

Earth Energy Systems in Ontario

Types, regulations and potential implications for Source Protection

South Georgian Bay Lake Simcoe Source Protection Meeting

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Protecting our environment.



Ontario

Outline

- Background
- Types of Systems
- Existing Requirements in Ontario
- Potential Environmental Risks
- Source Protection and Earth Energy Systems



Background

- Ontario is promoting green technologies and aims to be a leading green economy in North America
 - Includes earth energy systems
- Earth energy systems (EESs) are also known as low temperature geothermal systems, heat pump systems or geoexchange systems
- EESs are currently covered by a variety of legislative requirements in Ontario to protect the environment and human health and safety
- Technical Bulletin on Constructing Earth Energy Systems in Ontario released in September 2009 outlines Ontario's current requirements (<http://www.ene.gov.on.ca/publications/7219e.pdf>)
- Drinking Water Source Protection Technical Bulletin: Earth (Geothermal) Energy Systems released in November 2009 (<http://www.ontario.ca/drinkingwater/279217.pdf>)
- Ontario is considering changes to how the loop components of EESs are managed



Earth Energy Industry

- Earth energy technology has been used in Ontario for more than 20 years
- In recent years the industry has been growing rapidly (about 40% annually for the past 3 years in Canada)
- The number of installed EES worldwide is currently estimated to be around 1,100,000
- While firm statistics are not available it is believed that there are about:
 - 44,000 systems installed in Canada
 - 8,800 of these systems are in Ontario
- In 2008, the Ministry of Energy and Infrastructure provided funding towards the installation of approximately 1,400 EES using Ontario's Home Energy Audit and Retrofit Rebate Program



Types of Systems Used in Ontario

- Open Loop
 - Groundwater (water discharged to surface or groundwater)
 - Surface Water (lake, river or pond)
 - Standing column well (water taken and discharged from same well)
- Closed Loop
 - Vertical / angular
 - Horizontal (typically 2 to 2.5 m deep)
 - Surface Water (lake, river or pond)
 - Direct Expansion ("DX") – no heat exchanger - single continuous refrigerant loop
- Subsurface Thermal Storage
 - Aquifer Thermal Energy Storage
 - Borehole Thermal Energy Storage



Existing Requirements in Ontario - Summary

Ontario Water Resources Act (OWRA) and Wells Regulation

- Requirements for Wells and discharge to water

Environmental Protection Act (EPA) and Ground Source Heat Pumps Regulation

- Defines heat pump systems, bans use of methanol as a heat transfer fluid, and addresses discharge of contaminants to the environment

The Building Code Act and the Building Code

- Requires earth energy systems to be designed and installed in accordance with Design and Installation of Earth Energy Systems Series CSA Standard (C448 Series 2):
 - C448.1 standard for commercial and institutional buildings; and
 - C448.2 standard for residential and small buildings

Occupational Health and Safety Act (OHSA) and its regulations

- Installation and maintenance must be done in accordance with the OHSA, and its applicable regulations

Other requirements may include, but are not limited to:

- Certification requirements under the *Trades Qualification and Apprenticeship Act*
- Permit and inspection requirements under the *Electricity Act*
- Licenses issued under the *Oil, Gas and Salt Resource Act*
- Work permits under the *Public Lands Act*
- The regulations created under section 28 of the *Conservation Authorities Act*
- The Lakes and Rivers Improvement Act
- The Clean Water Act



Existing Requirements in Ontario

Ontario Water Resources Act (OWRA) and Wells Regulation

- Provides for the conservation, protection and management of Ontario's waters and for their efficient and sustainable use
- A hole for an earth energy system is considered a "well" if the constructed hole is used to locate groundwater, obtain groundwater, or test or otherwise obtain information about the groundwater
- This means all open loop holes, some closed loop holes and all test holes used to test or gather groundwater information for an EES must meet requirements set out in the OWRA and the Wells Regulation
- Includes licensing to engage in the business and work at the construction of wells, including installation of equipment
- Requirements for new well construction, maintenance and abandonment (decommissioning)
- Earth energy systems must not cause a discharge that may impair waters
- May require a Permit To Take Water or a sewage works discharge approval



Existing Requirements in Ontario

Environmental Protection Act (EPA) and Ground Source Heat Pumps Regulation

- Under the *Environmental Protection Act* it is an offence to discharge a contaminant into the natural environment that may cause an adverse effect
- The regulation defines a ground source heat pump as a heating and cooling system for buildings that uses a fluid to exchange heat with the ground or ground water and regulates the fluids that are allowed to be used in the systems
- The regulation bans methanol as a heat transfer fluid for EES constructed after 1998 and exempts all EESs from the requirement to obtain a certificate of approval for systems that may discharge a contaminant into the natural environment

The Building Code Act and the Building Code

- Requires earth energy systems to be designed and installed in accordance with the CAN/CSA C448.1 standard for commercial and institutional buildings and C448.2 standard for residential and small buildings
- C448.3- underground thermal energy storage is not adopted by the Building Code
- Requires a building permit to be issued by the municipality and site inspections by a municipal building official during installation
- Recent changes to CSA standard and the Building Code provide design and installation requirements for Direct Exchange (DX systems)



Existing Requirements in Ontario

Other Requirements

- Occupational Health and Safety Act (OHSA) and its Regulations
 - The installation and maintenance of earth energy systems must be done in accordance with the OHSA, and its applicable regulations (Construction Projects, Industrial Establishments, Confined Spaces and a number of designated substances regulations) to protect workers' health and safety
- Certain installation and repair work pertaining to or associated with earth energy systems may be subject to additional legislation. Other requirements may include, but are not limited to:
 - Certification requirements under the *Trades Qualification and Apprenticeship Act*
 - Permit and inspection requirements under the *Electricity Act*



Existing Requirements in Ontario

Design and Installation of Earth Energy Systems Series CSA Standard (C448 Series 2)

- C448.1 - for commercial and industrial buildings
- C448.2 - for residential and other small buildings
- C448.3 - for underground thermal energy storage systems for commercial and industrial buildings (not currently adopted by the Building Code)

Design and Installation of Earth Energy Systems Series CSA standard

- Standard covers minimum requirements for equipment and material selection, site survey, system design, installation, testing and verification, documentation, and commissioning
- Standard allows for design flexibility (e.g. selection of filling material for a borehole in a closed loop EES)
- Options for addressing potential environmental concerns are provided in C448.1 standard but are not mandatory.
- Does not cover standing column well EES



Existing Requirements in Ontario

Other Requirements

- Licenses issued under the *Oil, Gas and Salt Resource Act*
- Work permits under the *Public Lands Act*
- The regulations created under section 28 of the *Conservation Authorities Act* to prohibit, regulate or permit development near or in surface water.
- The Lakes and Rivers Improvement Act
- The Clean Water Act and its Regulations
- Other resource protection legislation not listed may apply under specific circumstances
- Some Ontario municipalities are addressing EES. For example the:
 - Region of Waterloo has included prohibition of EES in their official Plan to protect their municipal supplies
 - North Grenville March 2009 resolution to prohibit use of any EES located within a subdivision without a hydrogeological report



Potential Risks

1. **Preferential Pathways** - Improper siting, construction, maintenance or abandonment of boreholes used in EES that potentially intersects multiple aquifers
2. **Discharge water** from an open loop system may cause:
 - Temperature or chemistry impacts on the receiving surface water or groundwater
 - Erosion impacts to receiving surface waters
 - Discharge to a shallow aquifer may cause groundwater mounding and possible flooding problems
3. **Lowering groundwater level**
 - Pumping from an open loop well or wells may lower the water table or water level in an aquifer



Potential Risks

4. Heat Transfer Fluid Leak

- Improper installation, design, corrosion or accidents may cause tubes to crack or break releasing heat transfer fluid from EES into aquifers, surface water and natural environment

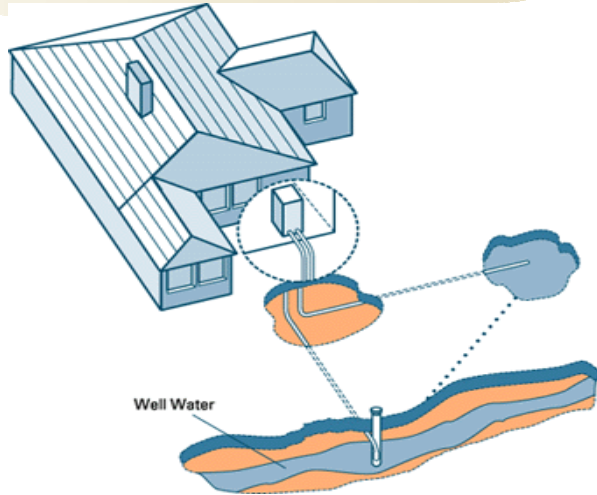
5. Temperature Imbalance

- Net annual temperature change around EES may have implications for resource sustainability or thermal interference on earth energy systems, water wells or surface water bodies. Interference can result in water quality impacts

Note: Geotechnical issues such as frost heave or subsidence could result from improperly completed loops, or changes in the subsurface conditions as a result of thermal fluctuations and should be considered. Where space is an issue and systems are placed too close to buildings, or in road allowances, unsafe conditions could be created.



Open Loop System - Groundwater



Potential Risks

- Preferential pathways
- Temperature imbalance
- Discharge water temperature / chemistry
- Water table lowering or mounding
- Shoreline erosion (for surface water discharge systems)

Current regulatory controls

- OWRA and Wells Regulation for well construction and equipment installation in wells
- OWRA - Permit to Take Water (non residential systems)
- OWRA – Certificate of approval for sewage works discharges
- Ontario Building Code (CSA C448 Standards) – Permit and inspection required
- The Clean Water Act and other requirements referred to previously may apply

Examples of Gaps and Issues

- Siting and design requirements to address risks
- Current certificate of approval requirements for single family dwellings
- Potential for encountering explosive gases (no detection requirement) or artesian flowing well conditions

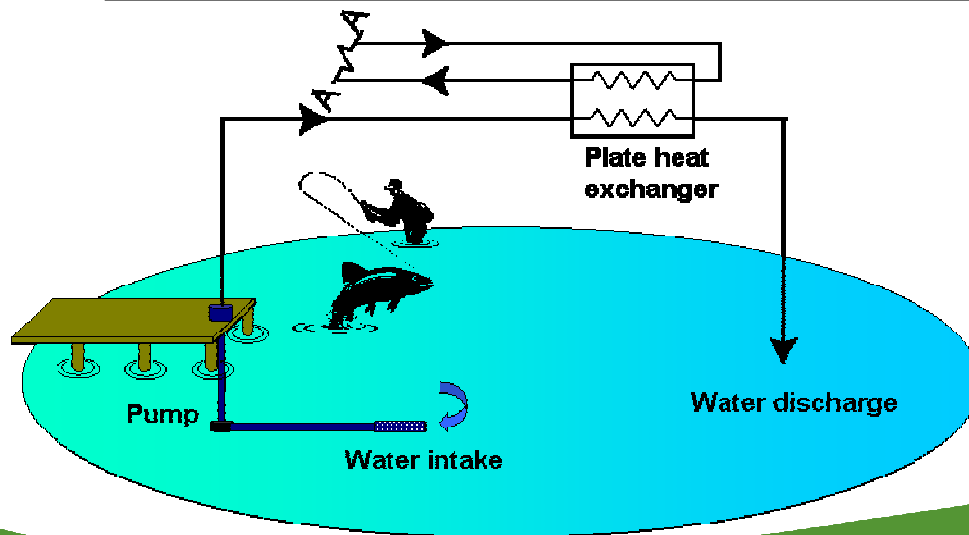
Open Loop System – Surface Water

Potential Risks

- Temperature imbalance
- Discharge water temperature and chemistry
- Shoreline erosion

Current regulatory controls

- Same as Open loop system – Groundwater except Wells regulation does not apply
- *The Clean Water Act, Conservation Authorities Act, Public Lands Act, Lakes and Rivers Improvement Act* may apply



Example Gaps and Issues

- Siting and design to address potential ecological issues (e.g. fish habitat)
- Collision Hazards

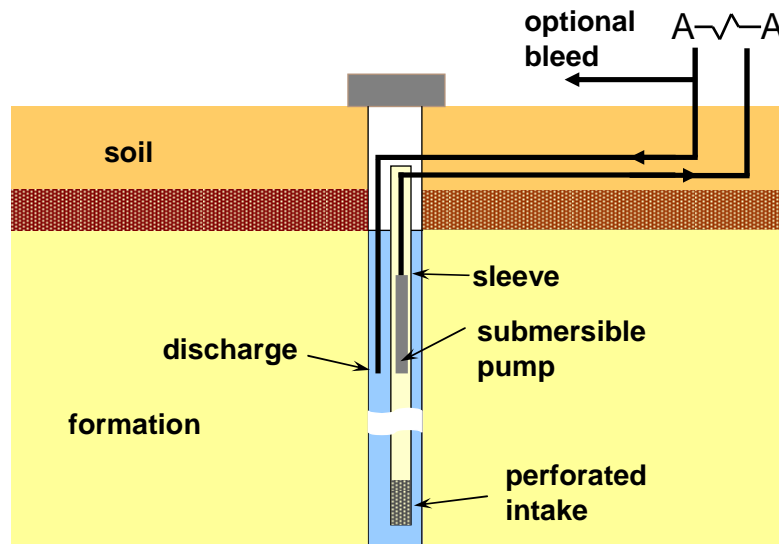
Open Loop System- Standing Column

Potential Risks

- Preferential pathways
- Temperature imbalance
- Discharge water temperature / chemistry

Current regulatory controls

- OWRA and Wells Regulation for well construction and equipment installation in wells
- OWRA - Permit to Take Water (non residential systems)
- OWRA – Certificate of approval for sewage works discharges
- Other requirements referred to previously may apply



Example Gaps and Issues

- Presently, CSA standard does not specifically address these systems
- Siting and design requirements to address risks
- Current certificate of approval requirements for single family dwellings
- Potential for encountering explosive gases (no detection requirement) or artesian flowing well conditions.

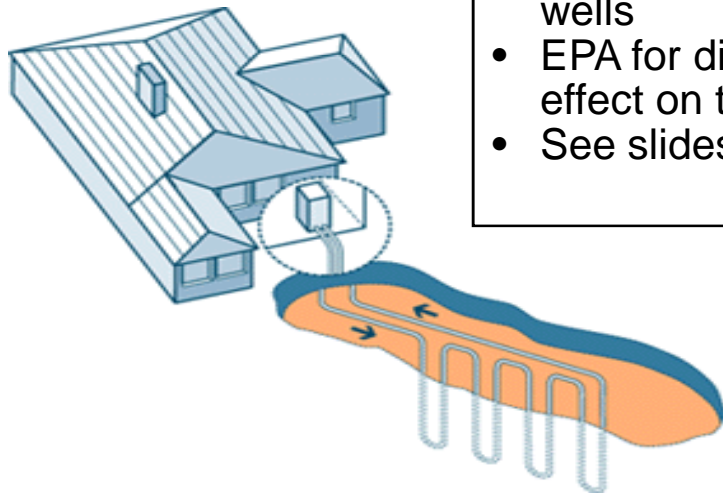
Closed Loop System – with Vertical Boreholes

Potential Risks

- Preferential pathways – possibly hundreds of potential pathways in a small area for large systems drilled through many aquifers
- Heat transfer fluid leak
- Temperature imbalance in larger systems or possibly multiple individual systems in close proximity

Current regulatory controls

- Building Code prescribes building permits and CSA standard C448
- Sometime OWRA and Wells regulation when holes are deemed wells
- EPA for discharges (e.g. leaks, heat) that may cause an adverse effect on the natural environment
- See slides 27 & 28 for other requirements



Example Gaps and Issues

- Potential for encountering explosive gases (no detection requirement) or artesian flowing well conditions, although the risks are similar
- No site assessment for small systems
- No clear environmental siting, maintenance, reporting or abandonment (decommissioning) standards

Closed Loop System – Surface Water

Potential Risk

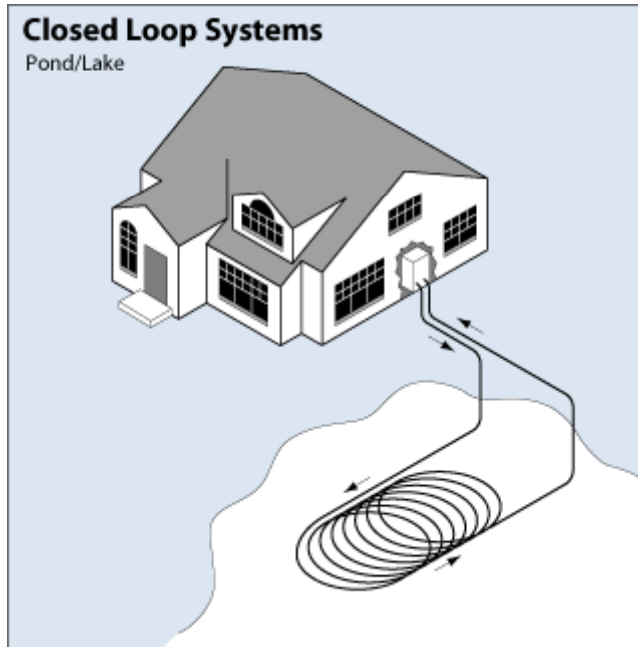
- Heat transfer fluid leak
- Temperature imbalance may effect local habitat

Current regulatory controls

- Building Code prescribes building permits and CSA standard C448
- EPA for discharges (e.g. leaks, heat) that may cause an adverse effect on the natural environment
- See slides 27 & 28 for other requirements
- Conservation Authorities Act, Public Lands Act, Lakes and Rivers Improvement Act may apply

Example Gaps and Issues

- Tethering and collision avoidance requirements



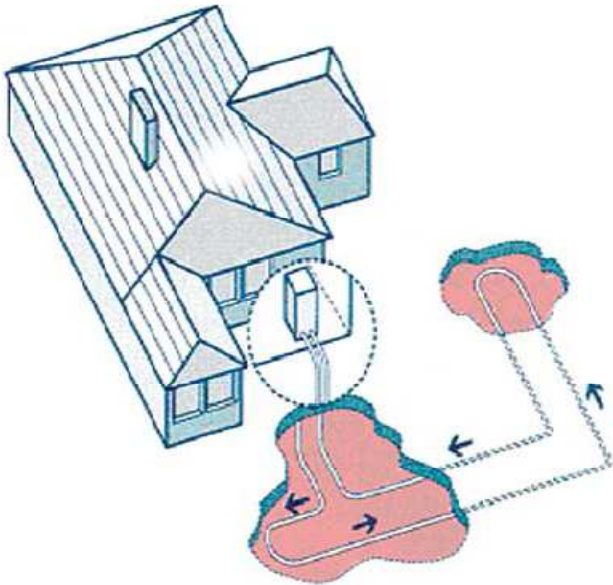
Closed Loop System - Horizontal

Potential Risk

- Heat transfer fluid leak
- Temperature imbalance

Current regulatory controls

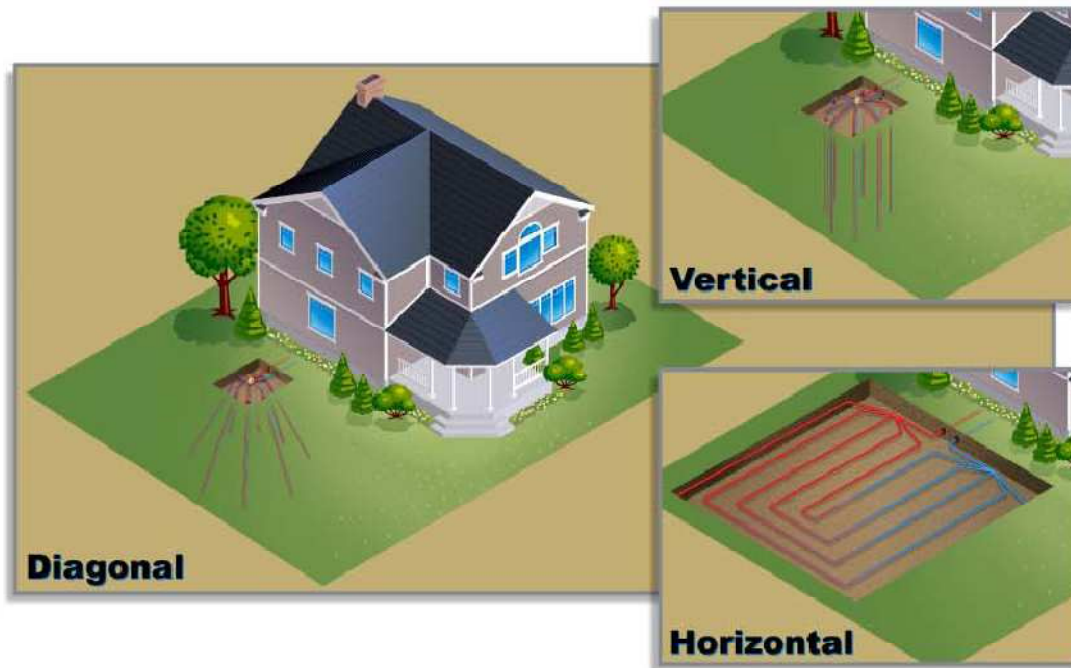
- Building Code prescribes building permits and CSA standard C448
- EPA for discharges (e.g. leaks, heat) that may cause an adverse effect on the natural environment
- Other requirements referred to previously may apply



Example Gaps and Issues

- Addressing environmental concerns for the site assessment are optional in CSA C448
- No clear environmental siting, maintenance, reporting or abandonment (decommissioning) standards

Closed Loop System – Direct Expansion



Potential Risks

- Preferential pathways
- Heat transfer fluid leak (refrigerant)
- Temperature imbalance

Current regulatory controls

- Building Code prescribes building permits and CSA standard C448
- EPA for discharges (e.g. leaks, heat) that may cause an adverse effect on the natural environment
- Other requirements referred to previously may apply

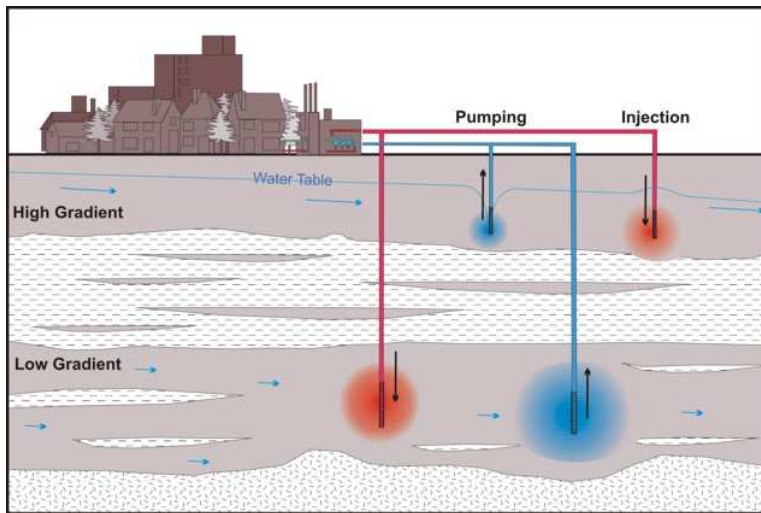
Example Gaps and Issues

- Addressing environmental concerns for the site assessment are optional in CSA C448
- No clear environmental siting, maintenance, reporting or abandonment (decommissioning) standards

Subsurface Thermal Storage

Potential Risks

- Preferential pathways
- Temperature imbalance and thermal plume movement
- Discharge water temperature / chemistry
- Water table lowering or mounding



Current regulatory controls

- OWRA and Wells Regulation for well construction and equipment installation in wells
- OWRA - Permit to Take Water (non residential systems)
- OWRA – Certificate of approval for sewage works discharges
- EPA for discharges that may cause an adverse effect on the natural environment
- Other requirements referred to previously may apply

Example Gaps and Issues

- CSA standard for thermal energy storage (C448.3) is not adopted in the Ontario Building Code
- Siting, design, operational, maintenance, and ultimately abandonment requirements are key to viability of system and to address risks

Source Protection

EES's as Transport Pathways

- Concern:
 - EES boreholes and wells pose a potential pathway for transport of contaminants or naturally occurring substances to travel from the surface to an aquifer or between aquifers.
- If EES boreholes or wells are considered a transport pathway in the Assessment Report the groundwater vulnerability score may be increased to account for this pathway.



Source Protection

EES's as Transport Pathways

- Under the current legislation, where a transport pathway is confirmed as a factor in contributing to a significant drinking water threat, addressing the pathway could be part of the risk management plan for addressing such a threat. This could include, but not be limited to:
 - requiring or confirming that the construction complies with CSA requirements
 - testing the well or boring, where possible, to determine if it provides a conduit for flow
 - monitoring the system to determine if there is enhanced flow or if there is any loss of heat transfer fluids from the system
 - providing an emergency contingency plan in the event that there is a leak to minimize the impact on source waters
 - restricting the installation or application of earth energy systems
 - decommissioning faulty or high risk earth energy systems



Source Protection

EES Water Quality Risks

- Potential Concerns:
 - The presence of the heat exchange fluids has the potential to impact the quality of source waters if it is released into the environment.
 - Transport of water from one aquifer or surface water system through another could result in impacts to receiving source waters.
 - Discharge of heated or cooled water or induced temperature changes to a source water could result in thermal impacts or changes to water chemistry.
- Earth Energy Systems are not a prescribed threat under the current regulations.



Source Protection

EES Water Quality Risks

- With respect to heat transfer fluids, preliminary analysis by the Ministry suggests that:
 - residential systems with low volumes of heat transfer fluids, would be considered a low drinking water threat in areas with a vulnerability of greater than 7, and
 - larger commercial or industrial systems with higher volumes of HTFs would be a:
 - significant drinking water threat in areas with a vulnerability score of 10,
 - moderate threat in areas with vulnerability scores between 7.5 and <10, and
 - low threat in areas with vulnerability scores between 5 and < The 7.5.
- The threat identification and risk assessment associated with water quality discharge from EES systems will need to be evaluated on a site specific basis and is dependant largely on the quality of the discharge water at the specific location.
- Thermal impacts are not likely to be considered a threat to source water quality as the potential influence is localized and temperature is not a contaminant of concern with respect to drinking water sources in Ontario.



Source Protection

EES Water Quantity Risks

- Concerns:
 - The taking of water from surface water or groundwater regimes for open loop systems could have an affect on the water budget for a given area.
- Where these systems extract water from the environment, this withdrawal should be considered under the water budget and water quantity risk assessment, where applicable.
- It is estimated that single residential systems typically use 25 to 40 litres per minute for heating and cooling, with maximums of 25,000 to 40,000 litres per day.
- Larger commercial or industrial systems can use significantly greater amounts of water.
- While permits to take water for residential earth energy water taking systems are not required if they are for normal household use (such as heating), the withdrawal should be considered in the overall water budget, particularly at a Tier 3 stage.
- It should be further noted that the operation of open loop systems could have a notable effect on the groundwater flow regime through the induction of piezometric changes due to the withdrawal and recharge of the water used.



Ontario's Current Focus

- Address potential impacts associated with earth energy systems (EES) while encouraging their use
- Focus is on the external loop not the heat pump
- Evaluate ability of regulatory framework to provide continued environmental protection and the conservation, protection and management of Ontario's waters
- Evaluate information gathered as part of recently completed reviews of:
 - Current regulatory requirements
 - Jurisdictional Review
 - Science and Engineering Review
 - Engagement Sessions
- Ongoing policy development:
 - Determine if there is a need for additional guidance, training and/or changes to current requirements
 - Develop options for consideration
 - Ongoing engagement
 - Recommendations and implementation



Questions and Issues

- The Ministry welcomes questions, comments, concerns and suggestions.
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Additional information on Earth Energy Systems in Ontario
can be obtained from:

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Drawing Sources:

- US Department of Energy
- Natural Resources Canada
- <http://www.dlsc.ca/how.htm>
- www.sfu.ca
- <http://www.earthlinked.com/learn-more/media-room/graphics>
- www.annapolisroyal.com/downloads/heatpumps.pdf

