SCHEDULE F – PROJECT COMPLETION REPORT TEMPLATE

VERY IMPORTANT:

Timing: You need to email a report, to your GMF project officer (contact info is in Schedule C), on the dates indicated in Schedule C or whenever FCM asks for such a report.

Copyright: Before you submit a report to FCM, make sure you hold the copyright for the report. If you're hiring a consultant to prepare the report, please make sure to get the copyright (see FCM's copyright tips document), or else FCM will not be able to disburse the Grant Amount.

Accessibility for people with disabilities: Please do not change the format, font, layout, etc. of this report. This template has been specially designed, following FCM's Accessibility Guidelines, in order to be accessible to people with disabilities.

Confidentiality: If your report contains any Confidential Information that you would prefer not be made available to the public (e.g. through a case study or other materials produced by FCM that relate to your Project), please submit two versions of the report:

1. **Complete report including Confidential Information:** Please clearly label this report with the word "**Confidential**" or similar wording and FCM will treat it as confidential.

2. **Abridged report excluding Confidential Information:** This report may be posted on the FCM website and otherwise made available to interested third parties, to help FCM meet its knowledge sharing objectives.

Please contact your project officer to receive an electronic copy of the Completion Report Template.

Upon completion of the project, a copy of the Final Deliverable must be submitted along with this Completion Report.

FCM will post your report on the Green Municipal Fund™ (GMF) website. This is because one of FCM's mandates is to help municipal governments share their knowledge and expertise regarding municipal environmental projects, plans and studies.

How to complete the Completion Report

The purpose of the Completion Report is to share the story of your community's experience in undertaking your project with others seeking to address similar issues in their own communities.

Please write the report in plain language that can be understood by people who are not specialists on the subject. A Completion Report is typically in the range of 5–10 pages, but may be longer or shorter, depending on the complexity of the project.

GMF grant recipients must enclose **final** copies of the Completion Report and the Final Deliverable with their final Request for Contribution. The reports, including all attachments and appendices, must be submitted in PDF format with searchable text functionality. Reports that are not clearly identifiable as final reports, such as those displaying headers, footers, titles or watermarks containing terms like "draft" or "for internal use only," will not be accepted by GMF. Additionally, reports must be dated. If you have questions about completing this report, please consult GMF staff.

GMF number	16953
Name of lead applicant (municipality or other partner)	Toronto and Region Conservation Authority
Name, title, full address, phone, fax and e-mail address of lead technical contact for this study	Bernie McIntyre, Senior Manager, Corporate Sustainability and Community Transformation 101 Exchange Ave Vaughan, Ont, L4K 5R6 (o) 416-661-6600 ext 5326 (m) 416-402-5232 Bernie.mcintyre@trca.ca
Date of the report	June 28, 2022

1. Introduction

a) Who was involved in doing the Feasibility Study, and what are their affiliations? Please include name, title and contact information. Those involved could include municipal staff, engineers and other consultants, a representative from a non-governmental organization, and others.

The feasibility study was led by staff from the TRCA with support a hydrogeological consulting firm and an engineering consulting firm. Below is a list of key individuals and consulting firms and their respective roles.

TRCA:
Staff led the project, undertook most of the report writing, reviewed consulting reports and supervised actions of the consultants.

Bernie McIntyre, Senior Manager, Corporate Sustainability and Community Transformation.
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Jed Braithwaite, Manager, Major Contracts
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Don Ford, Senior Manager, Hydrogeology and Engineering Services
Don.ford@trca.ca

Jason Choy, Program Manager Community Transformation
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Consultants:
The hydrogeological consultant prepared the scope of work for drilling program, supervised all field work, prepared hydrogeological assessment reports, prepared materials and applied for regulatory permits (EASR), prepared recommendations for detailed designs. The engineering consultant prepared the costing to compare ATES and Open loop systems.

Salas O'Brien:

Brian Beatty
Vice President
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Jeremy Beatty
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Gord Jarvis, Project Manager, Geothermal
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2. The Feasibility Study

a) Describe the process that you undertook to make this feasibility study a reality, from concept, to council approval, to RFP, to final deliverable.

The project followed a relatively normal process although, because one of the wells did not locate enough water supply the project had to be expanded to drill an additional well. The process included: 1) Recognition of the opportunity on site; 2) High level scoping of the opportunity (hire engineering consultant to do high level costing); 3) Approval from senior leadership to undertake a feasibility study; 4) Prepare detailed scope of work and RFP and hire hydrogeology consultant; 5) Funding application to FCM (this should have happened as step four); 6) Prepare scope of work for drilling program (consultant); 7) Hire water well driller; 8) Expand driller's scope of work to include a third well; 9) Prepare hydrogeological consultant report with analysis and recommendations; 9) Prepare recommendations to senior leadership for implementation; 10) Prepare detailed project report, FCM completion report and project case study.

At Step 9 in the process senior leadership approved moving forward with implementation of an open loop geothermal system.

b) What were the objectives of the Feasibility Study (what was it seeking to determine)?

The objective of the feasibility study was to determine if an Aquifer Thermal Energy Storage system (ATES) or an open loop geothermal system (OLGX) could meet the heating and cooling requirements of TRCA's new administrative office building, and if so, could it reduce capital expenditures, increase energy efficiency and reduce GHG emissions

c) What approach (or methodology) was used in the Feasibility Study to meet these objectives?

For the feasibility study we chose to compare the economic and environmental impacts of the two options, ATES and OLGX against the business as usual (BAU) approach of closed loop geothermal (CLGX). For the analysis we chose to look at the economic and environmental impacts with most emphasis on economics because the BAU approach is already recognized as one of the best environmental approaches to building heating and cooling.

d) Please describe any public consultations conducted as part of the Feasibility Study and their impact on the Study.

This project did not require public consultation, so none was undertaken.

3. Feasibility Study Findings and Recommendations

a) What were the environmental findings related to the options explored in the Feasibility Study? Please provide quantitative results and summary tables of these results (or the page numbers from the Feasibility Study report).

b) What were the financial findings related to the options explored in the Feasibility Study (for example, results of a cost-benefit analysis, financial savings identified, and so on)? Please provide quantitative results and summary tables of these results (or the page numbers from the Feasibility Study report).

c) Based on the environmental and financial findings above, what does the Feasibility Study recommend?

The table below summarizes the economics with respect to capital expenditures (capex) and operations and maintenance expenditures as well as GHG emissions and CAC emissions. The capex is based on several sources. The CLGX capex is based on market bid price plus project management, OLGX capex is based on actual costs incurred, ATES capex is based on OLGX capex plus additional costs for ATES specific items. The CLGX opex and OLGX opex are based on ASHRAE published values plus modelled energy consumption for the building and market electricity costs. ATES opex was based on the OLGX opex plus ATES specific items and modelled energy consumption and market electricity costs.

	CLGX	**OLGX**	**ATES**
Capital Expenditures	$1,325,583	$1,360,920.64	$1,626,957.17
Annual Operating and Maintenance Expenditures	Annual Operating Electricity Costs: $22,617 Annual Maintenance: $9,677 **Total= $32,294**	Annual Operating Electricity Costs: $19,460 Annual Maintenance: $19,354 **Total= $38,814**	Annual Operating Electricity Costs: $17,197 Annual Maintenance: $25,160 **Total= $42,357**
Long Term Maintenance and Repairs	Heat Transfer Fluid Replacement (15 years)-$2,000 Heat Exchanger Cleaning (10th year)- $790 Pump Replacement (25 years) $35,000	Well Rehabilitation (10th year)- $49,450 Heat Exchanger Cleaning (10th year)- $1,580 Submersible Pump Replacement (15- 20 years) - $52,500	Well Rehabilitation (10th year)- $74,175 Heat Exchanger Cleaning (10th year)- $1,580 Submersible Pump Replacement (15- 20 years) - $52,500
Emissions (Operating and Implementation)	Implementation Emissions- 51.9 tCO_2e Operating Emissions (25 years)- 81.75 tCO_2e **Total Carbon Emissions- 133.65 tCO_2e**	Implementation Emissions- 8.3 tCO_2e Operating Emissions (25 years)- 69.5 tCO_2e **Total Carbon Emissions- 77.8 tCO_2e**	Implementation Emissions- 15.6 tCO_2e Operating Emissions (25 years)- 61.75 tCO_2e **Total Carbon Emissions- 77.4 tCO_2e**
Clean Air Contaminants from Operations(kg)			
CO (kg)	9.76	8.40	7.42
Nox (kg)	10.30	8.86	7.83
SOx (kg)	2.12	1.83	1.61
PM10 (kg)	1.02	0.88	0.78
PM2.5 (kg)	0.95	0.82	0.73
VOC (kg)	0.33	0.28	0.25
Clean Air Contaminants from Implementation (kg)			
Non-Methane Hydrocarbons (kg)	34.2	5.472	10.26
Nox (kg)	72	11.52	21.6
PM (kg)	3.6	0.576	1.08
CO (kg)	630	100.8	189

An additional table of costs (see below) was also prepared to compare capex for the three systems without the costs associated with design, engineering and implementation changes that were required due to the TRCA building being under construction.

	CLGX	OLGX	ATES
Feasibility	$36,725.00	$243,613	$243,613
Engineering and Design	$45,850.00	$80,000	$140,000
Implementation	$1,122,500.00	$469,543	$704,315
Project Management (10%)	$120,508	$79,316	$133,177
Total	$1,325,583	$872,472	$1,196,721

Based on the results of the feasibility study, the OLGX system was chosen and is currently under construction. TRCA intends to monitor the system long term and communicate the results of the project to the market place.

4. Lead Applicant's Next Steps

a) Taking the Feasibility Study's recommendations into account, what next steps do you as the municipality plan to take? What potential benefits or internal municipal improvements would result from these next steps?

As mentioned earlier, the recommendations have been acted on and the OLGX system is currently being implemented.

5. Lessons Learned

In answering the questions in this section, please consider all aspects of undertaking the Study — from the initial planning through each essential task until the Final Study was prepared.

a) What would you recommend to other municipalities interested in doing a similar Feasibility Study? What would you do differently if you were to do this again?

b) What barriers or challenges (if any) did you encounter in doing this Feasibility Study? How did you overcome them?

There were a number of important lessons that were learned working through this project and they are summarized below:

1 The key lesson learned is that TRCA should have undertaken a hydrogeology study as soon as the decision was made to go with a geothermal system. The initial test borehole for the closed loop geothermal assessment could have been drilled as a well to assess the viability of both OLGX and CLGX systems. Such a study would have provided us with a more comprehensive understanding of the underlying hydrogeology for only a small added cost. Although the cost for the first well would have been a sunk cost (other than its use as a monitoring well) the study would have identified the potential for a OLGX during the design stage and thus would have saved the project many hundreds of thousands of dollars in implementation costs. This is where good collaboration and communication between different disciplines early in the project can help reduce implementation costs.

2 In our specific situation, incorporating the feasibility of OLGX and ATES earlier, as part of the design stage would have significantly reduced the total capital costs compared to the CLGX. TRCA

incurred significant redesign costs in this project because it had initially selected a CLGX system for the head office and procurement and construction had already begun. The mechanical and electrical design revisions effectively eliminated the capital cost savings that TRCA expected by pursuing OLGX. If TRCA had initially decided to explore the OLGX option at the design stage, it would have reduced the actual implementation costs by 40% or more.

3 When assessing the feasibility or implementing the supply and injection wells for an open loop system, the variability of the underlying geology can result in non-performing or under-performing wells. In our specific situation the second well drilled intersected a fine sand deposit at the depth of the deep aquifer and could only provide a sustained production of 50 gpm. The cost of this well became a sunk cost as it could not be used as part of the building HVAC system. TRCA moved forward with the third well based on the results of the first well and the experience of the hydrogeologist and well driller, that there was a high production aquifer under the site.

4 This feasibility study was undertaken in the middle of an active construction project, as such, we had to accept more risk than if we were undertaking this project prior to implementation. Based on the results from the first well and historic knowledge of the production potential of the deep aquifer in other locations, there was a high probability that we had located a high production aquifer. When the pilot hole for the third well confirmed that we had intersected a thick layer of coarse sediments, the decision was made to develop this well as a supply well for the new building. There was inherent risk with this decision because we did not yet have pumping tests to confirm the well's potential. However, the experience of the well driller and the participating hydrogeologists gave us confidence to invest the additional funds in a larger diameter well, stainless steel casing and extra well development. By utilizing one of the test wells as a production well the project reduced the overall capital cost of the OLGX system.

5 Once constructed, monitoring of OLGX system performance is crucial to ensure the longevity of the system. Monitoring changes in specific capacity of the aquifer and pressure drop across the heat exchanger can help to identify system issues and schedule maintenance as appropriate. It is also critical, where the aquifer has high levels of iron and other minerals, to ensure that the system is oxygen free. Otherwise, the well and heat exchange will have a higher risk of clogging and scaling, a fairly common issue.

6 To minimize the issues identified in point 5 above, engineering consultants may advocate for additional redundant wells (supply and injection), a redundant heat exchanger, and a supply side water filtration system. These additions would have significantly increased the capital costs of the project and are likely only a requirement for buildings that cannot schedule down times for maintenance (i.e., hospitals). Our Hydrogeology consultant recommended the monitoring identified in 5 above and regular maintenance of the heat exchanger and regular rehabilitation of the wells as well as HDPE welded pipe and positive pressure on the supply to ensure no oxygen infiltration. Based on the Hydrogeologist's recommendation we did not include the redundant systems. Well rehabilitation is a significant operating cost but the lack of oxygen in the system coupled with significant well development, should increase the time before we need to undertake this maintenance.

7 There are areas in the GTA and the rest of Ontario that have high production aquifers like the Laurentian Channel, that could support extensive OLGX systems. Given the variability of the underlying surficial geology at the local site scale and associated risk of encountering low production aquifer conditions, it would be worth-while undertaking a project to delineate the high production zones in these aquifers. The starting point would be to look at where these high production aquifers underly existing or proposed medium and high-density developments. Various geophysical assessment techniques such as gravity surveys, 2D electrical resistivity imaging, vertical electrical sounding, very low frequency, and seismic refraction, could be used for geological structure investigation, locating the aquifers and assessing the hydrogeological conditions and groundwater potential in these medium and high-density developments. These types of assessments could be used to better define the high production zones areas and increase the probability that a drilling program would intersect enough water to create a viable OLGX system and thus, minimize sunk costs.

6. Knowledge Sharing

a) Is there a website where more information about the Feasibility Study can be found? If so, please provide the relevant URL.

b) In addition to the Feasibility Study results, has your Feasibility Study led to other activities that could be of interest to another municipality (for example, a new policy for sustainable community development, a series of model by-laws, the design of a new operating practice, a manual on public consultation or a measurement tool to assess progress in moving toward greater sustainability)? If so, please list these outcomes, and include copies of the relevant documents (or website links).

The case study developed through this project will be published on the Sustainable Technology Evaluation Program website. The URL will be inserted here once the report is published on the website. We will circulate the report to organizations like Clean Air Partnership and send copies to our partner municipalities. Through the head office project we have started a relationship with NAIOP and we will be speaking with them about disseminating information to their membership.

We are looking to partner with Geological Survey of Canada (GSC) to explore the concept outlined in lesson learned #7 and further raise the profile of OLGX.

This project was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.