

## ***Well Construction Considerations and Permit Regulations Affecting Geothermal Heat Pump Systems***

Rising energy costs have generated increased interest in geothermal heat pump systems (GHPS). According to the U.S. Environmental Protection Agency, GHPS can save homeowners 40-60 percent in heating and cooling costs, over conventional HVAC systems. Geexchange technology reduces greenhouse gas emissions and household safety hazards associated with fossil fuel combustion. High performance commercial building designs regularly incorporate geothermal technology to reduce energy costs.

A GHPS using either a water well supply or return well for the disposal of used water requires a well construction permit issued by the local health department. Depending on the particular GHPS design, additional permits may be needed from the Department of Environmental Quality (DEQ).

The last page of this document contains a decision tree flowchart describing when and what types of DEQ permits may be required.

### **Definitions**

1. Geothermal Heat Pump System - a mechanical device, also known as a ground source heat pump or geexchange system, which uses the geothermal exchange properties and the relatively constant temperature of earth formations for heating or cooling a building space. A GHPS consists of three parts: 1) heat pump unit, 2) heat exchanger, and 3) heating/cooling distribution system (e.g., duct work).
2. Closed-Loop - a geothermal heat exchanger that circulates a nontoxic antifreeze heat transfer fluid through a loop or multiple loops of polyethylene piping installed below the ground surface or within a surface water body. Unlike an open-loop, a closed-loop heat exchanger does not involve the withdrawal of groundwater. The earth's heat is absorbed by the heat transfer fluid within the loop piping and transmitted to the heat pump unit's heat exchanger and compressor to provide heating. In the summer, the cycle is reversed and the GHPS removes heat from the building and transfers it into the earth.
3. Open-Loop - a geothermal heat exchanger that withdraws groundwater from a supply well, passes the groundwater through a heat pump, and discharges the temperature-altered water either back to the ground in a discharge (return) well or to the ground surface or into surface water. Typically, the temperature is altered 4 to 10 degrees. In smaller residential settings, a single drinking water well may supply groundwater for both the GHPS and standard domestic uses.
4. Direct Exchange – a type of closed-loop heat exchanger that uses loops of copper tubing installed in pits, trenches or vertical borings in the earth, through which a refrigerant is circulated.

5. Well - an opening in the surface of the earth for the purpose of removing fresh water or a test well, recharge well, waste disposal well, or a well used temporarily for dewatering purposes during construction (From Section 12701 of the Public Health Code).  
R 325.1606(3) of the well code further defines a well to include water supply wells, irrigation wells, heat exchange wells, and industrial wells.
6. Heat Exchange Well – a well used for the purpose of utilizing the geothermal properties of earth formations for heating or air conditioning (From R 325.1606(3) of the well code).
7. Standing Column Well – a semi-open-loop heat exchanger consisting of a vertical boring from which groundwater is withdrawn and into which groundwater that has passed through a GHPS is discharged.

### **Regulatory Authority**

Depending on the specific type of heat exchanger, the owner or installer of a GHPS may be subject to the following state or federal regulations:

a. [Well Construction Code](#)

Part 127, Water Supply and Sewer Systems, 1978 PA 368 (Public Health Code), as amended, (MCL 333.12701 et seq.) and the administrative rules comprising the Michigan Water Well Construction and Pump Installation Code (state well code) (R 325.1601 et seq.), provides a mechanism to protect groundwater by regulating the construction and abandonment of water supply wells, water discharge wells (or return wells), and standing column wells needed for some GHPS. Closed-loops associated with a GHPS are not regulated under the state well code.

b. [Discharges to Groundwater](#)

Discharges to groundwater are regulated under Part 31, Water Resources Protection, 1994 PA 451, Natural Resources and Environmental Protection Act (NREPA), (MCL 324.3101 et seq.) and Part 22 Rules (R 323.2201 et seq.).

c. [Discharges to Surface Water](#)

National Pollutant Discharge Elimination System (NPDES) surface water discharge permits are authorized by the 1972 amendments to the Federal Clean Water Act, Public Law 92-500, as amended, and the rules promulgated thereunder. Michigan has primacy to issue NPDES permits through Part 31 of NREPA, and promulgated rules.

d. [Water Use Reporting](#)

Part 327, of NREPA (MCL 324.32701 et seq.) establishes requirements for the reporting of water use.

e. [Underground Injection Control](#)

The federal Underground Injection Control (UIC) regulations are within Part C, Sections 1421-1426, Safe Drinking Water Act, passed by Congress in 1974. Michigan is not UIC primacy state. The federal UIC program is implemented directly by the U.S. Environmental Protection Agency, Region V, Chicago, Illinois.

f. [Other Laws and Regulations](#)

In addition to DEQ regulations, other state permits, such as mechanical, electrical, and plumbing are needed. Ordinances of some local units of government may have provisions pertaining to GHPS installations. Be sure to check with local officials and comply with all applicable local requirements.

## Permit Requirements and Construction Advisory for Closed Loop GHPSs

Boreholes for the installation of a vertical closed-loop may extend several hundred feet in depth. Since vertical closed-loops and direct-exchange loops may penetrate drinking water aquifers, it is critical that loop boreholes be properly grouted to protect drinking water. Sealing the space between the vertical loop piping and borehole from the bottom up to the ground surface with an appropriate low permeability grout, as recommended by the GHPS manufacturer and consistent with the state well code, is strongly advised. Thermally-enhanced bentonite grouts, designed to enhance closed-loop performance, are acceptable if the permeability of the set grout seal is  $1 \times 10^{-7}$  centimeters per second or lower. Grout must be placed from the bottom of the loop borehole up to the surface through a grout pipe. The grout pipe should be withdrawn as the grout reaches the surface. Drill cuttings should not be shoveled into the borehole. The DEQ advises that loop boreholes be constructed by Michigan [registered water well drilling contractors](#).

Since closed-loops do not extract groundwater, the DEQ does not have authority to regulate their installation under the well code. Certain provisions within the Michigan Residential Code (MRC), implemented by the Michigan Department of Labor & Economic Growth, Bureau of Construction Codes & Fire Safety, apply to GHPS closed loop piping. Section M2104.2.1 sets forth minimum standards for heat fusion, electrofusion and stab-type insert fittings for the joining of polyethylene piping and tubing. Section M 2105.1 has minimum criteria for pressure testing of the assembled loop system before backfilling. Pressure testing is required with water at 100 psi for 30 minutes with no leaks observed. Refer to the MRC for further details.

Closed-loops are installed either horizontally in ground trenches, vertically in a borehole, or submerged within a large pond or lake. Since the length of the closed-loop piping depends on the heating/cooling load of the building, large GHPS often use a series of vertical closed-loops interconnected by header piping. Several dozen boreholes of several hundred feet in depth may be needed. If a closed-loop is proposed to be installed within a pond, lake, river, an NPDES discharge permit may be required pursuant to Part 31, NREPA. To inquire whether a permit is needed or to apply for a permit, contact a DEQ district office or the DEQ Permits Section, Water Bureau in Lansing.

A DEQ permit will be required prior to construction if the GHPS heat exchanger is installed in a wetland, floodplain, river, lake or critical dune area. Also, if the heat exchanger installation will disturb more than 1 acre of land or is within 500 feet of a water body, a soil erosion permit (as required by Part 91, Soil Erosion and Sedimentation, NREPA, MCL 324.9101 et seq. and R 323.1701) must be obtained from the appropriate county soil erosion agency.

Because the fluid within a closed-loop heat exchanger does not directly contact the environment, a closed-loop is not considered a Class V well under the federal Underground Injection Control (UIC) regulations (40 CFR 144.3).

The location of trenches and boreholes for GHPS closed-loops should be well documented and recorded. Future excavation, without knowledge of loop locations, can result in damage and spillage of heat transfer fluids into the environment and interruption of building heating or cooling.

## **Permit Requirements and Construction Advisory for Open Loop GHPSs**

An open-loop GHPS can be installed in a variety of formats. In all cases, the supply well must be constructed in accordance with the GWQC rules and a well construction permit obtained from the local health department, where required under local ordinance. Additionally, the supply well must be constructed by a Michigan-registered water well driller, and the pump installed by either a Michigan-registered water well driller, pump installer or a licensed master plumber.

In addition to well construction permits, any open-loop system installed in a wetland, floodplain, or critical dune area, will require a permit from the DEQ, Land & Water Management Division.

The owner of an open-loop GHPS installed for commercial purposes, that uses a water well having the *capacity* to withdraw 100,000 gallons of water per day over any 30-day period, must report water use to the state of Michigan. Water withdrawal capacity of 100,000 gpd is equivalent to 70 gallons per minute. Registration is based upon the total pumping capacity of a facility's water system, regardless of how much water is actually withdrawn during a given year. A \$200.00 annual filing fee is required. Water use is reported to the DEQ Water Bureau. Agricultural water users have the option of reporting to the Michigan Department of Agriculture or to the DEQ. Large quantity (over 70 gpm) open-loop GHPS owners should contact the Water Use Reporting Program, DEQ, Water Bureau, for further details.

### **1. Open-loop systems discharging to the groundwater through a discharge (return) well.**

A local health department permit may be required for the discharge well, depending on the local well permitting ordinance. The discharge well must be constructed by a registered well driller in accordance with the state well code. A DEQ groundwater discharge permit will also be required if either of the following conditions are present:

- a. There is chemical addition to the GHPS.
- b. The GHPS has a rating greater than 300,000 Btu/hr.

The isolation distance between the GHPS supply and discharge wells should be based on the heat pump unit manufacturer's recommendations to minimize thermal interference effects on system efficiency. If possible, the discharge well should be located down gradient of both the geothermal water supply well and any drinking water supply well. The DEQ advises a minimum of 50 feet between the supply and return well, unless specified by the GHPS unit manufacturer.

Potable water supply wells should be isolated from GHPS discharge wells a minimum of 50 feet if the discharge water has no chemical additives. If chemical additives are used, the potable water supply well should be a minimum of 300 feet. Deviations from the minimum isolation distance provisions may be granted by the local health department in accordance with R 325.1613 of the well code.

The discharge of water within a return well should occur below the static water level in a manner that prevents the injection of air into the return well. Premature well plugging from precipitated ferric iron solids and biofouling may occur if air is introduced. GHPS discharge wells should be designed to discharge water back into the same aquifer from which the supply well withdraws groundwater to ensure that the quality of the discharged water does not degrade the quality of a drinking water aquifer.

An open-loop GHPS equipped with a well for discharging heat pump water back into an aquifer is considered a Class V well under federal Underground Injection Control regulations (40 CFR 144.3). The EPA may require a permit for a heat pump return well.

The use of chemical additives (such as biocides, algicides, or anti-scaling agents) would render the water unsuitable for discharge into the same aquifer as the heat pump supply aquifer. In such cases, the DEQ, Office of Geological Survey (OGS), Mineral Well Program, would require a deep injection well permit under Part 625, Mineral Wells, NREPA. Additionally, if the heat pump supply well withdraws groundwater from a brine-bearing aquifer, the OGS requires a permit for both the supply and discharge (return) wells.

2. **Open-loop system discharging to groundwater through an infiltration gallery similar to a common septic system drainfield.**

Either a local health department on-site wastewater permit or a DEQ discharge-to- groundwater permit may be required depending on local codes and the amount of daily flow. Also, a DEQ discharge to groundwater permit is required under Part 31, NREPA, if there is chemical addition to the GHPS or if the GHPS rating is greater than 300,000 btu/hr.

3. **Open-loop system discharging to the open ground surface with eventual infiltration.**

This type of disposal is allowed, but property owners need to be aware of the potential for nuisance conditions to be created. Based on site factors, such as soil conditions, topography, and the volume of water to be discharged, problems of soil erosion, sedimentation, freezing, or migration onto adjacent property, roadways, or drainage ditches may occur.

4. **Open-loop system discharging to a surface water body**

According to a Water Resources Commission 1980 policy statement, heat pump installations for single-family residential use are typically low-volume discharges, particularly in the cooling mode with not more than five-to-six gallons per minute and maximum temperatures of 90 to 95 degrees Fahrenheit. Flows for the heating mode are five-or-six times greater, but with temperatures below 50 degrees Fahrenheit.

Based upon these characteristics, and further that a large system for single-family residential use will be rated at not more than 120,000 BTU per hour; the Water Resources Commission expected that discharges to the groundwater or to surface water courses from such systems should have minimal impact on water quality. The Water Resources Commission policy statement (January 24, 1980) specifically stated:

" . . . heat pump facilities with a heat exchange capacity of 120,000 BTU per hour or less will not be required to have a discharge permit provided there are no chemical additives used in the system."

Most residential systems are not required to have a permit under this policy statement. However, if the use of additives is proposed or the heat exchange capacity exceeds 120,000 BTU per hour, then an application for discharge should be filed.

## Local Health Department Role

Local health departments play both advisory and regulatory roles regarding GHPS installations. In addition to the normal work done to permit a drinking water well for a facility, local health department personnel need to recognize the ground water resource protection issues associated with GHPS. If the proposed GHPS possibly needs a DEQ permit, the local health department staff should advise the owner or contractor accordingly.

Through contract with the DEQ, local health departments have a regulatory responsibility to implement the state well code and issue local well construction permits. R 325.1606(3)(c) in the well code provides the authority to regulate the construction of water supply wells supplying GHPS. Section 12701(d) of the Public Health Code provides the authority to regulate construction of the geothermal discharge well.

For further guidance, local health department staff should contact the DEQ, Well Construction Unit, Drinking Water and Environmental Health Section, Water Bureau, in Lansing at 517-241-1374, or by fax at 517-241-1328.

## GHPS Installer Training

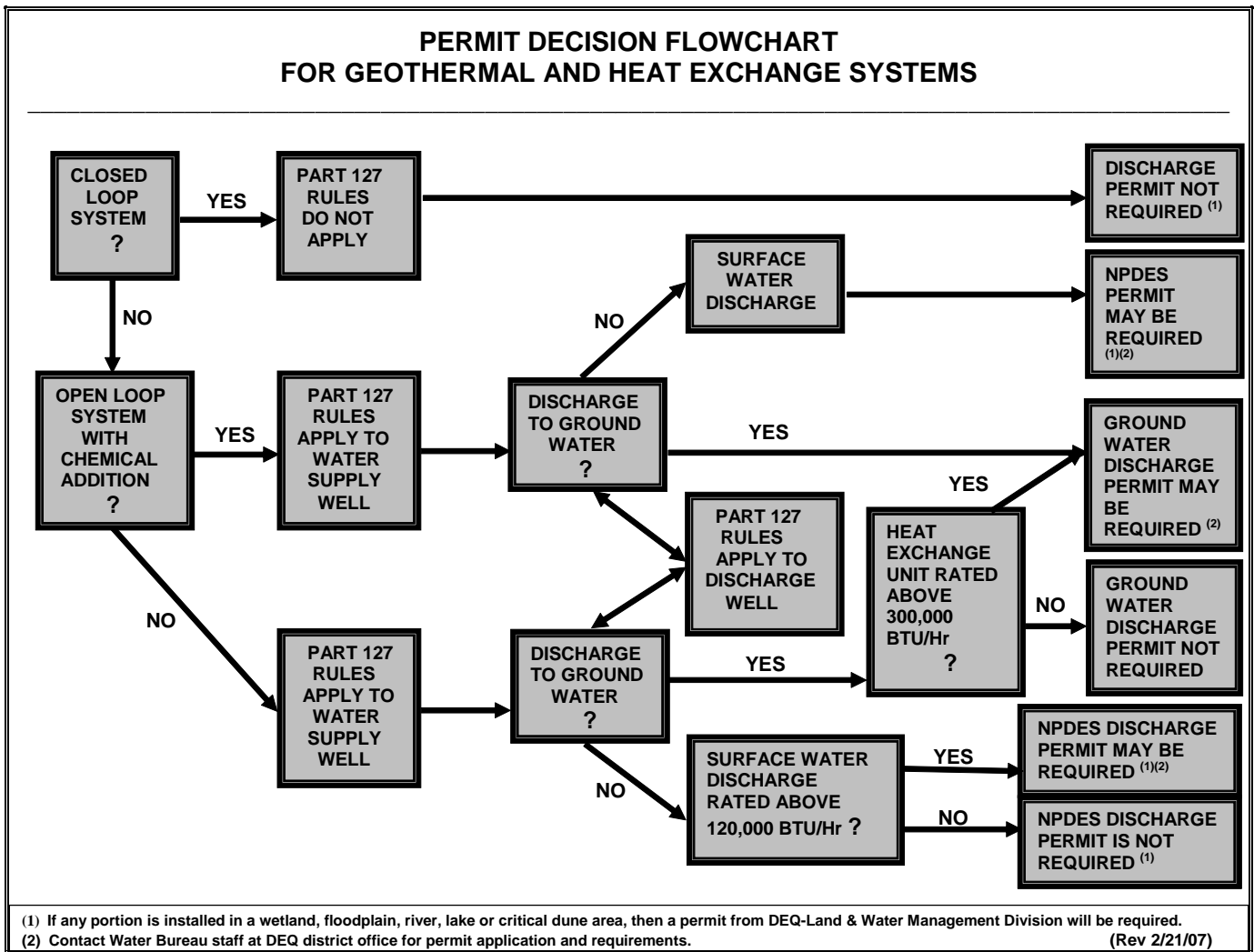
Water well drilling contractors interested in GHPS educational opportunities should contact the International Ground Source Heat Pump Association (IGSHPA) and National Ground Water Association (NGWA). The IGSHPA offers installer accreditation after completion of a workshop and exam and the NGWA sponsors a conference focusing on geothermal industry opportunities for well drillers.

## Information Sources

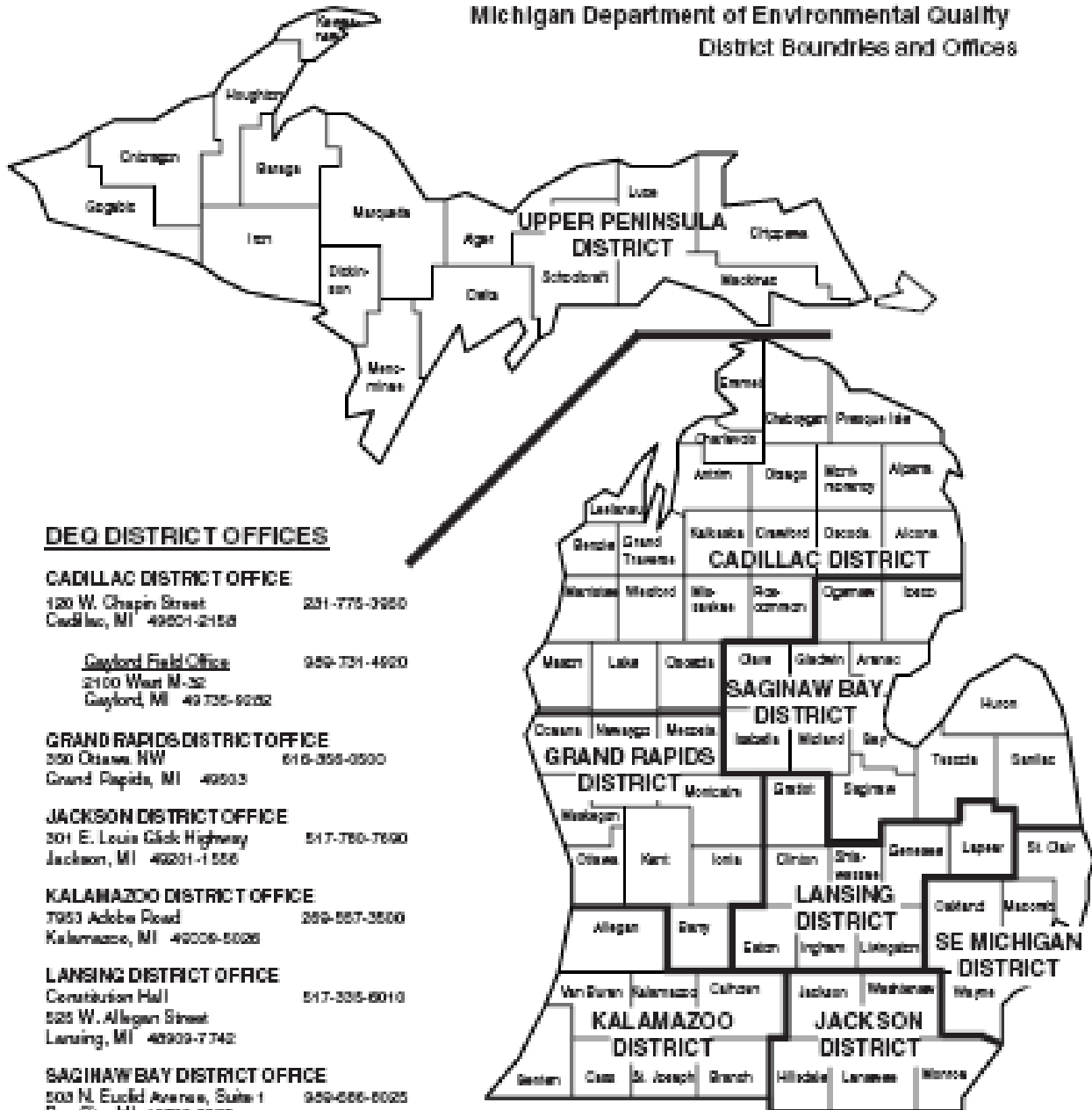
Several agencies and organizations have internet websites containing useful information about geothermal technology. Among them are:

1. American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), at [www.resourcecenter.ashrae.org](http://www.resourcecenter.ashrae.org)
2. Geothermal Heat Pump Consortium, Inc., at: [www.geoexchange.org](http://www.geoexchange.org)
3. International Ground Source Heat Pump Association, at: <http://www.igshpa.okstate.edu>
4. Michigan Geothermal Energy Association (MGEA): [www.earthcomfort.com](http://www.earthcomfort.com)
5. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Geothermal Technology Program at: [www.eere.energy.gov/geothermal](http://www.eere.energy.gov/geothermal)
6. *The Class V Underground Injection Control Study, Volume 19, Heat Pump and Air Conditioning Return Flow Wells*, U.S. Environmental Protection Agency, Office of Groundwater and Drinking Water, (4601) September 1999, EPA/816-R-99-014s. The document can be viewed at: [www.epa.gov/ogwdw/uic/classv/pdfs/volume19.pdf](http://www.epa.gov/ogwdw/uic/classv/pdfs/volume19.pdf)
7. *Michigan Residential Code, Incorporating the 2003 edition of the International Residential Code for One- and Two-Family Dwellings, 2003*, Copies are available from the Michigan Department of Labor & Economic Growth, Bureau of Construction Codes & Fire Safety, PO Box 30255, Lansing, MI 48909 at a cost of \$45.00.

8. *Ground Source Heat Pumps, The Energy Observer*, Quarterly Issue – June 2005, The Energy Office, Michigan Department of Labor & Economic Growth, PO Box 30221, Lansing, MI 48909, available at: [www.michigan.gov/documents/EO\\_06-05\\_131159\\_7.pdf](http://www.michigan.gov/documents/EO_06-05_131159_7.pdf)
9. Energy Star, Joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy, at: [www.energystar.gov/index.cfm?c=geo\\_heat.pr\\_geo\\_heat\\_pumps](http://www.energystar.gov/index.cfm?c=geo_heat.pr_geo_heat_pumps)
10. *Guidelines for the Construction of Vertical Boreholes for Closed Loop Heat Pump Systems*, 1997, National Ground Water Association, 601 Dempsey Road, Westerville, OH, 43081-8978.
11. *PPI Handbook of Polyethylene Pipe – HVAC Applications and Statement Q, Plastic Pipe Institute Position Statement on Polyethylene Materials For Closed-Loop Refrigeration and Heating Applications*, The Plastic Pipe Institute, at [www.plasticpipe.org](http://www.plasticpipe.org).



## Michigan Department of Environmental Quality District Boundaries and Offices



### DEQ DISTRICT OFFICES

#### CADILLAC DISTRICT OFFICE

120 W. Chapin Street  
Cadillac, MI 49801-2158 231-775-3680

Cadillac Field Office 231-775-3680  
2100 West M-52  
Gaylord, MI 49735-9052

#### GRAND RAPIDS DISTRICT OFFICE

350 Ottawa NW  
Grand Rapids, MI 49503 616-399-0500

#### JACKSON DISTRICT OFFICE

301 E. Louis Glick Highway  
Jackson, MI 49201-1556 517-780-7690

#### KALAMAZOO DISTRICT OFFICE

7953 Adobe Road  
Kalamazoo, MI 49009-5028 269-587-3500

#### LANSING DISTRICT OFFICE

Constitution Hall  
525 W. Allegan Street  
Lansing, MI 48209-7742 517-335-6010

#### SAGINAW BAY DISTRICT OFFICE

503 N. Euclid Avenue, Suite 1  
Bay City, MI 49706-2625 989-686-8025

#### SOUTHEAST MICHIGAN DISTRICT OFFICE

27700 Donald Court  
Warren, MI 48093-3793 588-753-3700

Detroit Field Office 313-488-4700  
Cadillac Place  
3055 West Grand Boulevard, Suite 2-300  
Detroit, MI 48202-8058

#### UPPER PENINSULA DISTRICT OFFICE

430 5th Street  
Gaylord, MI 49841 989-345-5300

#### ENVIRONMENTAL ASSISTANCE CENTER

(for general information):

Telephone: 800-252-0279

Fax: 517-241-0879

#### POLLUTION EMERGENCIES

Telephone: 800-252-4708

#### DEQ WEB PAGE

[www.michigan.gov/deq](http://www.michigan.gov/deq)