Technical Bulletin

Earth Energy Systems in Ontario

March 2013

Ontario

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Ontario Ministry of the Environment

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Introduction

This technical bulletin provides an overview of Ontario's environmental legislative framework governing the outside loop components of an *earth energy system*. The components of *earth energy systems* contained inside a residence, commercial building or other structures are beyond the scope of this document.

In this technical bulletin, *earth energy systems* are also referred to as low temperature geothermal systems or *ground source heat pumps*. *Earth energy systems* should not be confused with high temperature geothermal systems (over 50 degrees Celsius) that obtain heat from deep within the earth to produce heat and generate electricity (e.g., Iceland's geothermal heating system).

It is important that the siting, installation, maintenance and decommissioning of these systems be undertaken in a manner that protects public health and safety, and the environment, including groundwater and surface water. When installed in a safe manner, *earth energy systems* provide an excellent source of green heating and cooling for a variety of uses including residential, commercial, agricultural and industrial applications.

This technical bulletin replaces the technical bulletin titled "Constructing Earth Energy Systems in Ontario" published by the Ministry of the Environment, September 2009. It provides:

- additional information on the types of systems, including direct exchange (DX) systems that are installed in Ontario;
- possible risks associated with *earth energy systems*; and
- practices to mitigate such risks.

Notice: This bulletin is being provided for information purposes only and is not intended, nor should it be construed as providing legal advice in any circumstances. The applicable environmental legislation, including the following, should be consulted.

- Ontario Water Resources Act, R.S.O. 1990, c. O. 40
- R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40
- Ontario Regulation 387/04 (Water Taking) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40
- Building Code Act, 1992, S.O. 1992, c. 23
- Ontario Regulation 350/06 (Building Code) as amended made under the Building Code Act, 1992, S.O. 1992, c. 23
- Environmental Protection Act, R.S.O. 1990, c. E. 19
- Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19
- Ontario Regulation 463/10 (Ozone Depleting Substances and Other Halocarbons) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19
- Oil, Gas and Salt Resources Act, R.S.O., 1990 c. P. 12
- Occupational Health and Safety Act, R.S.O. 1990, c. O. 1
- Lakes and Rivers Improvement Act, R.S.O. 1990, c. L. 3
- Public Lands Act, R.S.O. 1990, c. P. 43
- Conservation Authorities Act, 1990, R.S.O., c. C. 27
- Clean Water Act, 2006, S.O. 2006, c. 22
- Fisheries Act, R.S.C., 1985, c. F-14

Legislation and regulations change from time to time so it is essential that the most current versions be used. Should you have any questions about the application or interpretation of the laws of Ontario or have other legal questions, you should consult a lawyer.

All figures in this technical bulletin are not to scale and are for illustrative purposes only. They do not necessarily represent full compliance with requirements found in the legislation and regulations cited.

Any reference in this technical bulletin to an *environmental compliance approval* includes a certificate of approval or provisional certificate of approval issued under section 9 or 39 of the Environmental Protection Act before October 31, 2011 and an approval granted under section 53 of the Ontario Water Resources Act before October 31, 2011.

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1.0 Earth Energy Systems and How They Work

Earth energy comes mainly from absorbed solar energy and conducted heat from the earth's molten interior, both stored in the *overburden*, rock and water of the earth. Below a certain depth, ground temperature is relatively constant all year long. Groundwater flowing through pores and fractures in soil or bedrock also has similar constant temperatures. Furthermore, surface water bodies, such as a river, pond or lake, generally exhibit less temperature fluctuation than occurs with air temperatures. Surface waters, the ground and groundwater are warmer than air temperature in winter and cooler than air in summer. An *earth energy system* uses the temperature differences to warm or cool buildings or other structures.

Earth energy systems are a heating and cooling system for buildings or structures that use a fluid to exchange heat with the ground or water.

An *earth energy system* is part of a heating, ventilation and air conditioning system (HVAC) for a building or structure. A typical *earth energy system* is comprised of three main components: the outside loop; the heat pump unit; and, the building's heating or cooling unit. Generally, an *earth energy system* works as follows: in the winter, the outside loop obtains heat from the soil, rock, groundwater or surface water. Heat in the outside loop is transferred to a refrigerant in the heat pump unit. Heat is then dissipated from the heat pump's refrigerant into the building's heating or cooling unit. The reverse occurs during summer. Heat from inside the building is extracted from the building's heating or cooling circuit. This heat is transferred to a refrigerant in the heat pump unit. Heat is then transferred to the outside loop and is released into the ground or surface water.

There are three basic types of outside loops for *earth energy systems*. The three types are an open loop, a closed loop and a direct expansion (DX) loop. These systems are described in sections 1.1, 1.2 and 1.3 of this technical bulletin.

There are also two types of thermal energy storage systems to exhaust heat to the ground or groundwater for heat storage and extraction. These thermal energy storage systems are described in section 1.4 of this technical bulletin.

It is estimated by the Canadian GeoExchange Coalition(CGC)[1] that approximately sixty seven per cent of the CGC certified *earth energy systems* installed in Ontario between 2006 and 2008 are closed loop horizontal systems, fifteen per cent are closed loop vertical systems, thirteen percent are open loop vertical systems and six percent are surface water systems. CGC certified earth

[1] The State of the Canadian Geothermal Heat Pump Industry 2010 published November 2010 by the Canadian GeoExchange Coalition, http://www.geo-exchange.ca/en/UserAttachments/article64_Industry%20Survey%202010_FINAL_E.pdf

energy systems are thought to represent approximately twenty five percent of the systems being installed in Ontario.

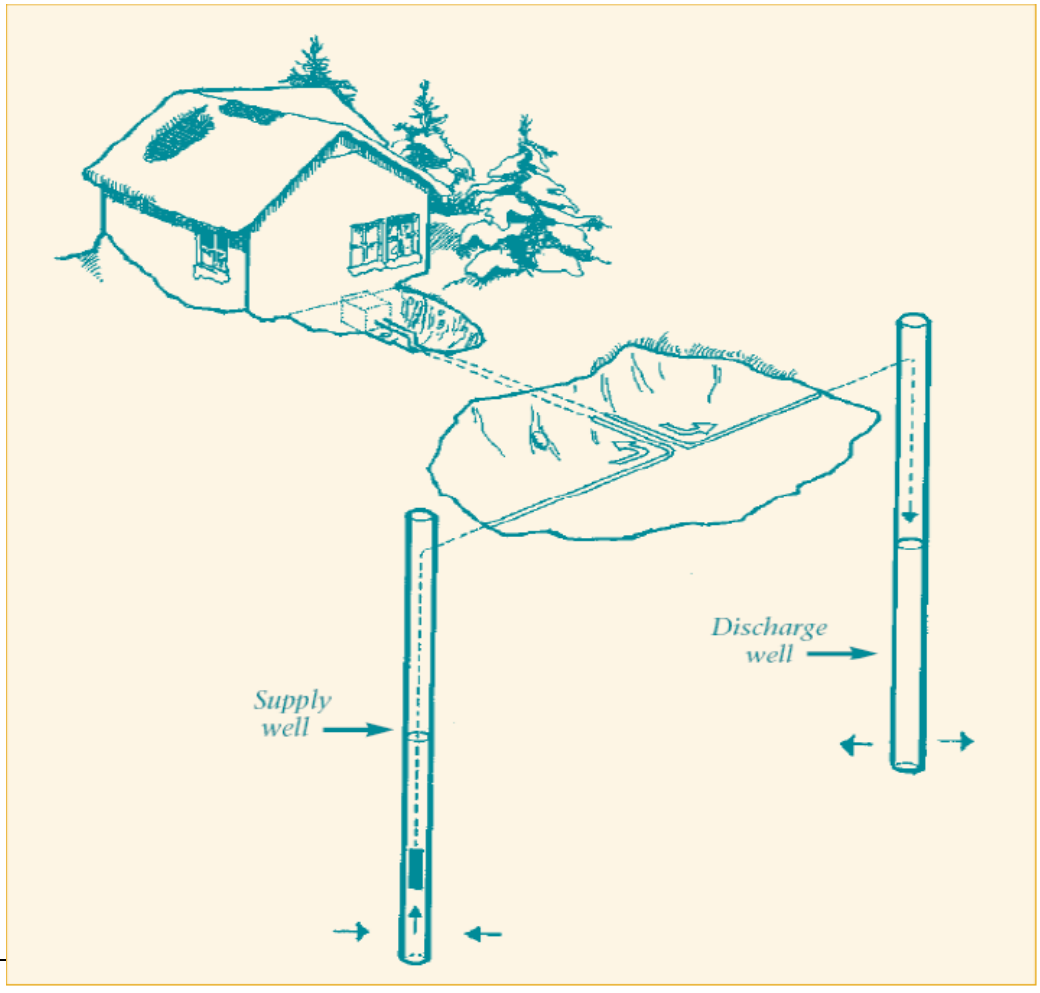
1.1 Open Loop Earth Energy Systems

There are three types of open loop systems which use groundwater or surface water as a *heat transfer fluid*. This water is circulated through a heat pump before being discharged back into an aquifer or other water body. The three forms are as follows.

1.1.1 Groundwater

Typically, groundwater is taken from a well, circulates through a heat pump and discharges to groundwater in another well, surface water, or *overburden* in a dry *hole*.

Figure 1: EXAMPLE OF A GROUNDWATER OPEN LOOP CIRCUIT USING A SUPPLY WELL AND A DISCHARGE WELL[2]



[2] Source: "Residential EarthEnergy Systems, A Buyers Guide" Natural Resources Canada, 2002. Reproduced with the permission of the Minister of Natural Resources Canada, 2010.

1.1.2 Groundwater – Standing Column Well

Groundwater taken from the deep zone in the well circulates through a heat pump and discharges into the upper portion of the same well.

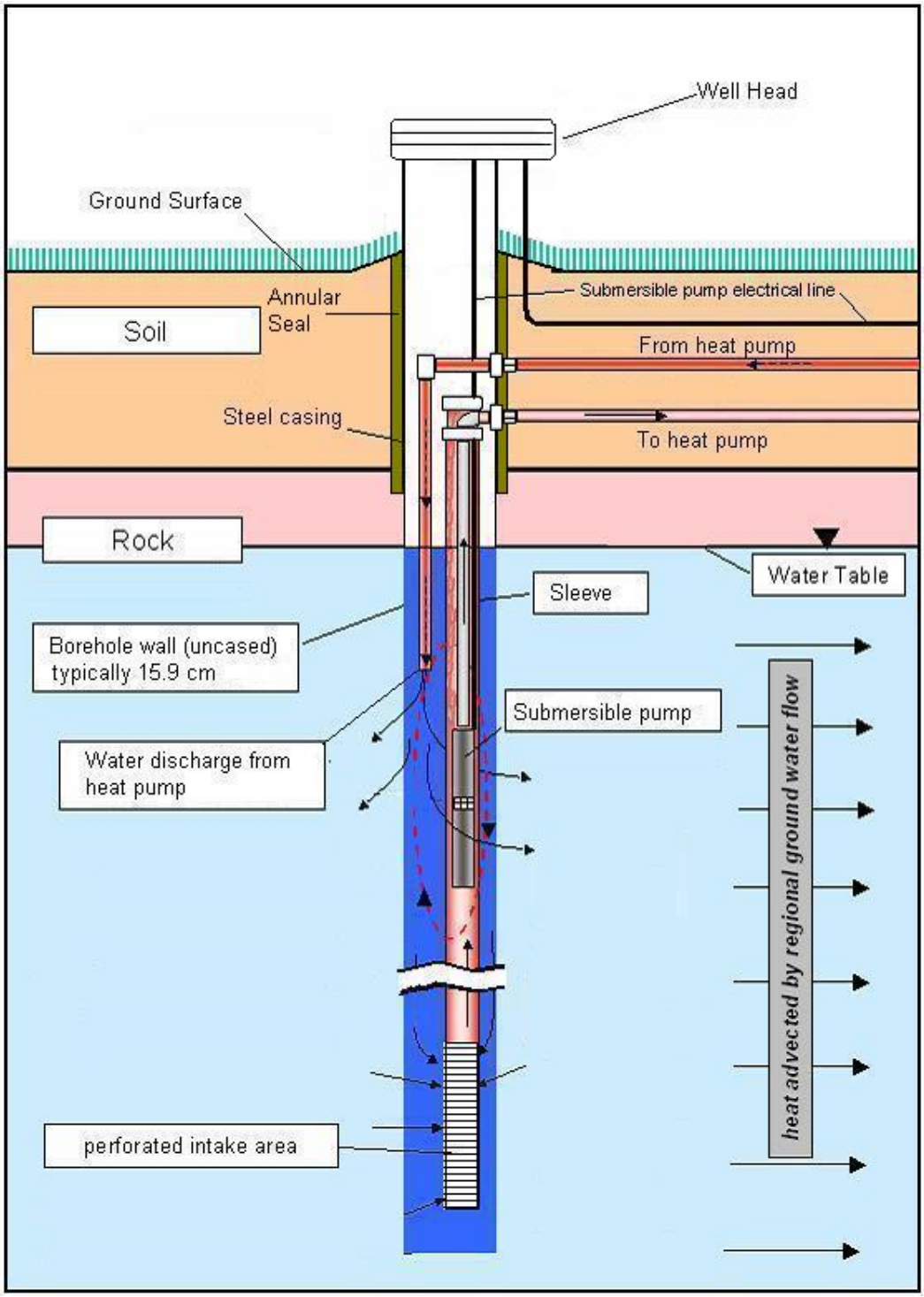


Figure 2: AN EXAMPLE OF A STANDING COLUMN WELL OPEN LOOP CIRCUIT[3]

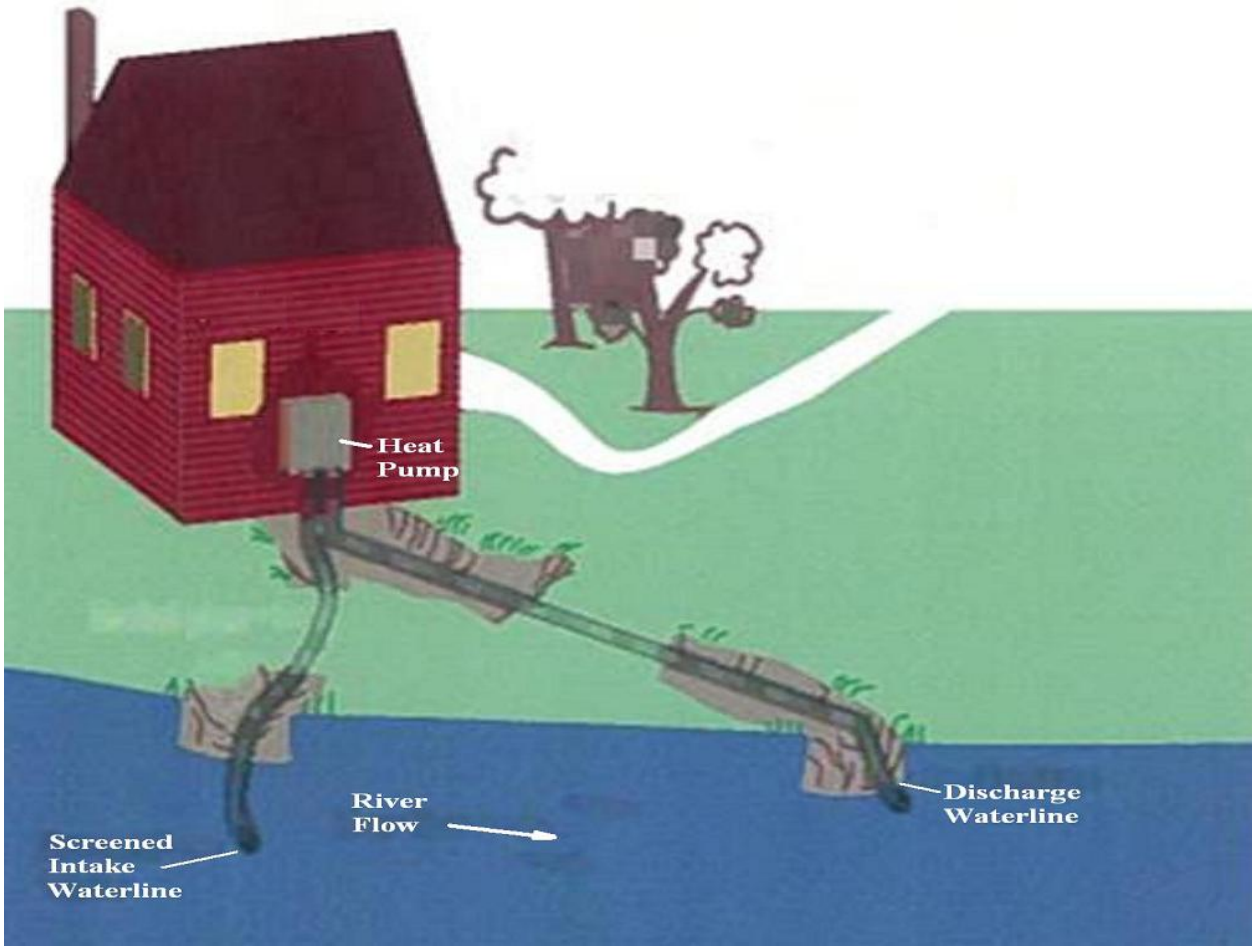
[3] Chiasson, A.D., 1999. *Standing column well* components and heat transfer processes. After unpublished figure, Building and Environmental Thermal Systems Research Group, Oklahoma State University, Stillwater, OK.

Open loop systems such as a *standing column well* system or a system with an intake well and a discharge well, each located in a different aquifer, provide pathways for rapid groundwater movement between aquifers and in this way pose potential for impairment of the natural environment.

1.1.3 Surface Water

Surface water, taken from a lake, river or pond, circulates through a heat pump and discharges back into the surface water body.

Figure 3: EXAMPLE OF A SURFACE WATER OPEN LOOP CIRCUIT[4]



[4] We gratefully acknowledge the Province of Nova Scotia, Department of Environment, for allowing us to adapt its Surface Water Heat Pumps images originally published in the Drop on Water "Surface Water Heat Pumps" fact sheet (http://www.gov.ns.ca/nse/water/docs/droponwaterFAQ_SurfaceWater-HeatPumps.pdf)

1.2 Closed Loop Earth Energy Systems

The outside loop of a closed *earth energy system* consists of a continuous *sealed* underground or submerged loop of tubes through which a *heat transfer fluid* passes and returns to the heat pump unit. The *heat transfer fluid* typically consists of a mixture of water, antifreeze, corrosion inhibitors and other additives. Common antifreezes used in a heat transfer system are denatured ethanol, propylene glycol and ethylene glycol. To reduce corrosion and increase lubrication, additives such as corrosion inhibitors or mineral oils are added to the *heat transfer fluid*. In the ground or surface water, heat moves between the *heat transfer fluid* and the soil, rock or water. The *heat transfer fluid* circulates back to the heat pump where the heat exchanges between the tube that contains the *heat transfer fluid* and the tube that contains the refrigerant in the heat pump unit. Generally, the outside loops for a closed loop system are installed in one of two configurations: vertical or horizontal.

1.2.1 Vertical Closed Loop

In a vertical system, a U-shaped loop of *tubing* is installed into drilled *holes* (Figure 4) which may be vertical or inclined (also referred to as angled *holes*). The *holes* are:

- backfilled with bentonite, cement or, in some cases, sand products; or
- not backfilled, i.e., left open, allowing groundwater to enter and fill the *holes*. If the *hole* is dry, potable water from another source is placed into the *hole*.

Figure 4: PHOTOGRAPH OF A CLOSED VERTICAL LOOP INSTALLED IN A VERTICAL BOREHOLE[5]

Figure 4 shows *tubing* placed in a vertical *hole* that is part of a closed loop *earth energy system*. At surface, the *hole* is held open by a temporary steel *casing*. The void space around the green *tubing* in the *hole* has been filled to almost the ground surface with a bentonite (manufactured swelling clay) product. The bentonite forms a seal to prevent the *hole* from acting as a pathway for contaminants.

[5] Photograph used with permission of Jamie MacKinnon, MacKinnon Well Drilling Limited.

Figure 5: AN EXAMPLE OF VERTICAL CLOSED LOOP SYSTEM[6]

1.2.2 Horizontal Closed Loop

In a horizontal system, the *tubing* is often installed into horizontal trenches that are typically excavated to a depth of 1 to 2.5 m depth below the ground surface. In some cases, a larger excavation is created to place coiled *tubing* into the ground. Once the *tubing* is placed into the excavation, the area is backfilled, initially with a material that will not puncture the *tubing*.

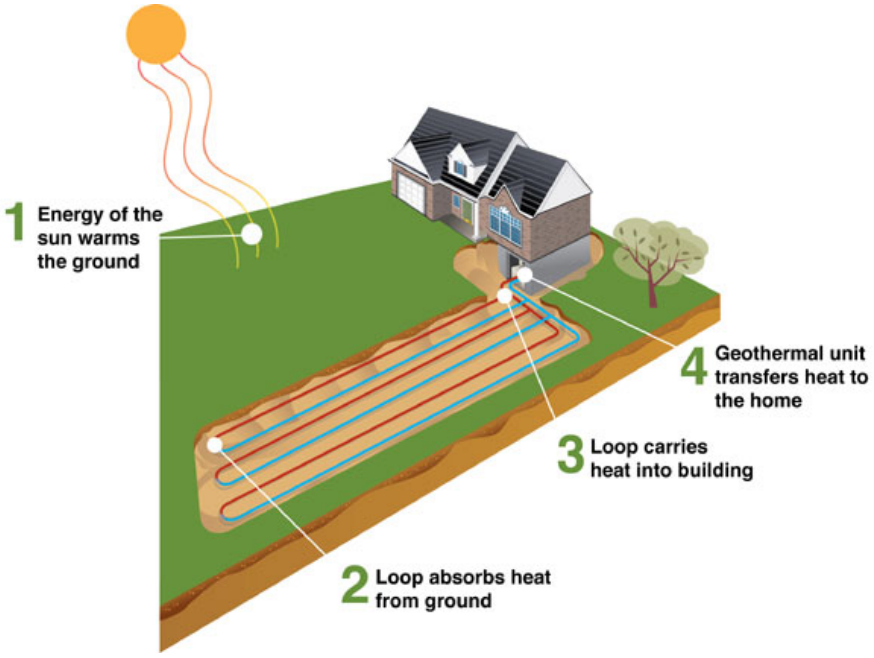
Figure 6: Photograph of Horizontal Closed Loop Partially installed[7]

Figure 6 shows an excavator creating a trench. Green *tubing* in the trench will be used to carry the *heat transfer fluid*. (Refer to section 2.6 regarding the Occupational Health and Safety Act for worker safety.)

[6] Illustration used with permission. Courtesy of Enertech Manufacturing, LLC.

[7] Photograph used with permission of Jamie MacKinnon, MacKinnon Well Drilling Limited.

Figure 7: EXAMPLE OF HORIZONTAL CLOSED LOOP SYSTEM[8]



1.2.3 Surface Water Closed Loop

Surface water, such as a, river, lake or pond, may be used in *earth energy systems*. In some surface water closed loop systems, the *tubing* is installed in a coiled fashion into the water body at a minimum of two metres below the surface. Other circuits have two tubes that extend to a single modular coiled *tubing* unit in the surface water (See Figure 9). The modular unit is typically affixed to the bottom of the surface water body but may be floating. These systems are sometimes called submerged closed loop *earth energy systems*.

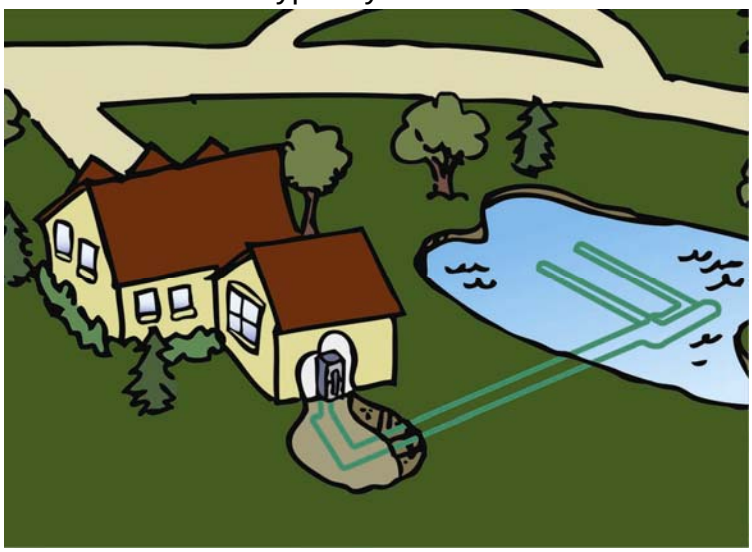


Figure 8: AN EXAMPLE OF A HORIZONTAL SUBMERGED EARTH ENERGY SYSTEM[9].

Figure 8 shows the *tubing* of the closed loop system placed in a coiled fashion in the pond. In many cases, separators are placed between adjacent loops to

[8] Image used with permission. Courtesy of NextEnergy Inc.

[9] Illustration used with permission. Courtesy of GeoSmart Energy

prevent chafing wear.

Figure 9: AN EXAMPLE OF A VERTICAL SUBMERGED EARTH ENERGY SYSTEM[10].

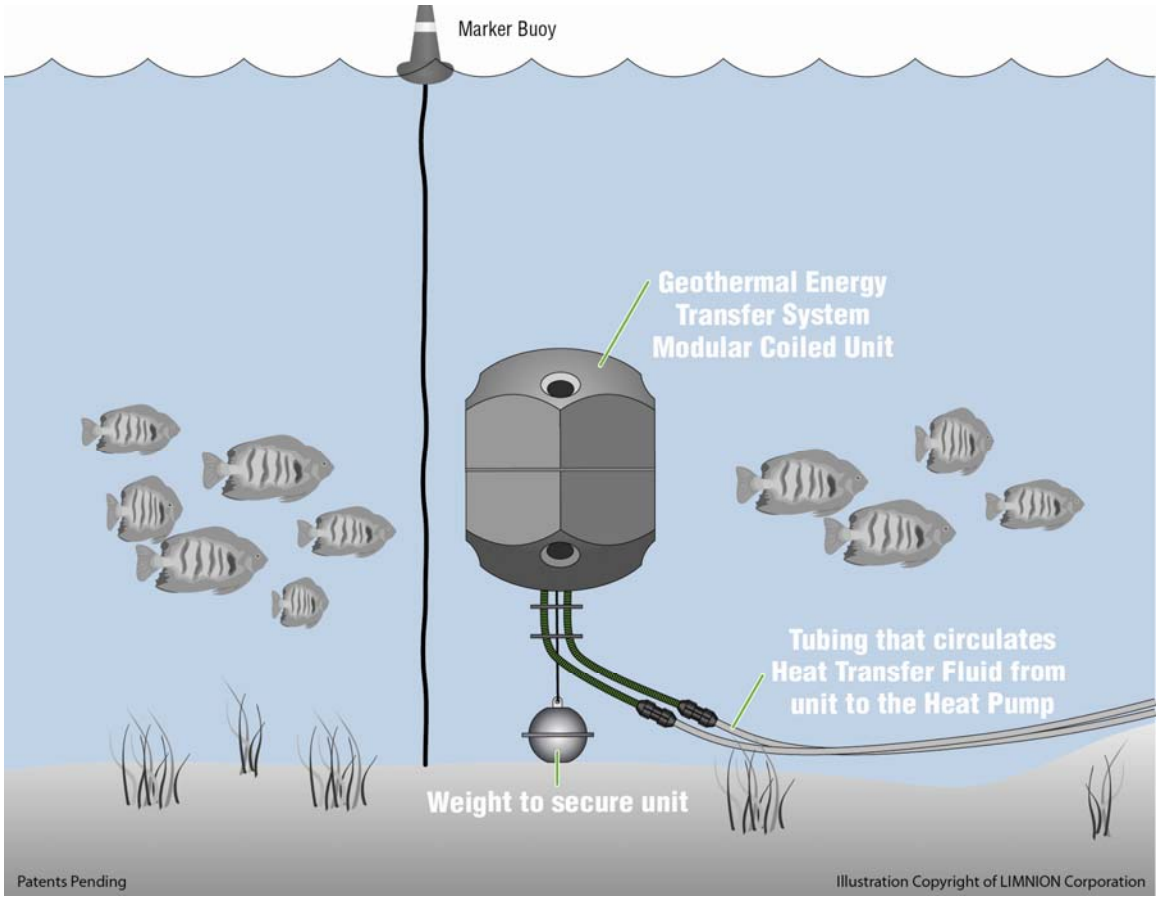


Figure 9 shows an example of two tubes extending out to a single coiled unit in the water. The tubes attach to the heat pump in the building. A *heat transfer fluid* circulates along the tubes between the coiled unit and the heat pump.

1.3 Direct Expansion (DX) Earth Energy Systems

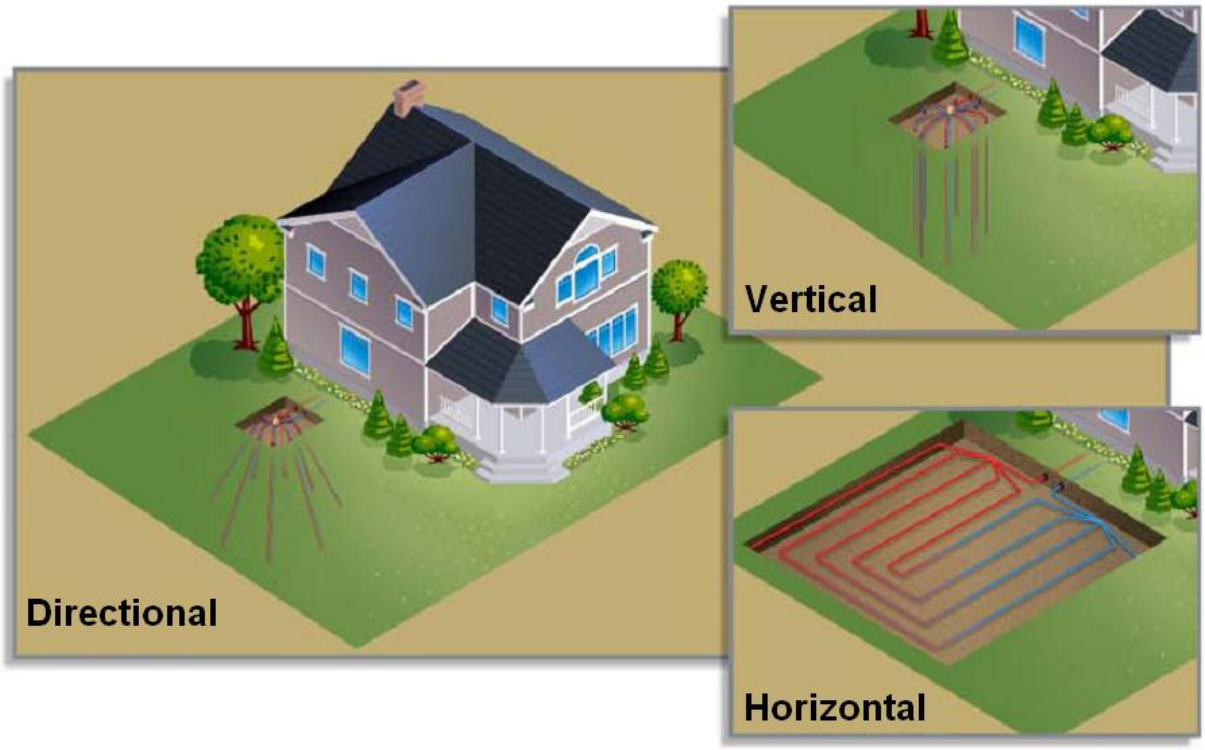
A DX system is a type of closed looped system that eliminates the need for an antifreeze mixture *heat transfer fluid*. In DX systems, the *heat transfer fluid* is a refrigerant. Commonly used refrigerants and banned refrigerants are discussed in sections 2.1 and 2.5 of the technical bulletin. The refrigerant from the heat pump is circulated through a continuous loop of *tubing* that extends from the heat pump into the ground.

[10] LIMA-1 Geothermal Energy Transfer System Courtesy of LIMNION Corporation

In a vertical DX system, the *tubing* is installed into vertical, including directional or angled, *holes* and backfilled with a bentonite, cement or sand product. Typically, the *hole* for a DX system is no more than 30 metres deep and usually is not as deep as a *hole* used in a closed loop system.

In a horizontal DX system, the *tubing* is placed in horizontal trenches that are typically excavated to about 2 to 2.5 metres in depth and then backfilled with the excavated material.

Figure 10: EXAMPLE OF DX CLOSED LOOPS WITHIN VERTICAL AND DIRECTIONAL HOLES AND IN HORIZONTAL TRENCHES[11]



1.4 Thermal Energy Storage Systems

These types of *earth energy systems* use vertical *holes* to exhaust heat to the ground or groundwater which provides a location for heat storage or extraction. Thermal energy storage systems can use an open loop or closed loop configuration to transfer the energy.

There are two common types of thermal energy storage systems in Ontario: aquifer thermal energy storage (ATES) system; and borehole thermal energy

[11] Illustration courtesy of Earth Linked Technologies, Inc.

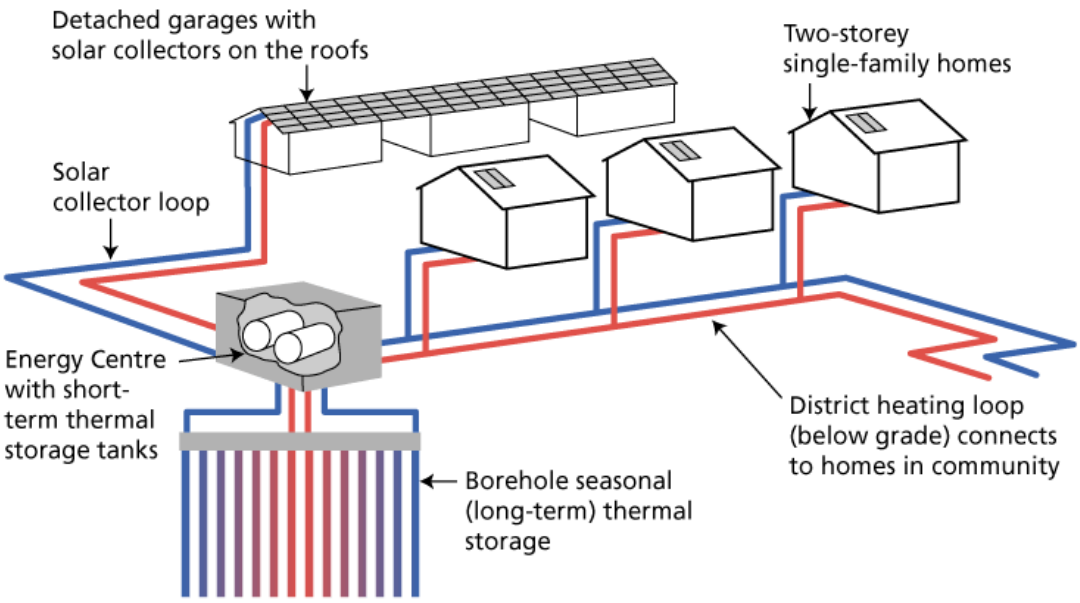
storage (BTES) system. Both the ATES and BTES systems allow for stored heat to be used at a later time or to discharge heat to cool a building or structure.

To store heat using an ATES system, warmed groundwater is returned to an aquifer in the earth and stored until it is required for heating. When required, groundwater is pumped out and heat is extracted. An ATES system largely uses groundwater as the *heat transfer fluid*.

To store heat in a BTES system, a continuous *sealed* loop of tubes, through which a *heat transfer fluid* passes and returns, are placed into *holes* in a similar fashion to a closed loop system. The *heat transfer fluid* is circulated within *tubing*, absorbing heat from the surrounding rock, soil and groundwater and storing it for use at a later time. The *heat transfer fluid* does not flow into or mix with the surrounding rock, soil or groundwater in the borehole.

Further information on thermal energy storage systems can be reviewed in the article “Thermal Energy Storage, A Concise Overview”, by Marc Rosen, P. Eng. GeoConneXion Magazine, 2009: http://www.geo-exchange.ca/fr/UserFiles/File/India/Thermal%20Energy%20Storage%20A%20Concise%20Overview.pdf.

Figure 11: EXAMPLE OF A SUBSURFACE BOREHOLE THERMAL ENERGY STORAGE SYSTEM COMBINED WITH A SOLAR ENERGY COLLECTOR AND ABOVE GROUND THERMAL STORAGE USED IN THE DRAKE LANDING SOLAR COMMUNITY IN OKOTOKS, ALBERTA[12]



[12] Source: "Solar Seasonal Storage and District Loop". Natural Resources Canada, 2005. Reproduced with the permission of the Minister of Natural Resources Canada, 2011.

2.0 Earth Energy Systems - Legislative Overview

This section outlines the current pertinent legislative and regulatory framework in place to protect the environment and human health, and to address safety during the installation and use of *earth energy system* technology. The information from this section is summarized in Table 1.

2.1 Building Code Act and Regulation

Under the Building Code Regulation[13], *earth energy systems* form parts of a heating system. The Building Code Regulation sets minimum requirements governing the construction and renovation of most *earth energy systems*. Persons constructing and renovating heating systems are required to apply for a building permit. The Building Code Act and Regulation are enforced by municipal building officials. A person installing a system should consult with the local building department to obtain further information on applicable permits[14] and inspections that are required.

Although the Building Code Regulation does not provide prescriptive requirements for *standing column well* (see section 1.1.2 of this technical bulletin) and thermal energy storage *earth energy systems* (see section 1.4 of this technical bulletin), it is the responsibility of the designers and contractors to design and install earth energy systems in accordance with the applicable governing CSA Standard and all other applicable laws. Under Section 8 of the Building Code Act, 1992, S.O. 1992, c. 23[15] , no person shall construct or demolish a building or cause a building to be constructed or demolished unless a permit has been issued therefore by the chief building official.

If a designer chooses not to follow the prescriptive requirements of the Building Code Regulation, then the designer must propose an alternative design which meets the objectives and functional statements as stated in the Supplementary Standard SA-1 of the Building Code Regulation[16]. Since alternate solutions are

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[13] Ontario Regulation 350/06 (Building Code) as amended made under the Building Code Act, S.O. 1992, c 23, E-laws http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_060350_e.htm

[14] Subsection 8(1) of the Building Code Act, 1992, S.O. 1992, c. 23 prescribes no person shall construct or demolish a building or cause a building to be constructed or demolished unless a permit has been issued therefore by the chief building official, E-laws http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_92b23_e.htm

[15] Subsection 8(1) of the Building Code Act, 1992, S.O. 1992, c. 23, E-laws http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_92b23_e.htm

[16] When proposing an alternate design for an earth energy system, Supplementary Standard SA-1 requires a designer to meet objectives OH1.1, OH1.2, OS2.3 and OS3.4 found in Table 2.2.1.1 of the Building Code Regulation. A copy of Supplementary Standard SA-1 is found in Volume 2 of the 2006 Building Code Compendium. A copy of the 2006 Building Code Compendium, Published by the Ministry of Municipal

reviewed and approved by the municipality, a person installing an alternative design for an *earth energy system* should consult with the local building department to obtain further information.

The Building Code Regulation requires the construction or renovation of an *earth energy system* to conform to one of the following standards published by the Canadian Standards Association:

- CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings[17]
- CAN/CSA-C448.2-02, Design and Installation of Earth Energy Systems for Residential and Other Small Buildings[18]

The use and size of the building served by the *earth energy system* determines which of the two CAN/CSA standards applies. CAN/CSA-C448.2-02 applies to *earth energy systems* serving single dwelling units or buildings where the conditioned space is not more than 1400 m^2, while CAN/CSA-C448.1-02 applies to systems serving all other structures.

By referencing the CAN/CSA-C448.1-02 and CAN/CSA-C448.2-02 standards, the Building Code Regulation includes requirements for the construction or renovation of groundwater and surface water open loop *earth energy systems*, closed loop *earth energy systems*, and direct exchange *earth energy systems*.

The CAN/CSA-C448.1-02 and CAN/CSA-C448.2-02 standards require that the void space in any *holes* constructed for a new closed loop or direct exchange *earth energy system* be filled with a *grout* material (sealant) to reduce the risk of a *hole* acting as a pathway for the downward movement of potentially contaminated surface water that may impair groundwater[19].

If the *hole* is part of a closed loop vertical *earth energy system*, then the two standards require that the *grout* must be cement or bentonite, high solids clay bentonite *grout* in situations where the *grout* will not be subjected to freezing conditions, or thermally enhanced *grout*.

Affairs and Housing, Publication Number 510097 can be ordered through Service Ontario at http://www.ontario.ca/en/residents/index.htm.

[17] *Design and Installation of Earth Energy Systems*, CAN/CSA C448 Series-02, A National Standard of Canada, originally published February 2002, reprinted October 2009, prepared by Canadian Standards Association, ISBN 1-55324-844-9

[18] Ibid

[19] Sections 5.6.2 and 5.6.3 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

If the *hole* is part of a direct exchange *earth energy system*, then the two standards require that *grout* can be high solids clay bentonite *grout* in situations where the *grout* will not be subjected to freezing conditions, or thermally enhanced *grout*.

The two standards do not provide information on the type of grouting mixtures to use nor discuss when various types of bentonite or cement are to be placed into the *hole*. The standards, however, require that the contractor shall ensure that the grouting mixture is approved by the authority having jurisdiction if there are other special geological or hydrogeological conditions making a different grouting mixture more appropriate.

As a guideline, the CAN/CSA-C448.1-02 and CAN/CSA-C448.2-02 standards recommend that vertical, or inclined *holes*, should be properly *sealed* against contamination from external sources, from any contaminated stratigraphic units, or from units with poor groundwater quality that are intersected by the *holes*[20].

For closed loop *earth energy systems*, the CAN/CSA-C448.1-02 and CAN/CSA-C448.2-02 standards ban the use of potassium acetate as a *heat transfer fluid* due to its corrosive properties. The standards provide other restrictions on antifreezes and additives such as corrosion inhibitors used in *heat transfer fluid*s in order to reduce corrosion and reduce risks to the environment[21]. To reduce leaks, underground piping for *heat transfer fluid* must meet CAN/CSA B137.1-99 (part of B137 Series-99) titled Polyethylene Pipe, Tubing, and Fittings for Cold-Water Pressure Services and be pressure tested at key points during the installation of the pipes[22].

For the design of a surface water or submerged closed loop system, the standards[23] require consideration of the following:

- The physical limitation of the land area and shoreline conditions;
- The minimum disturbance to shorelines, pond, lake, or river beds, and aquatic habitat;
- Protection against wave, ice, and boat damage;

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[20] Annex A (Informative), A.2.1, h of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

[21] Section 5.5 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

[22] Section 5.2 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

[23] Section 6.4 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

- The requirement, in some provinces, for a shoreline alteration permit from the authority having jurisdiction;
- A minimum distance of 2 m (6.6 ft) between any part of the submerged heat-exchanger system and a potable water intake;
- The type of antifreeze or inhibitor approved by the authority having jurisdiction;
- The end use of the water surface area;
- Methods for securely fastening the submerged system to the bottom, taking into consideration that this system could become coated with ice, making it buoyant; and
- Anticipated minimum water levels

For a direct exchange *earth energy system*, the standards[24] require that the:

- refrigerant used be listed in CAN/CSA B52 titled Mechanical Refrigeration Code[25]; and
- *heat transfer fluid* underground piping and fittings;
    - meet ASTM B 280-08 titled Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service;
    - meet CAN/ CSA B16.22 titled Wrought Copper and Copper Alloy Solder Joint Pressure Fittings; and
    - be installed in accordance with CAN/CSA B52 titled Mechanical Refrigeration Code[26] and be pressure tested at key points during the installation of the pipes[27].

[24] Sections 5.2, 5.5 and 9 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

[25] Section 5.5 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

[26] Section 5.2 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

[27] Section 9 of CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings, Reprinted October 2009

2.2 Ontario College of Trades and Apprenticeship Act (formerly regulated under the Trades Qualification and Apprenticeship Act, revoked April 8, 2013)

Effective April 8, 2013 the Ontario College of Trades and Apprenticeship Act, 2009, S.O. 2009, c. 22[28] (OCTAA) and its regulations establish trades certification and training requirements for persons who work at the construction, alteration and maintenance of certain buildings and building HVAC (heating, ventilation, and air conditioning) systems, including earth energy systems. This legislation is administered by the Ontario College of Trades (OCOT).

Prior to April 8, 2013 similar certification and training requirements existed under the Trades Qualification and Apprenticeship Act, R.S.O. 1990, c. T. 17 (repealed April 8, 2013) (TQAA) and associated regulations[29] . The TQAA was administered by the Ministry of Training, Colleges and Universities (MTCU).

The three trades certificates relevant to the construction and installation of the external loop of earth energy systems are plumber, refrigeration and air conditioning mechanic and steamfitter. For example, a refrigeration and air conditioning mechanic's certificate is required to hook up the tubing to the heat exchange unit.

For further information about skilled trades, the Ontario College of Trades and *the Ontario College of Trades and Apprenticeship Act, 2009*, please refer to their website: http://www.collegeoftrades.ca/.

[28] Ontario College of Trades and Apprenticeship Act, 2009, S.O. 2009, c.2 2. E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_09o22_e.htm

[29] Trade Qualification and Apprenticeship Act, R.S.O. 1990, c. T. 17. E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90t17_e.htm

2.3 Green Energy Act

The Green Energy Act, 2009 (GEA)[30] affirms the Government of Ontario's commitment to fostering the growth of renewable energy projects, which use cleaner sources of energy, to removing barriers to and promoting opportunities for renewable energy projects and a green economy. The GEA defines "renewable energy source" to include geothermal energy.

Ground source energy is designated under O. Reg. 15/10 made under the GEA [31], as a renewable energy source for purposes of subsection 5 (1) of the Green Energy Act, 2009 if the ground source energy is harnessed by ground source heat pump technology and the ground source heat pump technology is installed in compliance with the Building Code Act.

The effect of this designation is that a person is permitted to harness ground source energy in the manner described in O. Reg. 15/10 despite most restrictions imposed in a municipal by-law, a condominium by-law, an encumbrance on real property or an agreement. However, by-laws, instruments and other restrictions that relate to the protection of groundwater, trees, various heritage sites, or the regulating by the conservation authority of any activity or matter that is subject to a conservation authority regulation[32] would continue to apply to restrict the use of ground source energy[33].

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[30] Subsection 1(1) of the Green Energy Act, 2009, S.O. 2009, c. 12, Sched. A. E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_09g12_e.htm#BK0

[31] Ontario Regulation 15/10 made under the Green Energy Act, 2009, S.O. 2009, c. 12, Sched. A, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_100015_e.htm

[32] Conservation authorities regulations, specific to each conservation authority, made under the Conservation Authorities Act, R.S.O. 1990, c. C. 27, E-laws - http://www.e-laws.gov.on.ca/Download?dDocName=elaws_statutes_90c27_e

[33] Section 3 of Ontario Regulation 15/10 made under the Green Energy Act, 2009, S.O. 2009, c. 12, Sched. A, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_100015_e.htm

2.4 The Environmental Protection Act (EPA)

The purpose of Environmental Protection Act [34] is to provide for the protection and conservation of the natural environment.

The Environmental Protection Act and its regulations define *ground source heat pump* systems[35] (i.e. *earth energy systems*), address the types of *heat transfer fluid*[36], including refrigerants[37], used in an *earth energy system* and address the discharge of contaminants into the natural environment.

2.4.1 General Prohibition

Subsection 14(1) of the Environmental Protection Act states that a person shall not discharge a contaminant or cause or permit the discharge of a contaminant into the natural environment, if the discharge causes or may cause an adverse effect.

The owner or operator must report the discharge to the Ministry of the Environment's Spills Action Centre at 1-800-268-6060. Failure to report a discharge is an offence under the Environmental Protection Act.

2.4.2 Environmental Compliance Approval

Natural gases are found with depth in several parts of Ontario. Some of these gases, such as methane and hydrogen sulphide, are explosive.

To protect public safety (i.e. the public and installers) and the environment in the event hazardous natural gas is encountered during geothermal system installation, the Ministry of the Environment identified the need for legislation to address the drilling of *vertical closed loop ground source heat pumps*, also known as *vertical closed loop earth energy systems*. This new legislation will help to reduce the risks associated with encountering *hazardous gas* while drilling and constructing these types of *earth energy systems*.

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[34] Environmental Protection Act, R.S.O. 1990, c. E. 19. E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90e19_e.htm

[35] Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_120098_e.htm

[36] Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws: http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_120098_e.htm

[37] Ontario Regulation 463/10 (Ozone Depleting Substances and Other Halocarbons) as amended made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_100463_e.htm

As part of the legislative changes, the Ministry of the Environment revoked and replaced Ontario Regulation 177/98 with Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 17. The government also amended Ontario Regulation 245/11 and Ontario Regulation 524/98 made under the Environmental Protection Act. The legislative requirements are as follows.

Pursuant to section 9 of the Environmental Protection Act, before a person constructs, alters, extends, or replaces a portion of a *vertical closed loop earth energy system*, that extends, or will extend, more than 5.0 metres below the *original ground surface*, the person must obtain an *environmental compliance approval* under Part II.1 of the Environmental Protection Act[38].

The requirements or conditions described in an *environmental compliance approval* are legal requirements. The *holder* of the *environmental compliance approval* is responsible for compliance and must take measures to ensure that the activities related to installing a *vertical closed loop earth energy system* comply with the requirements of the *environmental compliance approval*.

Under the Ground Source Heat Pump Regulation (Ontario Regulation. 98/12), the Ministry of the Environment can issue an approval to:

- an earth energy installer, or the installer's business, responsible for the entire installation work on the *earth energy system*,
- a drilling sub-contractor, or the sub-contractor's business, that drills the *holes* and installs the heat transfer *tubing* in the *holes*, or
- another party, including the owner, who wishes to apply and take responsibility for obtaining and complying with the *environmental compliance approval*.

The Ground Source Heat Pump Regulation outlines the requirements a person must meet to obtain a single or multi-site *environmental compliance approval* and to do work on a *vertical closed loop earth energy system*. For further information see section 2.5 of this technical bulletin.

[38] Sections 20.1 to 20.18 of the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90e19_e.htm

2.5 Ground Source Heat Pumps Regulation

2.5.1 Definitions

The Ground Source Heat Pumps Regulation made under the Environmental Protection Act[39] defines:

- a "*ground source heat pump*" as a system that is designed to heat and cool a building or structure by using a heat-transfer fluid to exchange heat with the ground or ground water.
- "*hazardous gas*" means a gas or mixture of gases that,

  (a) contains hydrocarbons (including methane), hydrogen sulphide or both,

  (b) originates from the natural environment, and

  (c) is present in an atmospheric concentration that may be explosive or flammable, may cause asphyxia or is otherwise hazardous;

- "*vertical closed loop ground source heat pump*" means a *ground source heat pump* that uses a continuous, *sealed*, underground heat exchanger consisting of subsurface *tubing* through which the heat-transfer fluid passes.

For the purposes of this technical bulletin, a *ground source heat pump* means the same thing as an *earth energy system*.

2.5.2 Heat Transfer Fluids

In Ontario, *heat transfer fluids* for closed loop and BTES *earth energy systems* generally contain a mixture of water and antifreeze (usually between 20 and 30 percent antifreeze[40]), corrosion inhibitors and other additives, to enhance thermal conductivity and prevent freezing of the refrigerant. In a direct exchange *earth energy system*, the *heat transfer fluid* is a refrigerant.

Because of the environmental concern over methanol, the Ground Source Heat Pumps Regulation bans the use of methanol as a *heat transfer fluid* in new closed looped *earth energy systems* and those that were constructed, altered, extended or replaced after June 1, 1998. As indicated in Section 2.1, the use of

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[39] Section 1 of Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_120098_e.htm

[40] Technical Information Note titled Safe Operating Procedure for Handling Ethanol published by the Canadian GeoExchange Coalition and Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) CGC-TN-2011-01, April 13 2011, website: http://www.geo-exchange.ca/en/UserAttachments/article76_TN-2011-01_ETHANOL_E_FINAL.pdf

potassium acetate is banned by the CAN/CSA-C448.1-02 and CAN/CSA-C448.2-02 standards due to its corrosive properties. These standards are referenced by the Building Code.

Common *heat transfer fluids* for closed looped and BTES *earth energy systems* that are acceptable under the Ground Source Heat Pump Regulation include denatured ethanol, propylene glycol and ethylene glycol mixed with water. A refrigerant for a direct exchange *earth energy system* is also considered a *heat transfer fluid* under the Ground Source Heat Pump Regulation.

2.5.3 Exceptions and Exemptions from an ECA under the Ground Source Heat Pump Regulation

Ontario Regulation 98/12 establishes that the use, operation, construction, alteration, extension and replacement of an *earth energy system* (i.e., a *ground source heat pump*) are exempted from section 9 of the Environmental Protection Act, except for the following:

1. The use, operation, construction, alteration, extension and replacement of a *ground source heat pump* that uses methanol as a heat-transfer fluid.
2. The construction, alteration, extension and replacement of the portion of a *vertical closed loop ground source heat pump* that extends or will extend more than 5.0 metres below the level of the *original ground surface*[41].

A person is not required to have an *environmental compliance approval* for:

- a closed loop *ground source heat pump* that does not extend or will not extend more than 5 metres below the *original ground surface*. This includes most horizontal closed loop *ground source heat pump*;
- an open loop *ground source heat pump* or a submerged (surface water) closed loop *ground source heat pump*;
- the portion of the *ground source heat pump* heating and cooling system that is found in a building or a structure such as a pool; and
- a closed loop *ground source heat pump* that uses methanol as a *heat transfer fluid* and was installed before January 1, 1998.

2.5.4 Environmental Compliance Approval Requirements

As part of an application for an *environmental compliance approval*, Ontario Regulation 98/12 requires that the applicant submit a *work plan* that is prepared by a licensed engineering practitioner or a professional geoscientist as defined in

[41] Section 2 of Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_120098_e.htm

the regulation. Ontario Regulation 98/12 outlines the Ministry of the Environment's requirements for submission of a proposed *work plan* as part of an application for an ECA.

See the Instructions for Completing an Application for an *Environmental Compliance Approval* (ECA) for *Vertical Closed Loop* Ground Source Heat Pumps (Draft) published by the Ministry of the Environment in June 2012 for further information on applying for an environmental compliance approval for a *vertical closed loop ground source heat pump (i.e. an earth energy system*). The document can be found at the following website: http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2012/011-6520%20ECA%20Instructions.pdf [42].

If *hazardous gas* is encountered during the construction, alteration, extension or replacement of a *vertical closed loop earth energy system*, Ontario Regulation 98/12 requires that the person doing the work shall, immediately and in accordance with any *environmental compliance approval*,

(a) ensure that any space around the underground heat exchanger is *sealed* to prevent any movement of *hazardous gas* between subsurface formations or between a subsurface formation and the ground surface, or otherwise manage the gas in a way that removes any potential hazard; and

(b) *decommission* the *earth energy system* if the measures are not taken or are taken but do not remove all potential hazards [43].

If *hazardous gas* is encountered during the construction, alteration, extension or replacement of a *vertical closed loop ground source heat pump*, Ontario Regulation 98/12 requires that the person doing the work shall immediately give notice of the condition to,

(a) the local fire department;

(b) the occupant of the building served or to be served by the heat pump;

(c) the Ministry's Spills Action Centre;

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[42] Instructions for Completing an Application for an Environmental Compliance Approval (ECA) Vertical Closed Loop Ground Source Heat Pumps. Draft, June 2012, Published by the Ministry of the Environment, website - http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2012/011-6520%20ECA%20Instructions.pdf

[43] Section 2 of Ontario Regulation 98/12 (Ground Source Heat Pumps) made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_120098_e.htm

(d) the clerk of each municipality where the building described in clause (b) is located;

(e) the owner of the land on which the building served by the heat pump; and,

(f) the purchaser of the heat pump.

2.6 Ozone Depleting Substances and Other Halocarbons Regulation

The heat transfer fluid in the exterior loop of some earth energy systems, such as direct exchange (DX) systems, uses a refrigerant that could contain ozone depleting substances or halocarbons. Hydrochlorofluorocarbons (HCFCs) are considered to be class 2 ozone depleting substances and R-407A and R-407C are examples of halocarbons.

To help protect the natural environment from the release of refrigerants, the Ozone Depleting Substances and Other Halocarbons Regulation as amended, made under the Environmental Protection Act[44] applies to refrigerants containing ozone depleting substances or halocarbons.

The regulation defines “refrigerant” and “refrigerant equipment” as follows:

- “refrigerant” means any liquid or gas that is or that contain a class 1 ozone depleting substance, a class 2 ozone depleting substance or a halocarbon and that is used in refrigeration equipment.
- “refrigeration equipment” means an air-conditioning, heat pump, refrigeration or freezer unit, including a motor-vehicle air-conditioner, where that unit is designed to contain, contains or has contained a class 1 ozone depleting substance, a class 2 ozone depleting substance or a halocarbon.

The regulation establishes that no person shall discharge or permit the discharge of refrigerant that is or that contains a class 2 ozone depleting substance or a halocarbon into the natural environment or within a building[45].

If a person discharges or causes or permits the discharge of 100 kilograms or more of refrigerant into the air within a building or into the natural environment, then under the Ozone Depleting Substances and Other Halocarbons Regulation

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[44] Ontario Regulation 463/10 (Ozone Depleting Substances and Other Halocarbons) as amended made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_100463_e.htm

[45] Subsection 19(1) of Regulation 463/10 (Ozone Depleting Substances and Other Halocarbons) as amended made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_100463_e.htm

the person is required to report that discharge to the Ministry of the Environment as soon as reasonably possible after the discharge occurs[46].

Subsection 22(1) of the above noted regulation requires that no person shall service or test refrigeration equipment that contains a refrigerant unless the person is certified under section 34 and,

(a) the person or his or her employer owns equipment that is capable of collecting and capturing the refrigerant; or

(b) the person or his or her employer has a written contract with a person who owns equipment that is capable of collecting and capturing the refrigerant and the contract provides for immediate access to that equipment.

2.7 The Ontario Water Resources Act (OWRA)

The purpose of Ontario Water Resources Act, R.S.O. 1990, c. O. 40[47] is to provide for the conservation, protection and management of Ontario's waters and for their efficient and sustainable use, in order to promote Ontario's long-term environmental, social and economic well-being.

The Ontario Water Resources Act and some of the regulations made under the Act, provide requirements for "wells", for the taking of water, and for the discharging of material directly or indirectly into the environment. Many of these requirements apply to *earth energy systems* that use groundwater or surface water.

2.7.1 General Prohibition

It is an offence under subsection 30(1) of the Ontario Water Resources Act for a person to cause or permit the discharge of any material of any kind into the natural environment that may impair the quality of any waters.

2.7.2 Permit to Take Water

To protect, conserve and manage water resources, the Ministry of the Environment administers and enforces a permit program for the taking of water.

If an open loop or ATES *earth energy system* for a commercial or industrial building is taking water at a volume of more than 50,000 litres on any one day from a well, a mine or a surface water body, then section 34 of the Ontario Water

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[46] Subsection 19(2) of Regulation 463/10 (Ozone Depleting Substances and Other Halocarbons) as amended made under the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_100463_e.htm

[47] Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o40_e.htm

Resources Act requires that a Permit to Take Water[48] be obtained from the Ministry of the Environment as detailed in the Water Taking Regulation[49].

If, during the construction of any *earth energy system*, a person will be dewatering or testing the water at a volume of more than 50,000 litres on any one day, then a Permit to Take Water must first be obtained from the Ministry of the Environment as detailed in the Water Taking Regulation. Groundwater examples include the following:

- If a well, *hole* or trench intersects groundwater and more than 50,000 litres of water in a day is being removed out of the *hole* during the construction process, then the person constructing the well, *hole* or trench must have a valid Permit To Take Water.
- If a person conducts a pumping test on a well to determine the yield of the well or aquifer and the person pumps more than 50,000 litres of water in a day, then the person must have a valid Permit To Take Water.

Also, if a water taking of any amount causes interference with any private or public interest in the water, a Director may prohibit a person from taking the water without a permit issued by the Director[50].

Circumstances where a person could take more than 50,000 litres of water or cause interference with any private or public interest in the water include:

- flowing conditions encountered during the drilling of the *hole*,
- flowing conditions that persist or commence at a later time, such as during operation of the *earth energy system* or after *abandonment*,
- the taking of water from a well that is part of an open loop or ATES *earth energy system* for a commercial or industrial building, or
- groundwater discharges from a *hole* during the construction of a closed loop *earth energy system*.

Where a person has committed an offence under section 34 of the Ontario Water Resources Act, a designated Director or Provincial Officer under the Ontario Water Resources Act may, among other things, order the person taking the water to:

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[48] Section 34 of the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o40_e.htm

[49] Ontario Regulation 387/04 (Water Taking) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_040387_e.htm

[50] Subsection 34(4) of the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o40_e.htm

- stop the taking or discharge and to obtain a Permit To Take Water
- obtain a Permit To Take Water, or
- stop or regulate the taking

If the water taking of an open loop *earth energy system* is for the heating and cooling of an individual household, a person is exempt from the requirement to obtain a Permit to Take Water.

A Permit To Take Water is generally not required for the operation of a closed loop, DX or BTES *earth energy system* used to heat or cool an industrial commercial building because, although *tubing* is installed into the *hole* or surface water body, no water is being taken.

2.7.3 Discharging Water and Sewage Works Approvals

To help protect waters from discharges that may cause impairment, the Ministry of the Environment administers and enforces a sewage works *environmental compliance approval* program.

Pursuant to section 53 of the Ontario Water Resources Act [51], an *environmental compliance approval* under Part II.1 of the Environmental Protection Act[52] is required to use, operate, establish, alter, extend or replace a new or existing open loop *earth energy system* or an ATES *earth energy system,* that discharges directly, or indirectly, into surface water or groundwater. This requirement to obtain a sewage works *environmental compliance approval* also applies to an individual household open loop *earth energy system* or ATES *earth energy system*.

Closed loop or direct exchange *earth energy systems* are not designed to discharge water or other material into the environment, therefore, a sewage works *environmental compliance approval* is not required for the operation of a closed loop or direct exchange earth energy system as these systems are designed to keep the heat tr*ansfer fluid* or refrigerant within the *tubing*.

You may however, require an environmental compliance approval during the construction of a closed loop or direct exchange *earth energy system* if, during this period, water is being discharged directly or indirectly into a ditch, drain or storm sewer or a well, lake, river, pond, spring, stream, reservoir or other water or watercourse.

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[51] Section 53 of the Ontario Water Resources Act, R.S.O. 1990, c. O. 40 E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o40_e.htm

[52] Sections 20.1 to 20.18 of the Environmental Protection Act, R.S.O. 1990, c. E. 19, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90e19_e.htm

2.7.4 "Wells" under the Ontario Water Resources Act

Improperly constructed or poorly maintained wells can act as direct pathways for contaminants to enter groundwater or for mineralized water or gas bearing formations to impair groundwater that could be used for drinking water.

During installation of *earth energy systems*, *holes* are made in the ground. Some of these *holes* may meet the definition of **"**well**"** in the Ontario Water Resources Act[53].

Subsection 1(1) of the Ontario Water Resources Act defines a "well" as:

> "a *hole* made in the ground to locate or to obtain ground water or to test or to obtain information in respect of ground water or an aquifer, and includes a spring around or in which works are made or equipment is installed for collection or transmission of water and that is or is likely to be used as a source of water for human consumption."

The Wells Regulation further defines two types of "wells", the "test hole"[54] and "dewatering well"[55].

> A test hole means a "well" that,
>
> (a) is made to test or to obtain information in respect of groundwater or an aquifer, and
>
> (b) is not used or intended for use as a source of water for agriculture or human consumption;
>
> A dewatering well means a "well" that is not used or intended for use as a source of water for agriculture or human consumption and that is made,
>
> (a) to lower or control the level of groundwater in the area of the well, or
>
> (b) to remove materials that may be in the groundwater;

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[53] Well, subsection 1(1) of the Ontario Water Resources Act, R.S.O. 1990, c. O. 40 E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o40_e.htm

[54] Subsection 1(1) of R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, "test hole", E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900903_e.htm

[55] Subsection 1(1) of R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, "dewatering well", E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900903_e.htm

The determination of whether a *hole* is or is not a "well" is based on the purpose of construction of the *hole*. For example, a *hole* is a "well" if it is made to:

- locate groundwater,
- obtain groundwater, or
- conduct a test on the groundwater in the *hole* or obtain information on groundwater or an aquifer.

When constructing an open loop or aquifer thermal energy storage (ATES) system with vertical *holes*, the person constructing the *hole* should consider the following:

- A *hole* from which groundwater is obtained falls within the definition of a well under the Ontario Water Resources Act.
- If water is discharged from a heat pump back to the same aquifer or another aquifer through another *hole* that was constructed to locate or test ground water, then the second *hole* is also considered to be a "well."

If during the construction of a closed loop, direct exchange, or borehole thermal energy storage (BTES) system a person performs the following activities, then the *hole* will meet the definition of a "well" as defined by the Ontario Water Resources Act:

- Conducts a test on the groundwater in the *hole*. This would include any *hole* that is tested and would eventually be used to hold heat transfer *tubing*. A test on the groundwater would include:
  - measuring a groundwater level in the *hole*,
  - field testing the quality, including tasting and smelling, of the groundwater,
  - obtaining a water sample of the groundwater for laboratory analysis,
  - conducting a short duration pumping test in the *hole,*
  - conducting hydraulic conductivity tests, including rising or falling head tests in the *hole*, or
  - conducting thermal conductivity tests of the groundwater to determine the groundwater's temperature.
- Obtains information on the groundwater or an aquifer intercepted by the *hole*. This would include any *hole* where the person obtains the above information and eventually uses the *hole* to hold heat transfer *tubing*. Obtaining information on the groundwater or an aquifer would include recording the depth of groundwater while drilling.
- Locates and dewaters groundwater for the purposes of lowering the groundwater level in other nearby *holes*. This would include any *hole* that is used to lower the groundwater level and is then used to hold heat transfer *tubing*.

- Locates and uses groundwater in a *hole* that may be used to conduct heat from a *heat transfer fluid* circulating through *tubing* within the *hole*. This would include any vertical or closed loop *earth energy system* installed below the water table in a vertical *hole.*

In a closed loop, direct exchange or BTES earth system, the *hole* is not considered to be a "well" under the Ontario Water Resources Act, if a person creates the *hole* solely to install the loop of heat transfer tubes.

There are other systems and scenarios that are not discussed above. Each scenario needs to be evaluated on its own merits to determine whether or not a *hole* is a "well" as defined in the Ontario Water Resources Act.

A "well", including any well that is part of an *earth energy system*, and is not otherwise exempt, must be constructed by a person who holds a valid well technician licence of the correct class and also holds a valid well contractor licence or who works for the *holder* of a valid well contractor licence. Further guidance is found in Chapter 3 of the Water Supply Wells – Requirements and Best Management Practices manual published by the Ministry of the Environment, December 2009 (Website - http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html).

The person constructing the "well" must meet all of the requirements found in the Wells Regulation such as requirements for well siting and construction.

2.8 Wells Regulation

If a *hole* excavated for an *earth energy system* which meets the definition of "well" under the Ontario Water Resources Act, then the requirements of the Wells Regulation[56] and Wells section of the Ontario Water Resources Act (sections 35 to 51) apply.

The Wells Regulation sets well construction, maintenance, tagging, notification, well record and *abandonment* requirements and imposes well licensing requirements for various well construction activities. These requirements are intended to provide a multiple barrier approach to reduce the risk of a well acting as a pathway for contaminants to migrate along and impair groundwater.

If the *hole* is considered to be a "well" under the Ontario Water Resources Act and the person wishes to use the well for a closed loop or direct exchange *earth*

[56] R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900903_e.htm

energy system, then the well owner must first abandon or *overdrill* the well in accordance with the Wells Regulation[57].

If the *hole* is considered to be a "well" under the Ontario Water Resources Act and:

- mineralized water is encountered, the well owner must immediately abandon the well in accordance with the Wells Regulation, with some exceptions, outlined below [58].
- natural gas is encountered, the well owner must take steps to manage the gas in a way that prevents hazardous gas impacts or immediately abandon the well [59].

The *abandonment* requirement for mineralized water does not apply to some wells such as a test *hole* or dewatering well. In some circumstances, a written consent not to abandon a well may be issued by the Wells Director at the Ministry of the Environment. Further guidance is found in Chapter 14 of the Water Supply Wells – Requirements and Best Management Practices manual published by the Ministry of the Environment, December 2009 (Website - http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html).

Clarification of the Wells Regulation requirements for water supply wells can be found in the Water Supply Wells – Requirements and Best Management Practices manual published by the Ministry of the Environment in December 2009[60].

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[57] Subsection 21(3) and 21.1 of R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900903_e.htm

[58] Subsection 21(4) of R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900903_e.htm

[59] Subsection 21(6) of R.R.O. 1990, Regulation 903 (Wells) as amended made under the Ontario Water Resources Act, R.S.O. 1990, c. O. 40, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900903_e.htm

[60] Water Supply Wells – Requirements and Best Management Practices manual, Ministry of the Environment, December 2009, Publication Number 7333e, http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

2.9 Occupational Health and Safety Act

To protect the health and safety of workers, the installation, repair and maintenance of *earth energy systems* must be done in accordance with the Occupational Health and Safety Act (OHSA)[61], and its applicable regulations. The OHSA is enforced by the Ministry of Labour.

2.10 Fire Protection and Prevention Act

To prevent fires and explosions, the Fire Protection and Prevention Act[62] and the Fire Code[63] as amended, made under this Act also apply to the operation of any *earth energy system* using a flammable *heat transfer fluid*. A flammable *heat transfer fluid* includes an ethanol to water mixture as low as 20% by volume[64].

2.11 Clean Water Act

The Clean Water Act[65] was enacted to protect existing and future sources of drinking water in Ontario. Under this legislation, local source protection committees have completed science based assessment reports identifying areas where sources of drinking water are most vulnerable, and the activities that have the highest potential to impair the quality or quantity of these drinking water sources. Approved assessment reports can be accessed through the following web site: http://www.conservation-ontario.on.ca/source_protection/otherswpregionsindex.htm . Source protection plans, which are approved by the Minister of the Environment, must set out policies to address activities that pose a risk to drinking water.

There are a number of ways that new or existing *earth energy systems* may be considered in source protection assessment reports and affected by source protection plan policies. Specifically, closed loop and direct exchange systems may be identified locally as a threat to the quality of drinking water and they could be considered a transport (preferential) pathway for contamination to a source of drinking water. Transport pathways may affect the vulnerability of the immediate

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[61] Occupational Health and Safety Act, R.S.O. 1990, c O. 1, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o01_e.htm

[62] Fire Protection and Prevention Act, 1997, S.O. 1997, c. 4, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_97f04_e.htm

[63] Ontario Regulation 213/07 (Fire Code) as amended made under the Fire Protection and Prevention Act, 1997, S.O. 1997 c. 4, E-laws - http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_070213_e.htm

[64] http://www.csao.org/UploadFiles/Advisories_Guidelines/Geothermal_systems.pdf

[65] Clean Water Act, 2006, S.O. 2006, C. 22, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_06c22_e.htm

surrounding area, potentially increasing the risk posed by nearby activities. Also, open loop systems that withdraw water from a well may be identified as a risk to water quantity and as a transport pathway for contamination to a source of drinking water.

Earth energy systems that are identified in the local assessment report as posing a significant threat to water quality or quantity may be subject to policies to manage the threat or that prohibit the *earth energy system* from being located in a particular area. If an *earth energy system* is considered a transport pathway, a nearby activity that might otherwise not pose a significant risk to drinking water could be subject to a range of policies to address the activity.

Source protection plan policies may also be included to suggest strategic actions for transport pathways within wellhead protection areas and surface water intake protection zones to ensure the transport pathway will cease to endanger the raw water supply of a drinking water system. For example, if a Source Protection Committee has reason to believe that a restriction on an *earth energy system* is needed to protect source water, then the committee can suggest that a local municipality pass a by-law or planning approval to restrict the location of an *earth energy system*. Municipalities are also empowered to take such actions directly, outside of the source protection planning process. For further information, refer to "Section 2.3 – Green Energy Act" of this technical bulletin.

2.12 Federal Fisheries Act

The federal Fisheries Act[66] may apply to the installation, operation and water takings and discharges related to open loop energy systems using surface water. Surface water takings should adhere to the screening requirements provided by the federal Department of Fisheries and Oceans Freshwater Intake End-of-Pipe Fish Screen Guideline (see http://www.dfo-mpo.gc.ca/library/223669.pdf).

The Fisheries Act may also apply to shoreline works for all *earth energy systems* that have the potential to impact fish or fish habitat. Information on *Fisheries Act* requirements can be obtained from the Fisheries and Oceans Canada (DFO) web page: http://www.dfo-mpo.gc.ca/habitat

[66] Fisheries Act (R.S.C., 1985, c. F-14), as amended, http://laws-lois.justice.gc.ca/eng/acts/F-14/

2.13 Public Lands Act and other Legislation Relevant to Surface Water

Authorizations (work permits) and tenure (land use occupational authority) under the Public Lands Act[67] may be required for the installation of an *earth energy system* on the bed, or below the bed, of a Crown owned lake, river or stream.

In some scenarios, work permits and tenure are not required for activities that may be associated with the installation of an *earth energy system*.

Tenure is not required for:

- Thermal lake loops (heat loops) located (placed on the surface of the lake bed) in front of the owner's property (PL 3.03.01 Free Use Policy).

A work permit is not required for:

- Dredging that is undertaken for the installation of service cables, heat loops or water intakes for use by private residences (PLA O. Reg. 453/96).

Approval under the Lakes and Rivers Improvements Act (LRIA)[68] may be required from the Ministry of Natural Resources for commercial and industrial *earth energy systems* if the installation involves damming, forwarding or diverting water in an area outside the jurisdiction of a conservation authority (LRIA). (LRIA approval is also required from MNR to construct or decommission a dam that holds back water in a river, lake, pond or stream to raise the water level, create a reservoir to control flooding or divert water).

Please consult with the local MNR district office to determine what authorizations or tenure requirements may apply to a specific project. Note that this is not an exhaustive list of legislation and regulations administered by MNR that may apply.

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[67] Public Lands Act, R.S.O. 1990, c. P. 43, http://www.e-laws.gov.on.ca/Download?dDocName=elaws_statutes_90p43_e

[68] Lakes and Rivers Improvement Act, R.S.O. 1990, c. L. 3, http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90103_e.htm

2.14 Conservation Authorities Act

Under the Conservation Authorities Act[69], conservation authorities regulate development through a permitting process in areas related to or prone to water related hazards within the conservation authority's jurisdiction, for purposes of public safety, natural hazard prevention and management. A conservation authority may grant or deny permission, or grant permission with conditions for development as defined under the Act where it deems that the control of flooding, erosion, dynamic beaches, pollution or the conservation of land is not affected. Under Section 28 of the Conservation Authorities Act, conservation authorities also regulate activities that may change or interfere in any way with the existing channel of a watercourse or change or interfere in any way with a wetland. The regulated areas include hazardous lands such as unstable soils (Leda clay, organic soils) and unstable bedrock (karst), wetlands, areas adjacent to wetlands, shorelines and areas susceptible to flooding and associated allowances, i.e. areas adjacent or close to the shoreline of the Great Lakes-St. Lawrence River System, connecting channels or to inland lakes, river or stream valleys, (including valleylands) and watercourses as defined under the Act.

Before installing an *earth energy system* in a river or stream valley, a watercourse, a wetland, Great Lakes or a lake shoreline or in hazardous lands within conservation authority jurisdiction, you should check with the local conservation authority to determine if a permit is required under section 28 of the Conservation Authorities Act.

To find out what legislative and regulatory requirements may apply, prior to doing work in or on the bed of a water body or near or adjacent to a shoreline or shorelands area, check with the local Ministry of Natural Resources District Office, or local conservation authority. See the end of this technical bulletin (Section 4.0) for contact information.

[69] Conservation Authorities Act, R.S.O. 1990, c. C. 27, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90c27_e.htm

2.15 The Oil, Gas and Salt Resources Act

Under subsection 1(1) of the Oil, Gas and Salt Resources Act [70] a "well" means:

> a *hole* in the ground, whether completely drilled or in the process of being drilled, for the purpose of,
>
> (a) the production of oil, gas or formation water, including the production of coal bed methane but excluding the production of fresh water,
>
> (b) the injection, storage and withdrawal of oil, gas, other hydrocarbons or other approved substances in an underground geological formation,
>
> (c) the disposal of oil field fluid in an underground geological formation,
>
> (d) solution mining, or
>
> (e) geological evaluation or testing rocks of Cambrian or more recent age.

Holes drilled into Paleozoic bedrock to collect geological information as required by CAN/CSA-C448.1-02, *Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings* may be considered a "well" under the Oil, Gas and Salt Resources Act. Where a *hole* is considered a "well" under the Oil, Gas and Salt Resources Act, the person constructing the well must obtain a well licence under the Act.

Persons installing *earth energy systems* should consult with the Petroleum Resources Centre of the Ministry of Natural Resources located in London, Ontario, telephone: 519-873-4634 or website: http://www.mnr.gov.on.ca/en/ContactUs/index.html for further information before construction of the system commences.

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[70] Oil, Gas and Salt Resources Act, R.S.O., 1990 c. P. 12, E-laws: http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90p12_e.htm

2.16 Other Provincial Legislation

Certain installation and maintenance work pertaining to or associated with *earth energy systems* may be subject to additional legislative and regulatory controls. Other requirements may include, but are not limited to:

- Permit and inspection requirements under the Electricity Act, 1998, S.O. 1998. c. 15, Schedule A;
- Planning decisions including the supply, efficient use and conservation and protection of ecosystems under Planning Act, R.S.O. 1990, c. P. 13; and,
- Permit requirements under Dangerous Goods Transportation Act, R.S.O. 1990, c. D. 1

3.0 Recognizing and Minimizing Risks

There are potential environmental risks associated with *earth energy systems*. Some of these risks could include fluid and gas migration of fluids, gas and other contaminants along *preferential pathways*; erosion and contamination by discharge water; and possible adverse effects of temperature imbalances. The legislative and regulatory requirements outlined in section 2 of this bulletin help to protect against environmental risks posed by *earth energy systems*. Additional information is provided in this section to assist people in recognizing environmental risks and to help further protect the environment and the health and safety of Ontarians.

3.1 Vertical Holes

The discussion in this section applies to all vertical *holes*, including open loop, closed loop, direct exchange, and angled (or inclined) *holes*.

Many *earth energy systems* have vertical or angled *holes* that could allow direct access from the ground surface to groundwater resources used for drinking water. There is the potential for a *hole* used in the loop of an *earth energy system* to act as a "preferential flow pathway" for contaminants, natural gas, mineralized water and other foreign materials to move between groundwater zones or between the ground surface and the groundwater. Transport along *preferential pathways* can result from improper siting, construction, maintenance or *abandonment* of *holes* that intersect one or multiple aquifers and other subsurface formations.

3.1.1 Siting Vertical Holes

Siting an *earth energy system* near a source of contamination increases the risk of the contaminant moving along a *hole* and potentially impairing groundwater, surface water or drinking water wells. Siting considerations including minimum setback distances from contamination sources, property boundaries, buildings, other *earth energy systems*, drinking water wells and surface water bodies:

- if applicable, must meet the minimum legal requirements such as the Wells Regulation and
- if no legal requirements exist, should be set according to advice from a professional geoscientist[71] or professional engineer[72]. As a sound practice, the professional geoscientist or professional engineer should

[71] Professional geoscientist registered under the Professional Geoscientist Act, R.S.O. 1990, c. P.28, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_00p13_e.htm

[72] Professional engineer licensed under the Professional Engineers Act, 2000, S.O. 2000, c. 13, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90p28_e.htm

consider the minimum siting requirements found in Chapter 4 of the Water Supply Wells – Requirements and Best Management Practices Manual published by the Ministry of the Environment, December 2009[73].

3.1.2 Constructing Vertical Holes

Earth energy systems that use vertical or inclined *holes* can extend deeper than most drilled water wells.

Groundwater in *sedimentary bedrocks* is frequently salty or sulphurous, particularly at greater depths. Oil and gas deposits also reside within these rocks. In some circumstances, oil and gas have migrated into the overlying *overburden*. Mineralized water, gas and oil can migrate along open *holes* associated with an *earth energy system* and impair other fresh groundwater zones.

Artesian flow of water onto the ground surface is difficult to control and can result when zones where groundwater is under pressure are encountered in *overburden* or bedrock formations. Uncontrolled flow from a well or from a *hole* that is constructed for a *vertical closed loop earth energy system* can cause flooding problems or sink holes.

Open loop systems such as a *standing column well* system or a system with an intake well and a discharge well, each located in a different aquifer, provide pathways for rapid groundwater movement between aquifers and in this way pose a risk of environmental impairment.

The requirements in the Wells Regulation and Building Code Regulation address some concerns associated with drilling *holes* (see section 2 of this technical bulletin for further information on the Wells Regulation).

Also, as mentioned earlier, the Ground Source Heat Pumps Regulation (Ontario Regulation 98/12) provides specific requirements for *vertical closed loop* geothermal systems to address concerns about encountering *hazardous gas* in drilled *holes*. This section addresses other risks, not covered in Ontario Regulation 98/12.

A licensed engineering practitioner[74] or professional geoscientist[75] should be retained by the *earth energy system* owner or installer to identify and address

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[73] Water Supply Wells – Requirements and Best Management Practices manual, Ministry of the Environment, December 2009, Publication Number 7333e, http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

[74] Professional engineer licensed under the Professional Engineers Act, 2000, S.O. 2000, c. 13, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90p28_e.htm

[75] Professional geoscientist registered under the Professional Geoscientist Act, R.S.O. 1990, c. P.28, E-laws - http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_00p13_e.htm

concerns associated with the drilling of the *holes* such as uncontrolled flowing water conditions. The licensed engineering practitioner or professional geoscientist should design and provide oversight on construction of deeper *holes* especially when drilling into *sedimentary bedrock* of Cambrian age or younger in southern Ontario or artesian aquifers that can cause uncontrolled water flow from wells and other *holes*. Persons designing *earth energy systems* should study:

1. the local geology including well records from the Ministry of the Environment,
2. oil and gas well records and other information found in the Oil, Gas and Salt Resources Library of the Ministry of Natural Resources,
3. Assessment Reports prepared under the Clean Water Act, and
4. area hydrogeological reports to determine the likelihood of encountering oil, gas or mineralized water at proposed drilling depths when drilling into bedrock formations.

Earth energy system designers should consider the following:

- If oil is expected to be encountered, design and construct each *hole* to the requirements of the Oil, Gas and Salt Resources Act and its regulations and standards, as a minimum, including the use of blow-out prevention or gas *diversion equipment*.
- The guidance for constructing wells in Chapter 12 of the Water Supply Wells – Requirements and Best Management Practices manual published by the Ministry of the Environment, December 2009[76] at locations where artesian head elevation is potentially above ground surface and water may flow at surface.
- CAN/CSA-C448.3-02 standard, Design and Installation of Underground Thermal Energy Storage Systems for Commercial and Institutional Buildings for designing ATES and BTES earth energy systems.

Persons constructing *holes* or installing equipment should be trained, experienced, equipped and, if necessary, licensed to use the equipment and materials for installing an earth energy system in a specific environment. For example, if a person is constructing *holes* in artesian aquifers that could cause uncontrolled flows at surface, the person:

- should have past experience in stopping the flow of water from the *holes*,

[76] Water Supply Wells – Requirements and Best Management Practices manual, Ministry of the Environment, December 2009, Publication Number 7333e, http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

- must, where the *hole* is a well as defined under the Ontario Water Resources Act, hold a valid well technician licence of the appropriate class, and
- must, where the *hole* is a well as defined under the Ontario Water Resources Act, hold or work for the *holder* of a valid well contractor licence.

If contamination, such as a hazardous waste, is encountered during the construction of a *hole* associated with an earth energy system, the person constructing the *hole* should stop work immediately to reduce serious dangers to the site crew, well owner and the environment. If the *hole* is a "well" as defined in the Ontario Water Resources Act and to meet the obligation of reporting natural gas to the Director, the person constructing the well can contact the Ministry of the Environment through the Ministry's Spills Action Centre (SAC) at 1-800-268-6060. The SAC is available to take calls 24 hours a day, every day of the year.

Depending on circumstance, the Ministry of the Environment can offer assistance and notify other interested agencies to help reduce dangers to the site crew, well owner and the environment.

After *heat transfer fluid tubing* is installed in a *hole* for a closed loop, direct exchange or BTES system, a material is usually placed in the *hole* to fill the remaining void space. In order for the earth energy system to function, the material needs to conduct the heat between the *heat transfer fluid* located within the *tubing* and the earth.

In many older systems and some new systems, some or all of the material used in the void space of the vertical *hole* is sand, gravel or drill cuttings. In some other cases, the void space is left unfilled to allow groundwater to be used for thermal convection. For all of these systems, the vertical *holes* are preferential flow pathways along which fluid and gas may migrate and pose an environmental risk.

The void space in each *hole* that is part of an earth energy system should be *sealed* at the time of construction with a material than can stop the vertical migration of fluids or gases while offering the best heat transfer. Placement of a sealing material in the entire void space in the *hole* at the time of initial construction can also help the owner significantly reduce the cost of properly sealing the *hole* at the time of *decommissioning* (i.e. proper *abandonment*). The most common sealing products are bentonite (manufactured swelling clay) and cement. Each product has different properties. Sealing materials and the water that is mixed with those materials must not impair the quality of the groundwater. Site conditions and system design should be carefully considered when choosing a sealant. For example, some manufacturers and installers of systems require:

- The use of a specialized heat resistant cement to reduce shrinkage cracks from thermal changes.

- The use of a sulphate resistant cement if hydrogen sulphide gas or sulphur water is present.
- The use of product other than bentonite if uncontrolled flows at surface or elevated salty water are present.

Some general bentonite or cement advantages and disadvantages are found in Table 6-2 of Chapter 6 of the "Water Supply Wells – Requirements and Best Management Practices manual" published by the Ministry of the Environment, December 2009[77]. Other practical information on cement is found in section 3 of the *Provincial Operating Standards*, Version 2.0, 2002 published by the Ministry of Natural Resources – website http://www.ogsrlibrary.com/documents/Provincial_Operating_Standards_v2_Jan_24_2002.pdf.

In closed loop, direct exchange, and BTES systems using vertical *holes*, the *hole* diameter is typically 10.2 centimetres or smaller. Spacers are used between the U-loop *tubing*. The small diameter *holes* and spacers allow the *heat transfer fluid tubing* to increase conductivity between the earth and the *heat transfer fluid*. The use of spacers also avoids *tubing* overlap and consequent *thermal interference*. The lack of a sealant between the pipe and side of the *hole*, however, increases the risk of the *hole* acting as a pathway for contaminants. To reduce the risk of the *hole* acting as a pathway, a person should consider:

- Lining and sealing the *hole* with a steel, plastic or geo-textile *casing* and sealant, and
- If the *tubing* is rigid enough, then attaching spacers and *centralizer*s to the pipes or tubes that prevent the pipes or tubes from touching the walls of the *hole*, and
- Using a bottom up placement technique such as pressure grouting, place a proper sealant for the environment into the void space of the *hole*.

[77] Water Supply Wells – Requirements and Best Management Practices manual, Ministry of the Environment, December 2009, Publication Number 7333e, http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

3.2 Surface Water

Often, a near shore[78] excavation is made to bury the pipe connection between the heat pump and the coil submerged in a surface water body. In addition to obtaining work permits and other approvals outlined in section 2.0 of the technical bulletin, steps must be taken to ensure that tubes from closed loop *earth energy systems* or waterlines from open loop systems will not impact fish and fish habitat. Things to consider include (but are not limited to) the use of an appropriate *heat transfer fluid*, use of appropriate trenching methods and location (e.g. limiting to near shore areas), avoidance of known fish spawning habitat, avoidance of areas where there are strong currents, dredging activities, or areas commonly used by fishermen or boaters that may drop anchor.

In order to prevent a violation of the federal *Fisheries Act,* contact should be made with the local conservation authority, or the Department of Fisheries and Oceans office in the area. Parks Canada should also be contacted if the project is located within its jurisdiction (including the Trent Severn Waterway and the Rideau Canal).

3.3 Heat Transfer Fluid including Refrigerant

Depending on the type of antifreeze and site-specific environmental conditions, a *heat transfer fluid* from an earth energy system may cause an adverse effect to the natural environment, impairment to groundwater or surface water, damage to property and a safety risk (e.g. fire) to owners, operators and workers if the *tubing* ruptures. Examples include:

- Ethanol (denatured ethanol) is flammable, corrosive, a health hazard and can have a potential environmental risk.
- Ethylene glycol and propylene glycol have potential to be an environmental risk to surface water bodies and groundwater.
- Additives to *heat transfer fluids* can include biocides, anti-corrosives, flow enhancers, and machine oil (to lubricate the pump) may degrade the environment.

Refrigerants commonly used in DX systems include R-410A and R-407C.

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[78] The definition of “near shore” depends on the surface water system (e.g. inland lake or Great Lake). For example, the Environmental Monitoring and Reporting Branch of the Ontario Ministry of the Environment uses depth contours to delineate “near shore” areas, with Lake Simcoe near shore being areas < 15 m in depth. Other definitions of “nearshore” can be found in the report titled “Nearshore Area of the Great Lakes 2009”, authored by Environment Canada and the US Environmental Protection Agency (http://binational.net/solec/sogl2009/SOGL_2009_nearshore_en.pdf)

Copper piping is commonly used for DX systems. In corrosive environments and in the vicinity of the water table, copper piping without *cathodic protection* may crack or corrode and allow for an uncontrolled discharge of refrigerant. If used in closed loop systems, lower density polyethylene *tubing* also has an increased risk of degradation and cracking.

In addition to meeting all of the legislative and regulatory requirements outlined in Section 2 the following should be considered to help reduce the risk of leaks, or other releases of these substances:

- that all persons installing *tubing* for closed loop, DX BTES *earth energy systems*, at a minimum, ensure the *tubing* meets the CAN/CSA C448-02 standard including pressure testing at key points during the installation.
- that all persons be properly trained to install, maintain and repair *earth energy systems* and if using ethanol, they follow the information found in:
    - The Health and Safety Advisory, Geothermal Systems: Ethanol and Ethanol/Water Mixtures, published by the Infrastructure Health and Safety Association and Developed in Association with the Ontario Ministry of Labour, website: http://www.csao.org/UploadFiles/Advisories_Guidelines/Geothermal_systems.pdf[79].
    - The Technical Information Note titled Safe Operating Procedure for Handling Ethanol published by the Canadian GeoExchange Coalition and Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI), website: http://www.geo-exchange.ca/en/UserAttachments/article76_TN-2011-01_ETHANOL_E_FINAL.pdf. [80]

[79] Health and Safety Advisory, Geothermal Systems: Ethanol and ethanol/water Mixtures, Published by the Infrastructure Health and Safety Association and Developed in Association with the Ontario Ministry of Labour, December 2010, website - http://www.csao.org/UploadFiles/Advisories_Guidelines/Geothermal_systems.pdf. Also note the alert a similar alert at the Heating, Refrigeration and Air Conditioning Institute of Canada - http://www.hrai.ca/memberalert.html

[80] Technical Information Note titled Safe Operating Procedure for Handling Ethanol published by the Canadian GeoExchange Coalition and Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) CGC-TN-2011-01, April 13 2011, website: http://www.geo-exchange.ca/en/UserAttachments/article76_TN-2011-01_ETHANOL_E_FINAL.pdf

3.4 Properly Decommissioning an Earth Energy System

Under the Ground Source Heat Pumps Regulation, there are regulatory requirements for *decommissioning* a *vertical closed loop* earth energy system when "*hazardous gas*" is encountered.

Also, the person abandoning a "well" for an open loop system must meet the plugging and sealing requirements prescribed in sections 21 and 21.1 of the Wells Regulation.

In addition to the above requirements in this section, if an earth energy system is not being used or maintained for future use, then the owner should consider the following actions in this section of the technical bulletin.

Proper *decommissioning* of an earth energy system mitigates potential hazards and helps to protect the environment from potential contaminant migration along *preferential pathways* and from discharges of *heat transfer fluid*. With abandoned systems involving vertical *holes*, both the loop piping and the *holes* can act as *preferential pathways* for the migration of contaminants if not properly *decommissioned*.

Detailed documentation of the original installation is helpful in determining the best course of action to properly *decommission* an earth energy system including removing the *heat transfer fluid* and plugging the earth energy system. Annex A of the CAN/CSA-C448-02 suggests the design documentation, including the type of *heat transfer fluid* being used, be provided to the owner of the system.

Vertical *holes* in some systems may intersect oil, mineralized groundwater or flowing conditions.

To reduce the risk of oil, mineralized water or flowing groundwater problems, an owner should retain a professional engineer or professional geoscientist experienced in hydrogeology, *earth energy systems* and, where warranted, petroleum resources before proceeding with the *decommissioning* of an earth energy system.

The retained professional engineer or professional geoscientist should conduct a geological study of the area before *decommissioning* commences.

The retained professional engineer or professional geoscientist should design the *decommissioning* of an earth energy system, which may include the drilling out of the *tubing* and then filling of these *holes*, based on the information obtained from the study and the minimum standards and requirements found in:

- Oil, Gas and Salt Resources Act, R.S.O. 1990, c. P. 12, its regulations and its standards.
- Oil, Gas and Salt Resources Act, *Provincial Operating Standards*, Version 2.0, 2002 published by the Ministry of Natural Resources

http://www.ogsrlibrary.com/documents/Provincial_Operating_Standards_v2_Jan_24_2002.pdf including the use of blow-out prevention and gas *diversion equipment* and a cement *grout* that is resistant to the formation and is resistant to heat.

- The Wells Regulation and Chapter 15 of the Water Supply Wells – Requirements and Best Management Practices Manual published by the Ministry of the Environment, December 2009.
- Annex A (Informative) of the CAN/CSA-C448.1-02, Design and Installation of Earth Energy Systems for Commercial and Institutional Buildings Design and Installation of Earth Energy Systems, CAN/CSA C448 Series-02, A National Standard of Canada, originally published February 2002, reprinted October 2009, prepared by Canadian Standards Association, ISBN 1-55324-844-9. Annex A provides additional environmental guidelines to reduce potential environmental risks associated with earth energy systems.

The retained professional engineer or professional geoscientist should, if necessary, determine the type of drilling fluids with additives that need to be used during the re-drilling of the *tubing* to counterbalance formation pressure to prevent water from entering the *hole* prematurely.

The person *decommissioning* the earth energy system should have the experience and training to deal with any identified contamination, flowing water and, if necessary, with *hazardous gas* to the standards set out in Oil, Gas and Salt Resources Act, R.S.O. 1990, c. P. 12, its regulations and its Provincial Operating Standard.

The person *decommissioning* the earth energy system should implement the design of the professional engineer or professional geoscientist and works under the supervision of the professional engineer or geoscientist.

If the system uses a *heat transfer fluid*, experienced professionals should carefully remove, store and then dispose of the *heat transfer fluid* in accordance with the requirements of the Environmental Protection Act and its regulations[81].

If an earth energy system includes any wells as defined in the Ontario Water Resources Act, the Wells Regulation sets out certain times or events when a well, as defined in the Ontario Water Resources Act, must be properly abandoned. Chapter 14 of the Water Supply Wells – Requirements and Best

[81] Ontario Regulation 347 (General – Waste Management) as amended made under the Environmental Protection Act, R.S.O. 1990, c. E. 19 and Ontario Regulation 463/10 (Ozone Depleting Substances and Other Halocarbons) as amended made under the Environmental Protection Act, R.S.O. 1990, c. E. 19

Management Practices Manual published by the Ministry of the Environment, December 2009[82] provides information on when a well must be abandoned.

Chapter 15 of the Water Supply Wells – Requirements and Best Management Practices Manual published by the Ministry of the Environment, December 2009[83] provides information on plugging and sealing wells to protect aquifers. The information and best management practices in Chapter 15 provide useful guidance to seal wells that are part of a properly abandoned earth energy system.

[82] Chapter 14, Water Supply Wells – Requirements and Best Management Practices manual, Ministry of the Environment, December 2009, Publication Number 7333e, http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

[83] Chapter 15, Water Supply Wells – Requirements and Best Management Practices manual, Ministry of the Environment, December 2009, Publication Number 7333e, http://www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

4.0 Additional Sources of Information and Links

A copy of the various legislation and regulations can be obtained from the E-Laws website at www.e-laws.gov.on.ca.

A copy of the *Water Supply Wells – Requirements and Best Management Practices* manual can be obtained from the Ministry of the Environment's web site at www.ene.gov.on.ca/environment/en/resources/STD01_078655.html

The publications are also available by calling the Ministry of the Environment's Public Information Centre at 1-800-565-4923 or (416) 325-4000.

A directory of licensed well contractors is available at http://www/waterwellontario.ca.

For further information about *earth energy systems*, source water protection and spills the nearest Ministry of the Environment office listed in the blue pages of the telephone directory can be contacted. General information is also available at the Ministry of the Environment's Public Information Centre at 1-800-565-4923 or (416) 325-4000. The Ministry of the Environment's website is at http://www.ene.gov.on.ca.

A copy of the CAN/CSA-C448 Series 02 titled Design and Installation of Earth Energy Systems can be ordered through the Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario L4W 5N6, telephone 1-800-463-6727, website http://www.csa.ca.

A copy of the Supplementary Standard SA-1 is found in Volume 2 of the 2006 Building Code Compendium. A copy of the 2006 Building Code Compendium, Published by the Ministry of Municipal Affairs and Housing, Publication Number 510097 can be ordered through Service Ontario at http://www.ontario.ca/en/residents/index.htm.

For further information about Trades regulation and requirements can be obtained from the Ministry of Training, Colleges and Universities, Programs Branch, at 416-314-4350 or 416-212-9255.

Information about the Ontario College of Trades and *the Ontario College of Trades and Apprenticeship Act, 2009*, can be obtained from their website: http://www.collegeoftrades.ca/.

More information on Permits to Take Water can be found at:
http://www.ene.gov.on.ca/environment/en/industry/assessment_and_approvals/water_taking/STDPROD_075554

A guide explaining the sewage works process is available at:
http://www.ene.gov.on.ca/envision/gp/4063e.htm.

Information on Ontario Regulation 98/12 (Ground Source Heat Pumps) and applying for an environmental compliance approval for construction of a vertical ground source earth energy system can be found at:
http://www.ontariocanada.com/registry/view.do?postingId=9527&language=en

Oil and gas well records are available from the Oil, Gas and Salt Resources Library, Ministry of Natural Resources, 669 Exeter Road, London, ON, N6E 1L3 or (519) 686-2772, http://www.ogsrlibrary.com.

Contact information for Ministry of Natural Resources Regional Offices can be found at:
http://www.mnr.gov.on.ca/en/ContactUs/2ColumnSubPage/STEL02_179002.html

Local conservation authority contact information can be found at:

http://www.conservation-ontario.on.ca/find/index.html.

Contact information for Department of Fisheries and Oceans Regional Offices can be found at:

http://www.dfo-mpo.gc.ca/regions/central/habitat/os-eo/provinces-territories-territoires/on/os-eo-dfo-mpo-eng.htm.

GLOSSARY

The following definitions and clarifications of technical terms in the text of the technical bulletin are provided in this section, and are for the purpose of and use with this document.

"*abandonment*" means the circumstances and timeframes in which any part of an open loop earth energy system that is a "well" as defined in the Ontario Water Resources Act must be abandoned and the requirements to be complied with when abandoning a well.

Well *abandonment* and the activities associated with well *abandonment* are separate from "constructing a well" or "well construction activities." (also see "*decommission*")

"*annular space*" means an open space between a *casing* and the side of a *hole* and includes:

- the space between two different *casing*s, and
- any void space after the heat transfer *tubing* has been placed into a *hole*.

"*casing(s)*" means metallic or non-metallic pipe placed in the *hole* for the purpose of supporting the sides of the *hole* and to act as a barrier preventing subsurface migration of a fluid or gas out of or into the *hole*, but does not include a "well" screen or "heat transfer *tubing*". (modified from Provincial Operating Standard)

"*cathodic protection*" means an electro-chemical, anti-corrosion technique for protection of metal structures such as copper *tubing* (in a DX system) or well casings, whereby weak electric currents are set up to offset the current associated with metal corrosion. (modified from Provincial Operating Standard)

"*centralizer*" means a *tubing* or *casing* accessory installed on the outside of a "*tubing*" or "casing" string to center the "*tubing*" or "*casing*" string inside the *hole* or outer "casing". (modified from Provincial Operating Standard)

"*decommission*", also "decommissioning" and "decommissioned", with respect to an earth energy system includes the permanent removal and sealing of an earth energy system including any *holes*, when it is taken permanently out of service. (also see "*abandonment*")

"*diversion equipment*" means equipment used to properly vent, disperse, flare or otherwise manage gas in a safe manner at or above the ground surface.

"*earth energy system*" means a heating and cooling system for buildings or structures that uses a fluid to exchange heat with the ground or water. An *earth energy system* is also referred to as low temperature geothermal system or *ground source heat pump*. *Earth energy systems* should not be confused with high temperature geothermal systems (over 50 degrees Celsius) that obtain heat from deep within the earth to produce heat.

"*environmental compliance approval*" (ECA) means an approval issued under Part II.1 of the Environmental Protection Act and includes a certificate of approval or provisional certificate of approval issued under section 9 or 39 of the Environmental Protection Act before October 31, 2011 and an approval granted under section 53 of the Ontario Water Resources Act before October 31, 2011.

"*formation*" means a body of rock or *overburden* characterized by a degree of homogeneous lithology that forms an identifiable geologic unit that can be mapped on the earth's surface or is traceable in the subsurface. A *formation* can include an aquifer.

"*ground source heat pump*" means an *earth energy system* that is designed to heat and cool a building or structure by using a heat-transfer fluid to exchange heat with the ground or ground water.

"*grout*", in the context of an *earth energy system*, means a low permeable material used to create a permanent seal throughout specific parts of a *hole* (see "Sealant" in this glossary)

"*hazardous gas*" means a gas or mixture of gases that,

(a) contains hydrocarbons (including methane), hydrogen sulphide or both,

(b) originates from the natural environment, and

(c) is present in an atmospheric concentration that may be explosive or flammable, may cause asphyxia or is otherwise hazardous; (section 1 of the Ontario Regulation 98/12)

"*heat transfer fluid*" means a liquid consisting of:

- in an open loop system, groundwater or surface water
- in a closed loop system, water and antifreeze agents and includes chemical inhibitors.
- In a direct exchange (DX) system, a refrigerant and includes chemical inhibitors.

"*holder*" when used in reference to a licence, permit or approval, means a person who is bound by the licence, permit or approval (subsection 1(1) of the Ontario Water Resources Act and Environmental Protection Act)

"horizontal closed loop earth energy system" is a type of closed loop *earth energy system* where the *tubing* is often installed into horizontal trenches that are typically excavated to a depth of 1 to 2.5 m depth below the ground surface.

"*hole*" includes a vertical or diagonal *hole* made in the ground for the:

- purposes of installing a "well" as defined in the Ontario Water Resources Act as part of an open loop *earth energy system* or
- sole purpose of installing *heat transfer fluid tubing* as part of a closed loop or direct exchange *earth energy system*

"*original ground surface*" means the surface of the ground at the *earth energy system* site immediately prior to the time the system construction, alteration, extension or *abandonment* activities take place. (modified from Chapter 2: Definitions and Clarifications of the Water Supply Wells – Requirements and Best Management Practices)

"*overdrill*" means re-drilling an existing *earth energy system hole* using a drill bit that is larger than the diameter of the existing system *tubing*, *casing* or *hole*. The drilling operation reams (or rips) out the existing materials in the *hole* including *tubing*, *casing* and annular seal. The technique is typically used to remove and install a deeper or replacement system and is also used to plug and seal system as part of *abandonment* or *decommissioning*.

"*overburden*" means loose or unconsolidated material overlying competent bedrock (modified from the Wells Regulation)

"*preferential pathway*" means any part of an exterior loop of an *earth energy system* which allows for an increased movement of a fluid including water or gas between subsurface *formations* or between a subsurface *formation* and the ground surface.

"*Provincial Operating Standards*" means the standards set out in "Oil, Gas and Salt Resources of Ontario Operating Standards", published by the Ministry [of Natural Resources], as amended from time to time". – website http://www.ogsrlibrary.com/documents/Provincial_Operating_Standards_v2_Jan_24_2002.pdf

“*sealed*” means, in relation to filling the void space or *annular space* in a *hole* for an *earth energy system*, a *grout* material such as a mixture of cement or bentonite that is used to prevent any movement of fluid or gas.

“sedimentary bedrock” for the purposes of this technical bulletin means *sedimentary bedrock* of Cambrian age or younger.

“*standing column well*” is a type of open-loop *earth energy system* where groundwater is taken from the deep zone in the well, circulates through a heat pump and discharges into the upper portion of the same well. (see section 1.1 of this technical bulletin for further information)

“*submerged earth energy system*” means a surface water closed loop *earth energy system* that exchanges heat below the surface of a water body (see section 1.2.3 for further information).

“surface *casing*” means a string of pipe or *casing* installed from the ground surface into the *hole* and the *annular space* is completely *sealed* with cement along the *casing*’s entire length. (*Provincial Operating Standards*)

“*thermal interference*” means a change in ambient temperature of groundwater or the earth *formations* that may cause an adverse effect on neighbouring properties (including other *earth energy systems* or groundwater users) as a result of the operation of an open or closed loop *earth energy system*.

“*tubing*” for the purposes of this document means the continuous, *sealed*, *tubing* that makes up an exterior loop of a closed loop or direct exchange earth energy through which a heat-transfer fluid passes. For most closed loop systems, the *tubing* is constructed of high density polyethylene (HDPE). For direct exchange, (DX) systems the *tubing* it is typically constructed of copper.

”*vertical closed loop earth energy system*” is a type of closed loop system where a U-shaped loop of *tubing* is installed into *holes* which may be vertical or inclined (also referred to as angled *holes*) (see section 1.2 of this technical bulletin for further information). It also means a “*vertical closed loop ground source heat pump*” as described in the Ground Source Heat Pump Regulation (Ontario Regulation 98/12).

“*work plan*” means a *work plan* developed, in accordance with Ontario Regulation 98/12 as part of an application for an *environmental compliance approval* and the

work plan approved as part of an *environmental compliance approval* and implemented as part of that *environmental compliance approval*.

Capitalized initials used in the text and symbols of this technical bulletin are defined as follows:

ATES:	Aquifer Thermal Energy Storage
BTES:	Borehole Thermal Energy Storage
CGC:	Canadian GeoExchange Coalition
CSA:	Canadian Standards Association
DX:	Direct Exchange
EES:	Earth Energy System
HDPE:	High Density PolyEthylene
HFC:	Hydroflourocarbons
HVAC:	Heating, Ventilating, and Air Conditioning
OWRA:	Ontario Water Resources Act, R.S.O. 1990, c. O. 40
MOE:	Ministry of the Environment
MNR:	Ministry of Natural Resources
OHSA:	Occupational Health and Safety Act
UTES:	Underground Thermal Energy Storage

TABLE 1

Table 1 is a three part table designed to provide Ontario's Environmental legislative framework for *earth energy system* outside heat exchange loops

Notes for Table 1:

(a) Enforced by the local municipality. A designer can choose to follow the prescriptive requirements of the Building Code Regulation (i.e. the relevant CAN/CSA 448-02 standard) or propose an alternative design which meets the objectives and functional statements as stated in the Supplementary Standard SA-1 of the Building Code Regulation.

(b) Enforced by Ministry of the Environment

(c) For cases where a person may dewater or divert water during construction or encounters water flowing, under artesian head, at ground surface. Also this applies for cases where unexpected flowing conditions are encountered unless Ministry of the Environment uses other regulatory tools.

(d) Systems operational prior to June 1, 1998, that continue to use methanol as a *heat transfer fluid*, would require approval.

(e) An installer of a closed loop *earth energy system* that extends or will extend more than 5.0 metres below the *original ground surface* requires an *environmental compliance approval*. Due to its shallow depth, the *environmental compliance approval* will not apply to *horizontal closed loop earth energy systems* in most cases.

Table 1 does not cover all system scenarios such as shallow horizontal excavation open loop systems. This table is intended to capture major environmental approvals, but does not capture all other requirements - for instance the Occupational Health and Safety Act.

Refer to this technical bulletin or E-laws for the actual wording of the applicable legislation or regulation.

Table 1: (Part 1 of 3) Ontario's Environmental Legislative Framework for Earth Energy System
[See notes before Table 1 for (a), (b) and (c)]

☑: Applies and Must be Obtained Before Installation ✓: Applies ✗: Does not apply

System Type / Legislation	Closed Loop and Direct Exchange			Open Loop			Thermal Storage	
	Horizontal Excavation	Vertical Hole	Surface Water (Submerged)	Vertical hole	Surface Water	Standing Column Well	ATES Vertical Holes	BTES Vertical Holes
Building Code Act Building Permit (a)	☑	☑	☑	☑	☑	☑	☑	☑
Building Code Regulation (CAN/CSA 448-02) (a)	✓	✓	✓	✓	✓	✗	✗	✗
Ontario Water Resources Act, Section 53 Sewage Works Approval (b)	☑(c)	☑(c)	☑(c)	☑	☑	☑	☑	☑
Ontario Water Resources Act, Section 30 Discharge into Waters Causing Impairment (b)	✓	✓	✓	✓	✓	✓	✓	✓
Ontario Water Resources Act, Section 34 Permit To Take Water (>50,000 litres/day) (b)	☑(c)	☑(c)	☑(c)	✗ Individual household ☑ All other cases	✗ Individual household ☑ All other cases	✗ Individual household ☑ All other cases	✗ Individual household ☑ All other cases	☑(c)

TABLE 1 (Part 2 of 3) Ontario's Environmental Legislative Framework for *Earth Energy System* Outside Loops
[See notes before Table 1 for (b), (d) and (e)]

☑: Applies and Must be Obtained Before Installation ✓: Applies ✘: Does not apply								
System Type / Legislation	Closed Loop and Direct Exchange			Open Loop			Thermal Storage	
	Horizontal Excavation	Vertical Hole	Surface Water (Submerged)	Vertical hole	Surface Water	Standing Column Well	ATES Vertical Holes	BTES Vertical Holes
Ontario Water Resources Act, Sections 39 and 43 Licence to work at construction of well (b)	✘ Trenches are exempt	☑ If hole meets definition of well in OWRA	✘	☑ If hole meets definition of well in OWRA	✘	☑ If hole meets definition of well in OWRA	☑ If hole meets definition of well in OWRA	☑ If hole meets definition of well in OWRA
Wells Regulation (b) **Well siting, construction maintenance and *abandonment* requirements**	✘ Trenches are exempt	✓ If hole meets definition of well in OWRA	✘	✓ If hole meets definition of well in OWRA	✘	✓ If hole meets definition of well in OWRA	✓ If hole meets definition of well in OWRA	✓ If hole meets definition of well in OWRA
Environmental Protection Act , Section 9 Environmental Compliance Approval (b)	✘ (d)(e)	☑ (d)(e)	✘	✘	✘	✘	✘	☑ (d)(e)

TABLE 1 (Part 3 of 3) Ontario's Environmental Legislative Framework for *Earth Energy System* Outside Loops
[See notes before Table 1 for (b) and (e)]

☑: Applies and Must be Obtained Before Installation ✓: Applies ✘: Does not apply								
System Type / Legislation	Closed Loop and Direct Exchange			Open Loop			Thermal Storage	
	Horizontal Excavation	Vertical Hole	Surface Water (Submerged)	Vertical hole	Surface Water	Standing Column Well	ATES Vertical Holes	BTES Vertical Holes
Environmental Protection Act , Section 14 Discharge into Natural Environment Causes Adverse Effect (b)	✓	✓	✓	✓	✓	✓	✓	✓
Ground Source Heat Pumps Regulation (b)	✘(e)	✓(e)	✘	✘	✘	✘	✘	✓(e)
Ozone Depleting Substances and Other Halocarbons Regulation (b)	✓ Applies to Direct Exchange	✓ Applies to Direct Exchange	✓ Applies to Direct Exchange	✘	✘	✘	✘	✓ Applies to Direct Exchange