

Guidelines for the construction of ground sourced heat pump systems

1.0 DEFINITIONS

GSHP

Acronym for ground source heat pump.

GWSHP

Acronym for ground and water source heat pumps

DX

Acronym for direct exchange geothermal system

Aquifer

A water bearing stratum of permeable rock, sand, or gravel.

Borehole

A hole drilled into the earth, either vertical or non-vertical, to access subsurface resources such as, but not limited to, water or heat energy.

Direct Exchange system

A type of closed loop system that uses a refrigerant as a heat transfer fluid instead of an antifreeze mixture.

Heat transfer fluid

A fluid consisting of water and corrosion inhibitors, antifreeze and refrigerant depending on system and environment

Circulating fluid

The refrigerant in a closed loop heat pump used to transfer heat to and from the earth or water body to a central heat exchanger.

Closed loop system

A heat pump system which transfers heat to or from circulating heat-transfer fluids in a pipe. There is no fluid transfer between the fluid inside the pipe and the surrounding ground, water or air. A closed loop system may have pipe buried in the earth, vertically positioned in a borehole, or immersed in water (pond and ocean loops).

CSA

Acronym for the Canadian Standards Association. This association has established standards for GWSHP installations

Designer

A person who has specific training and experience with heat pumps and installation.

Electrical Contractor

The holder of an electrical contractor's certificate issued in accordance with Section 6 of the Electrical Regulations.

Geoexchange

When referring to geothermal applications, the act of transferring naturally emitted energy from the earth for human use or transferring anthropogenically impacted energy to the earth.

Geothermal energy

Naturally emitted energy from inside the earth that is available for heating applications in heat pumps.

Heat pump

A mechanical device that is designed to transfer energy to or from a medium such as water or some other fluid in order to cause a cooling or heating effect. This device is usually located on the earth's surface or in a structure such as a dwelling or building.

Hydrogeologist

A person qualified to study and report subsurface properties, composition, bedrock and unconsolidated structure, and depth as they relate to groundwater flow, quantity and quality

Minister

The Minister of Environment and Climate Change, or a person designated by the Minister to act on the Minister's behalf.

Open loop system

A heat pump system that withdraws water from a well or surface water supply, passes it through a heat exchanger or other device and discharges the water to a surface body of water, storm or sanitary sewer system, or well.

PEGNL

Professional Engineers and Geoscientists of Newfoundland and Labrador

Professional engineer

A person responsible for the design as accredited and registered by the authority having jurisdiction.

Service

Refers to the Halocarbon Regulation and includes construction, installation, testing, maintenance, adjusting, repairing, charging, recharging, relocation, moving, decommissioning, dismantling, removal and disposal.

Well interference

The result of a pumping water well where the drawdown cone interferes with another water well. The result of an injection well for waste water from a heat pump on nearby water wells; and the result of thermal effects from closed- or open-loop boreholes on water chemistry in a nearby water well(s).

WRMD

Acronym for Water Resources Management Division

WSHP

Acronym for water-sourced heat pump that obtains water from another source other than groundwater (streams, lakes, oceans).

2.0 INTRODUCTION

The construction of ground and water-sourced heat pumps (GWSHP) has been steadily increasing in this Province. Their high coefficient of performance, and reduced environmental impact, has provided an attractive alternative to fossil fuel heating systems, especially for non-domestic uses. GWSHP are a more efficient heating system and can significantly reduce annual energy use by using latent heat from under the earth's surface.

A reduction in energy use translates to a reduction in greenhouse gas emissions. With climate change becoming a serious reality, GWSHP are one of the most environmentally friendly ways of heating and cooling known today.

Local GWSHP are of three types. One type, called an open loop system, either extracts heat (heating) from groundwater pumped from a well or transfers heat (air conditioning) from a structure to heat exchanger where warm discharge water is released into a water body, storm sewer or well. The second and more common type, is a closed loop system, which circulates a fluid through pipes in the ground, surface waters (pond loop), or the ocean (ocean loop), again transferring heat from or to a fluid as it passes through the heat exchanger. The third type is a direct exchange (DX) system, which is a type of closed loop system that uses a refrigerant as a heat transfer fluid instead of an antifreeze mixture. For all types of systems, there is often a requirement that water wells or boreholes be drilled into the subsurface and consequently into aquifers, to obtain either an adequate water supply and heated water in the case of open systems, or to extract the latent heat of the earth at depth as in the case of closed loop systems. These types of systems are classed as vertical open and closed loop GWSHPs and may require wells and boreholes be drilled up to, but seldom beyond 450 metres into the earth.

The Well Drilling Regulations¹ under the *Water Resources Act*² specify construction and siting of water wells to protect the groundwater resources of this Province. There are presently more than 25,000 drilled wells for many uses, including geothermal, in the Province.

The current Act and Regulations do not specifically mention the construction of geothermal applications of ground- and water-sourced heat pumps. The construction of water wells for the installation of open loop systems is addressed under the *Water Resources Act*² however; the reinjection of wastewater from heat exchangers into aquifers may cause an environmental impact. Closed loop systems also penetrate shallow and deep aquifers to utilize earth energy. These systems must also be constructed to a standard as not to allow adverse changes to the groundwater resource.

The drilling of water wells for the installation of a vertical open loop system is addressed by the Well Drilling Regulations¹ under the *Water Resources Act*² since groundwater is being withdrawn from the resource. However, any environmental concerns regarding the drilling of boreholes for the piping of vertical closed loop ground sourced heat pumps cannot be linked to the Well Drilling Regulations¹ under the *Water Resources Act*², as there is no withdrawal of groundwater. There is also no regulatory control over the type of fluid used in the closed loop system nor is there any control over the location in relation to resource degradation of adjacent groundwater users.

This guidance document has been formulated from available information in other provinces, states, interest agencies, and the CSA to address the environmental concerns regarding the geothermal applications of open and closed loop GWSHP's. This guidance addresses situations where there is a danger of groundwater contamination or well interference with other resource users.

It is recommended that every ground and water source heat pump installation follow the codes as established by the Canadian Standards Association document: CAN/CSA-C448-02 CONSOLIDATED - Design and Installation of Earth Energy Systems available from Standards Sales, Canadian Standards Association, 178 Rexdale Blvd., Rexdale, Ontario, M9W 1R3, phone: (416) 747-4044, fax: (416) 747-4149 or online from <https://www.csagroup.org/store/product/2414957/>.

The introduction into the ground of circulating water or other fluids constitutes a matter of legitimate government concern with respect to issues of public health, safety, and welfare. The environmental concerns during construction and operation of these GWSHPs are:

- Closed loop GSHP circulating heat transfer fluids (including refrigerants for DX systems) could escape and migrate into the groundwater.
- Improperly constructed boreholes, wells and borings could serve as channels of contamination from the surface to the subsurface or from one aquifer to another.
- Open loop systems could affect the groundwater supply of adjacent groundwater users (interference) where excessive amounts of well water is pumped from the aquifer(s).
- Open loop systems may alter groundwater chemistry, temperature and aquifer dynamics due to re-injection of physically or chemically altered water from exchangers.
- Closed loop systems may alter the temperature of an aquifer and thereby affect water chemistry of nearby water wells.

For these reasons, the following guidance document concerning the installation of these systems has been developed. This guidance document addresses only those parts of the construction that are perceived to have an impact on the environment, particularly local groundwater resources.

3.0 OBJECTIVE

- i) The purpose of this guidance document is to provide adequate protection for groundwater resources and groundwater users in the vicinity of newly constructed ground sourced heat pumps and;
- ii) To provide generic guidance for the construction of ground sourced heat pump systems.

4.0 LEGISLATION

The Well Drilling Regulations¹ under the *Water Resources Act*² states the construction specifications of boreholes and wells and thereby pertains to the installation and use of

open and closed loop ground and water sourced heat pump systems involving borehole or well construction.

The Halocarbons Regulation³ under the *Environmental Protection Act*⁴ applies to the refrigerants used in the Direct Exchange (DX) closed loop systems.

The Electrical Regulations⁵ under the *Public Safety Act*⁶ applies to the permitting requirements to install any heat pump to an existing commercial or non-commercial building.

5.0 GENERAL ENVIRONMENTAL INSTALLATION CONSIDERATIONS

5.1 Permit

An electrical permit under the Electrical Regulations⁵ of the *Public Safety Act*⁶ is required for the installation of a heat pump to an existing or new non-commercial or commercial building. This type of permit is obtained by the electrical contractor and is applied for through the Department of Digital Government and Service NL. A link to the application can be found here: <https://www.gov.nl.ca/dgsnl/files/forms-pdf-electrical-permit.pdf>

A non-domestic well permit is required before construction commences of any non-domestic heat pump system using water wells or boreholes. A non-domestic well is defined as a drilled well intended to supply water for any application other than a single-family dwelling. The conditions of the non-domestic well permit will stipulate requirements needed to address any perceived environmental concerns as noted in the permit application. No ground or water sourced heat pump is permitted to discharge wastewater to or down any well or borehole. For systems discharging to surface waters, a permit for altering of a body of water will be required, and is available from the Water Resources Management Division or online here https://www.gov.nl.ca/ecc/files/main_application.pdf.

In addition, no ground or water sourced heat pump (GWSHP) shall be interconnected to a public water system, which returns water to the distribution system of the public water supply. No GWSHP are permitted to be installed within the buffer zones of a public water supply (as per WRMD's Guidance document *Management of Protected Water Supply Areas*⁷) nor within Zone 1 or 2 of a wellhead protection area (as per WRMD's guidance document *Guidance for Delineation of Wellhead Protection Areas*⁸). Return water may be disposed of to a private subsurface disposal system or municipal sanitary system with appropriate approvals. An application for a non-domestic well permit can be obtained online https://www.gov.nl.ca/ecc/files/Permit_Non-Domestic_Well_2021.pdf or from the Water Resources Management Division.

A non-domestic well permit is **not** required for:

- Installation of a closed loop GWSHP for single-family dwelling use
- 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 pumps
- A surface water open loop, closed loop or vertical submerged geothermal system. These types of systems will require a permit to alter a water body under Section 48 of the *Water Resources Act*².

All GWSHPs constructed for a single-family dwelling or residential use must be designed and installed by a qualified person as per the above CSA Standard and follow the CSA Standards for construction, installation and maintenance. No groundwater sourced or water sourced heat pump for single-family dwelling/residential use is permitted to discharge wastewater to or down any well or borehole.

5.2 Professional Engineer and Hydrogeologist

All GWSHPs constructed under a non-domestic well permit other than a single family dwelling (i.e. commercial, institutional or industrial purposes) must be designed by a registered Professional Engineer with the required work done by a Hydrogeologist as per the CSA Standard above.

All GWSHPs constructed for a single-family dwelling or residential use must be designed and installed by a qualified person as per the above CSA Standard and for DX systems an approved person must be used for install and service as per the Halocarbon Regulation³ under the *Environmental Protections Act*⁴.

5.3 Drilling Fluids

The drilling fluid for the water wells and boreholes must be potable water. Any additives must be listed in the CSA Standard above and be approved by the Minister.

5.4 Abandonment of Water Wells and Boreholes

All water wells and boreholes drilled for the purposes of a GWSHP and abandoned or otherwise not intended for use, shall be permanently sealed according to the publication *Guidelines for Sealing Groundwater Wells*⁹ available from this Department. The decommissioning of a closed loop GSHP shall include the recovery of any heat transfer fluid (including refrigerants for DX Systems) in the heat exchanger piping.

5.5 Drilling of Boreholes

Boreholes and water wells for the purpose of ground sourced heat pump applications shall be constructed by a licenced water well driller in the Province of Newfoundland and Labrador. A current list of licenced well drillers is available from this Department at <https://www.gov.nl.ca/ecc/waterres/cycle/groundwater/well/well-drilling-license-holders/>.

This well drill licensing stipulation does not currently apply to dug, augered, or driven wells.

6.0 GROUND SOURCED HEAT PUMPS (GSHP) VERTICAL CLOSED LOOP SYSTEMS

This type of geothermal application includes vertical or inclined boreholes or wells where there is no transfer of fluids between the stratum or aquifer and the piping in the borehole or well. This is the preferred type of heat pump. Water wells used to obtain groundwater for use in a heat pump shall be drilled according to the Well Drilling Regulations¹ under the *Water Resources Act*². Other types of closed-loop systems are not covered by this guidance document.

6.1 Circulating Heat-transfer Fluid

The circulating heat-transfer fluid in a closed loop system shall be a type listed in the CSA Standard above and be approved by the Minister. Common heat transfer fluids for closed looped systems are denatured ethanol, propylene glycol and ethylene glycol mixed with water. The use of methanol as a heat-transfer fluid is prohibited.

6.2 Grouting of Boreholes

The permanent sealing of the annular space including piping in the boreholes or wells is required and shall be done with a low permeable material that will fill the entire borehole or well and prevent:

1. The leakage of circulating fluid from damaged circulating pipes in the borehole.
2. Migration of contaminated surface water into the subsurface formations
3. Migration of groundwater between water bearing formations and subsurface formations
4. Migration of groundwater between water bearing formations and the ground surface
5. Aquifer depressurization by stopping upward migration of water in the annulus
6. Gas migration

It is recommended that pure bentonite clay be used for the grouting of the boreholes, tremied from bottom to top. This will reduce shrinkage and voids in the sealing materials.

Grouting of all boreholes must comply with the CSA Standard above.

6.3 Testing of Piping

Borehole piping used for closed loop systems shall be tested to the CSA Standard above.

6.4 Distances from Water Wells

To prevent the occurrence of well interference between a GWSHP borehole well and adjacent groundwater users, no GWSHP well shall be installed within 30 metres of the nearest water well, or a greater distance sufficient to prevent interference by larger systems.

6.5 Direct Exchange (DX) System

A Direct Exchange (DX) system is a variety of closed looped system that removes the need for an antifreeze mixture heat transfer fluid. In this type of system, the heat transfer fluid is a refrigerant. The refrigerant from the heat pump is circulated through a continuous loop of tubing that extends from the heat pump into the ground. In a vertical DX system, the tubing is installed into vertical or inclined holes and back filled with bentonite or cement. Typically, the hole for a DX system is no more than 30 metres deep.

For a DX system, the standards require that the:

- Refrigerant used be listed in CAN/CSA B52 titled Mechanical Refrigeration Code; 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 and be pressure tested at key points during the installation of the pipes

The heat transfer fluid in direct exchange (DX) systems uses a refrigerant that could contain ozone depleting substances or halocarbons. To aid in the protection of the environment from the release of refrigerants, the Halocarbons Regulation³ under the *Environmental Protection Act*⁴ applies to refrigerants containing ozone depleting substances or halocarbons. The regulation states:

(1) Unless expressly permitted by these regulations, the CFC code of practice or the requirements of ULC/ORD-C1058.5 (Standard for the Recovery of Halon) or ULC/ORD-C1058.18 (Standard for Servicing of Halon Equipment), a person shall not directly or indirectly release a regulated substance or cause or allow a regulated substance to be released into the environment, including the release of a regulated substance from

- (a) air conditioning or refrigeration equipment or fire extinguishing equipment; or
- (b) an approved container or device employed in the use, reuse, recycling, reclaiming, supply, transport or storage of a regulated substance.

(2) A person shall not store or destroy a regulated substance in a manner which may allow it to be released into the environment.

Reporting releases

(1) A release of more than 10 kilograms of a regulated substance shall be reported to the Department of Environment and Climate Change, Pollution Prevention Division, within one working day of the release and such report shall include the circumstances of the release and the actions taken.

Service - air conditioning or refrigeration equipment

(1) A person shall not service air conditioning or refrigeration equipment unless that person is an approved person.

(2) Air conditioning or refrigeration equipment shall be serviced in accordance with the CFC code of practice and these regulations.

(3) A person who services air conditioning or refrigeration equipment or does other work on air conditioning or refrigeration equipment that may result in the release of a refrigerant shall

(a) have available at the job site operational equipment that can recover and contain a refrigerant; and

(b) recover and reuse, recycle, reclaim or arrange for the destruction of a refrigerant that would otherwise be released during the servicing procedure.

(4) Devices used for the servicing of air conditioning or refrigeration equipment shall meet minimum standards specified by the CFC code of practice.

(5) A hazardous waste product, toxic substance or other foreign material, except gases used in testing or other material normally present in air conditioning or refrigeration equipment, shall not be intentionally mixed with recovered material.

(6) An owner of air conditioning or refrigeration equipment shall not cause the air conditioning or refrigeration equipment to be serviced by anyone who is not an approved person.

(7) The owner of a business that services air conditioning or refrigeration equipment shall ensure that each person employed in or by the business who services air conditioning equipment or refrigeration equipment is an approved person.

Approved person

(1) For purposes of the Halocarbon Regulation, an approved person is an individual

(a) who

- (i) has successfully completed an environmental awareness course on regulated substances which has been accepted by the minister, and
 - (ii) has been awarded a certificate bearing a registration number and wallet card signifying successful completion of the environmental awareness course; and
- (b) whose name and registration number has been recorded in a database accepted by the minister.

(2) A person shall not buy, borrow, lend or sell a certificate or use a certificate not issued to the bearer.

7.0 GROUNDWATER-SOURCED HEAT PUMPS (GWHP) VERTICAL OPEN LOOP SYSTEMS

This type of geothermal application includes vertical or inclined boreholes or wells where there is direct pumping of groundwater to the heat pump or a transfer of wastewater from a heat pump to a borehole or well for disposal to the aquifer(s) below. Water wells used to obtain groundwater for use in a heat pump shall be drilled according to the Well Drilling Regulations¹ under the *Water Resources Act*². The injection/return well(s) for the disposal of groundwater through a heat pump shall be used only for the injection of groundwater and, where possible, shall return the water to the same aquifer from which it was taken. Drilled return wells must be drilled by licenced water well drillers with casing sealed into the bedrock where bedrock is encountered. No chemical additives are to be used in the system.

All open loop systems designed to release water to an aquifer, regardless of depth, are **prohibited**. Open loop systems that release to natural surface water, ground surface or infrastructure (e.g. private subsurface disposal system or municipal sanitary system) may be approved as stated above and may require a permit to alter a water body under Section 48 of the *Water Resources Act*² and a water use licence if it is for non-domestic use.

8.0 OTHER TYPES OF GEOEXCHANGE SYSTEMS

All other types of systems (i.e. horizontal closed loop, surface water loop, ocean loop, vertical submerged) are not covered by this guidance document.

9.0 COMMENTS ON DRILLING GWSHP BOREHOLES IN GAS PRONE AREAS

In the design of some GWSHP's, boreholes in excess of 400 metres may be drilled. Depending on the area and lithology where the proposed GWSHP is situated, there is a risk of encountering flammable gas at depth. A contractor should be aware of this concern and strive to gain as much geological information as possible about the local area before drilling commences. This is especially true for the west coast of Newfoundland. Contact should be made with the Department of Industry, Energy and Technology, Petroleum Development Section, when a contractor suspects the possibility of encountering this situation.

For additional information on this topic or any other water resources related topics, please contact us at groundwatersection@gov.nl.ca.

10.0 WEBPAGE LINKS

¹ Well Drilling Regulations: <https://www.assembly.nl.ca/Legislation/sr/regulations/rc030063.htm>

² Water Resources Act: <https://www.assembly.nl.ca/Legislation/sr/statutes/w04-01.htm>

³ Halocarbon Regulation: <https://www.assembly.nl.ca/legislation/sr/regulations/rc050041.htm>

⁴ Environmental Protections Act: <https://www.assembly.nl.ca/legislation/sr/statutes/e14-2.htm>

⁵ Electrical Regulations: <https://www.assembly.nl.ca/legislation/sr/regulations/rc969120.htm>

⁶ Public Safety Act: <https://www.assembly.nl.ca/legislation/sr/statutes/p41-01.htm>

⁷ Management of Protected Water Supply Areas: <https://www.gov.nl.ca/ecc/files/waterres-regulations-appforms-designation-process-booklet-mar-2013.pdf>

⁸ Guidance for Delineation of Wellhead Protection Areas: <https://www.gov.nl.ca/ecc/files/waterres-regulations-appforms-guidance-for-delineation-of-wellhead-prot-area.pdf>

⁹ Guidelines for Sealing Groundwater Wells: <https://www.gov.nl.ca/ecc/files/waterres-cycle-groundwater-well-guidelines-for-sealing-groundwater-wells.pdf>