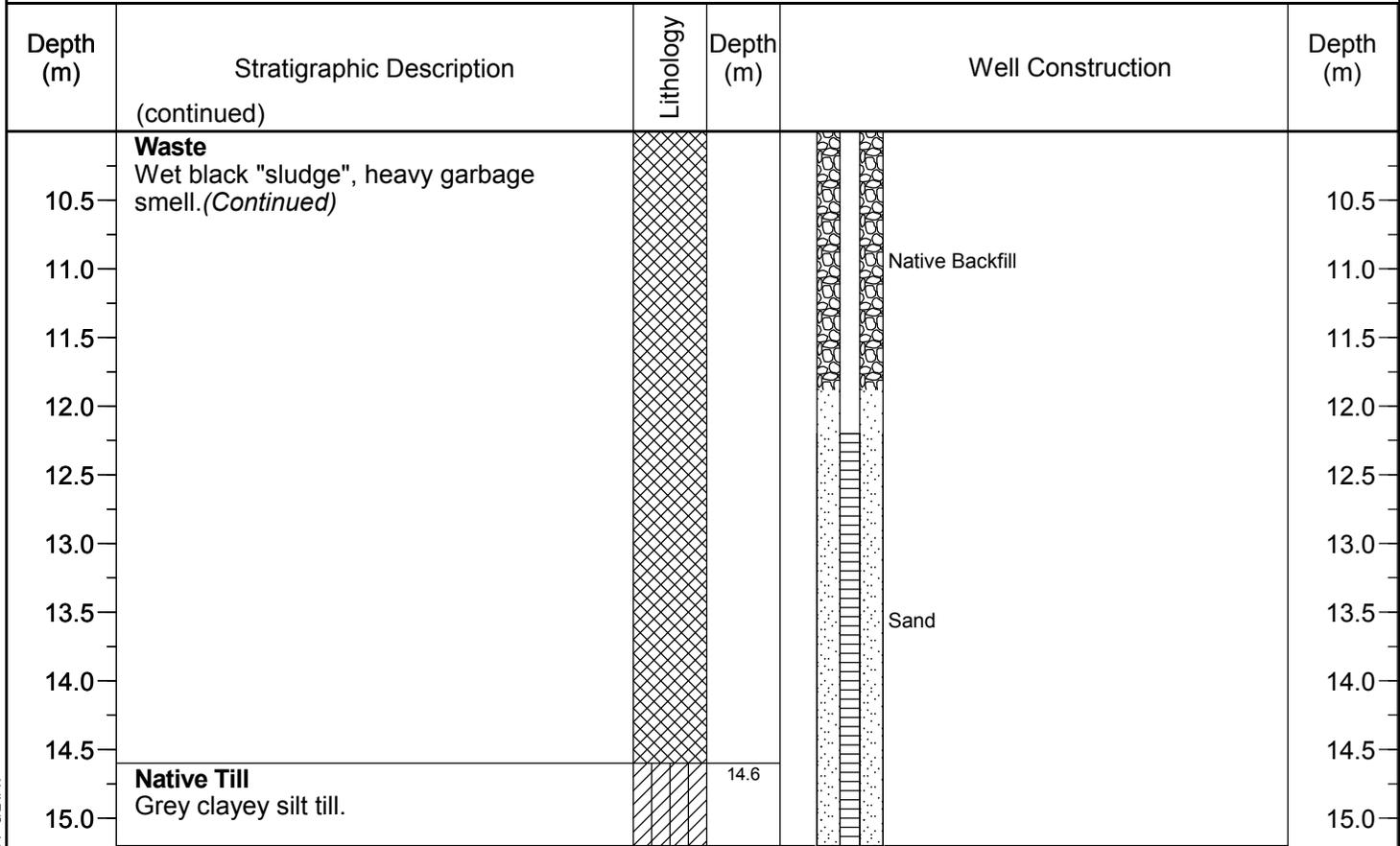
LITHOLOGY SYMBOLS

- Organics
- Fill

- Misc. Debris
- Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/23/17</u> Date Completed: <u>1/24/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

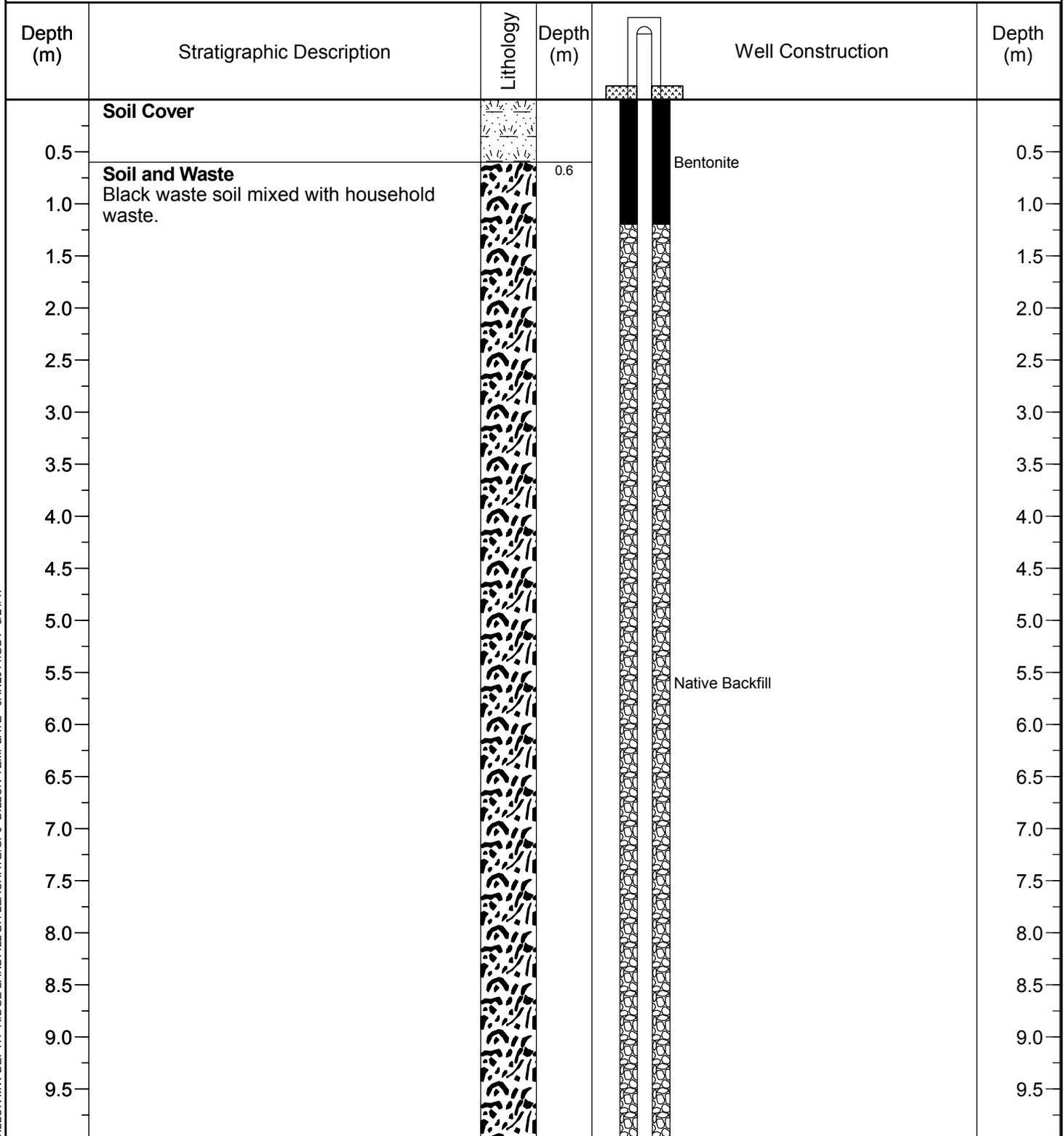
LITHOLOGY SYMBOLS

-  Organics
-  Fill

-  Misc. Debris
-  Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/24/17</u> Date Completed: <u>1/24/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

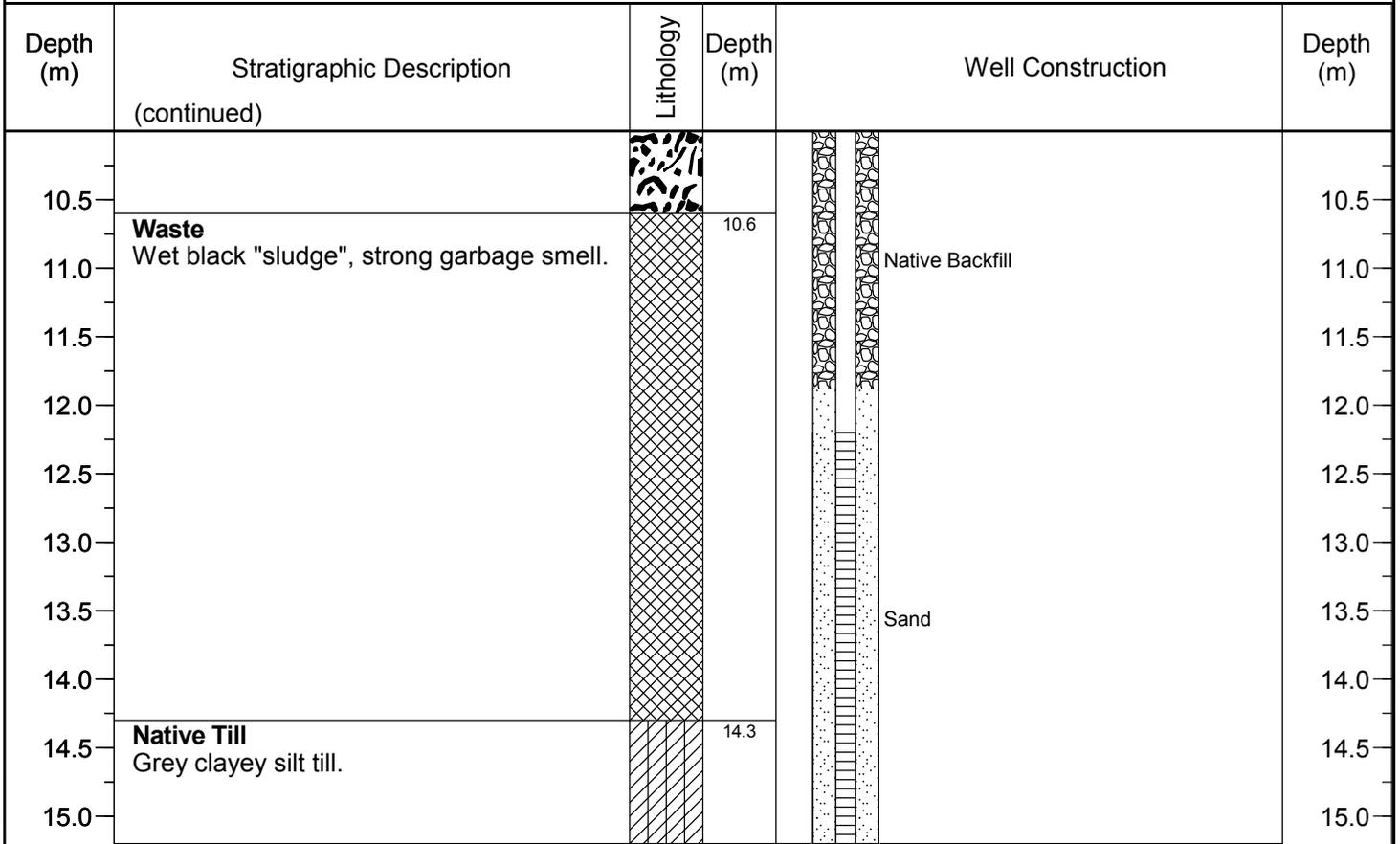
LITHOLOGY SYMBOLS

-  Organics
-  Fill

-  Misc. Debris
-  Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/24/17</u> Date Completed: <u>1/24/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

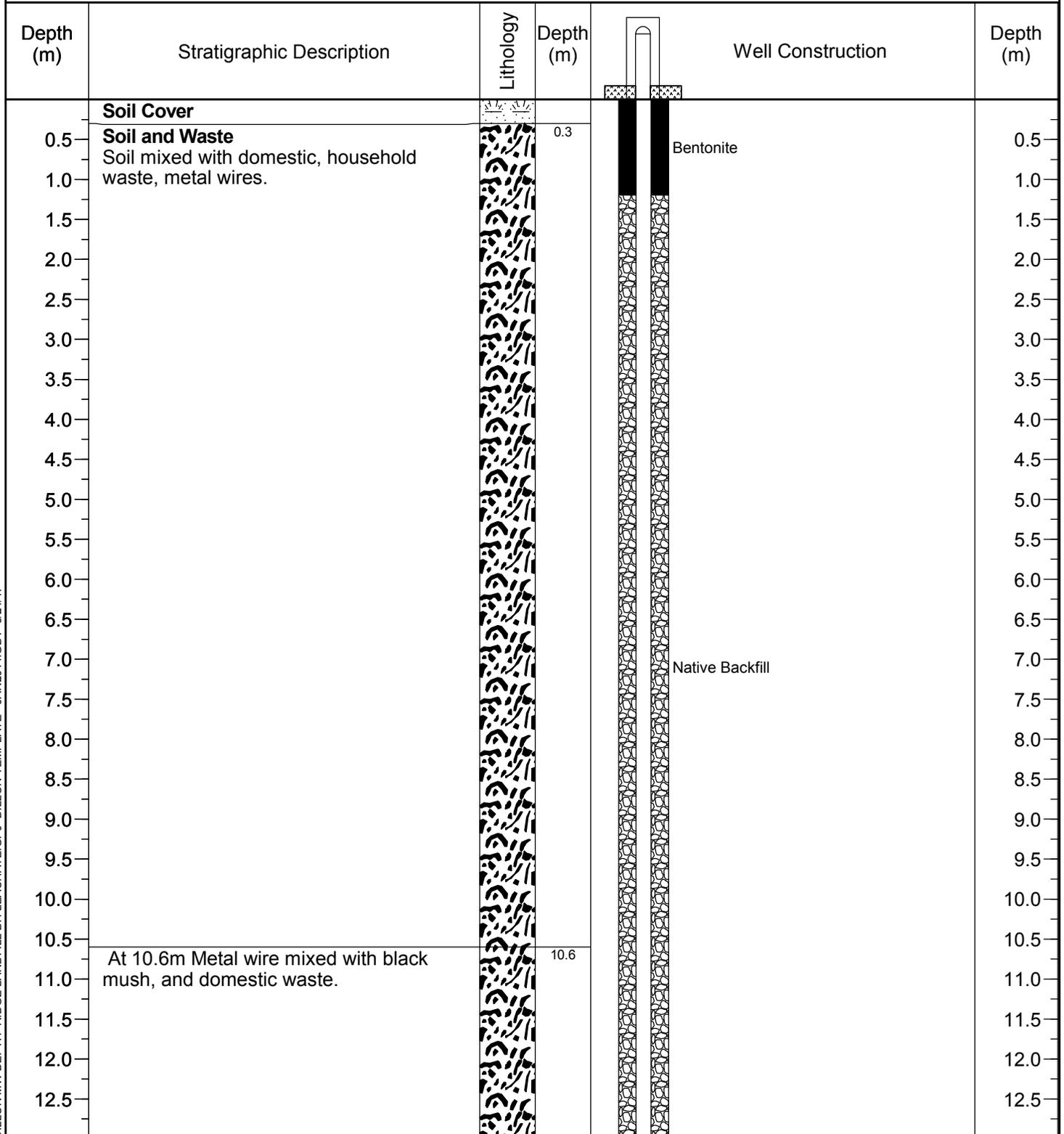
LITHOLOGY SYMBOLS

-  Organics
-  Fill

-  Misc. Debris
-  Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/24/17</u> Date Completed: <u>1/25/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

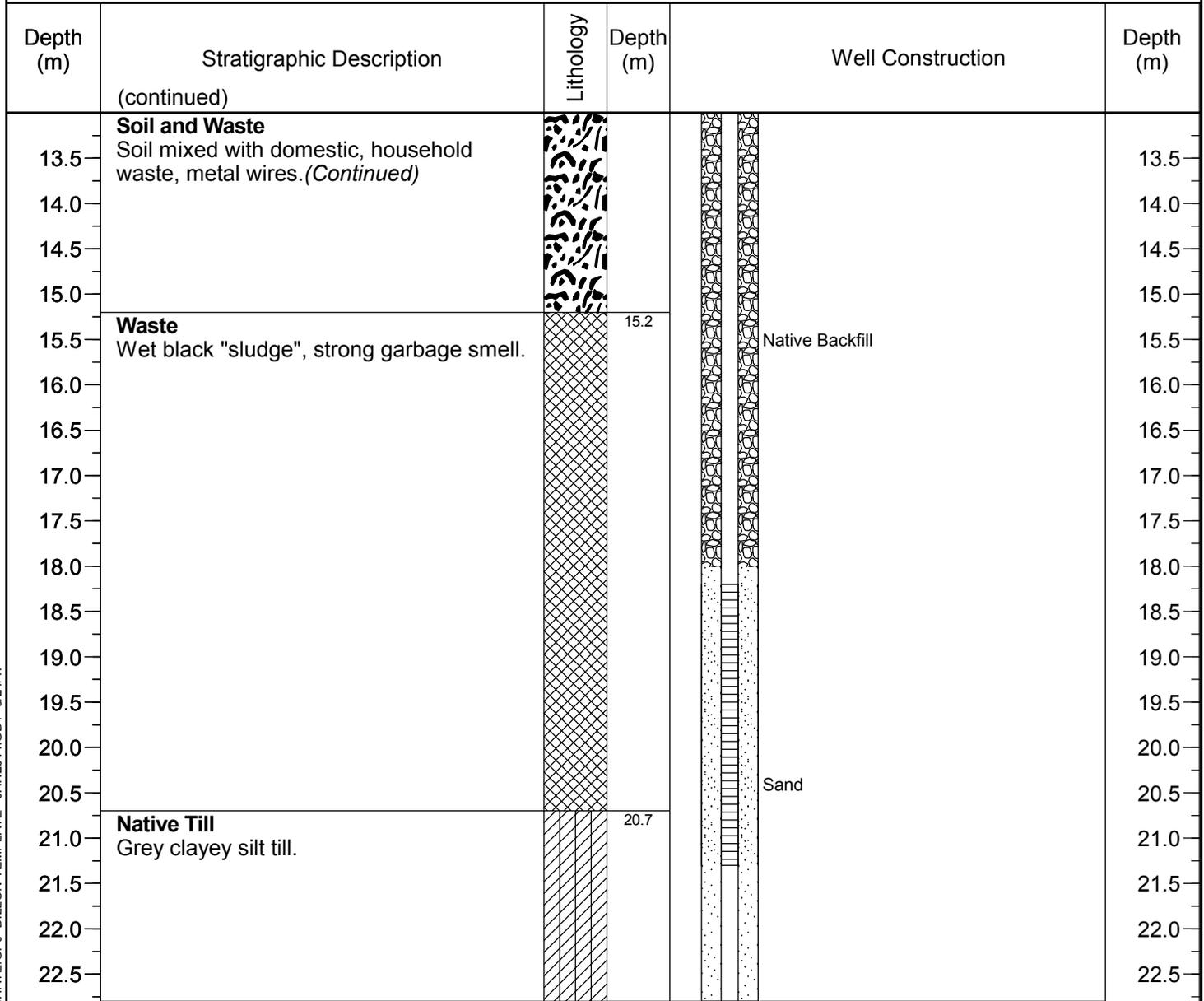
LITHOLOGY SYMBOLS

-  Organics
-  Fill

-  Misc. Debris
-  Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/24/17</u> Date Completed: <u>1/25/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

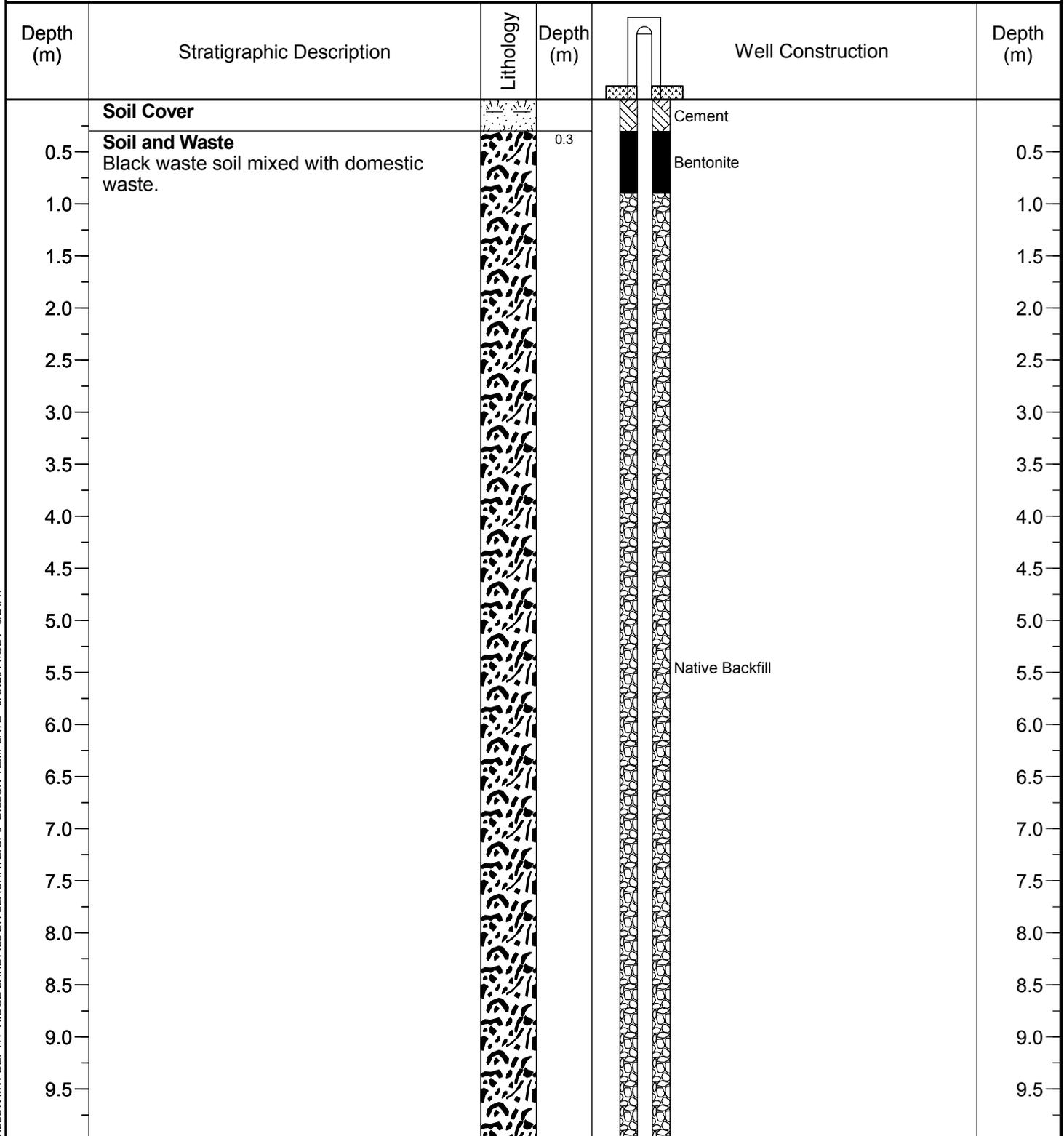
LITHOLOGY SYMBOLS

-  Organics
-  Fill

-  Misc. Debris
-  Clayey Silt

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/25/17</u> Date Completed: <u>1/26/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

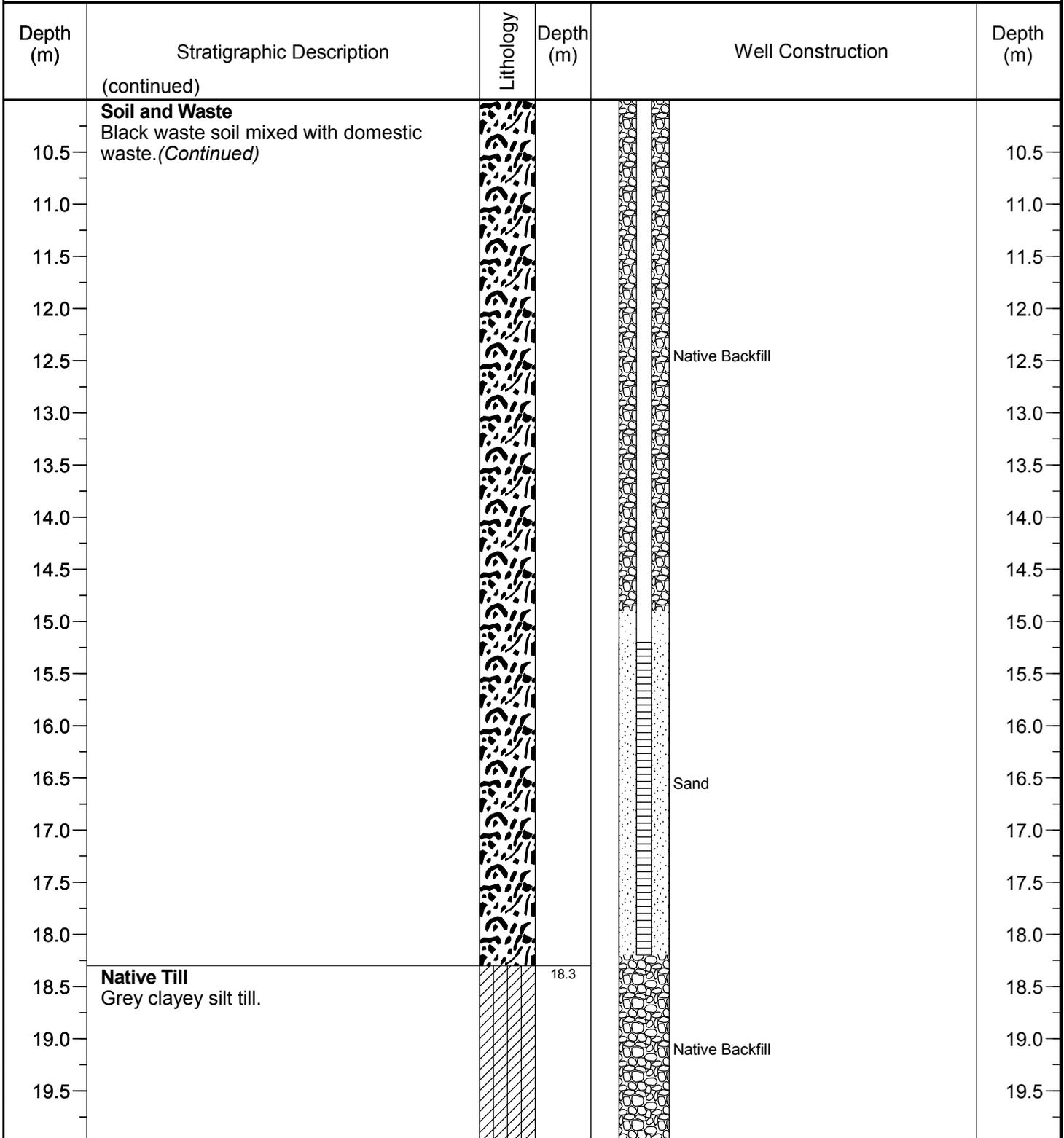
LITHOLOGY SYMBOLS

- Organics
- Clayey Silt

Misc. Debris

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/25/17</u> Date Completed: <u>1/26/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

LITHOLOGY SYMBOLS

-  Organics
-  Clayey Silt

-  Misc. Debris

SAMPLE TYPE



Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>J.Sikorski</u>	Date Started: <u>1/25/17</u> Date Completed: <u>1/26/17</u>

Depth (m)	Stratigraphic Description (continued)	Lithology	Depth (m)	Well Construction	Depth (m)
20.5 21.0	Native Till Grey clayey silt till. <i>(Continued)</i>		21.3	Native Backfill	20.5 21.0

DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

LITHOLOGY SYMBOLS



Organics



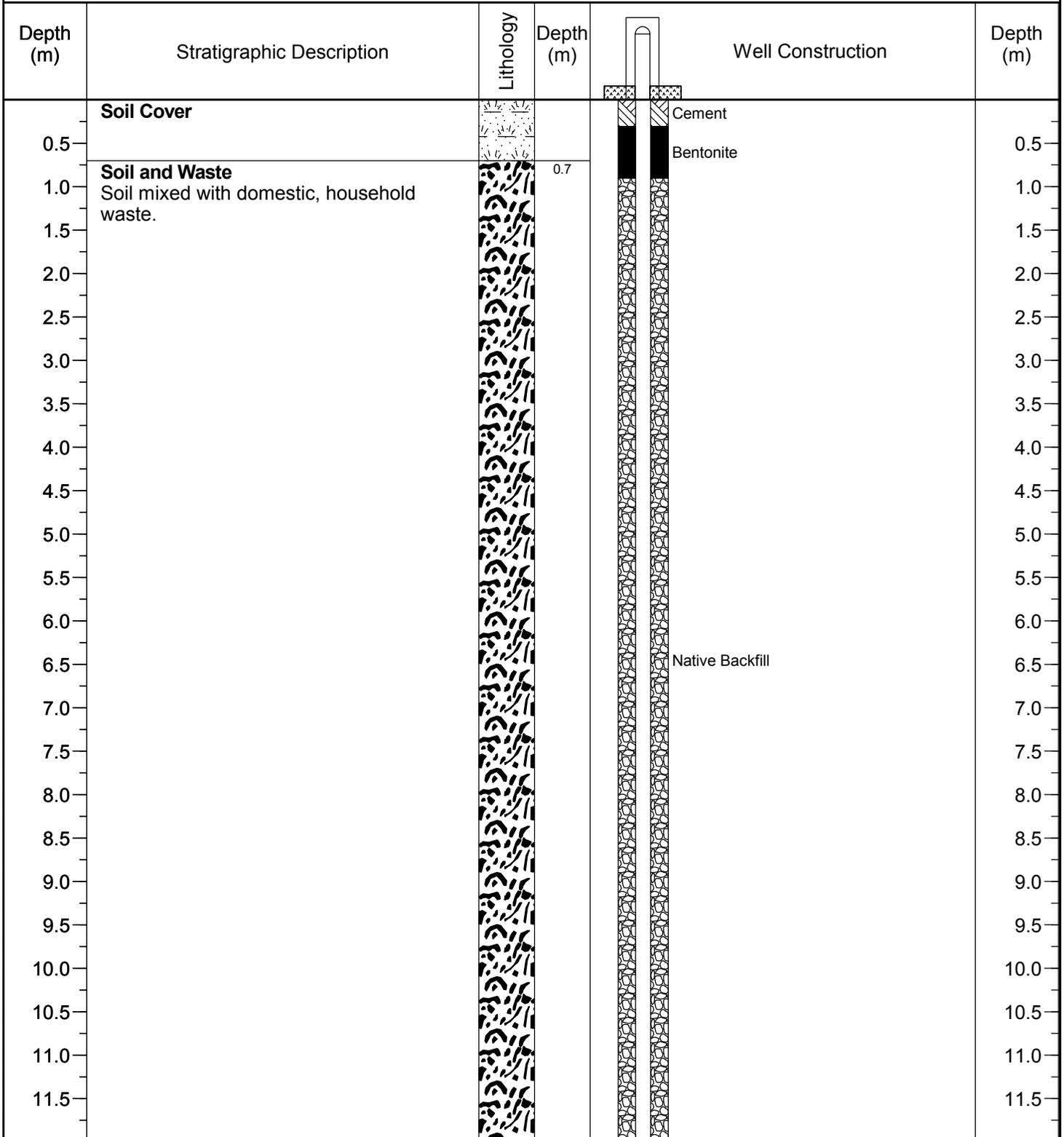
Clayey Silt



Misc. Debris

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>M. Pardhan</u>	Date Started: <u>1/26/17</u> Date Completed: <u>1/26/17</u>



DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

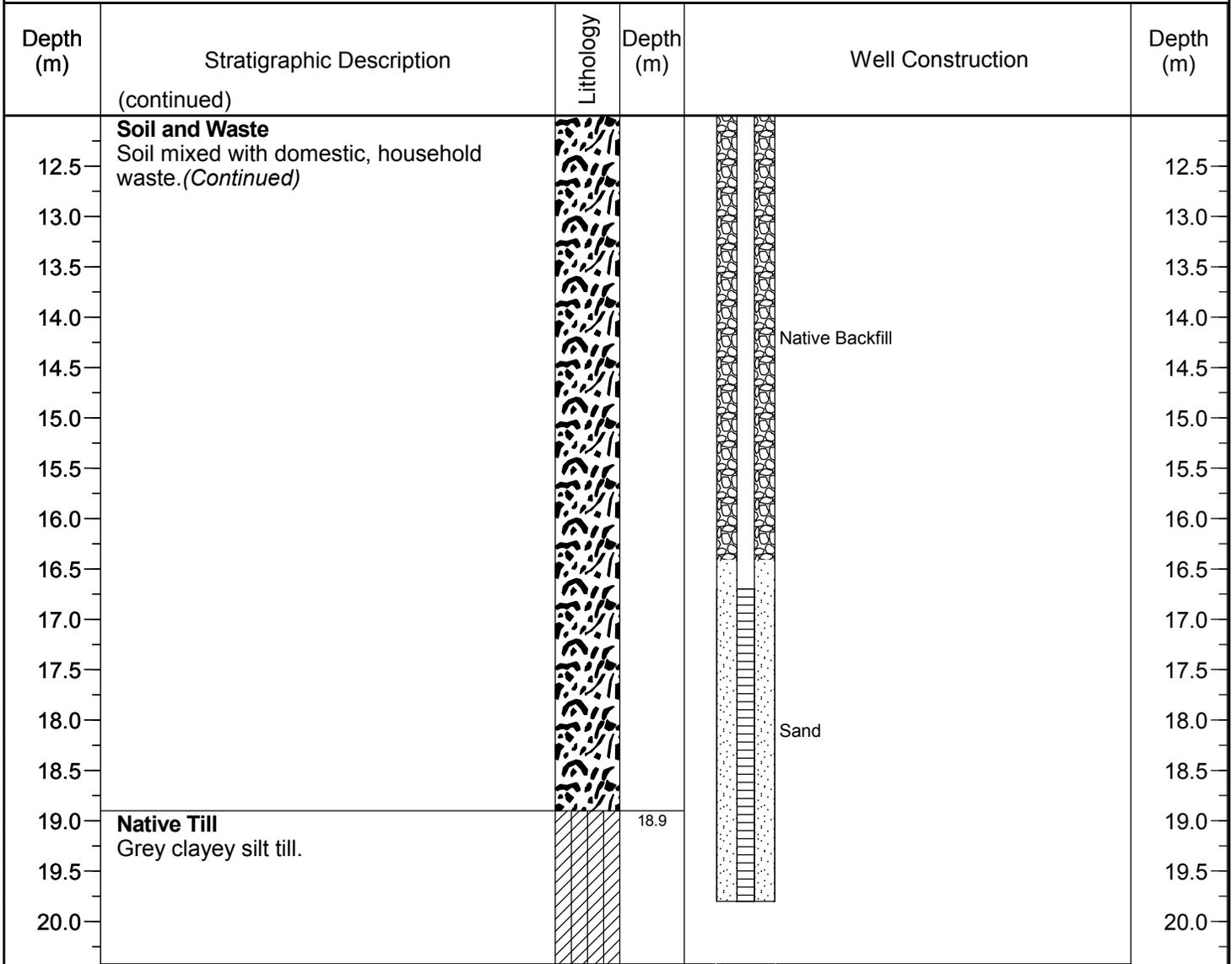
LITHOLOGY SYMBOLS

-  Organics
-  Clayey Silt

 Misc. Debris

SAMPLE TYPE

Client: <u>Progressive</u>	Project: <u>Ridge Landfill Expansion</u>
Project No.: <u>152456</u>	Location: <u>Blenheim ON</u>
Drilling Co.: <u>Direct Environmental</u>	Drilling Method: <u>Auger</u>
Supervised by: <u>M. Pardhan</u>	Date Started: <u>1/26/17</u> Date Completed: <u>1/26/17</u>



20.42

DILLON MW DEPTH RIDGE LANDFILL BH LEACHATE.GPJ DILLON TEMPLATE - JAN2011.GDT 3/21/17

LITHOLOGY SYMBOLS

-  Organics
-  Clayey Silt

-  Misc. Debris

SAMPLE TYPE

Appendix B

Leachate Well Photographs



Photo #1: Mound 1 Hole 1 (M1W1) – 20 ft Depth - January 23, 2017



Photo #2: Mound 1 Hole 1 (M1W1) - 35 ft Depth - January 23, 2017



Photo #3: Mound 1 Hole 1 (M1W1) - 55 ft Depth - January 23, 2017



Photo #4: Mound 1 Hole 2 (M1W2) - 15ft Depth - January 23, 2017



Photo #5: Mound 1 Hole 2 (M1W2) - 45ft Depth - January 23, 2017



Photo #6: Mound 2 Hole 1 (M2W1) - 20 ft Depth - January 24, 2017



Photo #7: Mound 2 Hole 2 (M2W2) - 15ft Depth - January 24, 2017



Photo #8: Mound 2 Hole 2 (M2W2) - 35ft Depth - January 24, 2017



Photo #9: Mound 2 Hole 2 (M2W2) - 50ft Depth - January 24, 2017



Photo #10: Mound 3 Hole 1 (M3W1) - 30ft Depth - January 25, 2017



Photo #11: Mound 3 Hole 1 (M3W1) - 45 ft Depth - January 25, 2017

Appendix C

Literature Review

C.1.0 Introduction

We conducted a literature review of four Canadian and two American landfill sites that are pursuing or have completed landfill mining operations. A summary is provided for each landfill followed by a discussion on problems and mitigation measures implemented during the mining operations.

Tables C-1 and C-2 in Section C.8 provide a summary of key details for landfill mining operations obtained for Canadian and USA sites, respectively.

C.2.0 Trail Waste Facility Landfill (Reclamation Pilot Program)

The Trail Waste Facility Landfill (Trail Landfill) is located in Ottawa and its reclamation (mining), as a possible landfill expansion alternative, was proposed in October 1998. Landfill mining was considered because it could mitigate existing groundwater impacts (by mining the existing landfill and constructing a new lined disposal area) and provide additional landfill capacity. A pilot-scale mining project was approved and completed in 2001 to assess mining feasibility for further consideration. Specifically, the following was reviewed during the pilot test:

- State of decomposition of the waste;
- Landfill net volume gain;
- Recovered materials type, quantities and quality;
- Odour effects and management;
- Health and safety issues;
- Interaction between reclamation activities and operation of the gas extraction system;
- Leachate management required in conjunction with landfill cap removal;
- Review of the most effective methods of excavation, processing and re-landfilling; and
- Achievable rates of production and costs for landfill reclamation operations.

The landfill received domestic/residential and commercial wastes and had two capped stages and two operational stages at the time of the pilot program.

An area of 825 m² of Stage 1 of the Trail Landfill, which was in operation from May 1980 to July 1986, was chosen for the pilot program and six gas probes were installed to monitor the gas component concentration in February 2001. After removing soil cover, drainage layer, high density polyethylene geomembrane, sand bedding and subgrade material, 4440 m³ of waste (5.5 m thick) was excavated during an eight-day period in March 2001. The waste was processed using an Erin 165 finger screener during a 9-day period and the fines were used as daily cover and the rest of the waste was recompacted and re-landfilled in the active working face of the landfill. The air space recovery for the pilot gained by processing and recompacting the waste was 18%.

The average existing apparent density was 580 kg/m³ (pre-mining) which increased to 650 kg/m³ after re-compaction (post-mining).

Waste characterization was performed on three 1.7 m³ representative samples from three locations and the result was as follows:

- Wood (7-13%);
- Plastics (17-22%);
- Paper (34-41%);
- Metals (6-7%);
- Glass (1%);
- Textiles (3-5%); and
- Fines (17-25%).

C.2.1 Concerns and Mitigation Measures

For this pilot work, management of leachate was not an issue due to low moisture content in the waste. Also, the weather conditions were favourable (i.e., no precipitation and low winds) during the pilot but for a full-scale operation over a long period of time, conditions would vary with the possibility of encountering saturated waste, perched leachate and unfavourable weather conditions that could result in the requirement to manage the leachate.

The decomposition of the biodegradable wastes produces landfill gas that would have associated odours and health and safety concerns during the excavation, processing, and re-landfilling of waste. Six gas probes were installed around the excavation perimeter to monitor and collect samples of landfill gas for characterization.

During the pilot project, temporary foam control agents were applied to the exposed waste surface in the excavation face and to the surfaces of the coarse and fine-screened stockpiled materials to control odours. Odour complaints associated with the mining pilot program were received from area residents from a distance up to 2.8 km from the pilot activities. Under full scale mining operations, odour emissions would vary by season and would require a more comprehensive and robust odour control plan.

In terms of health and safety, a minor fire developed under the screening unit's muffler which was extinguished using on-site hand held extinguishers. During the excavated waste characterization, five used hypodermic needles were encountered in one of the samples. The sorter was wearing hand protection, which prevented any injury.

The mining full-scale option was not chosen during the Trail Landfill expansion EA process as the selected preferred alternative did not include a mining component.

For additional details refer to *Table C-1* on *Section C.8*.

C.3.0 Sault Ste. Marie Municipal Landfill

The Sault Ste. Marie Municipal Landfill has an approved waste footprint of 44.6 ha and a disposal capacity of 2,260,000 m³ for waste and daily/intermediate cover.

The City is undergoing an EA where the preferred alternative is to expand the existing landfill to increase the site capacity to 6,460,000 m³ for disposal of solid residential, IC&I, construction and demolition (C&D) wastes and biosolids, assuming an apparent density of 0.56 t/m³. The proposed expansion alternative includes landfill mining as a component (i.e., excavate the existing waste and cover material, recover large size recyclable materials like tires, long metal rebars, concrete and boulders, earthen material or “fines” and return the residual waste to a lined cell).

The existing landfill has no liner and only a perimeter leachate control system and is located in gravel and sandy soils (i.e. highly permeable base). The site also has a soil deficit. The main driver behind landfill mining for the proposed expansion is to improve the groundwater conditions of the existing waste footprint with the installation of a liner. The secondary driver for mining is to recover fines to be used as daily/intermediate cover to offset the site soil deficit.

An area of approximately 3.4 ha is proposed to be mined and assuming an excavation of 320,000 m³ of waste and cover materials and 50% recovery, this will generate a disposal capacity of 160,000 m³ for waste and daily/intermediate cover.

C.3.1 Concerns and Mitigation Measures

As proposed in the Design and Operations Report, a site-specific health and safety plan should be prepared before mining operation and it should address:

- Physical, chemical and biological hazards such as gases (methane, hydrogen sulphide), sharps, wastewater biosolids, asbestos;
- Equipment traffic, and procedures to operate heavy equipment, processing equipment and tools; and
- Air quality, dust monitoring, airborne contaminant management, personal protective equipment (PPE), decontamination procedures and emergency procedures as well as procedures to manage anticipated or confirmed hazardous materials (e.g., asbestos).

A site specific preliminary odour management plan (OMP) was prepared as part of the EA. The OMP includes operational and administrative controls to mitigate odour emissions.

The proposed operational odour control measures for waste mining include:

- Minimize the area of active excavation to one day production whenever possible and cover with soil as soon as possible;

- Increase the slope of excavation considering the slope stability since a steeper slope will expose less waste and minimize odours (the slopes of exposed waste are expected to be between 4V:1H and 2H:1V);
- By-pass screening of waste where highly odorous waste (e.g., new waste) may be excavated;
- Avoid mining in known or suspected areas that may have perched leachate since perched leachate could cause odour emissions. Leachate or leachate impacted water should be drained or pumped as soon as possible to allow mining;
- Manage operations based on meteorological conditions to mitigate odour impacts. For example, avoidance of mining on hot days or when winds are blowing in the direction of residences and if possible conduct waste mining during wet days and/or colder months; and
- Use chemical and/or biological treatment to mitigate odour emissions.

The proposed administrative odour control measures for waste mining include:

- Training employees in the operational controls and related Standard Operating Procedures (SOPs);
- Selecting a contractor with adequate experience in waste mining projects and odour management;
- Incorporating requirements to strictly comply with the SOPs monitoring program; and
- Completing daily inspections of the active waste mining area(s) to document Site conditions, adherence to the control measures and SOPs, and potential odour impacts.

Another issue that needs to be addressed is dust and airborne contaminant management. Mining operations have the potential to generate dust during dry periods. Dust can be generated by typical mining operations such as cover stripping, waste and soil excavation, screening and heavy equipment and truck traffic. Dust is a concern because it may reduce visibility, generate airborne contaminants and potentially may become a nuisance to off-site receptors if not controlled at the source. A dust and airborne contaminant management plan should be prepared and implemented by the mining contractor and approved by the City and the contract administrator retained by the City.

For additional details refer to *Table C-1 on Section C.8.*

C.4.0 City of Barrie Landfill

In 2008, the City of Barrie started a landfill mining program as part of the remedial plan to address groundwater impacts in a high permeable (i.e. sandy) soils base. The re-engineering plan consisted of three phases during which about 60% of the landfill was reclaimed and lined. The reclamation project extended the landfill life by 18 years from 2017 to 2035.

A pilot reclamation program was performed in 2008 to test the approach and the full scale reclamation started in the winter of 2009 and was completed in December, 2015. About 1.6 million m³ of waste was

excavated at the rate of 1,000 m³/day. Prior to reclamation, the remaining airspace was approximately 850,000 m³ and it increased to 1,144,550 m³ at the end of reclamation in 2015 (Dewaele and Brunet, 2017). Excavated materials were about 47% overs and 53% fines and approximately 50% of volume was recovered with the landfill mining operations. The fines composition on a weight basis consisted of 74% of fine-grained sand, 15% of dry combustible consisting largely of paper, fibre and plastic (Dewaele and Brunet, 2017)

The cost to mine the landfill was \$10 to \$15 per m³ excluding liner and leachate collection system.

C.4.1 Concerns and Mitigation Measures

Odour was the major concern at the Barrie Landfill. The odour generation potential was grouped in different categories by the age of waste. Generally, younger wastes (within 7 years of being landfilled) are more odourous and so this waste was typically not processed but directly relocated to the new lined cell and landfilled immediately. Wastes between 7-14 years old were identified as having potential for odour but likely to be more manageable. Waste that was over 14 years old was assumed to be more stabilized and would generate less odours. Approximately 20% of the waste was re-landfilled without screening including newer waste with high odours during the excavation and asbestos (Dewaele and Brunet, 2017).

During the summer of 2010, an average of 10 complaints per day was received from local residents. The weather was checked regularly along with wind speed and direction to determine potential impacts to neighbouring residents and to plan mining operations accordingly. When possible, the operation was performed during wet conditions or the site was wetted to minimize odours. In addition, there was no screening of waste during the summer months (i.e., waste was excavated and then landfilled in the new cell immediately). Odour assessments were completed by taking readings regularly during the active mining periods.

For odour control, masking agents (200 Gallon reservoir attached to a fan), aerosols, foam canons and misters were used. The size of the open face of the operations was kept at a minimum and was covered with recaptured fines at the end of the day. Waste screening equipment was kept clean and operable to avoid downtime and delays to support odour control efforts.

Steeper working face reduced the exposed surface area and therefore reduced odour emissions. Interim waste slopes were as steep as 2:1 and sometimes the contractor excavated the waste at 1:1 slopes.

Only large items are typically recovered during mining operations. Recovered tires were shredded and used as internal road construction materials. Large concrete rubble was crushed and the aggregate used on site. Excavated wires from the landfill were contaminated with sand and debris to the point that the wires were not marketable to third party metal processors. The presence of wires and industrial fabrics slowed down the reclamation process (Dewaele and Brunet, 2017).

The landfill received asbestos during its operational life. There were Health & Safety protocols to handle asbestos, which included using respirators and other required PPE. When asbestos had been received at the landfill, it was bagged and tagged and their locations were marked at the landfill. During mining excavations, the asbestos containing materials was segregated and landfilled in the new lined cells. Asbestos was handled only during favourable weather conditions or alternatively the asbestos area was sprayed with water to minimize the potential for airborne releases of asbestos. Asbestos handling was avoided during windy conditions.

For additional details refer to *Table C-1* on *Section C.8*.

C.5.0 Blue Mountains Landfill

The Blue Mountains Landfill is owned and operated by the Town of The Blue Mountains and is located in Blue Mountains, Ontario. The total landfill property is about 23.1 ha and the landfill footprint is about 10.1 ha. The landfill includes the former Thornbury Landfill and the active Blue Mountains Landfill (collectively referred to as Blue Mountains Landfill) and it has been used for the disposal of waste since 1976. Both landfills are located in sandy deposits, rely on natural attenuation and do not have leachate collection systems. Both landfills received solid non-hazardous domestic waste and IC&I waste from within the municipal boundaries.

The Thornbury Landfill was capped with 1 m thick clayey soil cover material in 1996. The depth of the waste at the Thornbury Landfill is about 4 to 5 meters based on field investigations and with an area of approximately 2 ha, its volume is estimated to be 100,000 m³. The completed and partially filled portions of the Blue Mountains Landfill covers an area of about 8 ha and the thickness of the waste in the completed areas is estimated to be 6 m.

A vertical expansion combined with mining was approved in 2012 by MOECC. The main drivers for the landfill mining operations were to reduce groundwater impacts and to increase landfill capacity. The total landfill capacity of the proposed expansion was 470,000 m³ which increases the original capacity by 100,000 m³. The approval included the reclamation (mining) of the former Thornbury Landfill and the eastern one third of the Blue Mountains Landfill. The proposed reclamation project included 162,500 m³ of waste excavation in two stages of equal areas (Stage 1 in 2014 and Stage 2 in 2024). Based on previous field investigations, the overs to fines ratio was anticipated to be 40% to 60%.

The first phase of the landfill mining program was completed in 2014. Approximately 49,000 m³ of material was mined over one construction season at the Thornbury Landfill. The mining operations were relatively straightforward in this case because the waste was shallow and dry since it was buried through a trench and fill method with large amounts of native sandy soil and gravel between the waste trenches. Approximately \$2.6 million was spent to mine 49,000 m³ (\$53/m³) of material and to build a new cell with geomembrane/geosynthetic clay liner and leachate collection system. The cost for the landfill mining component ranged from \$10 to \$20 per m³.

C.5.1 Concerns and Mitigation Measures

The Thornbury Landfill was closed in the 1970s and the eastern part of the Blue Mountains Landfill was capped in 1996 therefore the waste in the reclamation area was 20-40 years old and therefore significant odour would not be expected during the reclamation operations. However, proper operational procedures were followed to manage odour concerns. These procedures included: keeping the excavation face small and cover it as soon as possible, having an odour neutralizing foam sprayer on site for use as needed, monitoring the wind and weather conditions (temperature, precipitation, humidity, etc.) and adjusting the reclamation operation accordingly to manage potential odour impacts.

During landfill mining, oversized waste and overs were hauled, landfilled, and covered and in the case of equipment failure or emergency situations, waste was covered with a minimum of 150 mm thick layer of fines until it was properly landfilled. Temporary waste stockpiles that could not be landfilled on the same day were covered with 300 mm of fines. Exposed waste that would not be excavated immediately and be inactive for a period of time was covered with 300 mm fines. At the end of each day, active excavation face was covered with a minimum of 150 mm fines.

It was critical to control the placement of materials in the hopper of the screening plant because some materials such as metal bars, large metal items or concrete blocks can cause damage to the feeding belt or screen of the screening plant. Large sized materials were pulled out of the screening process using an excavator or backhoe to avoid damages to the screener.

During the reclamation process, appropriate temporary erosion and sediment control measures were necessary until the final grading was completed and the vegetation was established. Erosion and sedimentation controls were inspected regularly.

Although the reclamation operations were not expected to have significant noise impacts on the neighbouring residents (located 1 km minimum from the mining operations), the Town considered mitigation measures such as lowering the backup beeper sound level and installing additional temporary acoustical barriers.

A project specific health and safety plan was developed for the project addressing hazard identification, mitigative measures, safe operating procedures, air and dust monitoring, personal protective equipment, personal and equipment decontamination, and emergency procedures.

For additional details refer to Table C-1 on Section C.8.

C.6.0 Perdido Landfill

The Perdido Landfill is located in Florida, US, and is owned and operated by Escambia County Department of Solid Waste Management. The unlined area of the landfill covers approximately 18.2 ha

(45 acres) and received municipal solid waste from residential and commercial sources and non-hazardous waste from industrial waste from 1981 to 1990.

The trench and fill method was used for waste disposal and in early 1990 the unlined cells were capped with soil. A number of factors made the reclamation of the unlined cells a favourable option. Firstly, the unlined cells caused groundwater impacts at the site and benzene and vinyl chloride were encountered at elevated levels outside the property boundary. Secondly, due to leachate outbreaks (seeps) and differential settlement, the maintenance of the unlined cells had been a challenge. Thirdly, the landfill expansion into adjacent areas was limited due to site specific constraints. Lastly, the final grade of the unlined cells was at least 30 m below the permitted final grades for the adjacent lined cells and this elevation difference could be used for landfilling more wastes.

In 2006, a preliminary technical and economic feasibility assessment was performed by excavating eight test pits and screening the excavated waste as well as analysing data from 39 boreholes to estimate the depth of the waste and the final cover. It was estimated that 30% of the material in the unlined areas was final cover. The fine material, produced by screening the waste, was estimated to be 24% of the volume. The feasibility assessment results suggested that the reclamation cost was lower than the value of the recovered airspace, screening the excavated soil and using the fines as daily covers. The landfill capacity gain was mainly due to the fact that the new cells in the mining area could be developed with a much higher elevation.

A pilot program was performed in 2008 to evaluate the nature and volume of the waste as well the cost and technical feasibility of the reclamation before considering a full scale project. About 42,000 m³ of material was excavated from a 1 hectare (2.5 acre) section during the pilot period. The pilot program provided information and data that were used in the full scale program.

The full scale project was planned in two phases. Phase I was conducted from 2009 to 2011 and about 371,000 m³ of waste was excavated from a 6.8 ha (17 acre) area. The volume of the final cover soil was estimated to be 126,350 m³ (34%). The combination volume of final cover soil, reclaimed soil, and bermed soil was approximately 62% of the mined airspace.

C.6.1 Concerns and Mitigation Measures

The waste screening process slowed down the project because of frequent equipment breakdowns. In 2010, a second screener was set up to increase the screening rate; however, typically only one screen was operating at a time.

A major issue during the mining was the transport of sediments from the mined area before stabilization with vegetation. Clayey-silt sediment was transported with stormwater runoff from the reclamation area to the stormwater pond and covered the entire sand drainage layer. Silt barrier fences were used to control further impacts.

Odour was not a concern during the reclamation project as it dissipated with distance (over 2 km from the mining operations to the closest receptors) and waste was more than 20 years old.

Litter was controlled by installing litter control fences.

The reclamation cost for this project was \$11/m³ (\$8.33 USD per m³) of airspace. This relative low unit cost is due to the fact that the new lined cell was filled at the mining site with a much higher elevation, i.e. the unit cost was spread across all capacity. Therefore, this cost is not representative of a typical landfill mining project.

For additional details refer to Table C-2 on Section C.8.

7.0 Ocean County Landfill Corporation (OCLC) Site

The Ocean County Landfill Corporation (OCLC) Site is a privately owned and operated sanitary landfill in Manchester Township, New Jersey. The landfill is constructed above sandy soil and the water table is just below the landfill base. The OCLC property has approximately 280 hectares (700 acres) and it serves 33 municipalities including the Ocean County. It receives 453,000 tonnes (500,000 tons) of waste per year and its remaining capacity is expected to last for 25 years (from December 2015).

Landfill mining was proposed for this landfill as an expansion option since vertical expansion of the landfill was challenging due to height restrictions imposed by the New Jersey Department of Environmental Protection (NJDEP). Lateral expansion would not be a feasible option due to surrounding neighbourhoods and wetlands. Also, the site had a soil deficit and there was history of high amounts of recyclables being landfilled. Soils and fines were recovered and used for daily/intermediate cover.

An extensive test pit program was conducted in July 2007 to assess waste characterization, delineation of limits and also to measure Biochemical Methane Potential (BMP) and hydrogen sulfide exposure. The test pit was also used to conduct visual observation regarding waste decomposition, odour, moisture, and perched conditions. BMP testing showed that the waste was largely decomposed. No perched leachate was encountered during the test pit program and it was observed that a large amount of soil had been used as daily cover during the waste placement. The cover soils above and below the liner were also thicker than expected, which made the mining operations more attractive because the landfill needed soils for future operations.

The landfill received approval to mine 3.06 million m³ (4 million yd³) of waste over an area of 27.5 ha (68 acres), including a pilot test. Excavating this amount of waste, screening, re-compacting the covers, and using the fines as daily cover would add an additional 0.96 million m³ (1.25 million yd³) of landfill capacity, which equals 31% of additional capacity and expand the operating life of the landfill by 1.5 years.

Landfill mining was planned in 3 phases over a 15-year period. For Phase 1, it was planned to excavate and screen 1.15 million m³ (1.5 million yd³) of waste. The mining started in September 2014 and 150,000 m³ (200,000 yd³) waste was mined in the first year.

The mining cost was estimated at \$24 per m³ (\$13.69 USD per yd³) excluding liner and leachate collection system.

C.7.1 Concerns and Mitigation Measures

The concerns for this particular site were relatively moderate. To mitigate various concerns and adjust the operations, a pilot test and various test pits were completed.

To mitigate odours, a stationary odour misting system was installed on poles and the mining operations was planned to take place downstream of the landfill gas collection system when possible.

To mitigate health and safety concerns, hydrogen sulphide masks were used when needed and a general rule was adopted to never allow anyone to approach the trommel while in operation; if the trommel needed to be checked or maintained, it should first be shut down.

For additional details refer to *Table C-2* on *Section C.8*.

C.8.0 Summary of Additional Landfill Mining Information

Tables C-1 and C-2 below provide a summary of key details for landfill mining operations for Canadian and USA sites.

Table C-1: Landfill Mining Summary for Canadian Sites

Name of the Landfill	Trail Landfill	Sault Ste. Marie Municipal Landfill	City of Barrie Landfill	Blue Mountains Landfill
Location	<ul style="list-style-type: none"> Ottawa, ON 	<ul style="list-style-type: none"> Sault Ste. Marie, ON 	<ul style="list-style-type: none"> Barrie, ON 	<ul style="list-style-type: none"> Blue Mountains, ON
Filling History	<ul style="list-style-type: none"> Stage 1 (before expansion approval): filling from May 1980 until July 1986 	<ul style="list-style-type: none"> Opened in the 1960s 	<ul style="list-style-type: none"> Opened in the 1960s 	<ul style="list-style-type: none"> Opened in 1976. The Thornbury site closed in 1994.
Current Phase of the Project	<ul style="list-style-type: none"> Below information is from pilot phase in 2001. Current status: EA approved June 1, 2005. Mining was not a component of the preferred alternative 	<ul style="list-style-type: none"> EA under approval. The Terms of Reference were approved. The environmental impact assessment reports have been submitted to MOECC 	<ul style="list-style-type: none"> Completed (60% of the existing landfill was reclaimed and lined) 	<ul style="list-style-type: none"> Stage 1 completed, Stage 2 planned for the future
Mining Timeline	<ul style="list-style-type: none"> Pilot: Feb 2001 (gas probe well installation). Excavation: March 6 to 15, 2001. Refuse processing: March 6 - 16, 2001 Pilot: 8 days for excavation and hauling; 16 days for screening and processing of material Full Scale (all Stage 1, 2 and east side of 3): Excavation and processing would take approximately 10 years 	<ul style="list-style-type: none"> Mining will start after the EA is approved by MOECC 3 years estimated 	<ul style="list-style-type: none"> 6 years for pilot and 3 phases 2008 pilot program Phase 1 completed in 2009 Phase 2 completed in 2013 Phase 3 from March 2013 to December 2015 	<ul style="list-style-type: none"> Stage 1: mining in 2014 and construction of lined cell in 2015 Stage 2: planned to start in 2024 Taking in account downtime, equipment breakdown, and weather condition etc., each stage should take between 9 months to a year to finish. Timeline assumes using screening equipment to handle approximately 500 m³/day over a 5 day working week with 8 hours per day
General Site Information	<ul style="list-style-type: none"> Total site area: 200 ha with 85.2 ha footprint Total approval capacity of 16,998,442 m³ Fill rate: 563,300 tonnes/year 	<ul style="list-style-type: none"> Existing fill Area: 25.8 ha Proposed expansion fill area addition: 17.8 ha Max fill rate: 78,500 tonnes/year 	<ul style="list-style-type: none"> Total site area of 121.3 ha with 18.6 ha footprint Approved capacity of 3,924,750 m³ Existing fill area: 18.6 ha Max fill rate: 81,000 tonnes/year 	<ul style="list-style-type: none"> Total site area of 23.1 ha with 10.1 ha waste footprint 370,000 m³ disposal capacity with approximately 52,000 m³ remaining (as of 2012) Site receives on average 4,330 tonnes of waste/year
Waste Type	<ul style="list-style-type: none"> Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids 	<ul style="list-style-type: none"> Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids 	<ul style="list-style-type: none"> Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids 	<ul style="list-style-type: none"> Solid residential, industrial, commercial and institutional (IC&I), construction and demolition (C&D) wastes and biosolids
Mining Area and Volumes	<ul style="list-style-type: none"> Pilot: 825 m² surface area (4440 m³ of refuse excavated) 	<ul style="list-style-type: none"> Proposed Mining Area: 3.4 ha 320,000 m³ to be excavated, of which 160,000 m³ will likely be recovered 	<ul style="list-style-type: none"> Excavated 1,620,000 m³ (44% of the total licensed landfill volume) between 2009 and 2015 Production rate: approximately 1000 m³/day of material screening 	<ul style="list-style-type: none"> Total of 162,500 m³ waste planned to be mined over 2 stages (81,250 m³ each stage) The volume of waste mined was actually 49,000 m³ and the rest was relocated or not mined Assumed production rate: approximately 500 m³/day of material screening over 5 days a week,

Name of the Landfill	Trail Landfill	Sault Ste. Marie Municipal Landfill	City of Barrie Landfill	Blue Mountains Landfill
				8 hours/day
Recovery Rate (%)	<ul style="list-style-type: none"> Pilot: 18.2% airspace recovery Overall: Approx. 13% estimated 	<ul style="list-style-type: none"> 50% (estimated) 	<ul style="list-style-type: none"> 50% 	
Mining Depth (m)	<ul style="list-style-type: none"> 8.5 m 	<ul style="list-style-type: none"> 10 m 	<ul style="list-style-type: none"> 20 m 	<ul style="list-style-type: none"> Up to 2.5 m
Types of Waste Recovered	<ul style="list-style-type: none"> 79% of the overall recovered volume was recyclable content: Wood (7-13%) Plastics (17-22%) Paper (34-41%) Metals (6-7%) Glass (1%) Textiles (3-5%) Fines (17-25%) 	<ul style="list-style-type: none"> Recovery of large size recyclable materials such as tires, long metal rebars, concrete rubble and boulders. Fines material to be used as daily cover 	<ul style="list-style-type: none"> Recovery of large size recyclable materials such as tires, long metal rebars, concrete and boulders Fines (approx. 875,000 m³), tires (approx. 3 million tires recovered which were then ground up and used internally for internal road base) 	<ul style="list-style-type: none"> Recovery of large size recyclable materials (white goods, tires, long metal rebars, concrete rubble and boulders) represented 40% recovery of fine materials represented 60% of overall recovered materials
Waste Apparent Density	<ul style="list-style-type: none"> Existing (pre-mining): 582.9 kg/m³ Re-compacted (post-mining): 646 kg/m³ 	<ul style="list-style-type: none"> 0.56 t/m³ 	<ul style="list-style-type: none"> 650-750 kg/m³ The apparent density of the re-compacted oversize fraction was 1,280 kg/m³ 	<ul style="list-style-type: none"> Historical range from 275 to 432 kg/m³
Equipment Used/Proposed	<ul style="list-style-type: none"> CAT 330 tracked Hydraulic shovel Volvo articulated trucks Erin 165 finger screener CAT 826C (35 tonne) landfill compactor CAT 330 excavator CAT 320 c/w Grapple CAT 980C rubber Tire Loader Application odour suppressant 	<ul style="list-style-type: none"> 1 Dozer Cat D7 2 Excavators fitted with hydraulic "thumbs" 2 Trommel screen(s) Loader 2 Articulated trucks Cat 735 Top loading trucks to haul waste 1 Hydraulic stacker (stacking conveyor) Water truck for dust control Odour misting system 1 Grinder 	<ul style="list-style-type: none"> 2 Dozer D6 2 Excavators 2 McClosky MCB 733 2 Trommel screens 1 50-ft stacker for the fines 4 articulated haul trucks 1 Cat 826 compactor Odour misting system 	<ul style="list-style-type: none"> Dozers Excavators with thumb Trommel screens Rubber tire loader Articulated trucks Top loading waste hauling vehicles Conveyors/stackers Water truck/tank for dust control/suppression Odour suppressant foam sprayer Odour neutralizing misting systems
Cost	<ul style="list-style-type: none"> \$35/m³ estimated for the full-scale mining project excluding liner and leachate collection system 	<ul style="list-style-type: none"> Not available (proposed mining is under approval) 	<ul style="list-style-type: none"> \$10 to \$15 per m³ excluding the liner and leachate collection system 	<ul style="list-style-type: none"> \$10 to \$20 per m³ excluding the liner and leachate collection system
References	<ul style="list-style-type: none"> J.L. Richards & Associates Ltd. (2001) https://www.ontario.ca/environment-and-energy/large-landfill-site-details?site=A461303 https://www.ontario.ca/page/trail-waste-facility-landfill-optimization-project 	<ul style="list-style-type: none"> Dillon (2017a) Feb 2016 Open Public House Displays: http://saultstemarie.ca/Cityweb/media/PWT/Public%20Works/SolidWasteEAFeb9Di splays.pdf 	<ul style="list-style-type: none"> Dillon (2011) Dillon (2013a) Dillon (2013b) Dillon (2014) Dillon (2017c) https://www.ontario.ca/environment-and-energy/large-landfill-site-details?site=A250101 http://www.barrie.ca/Living/GarbageAndRecycling/Pages/LandfillProject.aspx 	<ul style="list-style-type: none"> Golder (2014) Dillon (2017d)

Table C-2: Landfill Mining Summary for American Landfills

Name of the Landfill	Perdido Landfill	Ocean County Landfill Corporation Site
Location	<ul style="list-style-type: none"> Cantonment, Florida 	<ul style="list-style-type: none"> Manchester, New Jersey
Site History	<ul style="list-style-type: none"> Operational from 1981 to 1990 In early 1990 the unlined cells were capped with soil 	
Mining Timeline	<ul style="list-style-type: none"> In 2006, a preliminary technical and economic feasibility assessment was performed A pilot program was performed in 2008 Phase 1 of the full scale project was conducted from 2009 to 2011 	<ul style="list-style-type: none"> Started in Sept 2014 3 phases over a 15 year period
General Site Information	<ul style="list-style-type: none"> The unlined area of the landfill covers approximately 18.2 ha (45 acres) 	<ul style="list-style-type: none"> Site area: 280 Ha (700 acres) Waste footprint: 120 Ha (300 acres) Sandy soil with water table below the landfill base. Approx. 500,000 tonnes of solid waste disposed on annual basis at \$80 USD per ton
Waste Type	<ul style="list-style-type: none"> Received municipal solid waste from residential and commercial sources and non-hazardous waste from industrial sources 	<ul style="list-style-type: none"> Serves 33 municipalities comprising the Ocean County
Mining Area and Volumes	<ul style="list-style-type: none"> For the pilot project about 42,000 m³ material was excavated from a 1-ha section For the Phase 1, 371,000 m³ waste was excavated from 6.8 ha area 	<ul style="list-style-type: none"> Received approval to mine 3.06 million m³ (4 million yd³) Excavated 150,000 m³ (200,000 yd³) of material in the first year Mining started in September 2014 and still ongoing
Recovery Rate (%)	<ul style="list-style-type: none"> 62% 	<ul style="list-style-type: none"> Varied on a daily basis from 30% to 70%
Type(s) of Waste Recovered	<ul style="list-style-type: none"> Mostly fines, including soils 	<ul style="list-style-type: none"> Recovery of large size recyclable materials such as tires, long metal rebars, concrete and boulders Fines used as daily cover Drums with chemicals or any concerning materials were not found Asbestos outside the dedicated area were not found
Equipment Used	<ul style="list-style-type: none"> Four Excavators One dozer Two Trommel screens Six articulated dump trucks 	<ul style="list-style-type: none"> Excavator Trommel screen(s) 1 front end loader Truck(s) to haul waste 4 John Deere rock trucks
Cost	<ul style="list-style-type: none"> \$11 per m³ (\$8.33 USD per m³) Note that this cost is not representative of a typical mining project as explained above 	<ul style="list-style-type: none"> \$24 per m³ (\$13.69 USD per yd³) excluding liner and leachate collection system
Source	<ul style="list-style-type: none"> Jain et al. (2013) 	<ul style="list-style-type: none"> Cornestone Environmental (2014) Dillon (2015) Ocean County Landfill Corporation (2015) Dillon (2017b)

