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BARRIE LANDFILL RECLAMATION AND RE - ENGINEERING 2009 - 2015

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ABSTRACT

The City of Barrie's municipal solid waste landfill is located in a depleted sand pit and is in close proximity to residential development. The landfill opened in the 1960s and was slated for closure in 2017. Originally designed as a natural attenuation facility, leachate seepage from the waste to the groundwater and an adjacent stream, posed environmental risks and compliance issues. The risks were mitigated through a project completed between 2008 and 2015, involving the progressive excavation of approximately 1.6 million cubic metres of waste in the western 2/3 of the landfill, installation of an engineered state-of-the-art liner and leachate collection system, re-use of sand from the waste screening process and installation of a landfill gas collection system. The re-engineered landfill cells contain leachate from impacting groundwater and will allow existing purge well remedial system to be stopped earlier than initially predicted. The landfill gas collection and flaring system constructed as part of the project will result in reduction in the release of greenhouse gas. The total airspace remaining as a result of the reclamation and re-engineering translates to a site closure of 2035, a lifespan increase of 18 years. This increase resulted from the re-use of daily cover screened from the waste, as well as increased density achieved through recompaction activities. This project outcome is considered to be a success from the perspectives of improved environmental performance and improved utilization of an existing waste management asset, which will allow the City to continue to develop its long term Sustainable Waste Management Strategy.

Keywords: waste reclamation, landfill mining, airspace gain, environmental benefit, landfill remediation

1. INTRODUCTION

The Barrie landfill curently services the City of Barrie (population 140,000) and has been used to dispose of municipal solid waste (MSW) since the mid 1960s. Prior to 1973, the landfill also accepted waste from local industries, which was placed in the eastern third of the landfill (Cell 1). The landfill has a licenced volume of 3.9 Mm^3, a design footprint of 18.6 hectares and consists of three waste cells (Cells 1 to 3 from east to west, Figure 1) and a peak waste pile thickness of approximately 30 m. Prior to 2007, the landfill was constructed without an engineered liner and, as a result, groundwater collection systems consisting of a drain (Gallery) and purge wells have been constructed to intercept leachate impacts. The combined discharge of these systems is directed to the City's wastewater treatment plant.

An updated design and operations (D&O) plan was completed (Golder Associates, 2005), which included reclamation, or "mining", of waste in the western two thirds of the landfill and re-engineering of the landfill to incorporate a liner and leachate collection system, as well as a landfill gas collection system and flare. Although groundwater impacts from potentially hazardous waste in Cell 1 have not been identified, reclamation of waste in this cell was not recommended due to the possible presence of the hazardous material in this area. The reclamation operations were undertaken to bring the site into environmental compliance and reduce the period of time over which the purge well system will be required and thus reduce the discharge conveyed to the wastewater treatment plant.

Landfill reclamation for this project refers to the process whereby the existing waste fill is excavated, screened to remove the daily cover soil (soil component) and then the remaining large waste fraction is re-landfilled using a greater level of compaction and less soil cover than had originally been used. The screened daily cover component is referred to as "fines", whereas the remaining waste component is referred to as "overs". Whereas the primary intent of the reclamation at the Barrie Landfill is to reduce environmental impact, it was also expected to result in a recovery of air space, thus extending the operational life of the landfill.

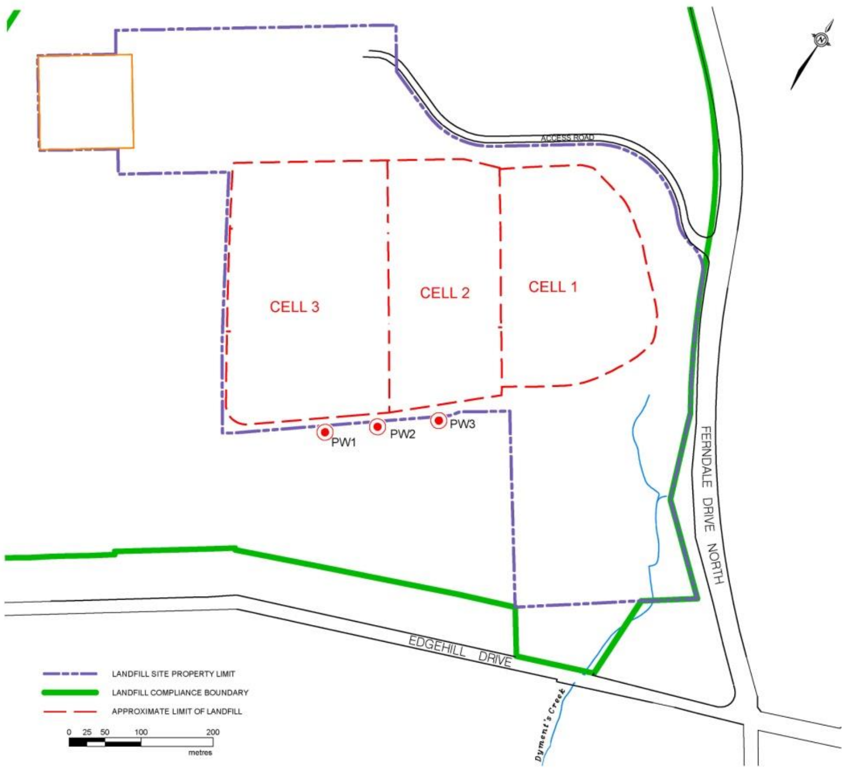

Figure 1: Barrie Landfill Site - Stream (blue) southeast of Cell 1, purge wells (red circles) to south of Cells 2 and 3.

At the commencement of the project, there was only one small lined area in the south of Cell 3 available to place the reclaimed and incoming waste, with an interim capacity of 130,000 m^3. A critical aspect of the project therefore involved the timing of waste reclamation and new cell construction, such that the available space in the new lined cells would be sufficient to hold the estimated volume of the reclaimed waste as well as incoming MSW and daily cover until the next cell could be constructed. Sequencing and design of the access by incoming waste trucks and the internal transfer of the processed fines and overs was also critical.

In 2007, a liner and leachate collection system were installed in the south end of Cell 3, where no waste had been placed to date. The liner, which meets the current requirements under Ontario Regulation 232/98 based on transport model predictions, consists of a composite of a geosynthetic clay liner and a 60 mil high density polyethylene liner with non-woven separator and cushion cloth and sand. A continuous stone drainage layer comprised of 50 mm diameter stone and a leachate collection system (LCS) overlie the liner, and are ultimately directed to the City's wastewater treatment plant. This design of liner and leachate collection was progressively extended into Cell 2 and the northern part of Cell 3 as the waste reclamation activities were completed in these areas. Figure 4 shows the construction of a new cell in the south half of Cell 2.

2. RECLAMATION PROGRAM

The reclamation project was based on a pilot scale waste mining operation carried out from November 2007 to February 2008 in the southern part of Cell 2, to confirm design assumptions and to plan the multi-year reclamation/re-engineering staging plan. Frequent and detailed surveys for a large volume sample (more than 13,200 m^3) of the excavated and waste fill areas were combined with weigh-in-motion measurements, which allowed a determination of the average in-situ density of the excavated waste, the percentage of fines and the average density that was achieved during recompaction of the oversize waste fraction. The fine (i.e., sand) fraction from this part of the landfill was 60% of the total waste (by volume). The in-place density of the excavated waste was 1,310 kg/m^3; the apparent density of the re-compacted oversize fraction was 1,280 kg/m^3, as compared to a typical compacted waste density of 750 kg/m^3. The high density of the in-place waste reflects the high proportion of soil used to cover the waste.

Subsequent to the pilot scale reclamation, full scale operations were completed between 2009 and 2015, of which 1,392,475 m^3 was excavated, screened and recompacted. The average apparent waste density achieved during the full operation was 1,180 kg/m^3, slightly lower than that identified in the pilot process. The operations were staged in three large phases, covering the south, central and northern parts of Cell 2 and 3. The first two phases are illustrated on Figures 2 and 3.

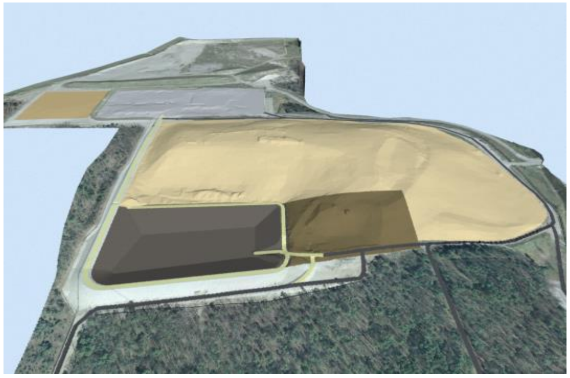

Figure 2: Phase 1 Reclamation

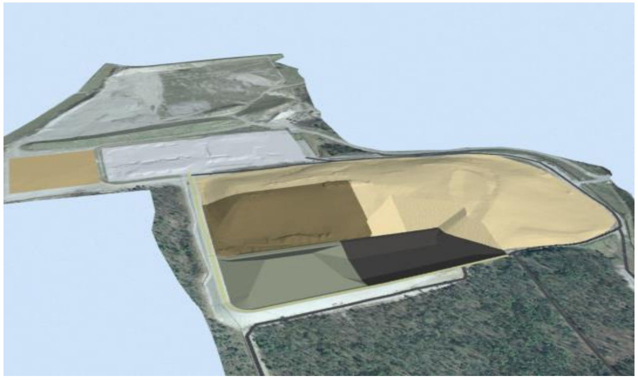

Figure 3: Phase 2 Reclamation

A total of 1,620,000 m^3 of waste was excavated between 2009 and 2015, representing 44% of the total licenced landfill volume. A total of 331,781 m^3 of the waste was excavated and re-landfilled without screening, including asbestos and newer waste which exhibited high odours during excavation. The fines component over the entire project averaged 52-53%, however the percentage varied substantially on a day-to-day basis. The excavated waste consisted of a variable mix of residential and commercial refuse and in some cases, substantial thicknesses of cover material. Significant quantities of telephone wire, industrial fabric cut-offs and tires were encountered, notably in the southern part of Cell 2, which slowed the rate of screening. In some areas large wood stumps and construction concrete rubble was encountered. The wire and industrial fabric served as the greatest operational challenge; however tires comprised the greatest percentage of large items in the waste. The waste materials in newer part of the landfill (Cell 3) consisted largely of “uniform” waste and contained few tires or material that affected screening; as a result, the overall daily production increased.

The waste screening operations for the full scale reclamation were undertaken using two 2.1 m diameter 10 m long rotating drum “trommel” screens with 52 mm openings (Figure 5). These screens were typically staged at the base of a waste slope and excavation operations were adjusted to push or occasionally transport waste to the screens. A 15 m stacker was occasionally used in order to manage the fines. The heavy equipment used in the operations typically included two to three large excavators with thumbs, two D-6 bulldozers and four articulated haul trucks (25 to 35 tonnes). The production rate for each screen averaged approximately 140 m^3/hour for each screen over the project period.

Figure 4: Construction of lined waste cell

Figure 5: Waste Screening Operation

Odour control and assessment of the potential for air quality impacts, notably relative to the potential for off-site impacts, was a significant part of the project planning and implementation. Sampling of the landfill gas and of air quality upwind and downwind of the landfill indicated that there were no anticipated exceedances of the regulatory standards or unacceptable health impact related to the reclamation process (Golder, 2011). The City implemented regular odour inspections surrounding the site, targeted at identifying perceptible odours, which were ranked according to type, frequency and strength of the odours. Site operations were adjusted (covering of waste, cessation of activities) as required, to ensure minimal impact to residents.

3. FINES COMPONENT ANALYSIS

The management of the volume of the fines component produced during the reclamation process was a significant challenge. A portion of this material was also used for interim cover on the lower slopes of the completed areas, which is further covered by topsoil. Analyses relating to the potential influence of this latter for use as interim cover have been completed and indicate that the fines material placed in these areas are not expected to adversely influence off-site surface water. This analysis was based in part on comparison of the in-place fines after a number of years, to that of the fines materials collected during the waste screening process.

The geotechnical and geochemical nature of the fines from the screening process was assessed in order to determine potential alternative uses other than daily cover. This included use as a base material below the liner, final cover and off-site fill. On a weight basis, the fines consisted primarily (74%) of fine grained sand, followed by dry combustibles (15.4%) consisting largely of paper and fibre and plastic (7%).

The grain size of the fine component was largely consistent with that of fine sand, which was sourced from the on-site soils for daily cover. Figure 6 illustrates the grain size distribution of a typical sample of the fines fraction from waste placed after approximately 1992. This material is lighter than typical results for sand, as a result of the inclusion of paper and plastic, and is also slightly wetter, as a result of the inclusion of the organic/wood fraction. Geotechnical testing of the material was completed to confirm the properties for use as cover and base fill.

Table 1: Relative proportions of fine fraction from the waste screening process

Fraction	Air Dry Mass (g)	% of Total
Inert (sand)	2392.2	73.7
Metal	13.9	0.4
Combustible	498.7	15.4
Wet/Putrescible	112.7	3.5
Plastics	226.8	7.0
TOTAL	3244.0	100.0

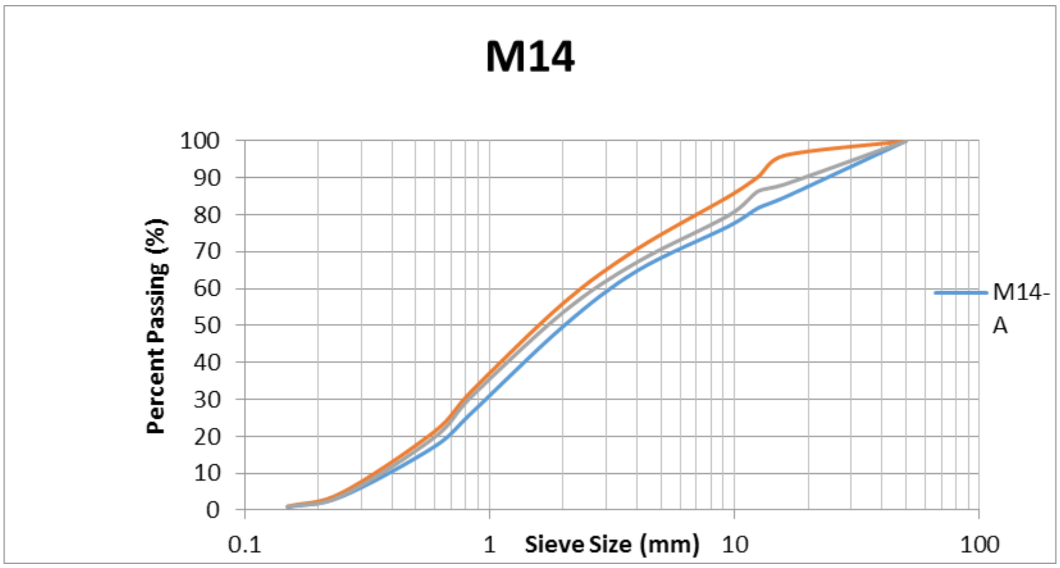

Figure 6: Grain size distribution of a typical sample of fine fraction from reclamation

Geochemical assessment of the fine material upon screening indicated that it largely meets the Ontario Table 2 standards for final cover material quality below the vegetated topsoil layer, with a few exceptions. The electrical conductivity of the material is elevated, consistent with the fines fraction being in contact with water leaching salts from the waste materials. Concentrations of boron and copper are occasionally slightly elevated above the standards. Sampling of fines material placed since 2009 indicates that their quality improves as precipitation infiltrates through this material to the waste, leaching the remaining salts. Based on an analysis of soil and runoff quality using a risk assessment approach, it has been determined that the quality of the runoff from the site will not adversely impact off-site streams.

4. ENVIRONMENTAL BENEFITS

At the time of the commencement of the landfill reclamation and re-engineering project, the environmental control systems at the Barrie Landfill consisted of (i) a groundwater collection gallery (Gallery) east of Cell 1 and (ii) a system of groundwater extraction (purge) wells. These systems were installed in 1973 and 2007, respectively, to control groundwater impacted by the landfill leachate infiltrating through the native sandy materials under the landfill. The groundwater from these systems is directed to the City's wastewater treatment plant, at a rate of approximately 1,750 m^3/day in 2014 (Golder Associates, 2015).

The benefit of installation of the liner and LCS is that the leachate will be captured directly and no longer mix with the underlying groundwater flow. Once the existing plume in the aquifer under the landfill is captured by the purge well system and it is subsequently shut down, the flows to the wastewater treatment system will be reduced.

Furthermore, the cost of operating and maintaining the active purge well system will end, and the leachate collection will be limited to gravity drainage (i.e., non-mechanical) of the LCS and the Gallery.

In addition to the above systems, a landfill gas (LFG) collection and flaring system was installed in the reclaimed portions of the waste in order to reduce the effects greenhouse gas emissions. The LFG collection system consists of vertical wells and horizontal trenches, which are connected to a gas header extending from the south perimeter of the landfill, west and ultimately north to the LFG extraction plant. This system is currently collecting and flaring approximately 340 m^3/hr of landfill gas and it is predicted that a maximum collection rate of up to approximately 500 m^3/hour may be achieved. On this basis, and considering current approaches to funding of LFG power generation projects, installation of a 500 to 850 kW generator is considered feasible. A financial assessment of the feasibility of generating electricity from the LFG is currently underway.

Overall, the reclamation and re-engineering project has resulted in a net benefit to the environment though the reduction of the release of leachate to the groundwater and the capture of methane gas and flaring to reduce greenhouse gas emissions. Additional benefits were achieved in terms of the expected long-term reduction in flows to the wastewater treatment facility, as well as potentially the income from the generation of electricity from landfill gas.

5. AIRSPACE GAIN

In 2004, it was predicted that the Barrie landfill would be filled to capacity by 2017, based on the existing design. The approval of the reclamation operations in the D&O plan was predicated on no change to the total original licenced waste volume, 3.9 Mm^3. It was initially predicted, based solely on a 50 / 50 % fines to overs ratio, that reclamation would result in an increased site life of 7 years (i.e., 2024).

A total of approximately 742,200 m^3 of fines were produced during the reclamation process, which has been partly used during the placement and recompaction of the screened overs from the reclamation process and the incoming MSW from 2009 to date. The remainder of the fines will be used in future for daily and interim cover, and possibly final cover. A total of approximately 200,000 m^3 of fines have been stored over the interim filled areas in the central parts of Cells 2 and 3, as well as on the east side of Cell 2.

In 2009, prior to reclamation, the remaining airspace was approximately 815,000 m^3; the remaining airspace at the end of reclamation in 2015 was 1,144,550 m^3. The resultant difference of approximately 330,000 m^3, plus the interim disposal of approximately 170,000 m^3 of incoming MSW over this period, represents the net increase in capacity associated with the reclamation.

Based on the current annual waste disposal rates (30,000 to 36,000 tonnes) and population growth predictions for the City, it has been estimated that the total lifespan of the landfill will extend to 2035. This, represents an 18-year gain in lifespan over the initial closure date of 2017. This gain represents the increases resulting from (i) re-use of the fines component as daily cover, (ii) greater density of compaction of the in-place materials and (iii) reductions in waste disposal rates achieved since the project began. Over the remaining lifespan of the landfill, it is expected that all of the remaining fines material will be used as daily cover. No importation of cover material is expected to be required, with the potential exception of the final years.

The benefit of the airspace gain to the City includes both the value of waste disposal from the perspective of alternatives including waste export, and the time which the City will have to implement their Sustainable Waste Management Strategy and to further develop options for additional reduction of the waste disposal rate through reduced waste generation and increased diversion.

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