APPENDIX TSD#1-H

Design & Operations Component

February 2013

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Appendix TSD#1-H

COMPARATIVE EVALUATION OF ALTERNATIVE SITES

TAGGART
GROUP OF COMPANIES

THE MILLER GROUP

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INTRODUCTION

Two properties that are owned or have been optioned by Taggart Miller have been identified for the proposed Capital Region Resource Recovery Centre (CRRRC) (the Alternative Sites). The Alternative Sites are described below:

- **North Russell Road Site (NRR Site)** – located in the northwest part of the Township of Russell about three kilometres east of the boundary with the City of Ottawa, and about five kilometres south of Provincial Highway 417 between the Boundary Road and Vars exits. The property consists of about 193 hectares (476 acres) of contiguous lands on Part of Lots 18 and 19, Concessions III and IV, Township of Russell.
- **Boundary Road Site (BR Site)** – located in the east part of the City of Ottawa, in the former Township of Cumberland and just southeast of the Highway 417/Boundary Road interchange. The property is on the east side of Boundary Road, east of an existing industrial park, north of Devine Road and west of Frontier Road. The property consists of about 175 hectares (430 acres) of land on Lots 23 to 25, Concession XI, Township of Cumberland.

The CRRRC is proposed to provide facilities and capacity for recovery of resources and diversion of material from disposal generated by the industrial, commercial and institutional (IC&I) and construction and demolition (C&D) sectors primarily in Ottawa and secondarily a portion of eastern Ontario, for management and utilization of surplus and contaminated soils, as well as landfill disposal capacity for material that is not diverted.

1.0 ASSESSMENT CRITERIA, INDICATORS AND DATA SOURCES

The design & operations component compared the Alternative Sites using the following criterion:

- Which Site is preferred regarding the anticipated amount of engineering required to assure Ministry of the Environment (MOE) groundwater quality criteria are met at the property boundary?

The indicator for the criterion is:

- Degree of engineered containment expected to be required for on-Site systems.

The data sources used were Ontario Regulation (O. Reg.) 232/98 and O. Reg. 268/11, published hydrogeological and geotechnical maps and reports, findings of on-Site testing completed for this project or otherwise available to confirm/compare information, preliminary determination of on-Site engineered leachate management system requirements and review of previous knowledge or experience for designs in similar geological settings in Ontario.

2.0 PRELIMINARY DESCRIPTION OF EXISTING ENVIRONMENT

The following sections describe the existing environmental conditions related to the design & operations component at each of the Alternative Sites based on published information and the preliminary investigations and assessments.

A detailed description of the geological, hydrogeological and geotechnical environments is provided in Appendix TSD#1-B. The following provides an overview of key considerations that would affect the degree of engineered containment expected to be required for the proposed on-Site systems.

2.1 North Russell Road Site

2.1.1 Geology and Hydrogeology Environment

The NRR Site lies within a flat lying clay landscape with little topographic relief, interrupted by ridges of glacial till and/or bedrock. The NRR Site is located within an extensive north-south trending deposit of glacial till soil, which typically consists of sandy silt to silty sand, with gravel, a trace of clay and variable cobble and boulder content. The till cover over the bedrock is relatively thin, likely varying from about zero to four metres. Regionally, the till feature protrudes up through, and is surrounded by, an extensive deposit of marine silty clay. The thickness of the clay generally increases with distance from the till ridge feature, to about 30 metres thick; the clay is generally underlain by a basal gravelly till deposit followed by bedrock.

The results of studies completed by the Geological Survey of Canada indicates that there is a continuous, narrow, north-south oriented esker (coarse gravel) feature, extending about 40 kilometres from near the Ottawa River in the north to between Winchester and Chesterville in the south. In the northern portion of the esker and in the portion south of about Morewood, the esker is often exposed at surface and in some locations has been developed as sand and gravel pits. In the central portion, the esker is buried beneath a thick deposit of silty clay and rests on top of the bedrock surface. The studies report that in the area between about Limoges and south of Russell/Embrun, the esker core is an approximately 200-metre wide zone, located just over four kilometres east of Eadie Road (at the intersection of Route 200 and St. Pierre Road) and trending slightly northeast, buried within a 25 to 30 metre thick deposit of silty clay soil. This esker is an important source of existing and potential groundwater supply, currently supplying water to a number of communities, (i.e., Vars, Limoges, Winchester and Chesterville). The majority of recharge to the esker is thought to occur from direct precipitation on areas where the granular esker materials are exposed, although some recharge may also occur via the basal till unit.

In terms of the bedrock geology, the area of the property is shown on published bedrock mapping as underlain by Queenston shale, which is the youngest formation of sedimentary rock in eastern Ontario. Queenston shale is a red, laminated to thickly bedded calcareous siltstone and shale. The property is located near the middle of a band of Queenston shale that is mapped to be approximately 4 kilometres north-south by 15 kilometres west-east. To the south, the uppermost bedrock is mapped to be limestone, while to the north and southwest Carlsbad Formation layered shale and limestone is shown. Preliminary investigations on the NRR Site indicate that shale is absent about half way across the portion of the Site east of Eadie Road (i.e., the shale band is not as extensive in the eastward direction as interpreted and shown on the published geological mapping). The Queenston Formation shale varies in thickness from zero at the eastern extent of the property to 28 metres in the northwestern portion of the NRR Site. Overall, the majority of the Queenston Formation and the Carlsbad Formation at the NRR Site has a low hydraulic conductivity (i.e., less than 1×10^{-8} m/sec); however, at some locations there is slightly higher permeability was measured in the upper portion of the Queenston Formation. There does not appear to be a zone of enhanced permeability at the contact between the Queenston Formation and the Carlsbad Formation.

The overburden at the NRR Site is typically less than two metres thick. The central portion of the NRR Site has various thicknesses of completely weathered shale overlying the shale bedrock. In the northwestern and southwestern portions of the NRR Site, the bedrock is typically overlain by glacial till. At some locations, the glacial till is overlain by a thin layer of silty clay or silty sand. East of Eadie Road on the eastern half of the

Concession IV portion of the property, the bedrock surface is deeper and overlain by a significant thickness of silty clay and glacial till.

In terms of regional hydrogeology, the groundwater flow direction in the bedrock and basal till is generally east to northeast. Based on preliminary investigations and groundwater level monitoring at the NRR Site, shallow groundwater flow on the NRR Site is generally towards the northeast, with a seasonably variable local component of northwesterly flow in the upper bedrock zone indicated in the southwestern portion of the NRR Site. Intermediate bedrock zone groundwater flow directions for the NRR Site are interpreted to be towards the northeast on the portion of the Site west of Eadie Road, and also towards the east on the portion of the Site east of Eadie Road.

Based on the groundwater elevation data collected to date at the NRR Site, vertical gradients are typically downward, or absent, for most of the year, with some local seasonal variations. The NRR Site is interpreted to be in an area of groundwater recharge for the bedrock flow system.

Water supply to homes and farms in the rural area within which the NRR Site is located relies on individual wells. Published information for the general area suggests that most wells obtain their groundwater from zones within the shale and limestone. Where the bedrock is overlain by the clay deposit, wells often obtain their water from a permeable zone at the soil to bedrock contact. In general, water quality gets poorer with depth, associated with the age of the water. Well depths vary considerably due to the changes in geological setting. The majority of the development within the villages of Russell and Embrun were connected to a municipal water supply from the City of Ottawa in 2010, although some locations remain on individual wells.

2.1.2 Geotechnical Considerations

It is anticipated that the diversion and landfill components of the CRRRC would be located on the portion of the Site between North Russell and Eadie Roads. It is envisaged that the landfill and other on-Site facilities would be founded on or within the shale bedrock or on native (primarily glacial till) soils. Considering the NRR Site geology/hydrogeology, significant geotechnical constraints to the design & operations of the NRR Site are not expected.

2.1.3 Conceptual Engineered Containment Requirements

The waste disposal cells at the NRR Site would be situated so as to avoid the existing quarry footprint and would be excavated to approximately four to six metres below the existing ground surface, leaving at least one metre of shale in-place below the base of each cell. Based on the existing Site groundwater level data, this will be below the groundwater elevation in the shale.

The hydraulic conductivity of the shale (generally less than 1 x 10^{-8} m/sec) is not considered to be sufficiently low to provide long term off-Site groundwater protection (i.e., less than 10^{-9} m/sec is required for a primary or secondary liner layer in O. Reg. 232/98 and the supporting MOE Landfill Standards). Also, based on the available hydraulic conductivity data, the base of the cells may not be below the upper shale zone that is indicated to have higher permeability and underlies some areas of the Site. As such, it is likely that an engineered groundwater protection system would be required for the entire landfill portion of the CRRRC facility if it were to be situated at the NRR Site. Given that the base of the waste disposal cells would be founded in bedrock, it is anticipated that the requirements for the engineered groundwater protection system may be similar to the double composite liner, "Generic Design Option II" from the MOE Landfill Standards, which includes the following, from bottom to top:

- A secondary composite liner consisting of a 0.75-metre thick clayey liner with a maximum hydraulic conductivity of 1×10^{-9} m/sec and a high density polyethylene geomembrane liner;
- A secondary leachate collection system designed for a service life of 1,000 years;
- A primary liner consisting of a 0.75-metre thick clayey liner with a maximum hydraulic conductivity of 1×10^{-9} m/sec and a high density polyethylene geomembrane liner; and
- A primary leachate collection system designed for a service life of 60 years.

The clayey portions of the primary and secondary liner systems could possibly be replaced with a geosynthetic clay liner (GCL).

For the "Generic Design Option II", O. Reg. 232/98 requires an attenuation layer with a minimum thickness of one metre below the waste fill zone and groundwater protection system. This layer is required to have a hydraulic conductivity of less than 1×10^{-7} m/sec. It is expected that the native shale bedrock that is present below the base elevation of the landfill cells would be acceptable for this layer.

Since the leachate that is generated would be removed for treatment, the leachate level within the disposal cells would be kept near the base of the cell and below the groundwater level outside the cell. As such, the disposal cells would have inward gradients and flow. The exit of leachate would be inhibited not only by the liner system but by the inward groundwater gradient from the shale towards the disposal cells; this is referred to as a hydraulic trap condition.

The diversion facilities at the proposed CRRRC would primarily be within roofed buildings or other contained systems. As such, there would be negligible additional engineered containment requirements for facilities other than the landfill component, with the possible exception of any leachate treatment or holding ponds, which would require an engineered liner system.

Based on the above discussion, the following is a summary of the key considerations affecting the degree of engineered containment expected to be required for the proposed on-Site systems at the NRR Site.

2.1.4 Summary of D&O Considerations at the NRR Site

Component	Summary of Site Considerations
Design & Operations	■ The landfill and any leachate treatment or holding ponds is expected to require an engineered groundwater protection system. It is anticipated that for the landfill, the system would be similar to the "Generic Design Option II" from the MOE Landfill Standards (i.e., double composite liner with primary and secondary leachate collection systems).

2.2 Boundary Road Site

2.2.1 Geology and Hydrogeology Environment

The BR Site and surrounding areas are underlain by an extensive and thick deposit of silty clay soil of marine origin. The upper one to two metre zone is shown to consist of a discontinuous surface sand layer overlying weathered silty clay; this is underlain by the remainder of the silty clay deposit to a total depth of about 30 to 35 metres in the area of the BR Site. The clay deposit is in turn underlain by about 1.5 to 5 metres of a basal gravelly glacial till, followed by bedrock.

Published mapping by the Geological Survey of Canada shows that the bedrock beneath the area of the BR Site consists of interbedded shale and limestone of the Carlsbad Formation; the total thickness of this bedrock unit is reported to be in the range of about 115 to 150 metres.

In the absence of effective drainage in this flat lying terrain, the groundwater level in this fine grained soil is at, near or above the ground surface throughout much of the year. In view of its low permeability characteristic, there is anticipated to be limited horizontal or vertical groundwater flow in the silty clay deposit; groundwater movement in the silty clay deposit would be very locally influenced adjacent to ditches or other watercourses. The silty clay deposit is known to be an aquitard, which would not allow recharge of the basal till and bedrock by water infiltrating from surface. Groundwater flow occurs in the basal till and bedrock; the direction of regional groundwater flow in these zones is indicated to be towards the northeast.

Water supply to residences, farms and industrial properties in the area of the BR Site is from individual wells. Drilled wells in this area are able to obtain their water supply from the basal till/bedrock contact zone or from within the upper part of the bedrock. The yield of water from this zone is usually adequate in quantity for domestic use. In the immediate vicinity of the BR Site, the few wells registered in the MOE Water Well Information System are completed in the basal till/bedrock contact zone and are indicated to yield enough water for domestic use. However, the groundwater quality in the vicinity of the BR Site is reported as salty, sulphurous or mineralized; the presence of methane gas in the groundwater is also reported. Because of this naturally poor water quality at depth, shallow dug wells are typically used to provide water; some residents use bottled water for consumption because of concerns about bacterial contamination in the dug wells. These natural groundwater quality problems are known to exist as far as three or four km to the north of the BR Site to the area of Carlsbad Springs and also to the west. In the mid-1990s the City of Ottawa extended the municipal water supply to portions of the Carlsbad Springs area for this reason. Further to the southwest and southeast, drilled wells completed in the basal till are reported in the MOE well records as providing fresh groundwater quality.

As described in in Appendix TSD#1-B, recent preliminary investigations on the BR Site are consistent with previously published information and indicate that the overburden at the BR Site is comprised of approximately 0.2 metres of topsoil, underlain by 0.3 to 1.3 metres of silty sand, sand and/or sandy silt. Depending on the sand thickness, a discontinuous upper weathered clay zone can be present. These surficial layers are underlain by a thick deposit of sensitive clay to silty clay ranging in thickness from about 32 to 35 metres. The upper portion of the silty clay deposit is indicated to have a soft consistency; the shear strength increases with depth and becomes stiff.

The results of the initial Cone Penetration testing (CPT) indicate the presence of occasional sandy to silty seams within the upper portion of the silty clay. These were indicated at depths between about 1.8 and 6.6 metres below ground surface and are interpreted to vary in thickness from about 0.1 to 0.3 metres.

The silty clay is underlain by a deposit of glacial till ranging from about two to six metres in thickness before encountering the interbedded limestone and shale bedrock of the Carlsbad Formation.

Based on the results of the *in-situ* hydraulic conductivity testing completed at the Site to date, the following ranges in hydraulic conductivities were measured by hydraulic response testing in the overburden and bedrock formations at the Site:

- Shallow sand, silt and clay (Sandy Layer): 1 x 10^{-7} m/sec to 3 x 10^{-5} m/sec;
- Upper clay with sand/silt seam: 1 x 10^{-7} m/sec to 5 x 10^{-7} m/sec;
- Glacial Till: 1 x 10^{-6} m/sec to 4 x 10^{-6} m/sec; and
- Carlsbad Formation Bedrock: 3 x 10^{-7} m/sec to 2 x 10^{-5} m/sec.

Overall, the materials underlying the BR Site vary from tight to moderately permeable. The presence of sand/silt seams in the upper portion of the silty clay results in an increase in hydraulic conductivity, which may be about two orders of magnitude higher compared to typical clay values (1 x 10^{-12} m/sec to 1 x 10^{-9} m/sec) as reported by Freeze and Cherry (1979) (i.e., unweathered marine clay deposits are known to typically have a hydraulic conductivity of about 1 x 10^{-9} to 5 x 10^{-10} m/sec).

Based on groundwater levels collected in January 2013, the groundwater flow direction for the BR Site is interpreted to be towards the east within all of the stratigraphic layers. Based on the groundwater elevation data collected to date, vertical gradients at the Site are variable, but indicated to be typically weakly downward, or absent.

2.2.2 Geotechnical Considerations

The results of in situ vane testing in the unweathered clay to silty clay at the BR Site gave undrained shear strengths ranging from about 14 to greater than 100 kilopascals, generally increasing with depth. These results indicate a generally soft consistency to about 9 to 10 metres depth, followed by a firm consistency to about 15 to 18 metres depth, and stiff to very stiff below that.

The results of Atterberg limit testing carried out on four samples of the unweathered clay to silty clay indicate a high plasticity soil. The measured natural water contents of the samples were between about 71 and 87%.

If the CRRRC were to be located at the BR Site, the undrained shear strength of the upper silty clay zone is expected to govern the design of the landfill geometry (i.e., height and sideslope angles, in order to provide a stable configuration).

2.2.3 Conceptual Engineered Containment Requirements

The waste disposal cells at the BR Site would be excavated into the surficial sandy overburden deposits and/or a limited distance into the underlying silty clay. Based on the existing Site groundwater level data, this may be below the groundwater elevation in the silty clay.

Based on the permeability of the sandy deposit overlying the silty clay deposit, it is expected that an engineered groundwater protection system will be required on the excavated below-ground sideslopes of the waste disposal cells. Given the relatively steep grades of the below-ground sideslopes, it is expected that a single liner (e.g., geomembrane, GCL or compacted clay) that is keyed into the underlying unweathered silty clay would be sufficient.

Additional investigation work, testing and predictive modelling as set out in O. Reg. 223/98 will be required to determine whether a liner system is required on the base of the waste disposal cells. It is expected that the hydraulic conductivity of the unweathered silty clay would meet the recommended minimum hydraulic conductivity of 1×10^{-9} m/sec in O. Reg. 232/98 for groundwater protection; however, as noted above the preliminary on-Site testing to date indicates occasional sandy/silty seams in the upper portion of the clay deposit.

If a liner system is determined to be required on the base of the waste disposal cells, it is considered likely that a single liner (e.g., compacted clay or geomembrane) or a single composite liner (e.g., compacted clay or GCL and geomembrane) would be sufficient. Alternatively, incorporation of a vertical engineered cut-off feature around the perimeter of the waste disposal cells (keyed into the unweathered silty clay, below the elevation of the sand/silt seams) that would cut off any potential for leachate migration through the sand/silt seams could be considered. Such a perimeter cut-off would negate the need for a constructed liner system on both the base and the below-ground sideslopes of the waste cells.

A primary leachate collection system would be installed on the base and below-ground sideslopes of the waste disposal cells. Since the leachate that is generated would be removed for treatment, the leachate level within the disposal cells would be kept near the base of the cell and below the groundwater level outside the cell. As such, the disposal cells may have inward groundwater gradients. If this is the case, then the exit of leachate would be inhibited not only by the sideslope (and possibly bottom) liner system (if they are required), but by the inward movement of groundwater from the clay towards the disposal cells.

The diversion facilities at the proposed CRRRC would primarily be within roofed buildings or other contained systems. As such, there would be negligible additional engineered containment requirements for facilities other than the landfill component, with the possible exception of any leachate treatment or holding ponds, which would require an engineered liner system.

Based on the above discussion, the following is a summary of the key considerations affecting the degree of engineered containment expected to be required for the proposed on-Site systems at the BR Site.

2.2.4 Summary of D&O Considerations at the BR Site

Component	Summary of Site Considerations
Design & Operations	▪ The landfill portion and any leachate treatment or holding ponds are expected to require: ▪ A single liner on the excavated below-ground sideslopes (e.g., geomembrane, GCL or compacted clay) that is keyed into the underlying unweathered silty clay. ▪ A primary leachate collection system on the base and below-ground sideslopes of the waste disposal cells. ▪ Possibly a single liner or single composite liner on the base of the waste disposal cells or ponds, or a vertical cut-off feature around the landfill perimeter.

3.0 SITE COMPARISON – DESIGN & OPERATIONS

3.1 Comparison of Sites

Based on the design & operations *Summary of D&O Considerations* presented in the tables in Sections 2.1.4 and 2.2.4, the BR Site is likely to require a lower degree of engineered containment for the landfill and leachate treatment/holding pond components of the CRRRC.

Since these components would be founded in shale bedrock at the NRR Site, it is expected that a double composite liner system with both primary and secondary leachate collection systems would be required to provide adequate protection to groundwater.

At the BR Site a thick deposit of native silty clay soils would underlie the landfill and leachate treatment/holding pond components. Depending on 1) the findings of additional hydrogeological investigation work at the BR Site, particularly to investigate the depth and continuity of the sand/silt seams in the upper portion of the silty clay deposit and the hydraulic conductivity of the native silty clay, and 2) predictive modelling, a liner system may not be required on the base of the landfill or leachate treatment/holding pond components. It is expected that a liner system will be required on the below-grade sideslopes of the disposal cells, or as an alternative a vertical perimeter cut-off feature around the waste disposal cells (keyed into the unweathered silty clay, below the elevation of the sand/silt seams) could be constructed instead of any base or below-ground sideslope liner system. A primary leachate collection system will be required below the landfill.

3.2 Results of Site Comparison

Considering the design & operations assessment criteria and the indicator “Degree of engineered containment expected to be required for on-Site systems”, for the reasons described above the BR Site is the preferred Site for the CRRRC.

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