TECHNICAL BULLETIN
Constructing Earth Energy Systems in Ontario

This bulletin is for people who construct earth energy systems, also called geothermal systems, ground source heat pump systems or geoexchange systems. It explains the types of activities that are subject to the Ontario Water Resources Act (OWRA)[1], Regulation 903 (the Wells Regulation)[2], the Building Code[3], and requirements such as permits to take water and sewage works approvals.

Earth energy systems and how they work

Earth energy comes from stored energy in the soil and rock of the earth. Below a certain depth, ground temperature is relatively constant all year long. Groundwater flowing slowly through soil pores and bedrock fractures also has similar constant temperatures. The ground is warmer than the air in winter and cooler in summer. An earth energy system harnesses this underground temperature to heat and cool buildings.

The Ground Source Heat Pumps Regulation[4]defines a ground source heat pump as a heating and cooling system for buildings that uses a fluid to exchange heat with the ground or ground water.

There are two basic types of earth energy heat pump systems: open and closed loop.

Open loop systems

In an open loop system, groundwater pumped from a well or series of wells is circulated through a heat pump located inside the building. A heat pump extracts the heat and distributes it throughout the building. This type of system also cools by extracting heat from the air inside the building and transferring it to the water circulating through the system. The system then injects the water back into the aquifer through a well (in some cases this could be the same well where the water was taken from i.e. standing column system) or discharges it to a stream, river, lake or pond.

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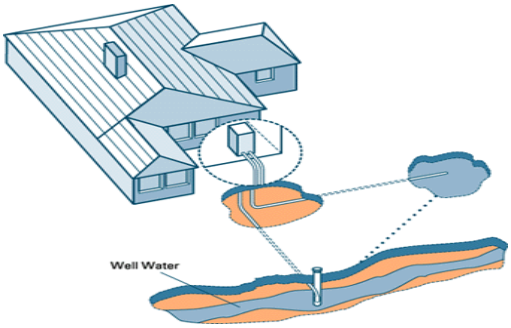
[1] Ontario Water Resources Act R.S.O. 1990, c. O.40
[2] Reg. 903 (Wells) R.R.O. 1990, made under the Ontario Water Resources Act, amended to O. Reg. 372/07
[3] Ontario Regulation 350/06 (Building Code) made under the Building Code Act 1992, amended to O. Reg. 205/08
[4] O. Reg. 177/98 (Ground Source Heat Pumps) made under the Environmental Protection Act R.S.O. 1990, c. E.19



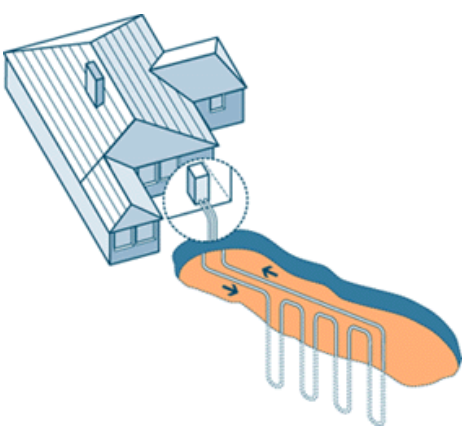
Source: Natural Resources Canada

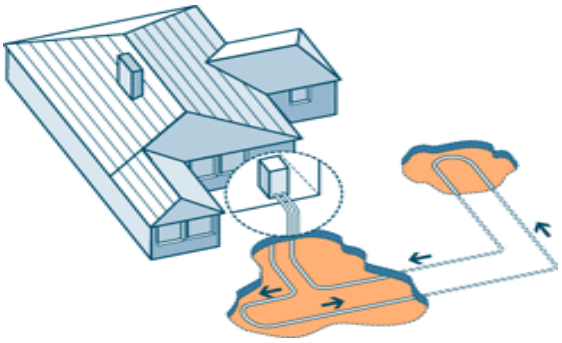
Closed loop systems

There are two types of closed loop system configurations: vertical and horizontal. Angle configurations are also possible.

In the vertical configuration, vertical holes are drilled into the ground. A U-shaped loop of pipe is installed in each hole. The remaining space in the hole is typically filled with a sealant to reduce the potential for vertical migration of contaminants and to maximize heat transfer. A heat transfer fluid circulates through the system of pipes connected to the heat pump inside the building.

The horizontal configuration works much the same way. The heat transfer fluid circulates through a system of buried pipes arranged horizontally in trenches. In both configurations, the heat transfer fluid in the loops of pipe absorbs the heat transferred from the ground and the heated fluid circulates to a heat pump. This pump heats the building by chilling the liquid. In winter, the chilled fluid is then pumped back into the loop to extract more heat from the ground. In summer, the opposite occurs; heat is extracted from the building and deposited in the ground. The heat transfer fluid does not come in contact with the soil, bedrock or groundwater.





Source: Natural Resources Canada

Regulatory Requirements for Installing Earth Energy Systems

Installing earth energy systems requires making holes in the ground. Some holes may meet the definition of **"well"** in the OWRA and, if so, must meet the requirements of the Wells Regulation.

Section 1 of the OWRA 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."*

To avoid the risk of contaminating groundwater, wells must meet the minimum requirements for constructing wells. Improperly constructed, maintained and abandoned (decommissioned) wells can create pathways for contamination to move from the surface down into the groundwater or from one layer or zone of groundwater to another.

Determining if a hole for installing an earth energy system is a "well"

Determination if a hole is or is not a well is based on the purpose of the hole. For example, a hole is a well if:

- it is made to locate groundwater
- it is made to obtain groundwater
- a person uses it to conduct a test on the groundwater in the hole or obtain information on groundwater or an aquifer

When constructing earth energy systems with vertical holes consider the following:

- In an open loop system, the hole from which groundwater is taken is a well under the OWRA. If water is discharged from the heat pump back to the aquifer through another hole, then the second hole is also a well.
- In a closed loop system, the hole is a well if a person conducts a test (including a short duration pumping test or hydraulic conductivity test) on the groundwater in the hole or if the hole is used to locate groundwater, or obtain information about the groundwater or an aquifer before it is used to install the pipes.
- A hole created solely to install the loop of heat transfer pipes is not a well.

There are other systems and scenarios that are not discussed above. Each scenario needs to be evaluated on its own merits to determine whether the hole is a well as defined in the OWRA.

It is important to note that it is an offence under subsection 30(1) of the OWRA for a person to discharge, cause or permit the discharge of any material of any kind into the natural environment that may impair the quality or quantity of any waters.

Requirements for open loop systems

Well construction in Ontario is governed by the OWRA (sections 35 to 51). If the hole being made in the ground is a well then the relevant licensing, construction, maintenance, tagging, notification, and abandonment requirements of the Wells Regulation apply.

Requirements for constructing, maintaining and abandoning wells prevent contamination from entering groundwater through the hole and are governed by the Wells Regulation. The regulation prescribes what must be done by the person constructing the well to ensure construction activities protect aquifers and water resource, quality and quantity, and the health and safety of the well owner and other water users.

Considerations for constructing and abandoning a closed loop system

Ontario Regulation 350/06 made under the Building Code Act[5] requires the design and installation of an earth energy system to conform to either of the following standards published by the Canadian Standards Association:

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

These standards set out minimum design and installation standards for earth energy systems to help reduce pathways for contaminants, spills of heat transfer fluids and other environmental risks.

To protect aquifers and eliminate potential hazards, an unused closed loop system should be properly abandoned in a manner that protects groundwater. This includes carefully removing all heat-transfer fluids from the subsurface pipes and disposing of the fluid properly.

It is also important to ensure that the loop piping and the holes made for them are not or do not become conduits for surface contaminants to aquifers or allow cross-contamination between aquifers. A professional geoscientist[6] or professional engineer[7] or in some situations a properly licensed well technician working for a licensed well contractor has the

[5] Building Code Act, 1992 S.O. 1992, Chapter 23

[6] Professional geoscientist licensed under the Professional Geoscientist Act, R.S.O. 1990, c. P.28
[7] Professional engineer licensed under the Professional Engineers Act, 2000, S.O. 2000, c. 13

knowledge to help determine appropriate abandonment (decommissioning) measures for individual situations.

Detailed documentation of the original installation (as required by the CSA standard for commercial and institutional buildings and suggested in Annex A to the CSA standard for houses and other small buildings) is helpful in determining the best course of action for abandoning the constructed holes of a closed loop system.

There is potential for the pipes in a closed-loop system to leak heat transfer fluids, such as propylene glycol and ethanol. These fluids, also used for de-icing, can pose a risk to the environment. The CSA standards recommend using High Density PolyEthylene (HDPE) plastic pipe and pressure testing the system to determine if there are any leaks at key points during the installation of the pipes. The Ground Source Heat Pumps Regulation (O. Reg. 177/98 made under the Environmental Protection Act) bans the use of methanol in all closed loop systems.

The CSA standard also requires that constructed holes for closed loop systems be continuously filled with grout from the bottom of the hole to the top to prevent surface water from entering the aquifer. If the hole is considered a well, then the requirements contained in the Wells Regulation must be followed.

The most common sealing materials used are bentonite and neat cement products; each with its own specific, unique and desirable properties. As such, site conditions need to be considered when choosing a sealant, including:

- the effectiveness of a bentonite slurry as a sealant may be reduced in highly mineralized water (eg. elevated salt);
- shrinkage and cracking which can occur when using a cement based product if the water and cement are mixed at an improper ratio; and
- a bentonite slurry may not have sufficient weight and strength to seal uncontrolled discharges of groundwater from a flowing well.

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

- Certification requirements under the Trades Qualification and Apprenticeship Act[8]
- Permit and inspection requirements under the Electricity Act[9] and/or the Building Code Act
- Ministry of Natural Resources (MNR) and/or Conservation Authority requirements when working in or on the bed of a water body or in a shorelands area. Please check with your local MNR district office and Conservation Authority to find out what regulatory requirements will apply.

[8] Trades Qualification and Apprenticeship Act, R.S.O. 1990, c. T.17
[9] Electricity Act, 1998, S.O. 1998, c. 15, Sched. A

Risks of drilling into sedimentary rock formations

When drilling vertical holes into sedimentary rock formations in southern Ontario, it is important to be aware of the following risks and take necessary precautions.

Oil and gas deposits can occur throughout the geologic section of sedimentary rock formations located in southern Ontario, and may also migrate into the overburden. Occurrences of pressured natural gas are a serious concern since the uncontrolled flow of gas from a hole (whether or not it is considered a well) can quickly lead to fire and explosion with potential loss of life and property. Using appropriate drilling procedures, and blow-out prevention and gas diversion equipment can mitigate risks when drilling into bedrock formations or where shallow overburden traps of natural gas have been known to occur.

Persons constructing earth energy systems should study the local geology including well and oil and gas well records to determine the likelihood of encountering oil and gas at proposed drilling depths when drilling into bedrock formations. When designing and/or installing a geothermal well system, consider retaining a professional geoscientist and/or a professional engineer. If a well, as defined under the OWRA, is being drilled, it must be constructed by a licensed well contractor employing licensed well technicians.

Fresh water, brackish water and saline water bearing zones, as well as oil and gas zones, can occur in close vertical proximity to each other within the sedimentary rock formations of southern Ontario. To prevent cross-contamination among the multiple zones, it is important to isolate and seal the zones in all holes. This is commonly accomplished by installing sealant in any remaining space between the underground closed loop pipes and the hole wall.

Questions and Answers

Who can construct a well, including an open loop earth energy system, in Ontario?

Only a licensed well contractor employing a licensed well technician to perform the work can construct a well, with one exception outlined below. This requirement applies if a hole for a heat exchange system meets the definition of a well under the OWRA. A well contractor licence issued by the Ministry of the Environment requires that businesses have liability insurance, employ only licensed well technicians to perform construction work and comply with all requirements of the Wells Regulation. The Wells Regulation details the licensing requirements for well contractors and technicians.

Section 43(3) of the OWRA provides an exemption from the licensing requirements for a person constructing a well on their own land or land owned by a family member. All other requirements of the Wells Regulation must be complied with.

Is a Permit To Take Water required for earth energy systems used to heat or cool ordinary households?

No. Generally, anyone taking more than 50,000 litres of water in a day from a well is required to obtain a permit but water takings for ordinary household uses such as heating and cooling are exempt. However, a Director, among other things, can always issue an order if a person's water taking interferes with another person's interest in water.

Is a Permit To Take Water required for <u>open loop</u> earth energy systems used to heat or cool industrial/commercial buildings?

Yes, if the system is taking more than 50,000, litres of water in a day up through a well directly to the heat pump. Permits to Take Water are required by the OWRA, as detailed in O. Reg. 387/04 (Water Taking)[10].

Is a Permit To Take Water required for <u>closed loop</u> earth energy systems used to heat or cool industrial/commercial buildings?

No. Although a pump is installed, no water is being taken. A permit to take water is required for a closed loop system if groundwater is discharged from the hole or if ground water is naturally discharging from the hole to the surface (flowing well) at a rate that exceeds 50,000 litres per day.

Is a sewage works approval required for an <u>open loop</u> earth energy system?

Yes, if the system has a design capacity of more than 10,000 litres of water per day. A sewage works Certificate of Approval issued by the Ministry of Environment under section 53 of the OWRA is required before constructing an open loop system. This also applies to residential systems using pumps capable of pumping 10,000 litres of water per day or more.

Is a sewage works approval required for a <u>closed loop</u> earth energy system?

No because no water is discharged from the system.

Is a building permit required to install an earth energy system?

Yes. A building permit and a site inspection by a municipal building official are required[11] for the installation of a new earth energy system or any change to an existing earth energy

[10] O. Reg. 387/04 (Water Taking) made under the Ontario Water Resources Act, amended to O. Reg. 451/07
[11] Section 8 of the Building Code Act 1992, amended to O. Reg. 205/08

system serving a building (i.e. replacing a heating, ventilating, or air conditioning system (HVAC) system with an earth energy system).

What's Next?

The Ministry of the Environment will continue to evaluate the potential environmental risks posed by earth energy systems to determine what additional requirements for earth energy systems may be appropriate to protect Ontario's surface and groundwater.

Where can I get more information?

Go to www.e-laws.gov.on.ca to read or get copies of:

- Ontario Regulation 387/04 (Water Taking) made under the Ontario Water Resources Act, amended to O. Reg. 451/07
- R.R.O. 1990, Regulation 903 (Wells) made under the Ontario Water Resources Act, amended to O. Reg. 372/07
- Ontario Water Resources Act R.S.O. 1990, CHAPTER O.40 as amended
- Ontario Regulation 350/06 (Building Code) made under the Building Code Act 1992, amended to O. Reg. 205/08
- Ontario Regulation 177/98 (Ground Source Heat Pumps) made under the Environmental Protection Act
- Environmental Protection Act R.S.O. 1990, c. E. 19.
- Building Code Act, 1992 S.O. 1992, Chapter 23

Copies of the OWRA and the Wells Regulation, and well tags and well records are also available by contacting the Wells Help Desk, Ministry of the Environment, 125 Resources Road, Toronto, ON, M9P 3V6 or 1-888-396-WELL (9355) or by calling Publications Ontario at 1-800-668-9938

Get well technician and contractor licence application forms at http://www.ontario.ca/ONT/portal51/drinkingwater/Combo?docId=STEL01_049359&breadcrumbLevel=1&lang=en&comboTarget=

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

For further information about wells, contact your nearest ministry office listed in the blue pages of your telephone directory. You can also call the ministry's Public Information Centre at 1-800-565-4923 or (416) 325-4000. The ministry's web site is at 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.

More information about Permit To Take Water requirements, applications, and fee schedules is available at http://www.ene.gov.on.ca/envision/water/pttw.htm.

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

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.