SALT LAKE COUNTY HEALTH DEPARTMENT

Ground Source Heat Pump Installation and Design Guideline

1. Introduction

Ground source heat pumps, also known as geothermal heat pumps or heat exchange units, can be a highly efficient renewable technology; however, they have the potential to irreversibly impair ground water drinking water sources in Salt Lake County.

Drinking water in Salt Lake County comes from a combination of surface and ground waters. Surface waters along the Wasatch Front include City Creek, Parleys Creek, Big Cottonwood Creek, and Little Cottonwood Creek. Stored surface waters include the Little Dell and Mountain Dell systems, as well as the Jordanelle and Deer Creek systems on the backside of the Wasatch Front.

Groundwater in Salt Lake County comes from a network of underground aquifers. Although it's difficult to see these aquifers, they underlie most of the valley and are a vital source of drinking water for Salt Lake County. Once these drinking water sources are contaminated, remediation is either very costly or unfeasible. It is the responsibility of the Salt Lake County Health Department and individual public water systems to protect these essential resources.

The purpose of this document is to provide Best Management Practices (BMP's) for the design, installation, location and maintenance of ground source heat pumps (GSHP) in order to protect the ground water sources of drinking water in Salt Lake County. These BMP's are designed to help prevent contamination of the deep aquifers, and cross contamination between the shallow and deep aquifers throughout Salt Lake County.

In August 2010 a drinking water well, located in Salt Lake County, was contaminated during an installation of a nearby GSHP system. As drilling operations concluded, an increase in sedimentation and iron levels in the drinking water resulted in closure of the well. If this event would have occurred earlier in the summer, temporary or permanent water use restrictions may have been placed on water users in the area. This type of contamination could have been avoided if Health Department and Planning ordinances and recommendations had been followed or if the contractor had contacted the local public water system.

2. Definitions

Term	***Definition***
ACS	American Chemical Society
AHWL	Annual high water level
Antifreeze	A water based solution with an additive to modify the freezing point of the liquid. Antifreeze solutions are used in the secondary loop of a geothermal heat pump system.
Applicant	The party seeking a permit for a GHSP system.
Aquifer	A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

Aquitard	A geologic formation that limits the flow of ground water from one aquifer to another. An aquitard is generally composed of clay or non-porous rock with low hydraulic conductivity.
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
Certified Geo-Exchange Designer (CGD)	Training and certification for installation personnel offered by IGSHPA.
Closed-loop	Utilizes two loops, a primary refrigerant loop contained in the appliance cabinet and a secondary loop buried in the ground. A re-circulating antifreeze solution exchanges heat through a heat exchanger with the secondary water loop that is buried underground. Closed loop systems can be installed vertically or horizontally.
Decommission	To take out of service. A formal, documented process by the State of Utah, Division of Water Rights is required to decommission a GSHP. GSHP systems that are not active, or are in a state of disrepair are required to be decommissioned.
Drinking Water Source Protection Zones (DWSP Zones)	Means the specified surface and subsurface area surrounding a groundwater source supplying a public water system, through which contaminants are reasonably likely to reach the groundwater source of drinking water. See Salt Lake County Water Source Protection Ordinance.
Drinking water well	A well installed to extract water from a zone of saturation below the ground surface that meets water quality standards for human consumption.
FCOZ	Salt Lake County Planning and Development Division's "Foothills and Canyons Overlay Zone"
Ground Source Heat Pump (GSHP), Geothermal heat pumps, Heat exchange units	A GSHP is a central heating and/or cooling system that pumps heat to or from the ground. It uses the earth as a heat source in the winter or a heat sink in the summer. These systems reduce operational costs of heating and cooling systems by taking advantage of moderate ground temperatures.
Groundwater source	Any well, spring, tunnel, adit, or other underground opening from or through which ground water flows or is pumped from subsurface water-bearing formations.
High purity	Meets American Chemical Society (ACS) reagent grade standards
Horizontal system	Horizontal systems are less than 30 feet below ground surface but below frost elevations. May be manifold or "slinky loop" configurations. These systems generally disturb a greater surface area and may not be suitable for areas where it is desirable to minimize ground disturbance.
IGSHPA	The International Ground Source Heat Pump Association
NSF	National Science Foundation. Often, for materials in contact with drinking water the NSF will combine with the American National Standards Institute (ANSI) to set standards.
Open-loop	Groundwater is extracted from one well and pumped through a heat exchanger inside the heat pump. Heat is either extracted or added by

	the primary refrigerant loop, and then the water is returned to a separate well and re-injected into the same aquifer.
P.E.	Licensed Professional Engineer
PE pipe	See polyethylene pipe
Perched aquifer	An aquifer that lies on top of another aquifer separated by an impermeable layer of substrate.
Polyethylene pipe	Polyethylene pipe (PE), suitable for secondary loop system for re-circulating solution in heat pump systems.
Primary loop	The refrigerant loop located in the appliance cabinet.
Public Water System (PWS)	A system, either publicly or privately owned, providing water through constructed conveyances for human consumption and other domestic uses, which has at least 15 service connections or serves an average of at least 25 individuals daily at least 60 days out of the year and includes collection, treatment, storage, or distribution facilities under the control of the operator and used primarily in connection with the system, or collection, pretreatment or storage facilities used primarily in connection with the system but not under the operator's control (see 19-4-102 of the Utah Code Annotated).
Reagent grade	Also known as the American Chemical Society (ACS) Reagent Grade– This designates a high purity chemical that meets minimum impurity specifications as determined by ACS. A Certificate of Analysis should be available from the supplier.
Re-circulating fluid	Generally refers to the antifreeze solution that is used in the secondary loop (ground to heat exchanger).
Riparian corridor	The active stream channel including the areas on both sides of the channel within 100 feet of the annual high water level.
Secondary loop	The re-circulating fluid loop that is buried in the ground.
Septic drain fields	Also known as a leach field, an arrangement of trenches with gravel and perforated pipe used to drain and provide some treatment for liquids from a septic tank. Includes required replacement drain field. See Utah Code R 317-4.
SLCPU	Salt Lake City Department of Public Utilities
SLCOHD	Salt Lake County Health Department
Stormwater detention/retention ponds	A pond designed to protect a specific area against flooding by catching runoff water from higher elevation areas and storing it for a limited period of a time.
Superfund sites	An uncontrolled or abandoned place where hazardous waste is located, possibly affecting local ecosystems or people.
Surface water	All water which is open to the atmosphere and subject to surface runoff (see also section R309-515-5(1)). This includes conveyances such as ditches, canals and aqueducts, as well as natural features.
Tailings	Well drilling tailings is the material that is created by the drilling process. It typically contains a combination of native soil and rock as well as any drilling fluids to aid with the drilling operation.

Vertical system	Systems with wells extending more than 30 feet below ground surface. Vertical system can be either opened or closed loop configurations.
Watershed	Shall mean the entire area in any canyon above the intake of a waterworks system within which water drains into any stream, tributary, or aquifer within Salt Lake County, including the anti-degradation segments of each stream identified as such in the Utah State Water Quality Standards. These areas are subject to Source Water Protection rules and Salt Lake County Health Department – Health Regulation #14-Watershed Regulation and SLC Watershed Ordinance 17.04.
Wetlands	Those areas inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands can be both natural or artificial, and perennial or ephemeral.

3. Recommended System Designs

Closed loop systems, both horizontal and vertical, are recommended in Salt Lake County. If installed and maintained correctly, these systems pose the least amount of risk to drinking water aquifers.

4. Non-recommended System Designs

a. Open loop systems are strongly discouraged as there is a high potential for contaminants to be injected into drinking water aquifers and/or surface waters.
b. Pond and river systems are not recommended due to the risk that the underwater portion of the system can leak re-circulating fluid into surface waters. The release of heat into a natural water body may also damage natural aquatic ecosystems.
c. Direct exchange systems where the refrigeration loop is buried directly in the soil pose a significant risk of ground water contamination.

5. Drilling Location

a. Salt Lake County restricts GSHP wells drilled in Source Protection Zones 1-4 as defined in the Salt Lake County Water Source Protection Ordinance 9.25. (See appendix B)
    i. Wells less than 30 feet deep are prohibited in Zones 1 and 2 and restricted in zones 3 and 4.
    ii. Wells greater than 30 feet deep are prohibited in Zones 1 through 4.
b. **Contact SLCOHD to determine if proposed wells sites are located in a source protection area. Phone number 385-468-3862.**
c. SLCoHD and SLCPU strongly discourage GSHP wells from being installed or drilled to any depth:
    i. In protected watershed areas as defined by SLCPU and SLCoHD Watershed Regulation 14. Special mitigation measures may be required in watershed areas to reduce the

risks of drinking water contamination.
ii. In wetland areas.
iii. In a delineated riparian corridor.
iv. In known superfund sites or through known contamination plumes.
v. Through an aquitard.
vi. In stormwater detention and retention ponds.
vii. In artesian areas.

d. Resrtrictions may apply if any portion of the parcel is located in a SLCPU designated primary and/or secondary recharge area.
e. **Contact SLCPU to determine if proposed wells sites are located in a SLCPU designated primary and/or secondary recharge area. Phone number 801-483-6750, tracie.kirkham@slcgov.com or jesse.stewart@slcgov.com**

6. Vertical Well Depth

In areas where an aquitard is suspected, care should be taken not to drill through the impermeable layer that separates the shallow aquifer from the drinking water aquifer beneath. Because shallow aquifers are closer to the surface, they generally collect a variety of contaminants. Drilling through the aquitard that separates the two aquifers creates a pathway for these contaminants to enter the drinking water aquifer.

7. Required Permits

State Well Drilling Permit

a. The applicant should first contact the State of Utah-Division of Water Rights to obtain a well drilling permit.
b. The State will then contact SLCoHD and SLCPU to receive recommendations regarding the location of GSHP wells. SLCoHD and SLCPU will determine if the proposed wells are located in one of the DWSP Zones.
    i. If wells are located in any of the a DWSP Zones, the applicant will receive a letter from the Division of Water Rights informing them that drilling in the proposed area to depths greater than 30 feet may be prohibited. In order to drill in the proposed area, the applicant should contact the PWS that is being affected to seek approval. The PWS may either decline the request or provide stipulations that should be met in order for wells to be approved. If the PWS is willing to consider GSHP wells contact should be made with SLCoHD to receive information about acquiring a land use agreement. (See Salt Lake County Water Source Protection Ordinance 9.25.110.B)

SLCPU Permit

c. If proposed GSHP wells are located within SLCPU service areas, source protection zones as defined under Salt Lake City Ordinance 21A.34.060, or in the protected watershed, permit applications should then be submitted to SLCPU. A permit application should include:
    i. A site plan (Drawn to scale, preferably 1 to 20 feet).
        1. Show property lines, location of existing structures on the property, Show location and number of wells, equipment and piping. Any special property considerations, such as designated no disturb areas or non-buildable areas,
        2. Show required set-backs as identified in Appendix A.

ii. Documentation that GSHP systems meet IGSHPA standards. The design procedure should follow a recognized methodology such as presented in:
    1. Closed-Loop/Ground-Source Heat Pump Systems: Installation Guide, GSHPA Publication, Oklahoma State University.
    2. Data Design Manual for Closed-Loop/Ground-Source Heat Pump Systems, ASHRAE.
iii. Soil thermal value and loop length calculations according to IGSHPA and ASHRAE standards.
iv. Heating and cooling capacity of equipment including calculations used to determine heating and cooling needs.
v. Operating pressures and flow rates.
iv. Re-circulating fluids and chemical additives (Please see #11 Circulation System).

Other Applicable Permits
Permits may also be required from the local jurisdiction for installing mechanical equipment, which includes heating and cooling systems in a building, home, or other structure.

8. Installation Personnel and Training Required

a. System designers should have the following qualifications:
    i. Residential systems up to 20 tons require a P.E., a certified CGD, or an IGSHPA certified installer with current credentials.
    ii. Commercial and large residential systems require a P.E., or a certified CGD, in addition, all designs must be stamped by a registered Utah P.E.
b. The well driller should be a licensed well driller in the state of Utah.
c. The loop contractor and ground heat exchanger fabricators should have certification, such as from IGSHPA, Certified Geo-exchange Designer (CGD) or similar training, experience and certification.

9. Ground Source Heat Pump Design and Materials

a. The GSHP design should be clearly documented as complying with manufacturer's standards.
b. The only acceptable pipe material for the underground buried portion of the ground heat exchanger is polyethylene (PE).
    i. The pipe and fittings of the buried system should be warranted by the manufacturer for ground source heat pump service.
    ii. Sufficient information should be permanently marked on the length of the pipe that allows the pipe to be properly identified.
    iii. Specification of PE pipe will be by cell classification number and should meet the appropriate ASTM specifications.

10. Pipe Joining Methods

a. When possible a continuous loop is recommended. This greatly reduces the risk of potential leaks and breaks.
b. Only factory joints should be used on vertical piping.

c. Acceptable methods for joining buried pipe systems are by socket, sidewall, electro, or butt fusion processes. Other methods are not acceptable. Follow manufactures specifications specifically for ground source heat pump systems.

11. Flushing, Purging, Pressure and Flow Testing

a. All fusion joints and loop lengths shall be checked to verify that no leaks have occurred due to fusion joining or shipping damage.
b. All loops will be pressure tested with culinary water before installation into the borehole (either a vertical bore [vertical loop] or horizontal bore [horizontal loop]) or into a trench (horizontal loop).
c. Heat exchangers should be tested hydrostatically at 150% of the pipe design rating or 300% of the system operating pressure if this value is the smaller of the two.
d. No visible leaks should occur within a 30 minute period. The Philips Hydrostatic Pressure Test II method is suggested.
e. Each supply and return circuit shall be flushed and purged in the forward and reverse directions with water at a minimum velocity of 2 ft/sec (0.6096 m/sec) through each piping section. Flow must be maintained for a minimum of 15 minutes in each direction to remove all debris and air. To verify that all air is removed from the system, the return water valve to the tank shall be closed. A change in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system. The heat exchanger system purging shall be completed separately from the building system.
f. Flow rates and pressure drops will be compared to calculated values to assure that there is no blockage or kinking of any pipe. If actual flow rate or pressure drop values differ from calculated design values by more than 10 percent, the problem shall be identified and corrected.
g. Before connection (header) trenches are backfilled, heat exchangers shall be pressure tested with water at 100 psi for 1 hour with no observed drop in pressure (greater than 10 psi OR +/- 10%). Site conditions may dictate backfilling prior to testing with water. A minimum air pressure of 45 psi shall be maintained on the ground heat exchanger during backfilling and until the final pressure test with water can be conducted.
h. After the conclusion of the ground heat exchanger pressure test, the ground heat exchanger shall be left filled with clean water and maintained under pressure until final connection to the building system.

12. Post-Installation Report

Within 30 days of completed installation, provide the following to SLCoHD:

a. A copy of the well log. If the system has more than one well, provide a copy of the log for the deepest well and provide GPS coordinates for the final location of all wells.
b. Results for pressure and flow testing.
c. Results can be emailed to: libenavidez@slco.org

13. Pipe Placement and Backfilling

a. Follow all applicable standards and rules as they pertain to buried pipe systems.
b. Backfill in accordance with IGSHPA guidelines and ASTM D 2774 “Underground

Installation of Thermoplastic Pressure Pipe" and pipe manufacturer's specification.

i. Pipe should be placed a minimum of 6 inches from the edge of the trench.
ii. Bedding should be placed 6 inches below, on top of, and on the sides, surrounding the horizontal piping. Bedding should be free of rocks with sharp edges, debris and contamination. Sand or similar material is preferred (no pea gravel).
iii. The trench backfill material should be clean engineered fill, or other approved material. Rock greater than 2 inches is not recommended.
iv. Return beds in narrow trenches should be partially backfilled by hand to properly support the pipes and prevent kinking.

c. All piping systems and materials placed in the well zone should be NSF approved.Tailings from well drilling operation should be properly disposed.
d. Bentonite based full length grouting is required prior to pressure testing on vertical portion of the systems.
e. It is recommended that horizontal portions of the system be flow and pressure tested before backfilling.
f. Tracer wire and tracking tape should both be placed to mark the location of all horizontal pipes.

14. Circulation System

These recommendations are intended to cover corrosion-inhibited, biodegradable, liquid antifreeze materials as received at the job site.

a. Acceptable re-circulating fluids include:
   i. Potable Water (recommended)
   ii. A blend of potable water and propylene glycol, typically a 20% solution
   iii. A blend of potable water and 10% or less methanol
   iv. A blend of potable water and 10% or less ethanol
b. The solution type should meet the American Chemical Society's (ACS) high purity grade.
c. In cases where the re-circulating fluid is considered flammable, the re-circulating fluid should be diluted with water to a point that it is nonflammable before it can be taken indoors.
e. Manufacturer's recommendations should be followed when charging the secondary loop with re- circulating fluid.
f. Any additional additives such as corrosion inhibitors should meet ASTM D1384 corrosion inhibition requirements and should biodegrade to less toxic compounds.
g. The fluid should be at least 90% biodegradable.
g. All systems should be labeled and identified at the service ports. The labels should be permanent and should include the following information:
   i. Company name
   ii. Company phone number and responsible party or person
   iii. Service date
   iv. Re-circulating fluid type
   v. Concentration
   vi. Pressure
   vii. Direction of flow
   viii. Any additives, if used

15. Recording, Operations and Maintenance

a. The following information will be added to the property record kept by Salt Lake County:
   i. Site plans showing well locations and depth
   ii. Heating and cooling capacity of system
   iii. Type and concentration of re-circulating fluid and refrigerant
   iv. Year system was put into service
   v. Location of buried piping
   vi. Installation company name and contact information
b. If extra fluid is added, submit the date and the amount of added fluid to the SLCoHD.

16. Decommissioning well

Improperly decommissioned vertical loop piping can serve as an uncontrolled invasion point for ground water contaminants. This may constitute a hazard to public health, safety, welfare, and to the preservation of the ground water resource.

a. Decommission a heat pump system by removing all re-circulating fluid, filling full length pipes and tubing with potable water or grout, and capping and sealing. Re-circulating fluid solution and refrigerants should be disposed of at a hazardous waste disposal facility.
b. Decommissioning must comply with State Rule R655-4-14, Abandonment of Wells. Documentation of the decommissioning action will be added to the property records.

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Appendix A

The following table describes the minimum recommended distances between components of the GSHP and pertinent ground features.

Setbacks	**Feet**
AHWL for any watercourse *(live or ephemeral stream, river, irrigation canal, subsurface drain canal, etc.)*	100*
Individual or nonpublic water source (grouted wells and springs)	100*
Septic drain field (primary and replacement)	100
Lake, pond, reservoir, stream	100*
Dry wash, gulch, gully	25*
Stormwater detention/retention pond (*underground or surface*) and rain garden from the high-water level	15
Culinary water supply line	10
Foundation of any building *(including garages and outbuildings)*	10
Swimming pool wall *(subsurface)*	10
Property line	5

*Ground features marked with an asterisk indicate that the setback also applies to the disturbance area created during installation.

Note: Exceptions to set backs listed in Table A will be reviewed on a case by case basis.

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Appendix B

Regulations, standards, and specifications:

a. Utah Code R 317-4
a. Salt Lake County Health Department –Health Regulation #14-Watershed Regulation
b. Salt Lake County Water Source Protection Ordinance
c. Salt Lake County –Planning and Development Division -Foothill Canyon Overlay Zone (FCOZ)
d. Salt Lake City Watershed Ordinance Chapter 17.04
e. IGSHPA (http://www.igshpa.okstate.edu/pdf_files/Standards2009s.pdf)
f. Closed-Loop/Ground-Source Heat Pump Systems: Installation Guide, GSHPA Publication, Oklahoma State University.
g. ASTM specifications for PE pipe (hydraulic conductivity ASTM C-177)
h. ANSI/NSF grouting material Standard 60
i. NSF piping systems
j. ACS standard
k. ASHRAE standards (soil thermal value and loop length calculations)
l. ASTM D1384 for re-circulating fluid additives

Appendix C

Contact Information:

a. Utah State Division of Water Rights, 801-538-7240
b. Salt Lake County Planning and Development, 801-468-2000
c. Salt Lake County Health Department, Water Quality and Hazardous Waste Bureau, 385-468-3862
d. Salt Lake City Department of Public Utilities, 801-483-6750