ATTACHMENT 2

Geology and Hydrogeology Work Plan

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1.0 INTRODUCTION

This document presents the proposed work plan for the Geology and Hydrogeology component of the environmental assessment (EA) of the Russell Township site for the proposed Capital Region Resource Recovery Centre (CRRRC). The work plan is part of the Terms of Reference (TOR) for the EA submitted for approval to the Minister of the Environment. The TOR sets out the proponent's proposed approach for addressing the Ontario *Environmental Assessment Act* (EAA) requirements when preparing the EA. In addition to EA requirements, the proponent has chosen to submit a combined EAA and *Environmental Protection Act* (EPA) and *Ontario Water Resources Act* (OWRA) application for approval. Therefore, additional detailed studies required for EPA/OWRA approval are included in this work plan.

2.0 ASSESSMENT FRAMEWORK

2.1 Overall Approach

The site-specific components of the EA/EPA/OWRA assessment are proposed to take place in three phases. The proposed phases consist of the following tasks:

- Phase 1 – EA:
  - Task 1 – Definition and Quantification of CRRRC Waste Streams;
  - Task 2 – Assessment of Alternative Haul Routes/Site Access Locations and Identify Preferred Route/Access Location;
  - Task 3 – Develop Alternative Methods for Overall Site Development;
  - Task 4 – Describe Existing Environment;
  - Task 5 – Assess Environmental Effects for each Proposed Alternative Method;
  - Task 6 – Compare Alternative Methods and Identify Preferred Site Development Alternative;
  - Task 7 – Evaluate Leachate Management Options and Identify Preferred Option; and
  - Task 8 – Cumulative Impact Assessment.
- Phase 2 – EPA/OWRA:
  - Task 9 – Complete EPA Level Site Design Activities for Preferred Alternative.
- Phase 3 – Documentation and Submission:
  - Task 10 – Prepare and Submit EAA and EPA/OWRA Documentation.

2.2 Project Team Organization

The project tasks will be organized to be completed by the following teams:

- The EA Management Team consists of the project director, project manager and project coordinator for the EA;
- The Design and Operations (D&O) Team consists of landfill design technical staff and CAD technicians; and
- The EA Team consists of discipline leads for each of ten different environmental components.

2.3 Study Areas

Data for the site-specific component of the EA will be collected and analyzed for three generic study areas presented in the TOR. The generic study areas are as follows:

- Site – The lands owned and/or optioned by Taggart Miller Environmental Services (Taggart Miller) for the proposed CRRRC;
- Site-vicinity – The lands in the vicinity of the Site (generally within 500 m of the Site boundaries, and modified as appropriate for specific technical disciplines as will be determined during the EA); and
- Haul Routes – The main access routes to the Site.

As noted, the generic study areas described above may be adjusted as required during the EA to suit the requirements of the Geology and Hydrogeology component.

3.0 ASSESSMENT CRITERIA AND INDICATORS

The Geology and Hydrogeology component will compare different methods of implementing the undertaking based on two assessment criteria as follows:

- Groundwater quality; and
- Groundwater flow.

The rationale, indicators and data sources for the proposed assessment criteria listed above are provided in the document titled Proposed Assessment Criteria of the proposed TOR.

4.0 DETAILED WORK PLAN

For the Geology and Hydrogeology Work Plan, activities will be carried out as part of Tasks 3, 4, 5, 6, 7, 8, 9 and 10.

4.1 Task 3: Develop Alternative Methods for Overall Site Development

This task will involve developing reasonable alternative methods of implementing the proposed CRRRC on the Site, and will be completed by the D&O Team. The Geology and Hydrogeology component will provide input based on available information on subsurface conditions as related to conceptual design of the disposal cell component.

4.2 Task 4: Describe Existing Environment

The proposed Geology and Hydrogeology Work Plan described herein builds on the data gathered during initial site assessments and augments the understanding of the Site to a level of detail suitable for the purpose of supporting a submission for combined EAA and EPA/OWRA application for approval for on-site diversion and on-site residual disposal components.

The geology and hydrogeology component includes the subcomponents groundwater quality and groundwater flow. The following tasks will be undertaken to characterize existing environmental conditions.

- Review conceptual Site design;
- Compile and interpret information from defined background sources, including published geological and hydrogeological maps and reports, water well data, regional groundwater and wellhead protection studies, regional and local topographic and drainage mapping, Environment Canada climatic normals and previous subsurface investigation findings and interpretation;
- Acquire and review published and unpublished research on the occurrence of Quaternary deformation features within about a 200 km radius of the proposed CRRRC Site;
- Consult with local Canadian earthquake experts to understand seismicity in this area and how seismic effects are approached and accommodated in local engineering and design practice;
- Review and compile regulations and practices for siting and design of waste disposal sites in other jurisdictions in Canada and internationally as related to seismicity and potential fault movement;
- Analyze the topography within a 5 km radius of the Site using high resolution digital elevation models (DEM) and LiDAR imagery (if available) to identify and interpret surface topographic features that might relate to surface faulting of the bedrock;
- Document the location and nature of any bedrock faults observed in natural exposures and drillholes within a 5 km radius of the proposed CRRRC Site including their level of calcite cementation and any evidence for near surface stress relief features. Considering the relatively thick soil cover in much of this area, it is expected that natural exposures will be limited, and the drillholes would likely be those drilled as part of the hydrogeological investigation of the Site. If feasible, selected drillholes will be positioned specifically to evaluate possible faults identified from the topographic analysis described above, and/or specific features identified may be assessed by observation in excavated test trenches;
- A reconnaissance level survey to document the location and nature of evidence of deformation/displacement or paleoliquifaction in natural and artificial exposures of Quaternary sediments within about a 20 km radius of the proposed CRRRC Site, including glacial and post-glacial deposits. If such evidence is found, then further studies may be required to establish whether these features have a glacial or tectonic origin;
- Utilize information obtained from literature and field reconnaissance to assess the potential risk for fault movement on and in the area of the Site;
- On the basis of the background data, prepare conceptual model of geological and hydrogeological conditions in the area of the proposed diversion and residual waste disposal facility alternatives (e.g.,

local aquifers, recharge points and the effect that historical blasting may have produced on the existing quarry and surrounding area);

- Conduct additional subsurface investigations to characterize the overburden and bedrock geology and physical properties in the area of the proposed diversion and residual waste disposal facility alternatives (i.e., cored boreholes with down-hole geophysical logging, rotary/percussion drilled holes with down-hole geophysical logging);Install an array of nested groundwater monitors completed at different elevations in order to characterize both the horizontal and vertical groundwater flow regime;
- Characterize the hydraulic conductivity of the bedrock formations and zones (i.e., using packer testing, hydro-geophysical logging, pumping tests, rising or falling head tests in monitoring wells);
- Determine seasonal variation in groundwater levels and flow orientations;
- Collect groundwater samples from on-site wells and select water supply wells in the area of the Site to characterize background groundwater quality for typical organic and inorganic landfill leachate parameters; In addition selected groundwater samples from on-site monitoring wells will be analyzed for O_{18} to assist in estimating the age of the water;
- Determine soil characteristics and distribution of soil thickness across area of proposed diversion and residual waste disposal facility alternatives;
- Develop the final conceptual model of geological and hydrogeological conditions in the area of proposed residual waste disposal facility alternatives, including groundwater and surface water interaction;
- Determine “linkages” with other components and data generation/transfer requirements.

Based on our current understanding of the Site geology and hydrogeology and the current conceptual Site development plans, a proposed geology and hydrogeology field program has been developed. The field program includes the drilling of fourteen (14) boreholes. The proposed locations of the 14 boreholes are shown on Figure 2-1. Details on the objectives of the drilling program along with the proposed drilling techniques, borehole depths, testing, etc. are presented in Table 2-1. If boreholes encounter a basal till layer or an upper more permeable shale zone, these locations would be identified for placement of a monitoring well installation. As a result of some of the proposed seismic background studies, it may be necessary to modify the proposed geology and hydrogeology field program.

In addition to the program summarized in Table 2-1, to assist with the seismic evaluation and potential for bedrock faults, the maximum horizontal stress orientation in the bedrock would be determined in at least two of the boreholes at different depths using a USBM gauge and the overcoring technique. The boreholes and depth intervals for this testing would be selected based on the findings of the reconnaissance and other investigations, and could include one near a fault (if a fault is suspected and/or identified) and one away from such a feature, or perhaps in two boreholes located to get coverage of the site.

Following completion of the field drilling and testing program, the packer test data and in-situ rising or falling head test data would be analyzed to develop hydraulic conductivity estimates for the soil or bedrock on and in the vicinity of the Site. If boreholes encounter a basal till layer, grain size analyses of soil sample(s) from this layer would be conducted such that its hydraulic conductivity could also be estimated empirically. If the quarry excavation is dewatered during the timeframe associated with the Geology and Hydrogeology Work Plan, groundwater levels would be monitored in adjacent monitoring wells to determine the radius of influence of the

quarry dewatering. As a minimum, the monitoring wells at proposed boreholes A, B, F, H, I, J, N and BH08-2 would be included in the groundwater level monitoring program associated with quarry dewatering.

The locations and critical elevations for all proposed boreholes/monitoring wells and the existing boreholes/monitoring wells would be surveyed to Geodetic datum.

Following the completion of the in-situ rising or falling head tests, a groundwater level monitoring program would be implemented. At a minimum, the groundwater levels would be measured in all existing monitoring wells on a monthly basis. The water level elevation in the quarry excavation would also be measured monthly using a staff gauge. Selected shallow and intermediate depth groundwater monitoring wells would be outfitted with dataloggers which would measure groundwater levels on a daily basis. These daily groundwater level measurements would be used to assess the daily and seasonal variations in groundwater levels and would permit an assessment of the groundwater level changes in relationship to precipitation events and relationship between the shallow groundwater flow zone and the intermediate groundwater flow zone. The groundwater level data would be used to characterize the horizontal and vertical groundwater flow regime at the Site.

In conjunction with the surface water discipline, and using information on the accumulated depth of water in the quarry over time, a water balance assessment of the drainage sub-watershed(s) around the existing quarry will be completed to determine the relative contributions of groundwater and surface water to recharge of the dewatered quarry. This will also provide an estimate of the bulk hydraulic conductivity of the shale bedrock.

Selected soils samples recovered during the borehole drilling program would be submitted for geotechnical lab testing including grain size distribution analyses.

Upon completion of the field program and data analysis associated with the Geology and Hydrogeology Work Plan (and allowing an adequate period of time for the collection of groundwater level data), the data would be utilized to develop the final conceptual model of the geological and hydrogeological conditions in the area of the Site.

4.3 Task 5: Assess Environmental Effects for Each Proposed Alternative Method

Based on the Site alternatives, and considering in-design mitigation measures, conduct predictive modelling of alternative residual disposal facility performance (contaminant modelling and if necessary flow modelling) and contaminating lifespan as per Ontario Regulation (O. Reg.) 232/98 for each of the alternatives using selected key parameters of concern. Based on the type and location of the alternative diversion facilities, assess the potential for impact on groundwater quality on and off-site. Evaluate footprint size of Site alternatives and estimate potential for change to recharging groundwater conditions and potential effects on off-site groundwater resources and water supply.

In terms of seismicity, it is anticipated based on all of the background information that the earthquake shaking hazard will be addressed by the application of existing probabilistic seismic hazard models that provide estimates of the severity of earthquake shaking at various return periods. The additional information on deformation and faulting collected as described above will be used to assess whether any modifications or enhancements to available regional probabilistic models are required. Based on these earthquake ground motions, appropriate measures will be developed as part of the alternative method designs.

4.4 Task 6: Compare Alternative Methods and Identify Preferred Site Development Alternative

Alternatives that are advanced through the approvability screening step (carried out by the D&O Team) will then undergo a detailed comparative evaluation. Using the final conceptual designs for each alternative, qualitative comparative evaluation of alternatives will be conducted by the EA Team.

The Groundwater and Hydrogeology component discipline will complete the following tasks:

- Compare the degree of potential effects using the criteria and indicators for the Geology and Hydrogeology component, rank the alternatives, and identify the preferred alternative from a Geological and Hydrogeolocial perspective;
- Generate predictions (groundwater quality, groundwater flow) for use in non-geology and hydrogeology components (e.g., surface water component); and
- If required, complete an assessment of post-construction water pumping of the existing quarry.

4.5 Task 7: EvaluateLeachate Management Options and Identify Preferred Option

This task will be completed by the D&O and Surface Water Teams. The surface water discipline will provide effluent discharge criteria and the D&O discipline will define the alternatives and evaluate the options. The Geology and Hydrogeology component will contribute to this task by estimating the leachate generation rate to be handled by the leachate treatment and disposal options and the contaminating lifespan with respect to leachate treatment.

4.6 Task 8: Cumulative Impact Assessment

The EA Team will work to identify the predicted effects of other existing or known proposed projects in the area of the site. The Geology and Hydrogeology component discipline will consider any identified groundwater effects together with those predicted during the comparative evaluation of alternative methods to determine if there are any unacceptable predicted cumulative effects.

4.7 Task 9: Complete EPA Level Site Design Activities for Preferred Alternative

Following completion of the Phase 1 - EA studies, which will result in the identification of the preferred undertaking and the assessment of its predicted effects on the environment, the proposed undertaking will undergo additional analysis as required for the submission of applications under the EPA and OWRA. The EPA/OWRA supporting documentation, along with the EA documents, will be submitted as a single package (contained in several individual volumes) to the MOE. It is anticipated that this combined submission will meet the requirements of all of the MOE approval processes for the proposed undertaking (overall Site development, residuals disposal component, diversion components and ancillary operational features). Depending on the EA conditions of approval or comments received on the EA, it may be necessary to supplement the EPA/OWRA documentation previously submitted; this would be done in the form of addenda or, only if required due to major changes, resubmission of modified reports.

The completed applications for EPA approval for the overall Site development, residuals disposal component and ancillary operational features must be accompanied by the Geology and Hydrogeology Study Report. The

Geology and Hydrogeology Study Report will be prepared as part of the EA study, and also serve as one of the supporting documents for EPA approval. Its purpose is to describe the existing geological, hydrogeological, hydrological and geotechnical conditions, and the detailed prediction of impacts associated with the preferred Site development alternative. It will include an assessment of the service lives of the engineered components as compared to the contaminating lifespan of the preferred alternative and will also include a detailed monitoring program, trigger mechanism and conceptual contingency plans.

4.8 Task 10: Prepare and Submit EA/EPA Documentation

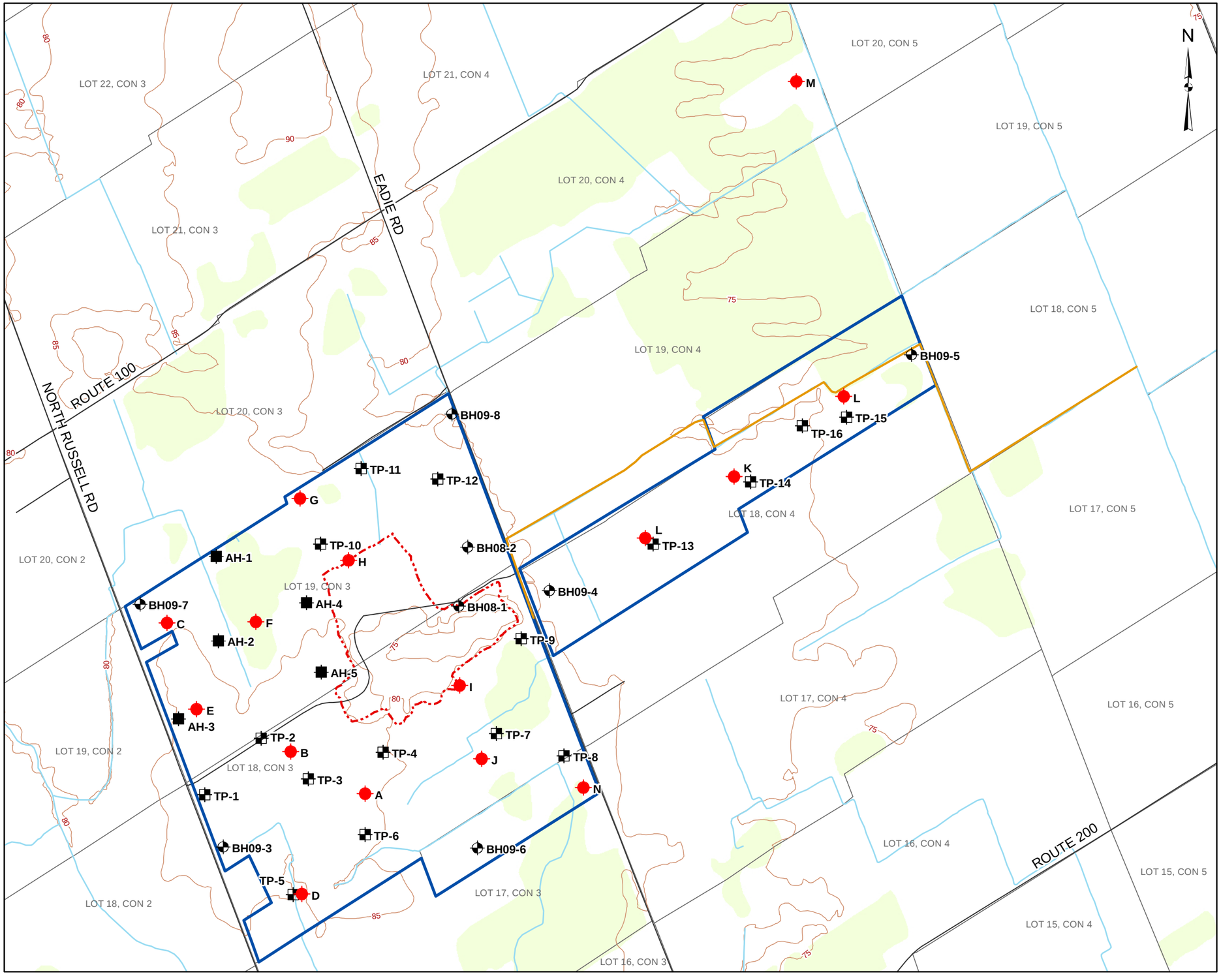
In support of the completion of this task the Geology and Hydrogeology component will carry out the following tasks:

- Document the assessments listed above, data sources and assessment results in a Geology and Hydrogeology Supporting Document that will form an appendix to the EA/EPA submission;
- Participate in meetings with the government review agencies including upfront consultations with the MOE during the EA to obtain pre-approval of tasks in the work plan as required; and
- Provide technical support during the review of the EA by the regulatory agencies and public.

Borehole Identifier	Proposed Borehole Location (See Figure 1)	Rationale for Borehole	Proposed Drilling Technique	Proposed Borehole Depth Below Ground Surface (metres)	Packer Testing	Geophysical Logging	Number of Monitoring Wells to be Installed in Borehole	In-situ Rising of Falling Head Tests in Monitoring Wells
A	Southwest part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; assist with characterization of interpreted shallow bedrock groundwater divide on west side of property; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered	Rotary drill with HQ core recovery	To be drilled to below Queenston/Carlsbad formational contact (approx. 15 m)	Yes	Apparent Conductivity Natural Gamma Optical Televiewer Caliper Fluid Temperature Fluid Resistivity Heat Pulse Flow Meter	Up to 2	Yes
B	Southwest part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; assist with characterization of interpreted shallow bedrock groundwater divide on west side of property and assist in defining intermediate groundwater flow direction; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered; assist in evaluation of potential presence of bedrock faulting	Rotary drill with HQ core recovery	To be drilled to below Queenston/Carlsbad formational contact (approx. 15 – 18 m)	Yes	Apparent Conductivity Natural Gamma	Up to 2	Yes
C	Northwest part of Taggart-Miller property west of Eadie Road	Angled borehole to be drilled on northwest part of property to investigate potential presence of bedrock faulting	Rotary drill with HQ core recovery	approx. 30 m	Yes	Apparent Conductivity Natural Gamma Optical Televiewer Caliper Fluid Temperature Fluid Resistivity Heat Pulse Flow Meter	Up to 2	Yes
D	Southwest part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; assist with characterization of interpreted shallow bedrock groundwater divide on west side of property; assist in defining intermediate groundwater flow direction; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered	Rotary drill with HQ core recovery	To be drilled to below Queenston/Carlsbad formational contact (approx. 15 – 18 m)	Yes	Apparent Conductivity Natural Gamma	Up to 2	Yes
E	Northwest part of Taggart-Miller property west of Eadie Road	Assist with characterization of interpreted shallow bedrock groundwater divide on west side of property	Rotary drill with HQ core recovery	approx. 5 – 8 m	No	Apparent Conductivity Natural Gamma	Up to 2	Yes
F	Northwest part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; assist with characterization of interpreted shallow bedrock groundwater divide on west side of property; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered; assist in defining shallow bedrock groundwater flow direction; assist in evaluation of potential presence of bedrock faulting	Rotary drill with HQ core recovery	approx. 15 m	Yes	Apparent Conductivity Natural Gamma Optical Televiewer Caliper Fluid Temperature Fluid Resistivity Heat Pulse Flow Meter	Up to 2	Yes

Borehole Identifier	Proposed Borehole Location (See Figure 1)	Rationale for Borehole	Proposed Drilling Technique	Proposed Borehole Depth Below Ground Surface (metres)	Packer Testing	Geophysical Logging	Number of Monitoring Wells to be Installed in Borehole	In-situ Rising of Falling Head Tests in Monitoring Wells
G	Northeast part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; assist in defining shallow and intermediate bedrock groundwater flow directions	Air percussion	approx. 25 - 30 m	No	Apparent Conductivity Natural Gamma	Up to 4	Yes
H	Northwest part of Taggart-Miller property west of Eadie Road; adjacent to existing quarry excavation	Investigate potential extent of quarry-related blast fracturing of bedrock; borehole will be drilled approximately 5 m north of limit of quarry excavation and to a depth of approximately 5 m below the existing quarry floor; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered	Rotary drill with HQ core recovery	approx. 16 – 18 m	Yes	Apparent Conductivity Natural Gamma Optical Televiewer Caliper Fluid Temperature Fluid Resistivity Heat Pulse Flow Meter	Up to 2	Yes
I	Southeast part of Taggart-Miller property west of Eadie Road	Investigate potential extent of quarry-related blast fracturing of bedrock; borehole will be drilled approximately 5 m south of limit of quarry excavation and to a depth of at least 5 m below the existing quarry floor; investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; ; assist in defining shallow bedrock groundwater flow direction; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered	Rotary drill with HQ core recovery	approx. 15 m	Yes	Apparent Conductivity Natural Gamma	Up to 2	Yes
J	Southeast part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered; assist in defining shallow bedrock groundwater flow direction	Rotary drill with HQ core recovery	approx. 15 m	Yes	Apparent Conductivity Natural Gamma Optical Televiewer Caliper Fluid Temperature Fluid Resistivity Heat Pulse Flow Meter	Up to 2	Yes
K	Central part of Taggart-Miller property east of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale between existing boreholes BH09-4 and BH09-5; possibly assist in defining shallow and/or intermediate bedrock groundwater flow directions (depending on depth to bedrock)	Rotary drill with HQ core recovery	15 – 30 m depending on thickness of overburden	Yes	Apparent Conductivity Natural Gamma	Up to 2	Yes
L	West or east part of Taggart-Miller property east of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale between existing boreholes BH09-4 or BH09-5 and proposed Borehole K; if Queenston Formation is encountered in Borehole K, then Borehole L would be drilled between Borehole K and existing Borehole BH09-5; if Queenston Formation is not encountered in Borehole K, then Borehole L would be drilled between Borehole K and existing Borehole BH09-4; possibly assist in defining shallow and/or intermediate bedrock groundwater flow direction (depending on depth to bedrock)	Rotary drill with HQ core recovery	15 – 20 m depending on thickness of overburden	Yes	Apparent Conductivity Natural Gamma	Up to 2	Yes

Borehole Identifier	Proposed Borehole Location (See Figure 1)	Rationale for Borehole	Proposed Drilling Technique	Proposed Borehole Depth Below Ground Surface (metres)	Packer Testing	Geophysical Logging	Number of Monitoring Wells to be Installed in Borehole	In-situ Rising of Falling Head Tests in Monitoring Wells
M	On property located on Lot 20, Concession 4 in the Township of Russell, Ontario	Investigate overburden and bedrock conditions on southeast corner of Lot 20, Concession 4 in the Township of Russell, Ontario; to assist in defining overburden and bedrock geology and groundwater conditions on a regional scale; assist in defining shallow and intermediate bedrock groundwater flow directions	Rotary drill with HQ core recovery	15 – 30 m depending on thickness of overburden	No	Apparent Conductivity Natural Gamma	Up to 2	Yes
N	Southeast part of Taggart-Miller property west of Eadie Road	Investigate the thickness of the overburden and the Queenston Formation shale to assist in setting base grades for disposal cells; monitoring wells could be used as part of monitoring array for a large scale pumping test in the event that the quarry excavation is dewatered; assist in defining shallow bedrock groundwater flow direction	Air percussion	approx. 25 m	No	Apparent Conductivity Natural Gamma	Up to 4	Yes



LEGEND

- PROPOSED BOREHOLE LOCATION
- AUGERHOLE LOCATION
- BOREHOLE/MONITORING WELL LOCATION
- TEST PIT LOCATION
- FOURNIER MUNICIPAL DRAIN
- ROAD
- WATERCOURSE
- CONTOUR
- LOT/CONCESSION
- WETLAND
- WOODED AREA
- LIMITS OF OWNED OR OPTIONED PROPERTY
- APPROXIMATE EXTENT OF EXISTING QUARRY EXCAVATION

NOTE

This figure is to be read in conjunction with the accompanying work plan

REFERENCE

Digital NRVIS MNR data produced by Golder Associates Ltd., used under license
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Projection: Transverse Mercator Datum: NAD 83 Coordinate System: UTM Zone 18

250 0 250 500
SCALE: 1:12,500 METRES

PROJECT
TERMS OF REFERENCE FOR ENVIRONMENTAL ASSESSMENT OF THE CAPITAL REGION RESOURCE RECOVERY CENTRE

TITLE
PROPOSED BOREHOLE LOCATIONS FOR GEOLOGY AND HYDROGEOLOGY WORK PLAN

Golder Associates
Ottawa, Ontario

PROJECT No. 09-1125-1008			SCALE AS SHOWN	REV. 0
DESIGN	KAM	18 MAY 2011	FIGURE: 2-1	
GIS	BT	01 DEC 2011		
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