CCE AWARD SUBMISSION

BARRIE LANDFILL RECLAMATION AND RE-ENGINEERING

Golder Associates

SUMMARY

The City of Barrie landfill was impacting water resources and required remediation. Golder was retained as the design engineer and construction manager to implement a long term project to redevelop the existing landfill. The eight year project involved innovative liner design, waste slope stability assessment and large-scale waste material management in a limited space. The project was completed on-time and within budget and resulted in the capture of leachate and landfill gas, the improvement of water quality and an 18-year extension of the total lifespan of the facility. As a result, the City has extended the life of an existing resource, recycled materials within the waste and met their environmental obligations.

PROJECT HIGHLIGHTS

The Barrie landfill has been operated since the mid-1960s for disposal of municipal solid waste. The licensed volume of the landfill is 3.9 million cubic metres, over a design footprint of 18.6 hectares and a peak waste pile thickness of approximately 30 m. The landfill was constructed without an engineered liner and, as a result, groundwater collection systems consisting of a drain and purge wells have been installed to intercept leachate impacts upstream of a nearby watercourse, Dyment's Creek. The combined discharge of these systems is directed to the City's wastewater treatment plant.

Figure 1 – Barrie landfill site and surroundings in 2012 showing completed, active and future reclamation areas. Residences visible 250 metres to the south (top of photo).

Golder was retained by the City to plan, design and implement a program of waste reclamation and engineered containment systems in order to remediate environmental impacts. This was achieved through the progressive excavation and screening of waste (reclamation), followed by the installation of liner, leachate and landfill gas collection systems to contain the source of the impacts.

Reclamation refers to the process whereby the existing waste fill is excavated, screened to remove the “fines” fraction (soil component) and then the remaining waste “overs“ are re-landfilled using a greater level of compaction and less soil cover than had originally been used. The waste screening operations for the reclamation were undertaken using two 2.1 m diameter 10 m long rotating drum “trommel” screens with 52 mm openings. 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 over the project period. In most years, over 200,000 m^3 of waste was processed on an almost continuous daily basis, including through the winter months.

Figure 2 – Waste screening operations – active face in background; stockpiles and processing equipment in foreground.

The project was completed over an eight year period (2009 – 2016), during which time a total of 1,620,000 m^3 of waste was excavated, representing 44% of the total licensed landfill volume. A total of 331,000 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 fraction averaged 52-53%, however the percentage varied substantially on a day-to-day basis.

INNOVATION

Whereas landfill reclamation and installation of engineered controls is not unique, this project involved challenges relating to the limited space, remaining fill volume, odour control, waste density and stability, which required unique engineering design and project sequencing. Innovations of landfill liner design, waste slope stability and gas collection accounted for the unique nature and a large volume of dense reclaimed waste, in order to achieve success.

The use of a composite geosynthetic liner, consisting of high density polyethylene and geosynthetic clay layers (replacing compacted clay) was the first approved use of this system for a landfill in Ontario. Modelling was used to show that this liner, along with diffusion characteristics of the thick unsaturated zone, could provide the necessary barrier to leachate migration. Further to this, the use of geogrid reinforcement on the side slopes to hold the drainage stone, in place of buttressing, was also new. Both of these design aspects have resulted in research-level data collection and analysis useful for subsequent landfill design. The use of a geosynthetic liner allowed for redesign of the landfill configuration to a lower elevation, reducing runoff, and more importantly allowed for cell sizing and rapid construction that could keep up with the rate of landfill reclamation and waste placement within the required schedule.

Figure 3 – Construction of the final phase of geosynthetic liner (2015).

The project began when the landfill was substantially filled, resulting in a significant challenge of tight working quarters. Because of this, it was necessary to cut the excavated slopes in the waste to 2H:1V. In order to prove that this could be safely done, a test section of the excavated waste slope was progressively cut to a slope slightly steeper than 1H:1H over a height of 20 m, while monitoring the slope face and inclinometers installed at the crest of the slope prior to steepening. This data, along with laboratory testing of waste cores and modelling, was used to obtain regulatory approval for construction of steep slopes.

Assessment of landfill gas production from reclaimed waste, and design of collection systems were also innovative and based on testing of existing and re-compacted reclaimed waste within the landfill. The collection and flaring system designs accounted for increased density of the waste through closer spacing and connection of the horizontal trenches to the leachate collection system drainage.

Control of odours within 250 metres of the nearest private residence was achieved by progressive application of control measures using weather data, hourly odour measurement as well as night operations, to reduce impacts. Progressive evaluation of odour control

Figure 4 – Tight working area and steep slopes, waste fill in background, new cell in centre, waste excavation in foreground (2009).

Figure 5– Landfill gas flare and plant..

measures was used to determine that staging and covering of odorous waste with soil was more effective and inexpensive compared to odour suppressant foam; the use of odour neutralizing misters was effective in the short-term when directed at point sources of odorous waste.

Fine soil screened from the excavated waste accounted for over 50% of the total volume and therefore management and re-use of this material, notably as daily cover, was critical to gaining airspace. Sampling of this material and testing of the chemical and geotechnical properties was undertaken and the results were used to support the use of fines as final cover through a Risk Assessment process, which was approved by the regulators. As a result, it is estimated that at the end of the project, all of the existing fines will be re-used for the entire extended lifespan of the landfill.

COMPLEXITY

The waste materials encountered during the project were extremely variable owing to the materials disposed over time, notably during periods when industrial manufacturing was more prevalent. 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 older waste placed in the 1980s, 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. Part of the project planning therefore included design changes to the screening plant, as well as development of pre-picking operations and re-use of materials as temporary construction roads.

At the beginning of the project, there was less than 130,000 cubic metres of airspace available for immediate use, and new incoming waste needed to be accommodated daily, totalling up to 30,000 m^3 for each year of the project. A critical aspect of the project involved planning of waste reclamation and new cell construction timing, such that the available space in new lined cells could hold the reclaimed and incoming new waste until the next cell could be constructed.

The ultimate management of the materials and design of the future waste cell layout was an important aspect of the project, as the fines screened from the waste had to be stored within the landfill footprint in an accessible location for future use. Double handling of material was avoided and the final landfill design resulted in fines stored centrally in an area which will be filled last. Detailed designs of future waste cells and fines storage were developed, along with scheduling of reclamation and liner construction. Added to this was the need to develop concurrent landfill gas collection and stormwater controls.

Figure 6 – Challenging waste materials including tires, wire and industrial fabric cut-offs.

Public concerns with respect to air quality and odours were a significant part of the project planning process. This was complicated by the presence of odours from other sources including composting and agriculture. These concerns were addressed through sampling of landfill gas and air quality and development of risk-based air quality standards. Further to this, a system involving off-site odour monitoring and contractor response and control was developed to ensure rapid response to odour complaints, at minimal effect to the reclamation production rate. Challenges related to odorous waste, notably when younger high odour waste was processed from the top of the landfill, were addressed through a large scale night reclamation operation and during favourable wind conditions.

Figure 7 – Waste excavation and direct haul operations undertaken at night to limit odour impacts (2010).

The existing approved stormwater collection system was based on a 25-year stormwater design basis. It was recognized that climate change influenced storm intensity and the existing design would likely result in off-site discharge of high flows. As a result, the stormwater management system was redesigned to contain and infiltrate a 100 year storm on-site through the use of a series of engineered ponds and natural swales. Furthermore, the system was designed to contain and redirect higher intensity flows, notably under frozen ground conditions, away from residences located within 250 metres of the landfill.

Figure 8 – Stormwater ponds control runoff and promote groundwater recharge (2016).

SOCIAL AND/OR ECONOMIC BENEFITS

The primary social and economic benefits to society resulting from this project related to improved odour controls and improved site facilities and the extension of the lifespan of the existing landfill.

Prior to the project, there was no landfill gas collection system, and therefore the odours associated with the landfill gas generation were not controlled. As a result of the project, local residents will benefit from reduced odours related to waste disposal within the new cells.

In 2004, the landfill was predicted to be at capacity by 2017; the reclamation project resulted in extension of the landfill lifespan to 2035, an increase of 18 years. This gain resulted from re-use of the fines component as cover, greater density of compaction of the in-place materials and reductions in waste disposal rates achieved since the project began. The benefit of the airspace gain includes both the value of waste disposal from the perspective of alternatives including waste export, and the additional time 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.

It is estimated that approximately 500,000 m^3 of airspace was gained as a result of the project. The cost of each cubic metre of airspace at the landfill is estimated to range from approximately $80 to $125. The value of the resulting airspace increase is therefore estimated at between $40 and $60 million.

ENVIRONMENTAL BENEFITS

The primary environmental benefits to society resulting from this project relate to the control of leachate and landfill gas and reduced future collection of groundwater. The project also included sustainability principles through the re-use of daily cover and landfill infrastructure.

The benefit of the new liner and leachate collection systems is that up to approximately 60 m^3 of leachate will be captured and no longer mix with the underlying groundwater. Once the existing impacted groundwater under the landfill is captured by the purge well system, flows to the wastewater treatment system will be reduced and, as a result, a greater volume of clean groundwater will discharge as baseflow to the local streams. Furthermore, the energy used to operate the groundwater purge well system will no longer be required.

Figure 9 – Dyment's Creek downstream of the Barrie landfill following remedial measures.

The collection and flaring system installed in the reclaimed portions of the waste will capture landfill gas, reducing the effects of greenhouse gas emissions. This system is currently collecting and flaring approximately 340 m^3/hr of gas and it is predicted that a maximum collection rate of up to approximately 500 m^3/hour may be achieved. On this basis, installation of a 500 to 850 kW generator powered by landfill gas is considered feasible; alternative uses including renewable natural gas may also be considered.

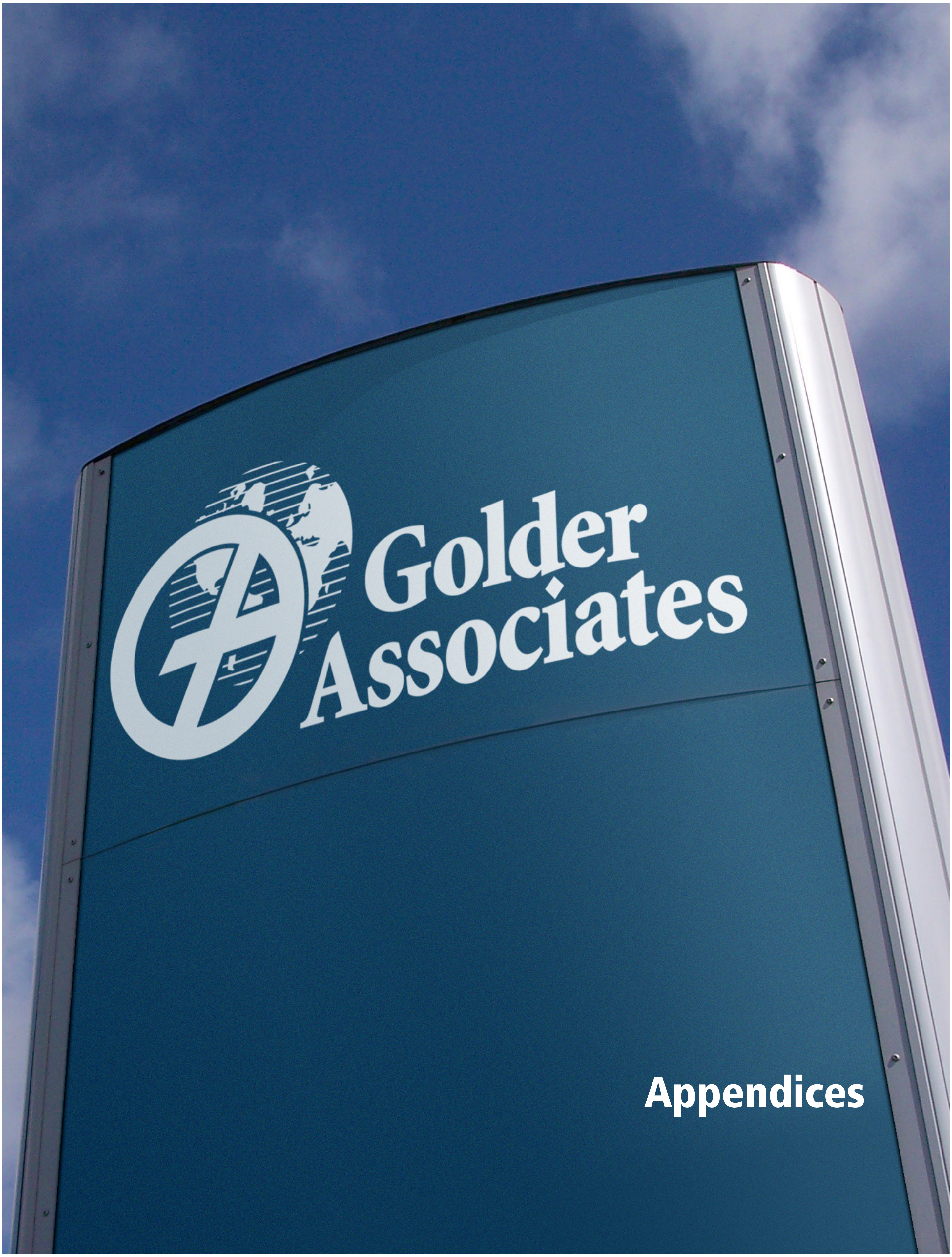
The updated stormwater design improved on-site infiltration of water to recharge the aquifers, in part as a result of the lowered profile resulting from the cell redesign. Furthermore, this design incorporated climate change predictions and reduced the potential for off-site impacts.

MEETING CLIENT NEEDS

The City of Barrie's objectives for the project were centred around the requirement to ensure that their landfill site was designed and operated to minimize impact on the environment while at the same time achieving the City's overall sustainability and budgetary requirements. Further to this, all works were required to be approved by the regulators and procured through a competitive process. The project was approved by City Council in 2008 and was slated for completion prior to the initially estimated closure date of 2017. The project was consistently on-time and was completed on-budget through a managed process involving a team of City, Golder and contractor leads.

Contractor selection was key to this project, and through coordinated efforts between Golder and the City, a fair process was developed which resulted in experienced contractors who delivered results. Careful management of the overall project scope and budget resulted in achieving the environmental and engineering design objectives, as well as overall improvements to site design and operational layout exceeding the design requirements. This resulted in a more efficient facility including changes to public drop-off facilities and improved environmental controls.

The overall objective of improving environmental performance of the landfill design was achieved through the installation of liner, leachate collection and landfill gas collection systems, which will also reduce the discharge to the wastewater treatment system. Further to this, the City's objective of sustainability was achieved through an 18 year increased landfill lifespan, to the year 2035, over a decade longer than initially expected.



Appendices

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Golder Associates

solutions@golder.com
www.golder.com

Africa	+ 27 11 254 4800	Europe	+ 44 1628 851851
Asia	+ 86 21 6258 5522	North America	+ 1 800 275 3281
Australasia	+ 61 3 8862 3500	South America	+ 56 2 2616 2000