Hydrogeologic Guidelines for Large Scale Geothermal Heat Pump Systems

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This Can Happen with “Ideal” Water?
Un-Closed Loop
Twenty-five percent of Earth’s land surface is underlain by limestones and dolostones that can form caves and other karst features.

Source: American Geological Institute, 2005, “Living with Karst”
7 ppm Iron
Didn’t Seem
Like Much
Holey Moley!
More than 1000 gallons of grout needed to fill a borehole volume of 450 gallons
Going green...

~$8,500,000

- $4,500,000 to construct 480 geothermal wells
- HVAC system will save $200,000 per year
- repay the initial investment in 13 years
Building on Success?

- 6 more geothermal projects
- 120 wells per project
- 400 feet per well

In the summer, the system will cool the buildings. In the winter, it can help warm them. Supplements heating systems make up the difference to bring buildings to a comfortable temperature.

The geothermal wells are part of the Columbus schools’ strategy to reduce energy costs, said Carole Olshavsky, the district’s head of facilities.

“We’re able to design building systems that are over 30 percent more efficient than standard buildings,” Olshavsky said.

Six buildings will get geothermal


general is more expensive to build, the district was able to keep the overall project costs roughly the same, she said.

Contractors will drill as many as 120 wells up to 400 feet deep at each site, Olshavsky said. Water will circulate through pipes in the wells, soaking up heat from the earth in the winter and transmitting it into the buildings. In the summer, it does the reverse.

The water will run to electric-powered heat pumps scattered throughout the buildings — roughly one for every two classrooms.

Geothermal is one of the options that districts can choose when building or renovating a school co-
Motivation for Guidelines

• Growing number of examples where hydrogeologic investigation/ information would have saved time, money, project

• Help project team members understand impact of underlying geology and hydrogeology on system performance and durability

• Increase the likelihood of large scale project success
  – Effective for system owner and buildings served
  – Address strengths and concerns of project team members
  – Protect ground water & public health
Anticipated Audience

- Geothermal systems professionals
- Drilling contractors
- Geologists and hydrogeologists
- Building industry professionals
- Owners & developers
- Municipal engineers & planners
- Regulators
- General public
General Contents

• GSHP system benefits
• Basic ground heat exchanger choices & engineering for large scale systems
• Key hydrogeologic considerations when choosing the ground heat exchanger & drilling approach
• Sample assessment method for site suitability and ground coupling options
• Links to information about state requirements, permitting, supporting references
### Table 4.5b Guidance for Interpreting Water Analysis

<table>
<thead>
<tr>
<th>Groundwater Characteristic/Constituent</th>
<th>What to Look For</th>
<th>Potential Impact on GSHP System</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>&lt;7.5</td>
<td>Tendency for corrosion</td>
</tr>
<tr>
<td></td>
<td>&gt;7.5</td>
<td>Tendency for mineral precipitation</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>&gt; 4 mg/L</td>
<td>Promotes bacterial growth and precipitation of metals</td>
</tr>
<tr>
<td>Conductivity</td>
<td>&lt; 100 microsiemens</td>
<td>Increased corrosion</td>
</tr>
<tr>
<td>ORP (redox potential, bulk)</td>
<td>&gt;25%</td>
<td>Probable metallic ion states (tendency for metal precipitation), microbial activity</td>
</tr>
<tr>
<td>Change in ORP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total dissolved solids (TDS)</td>
<td>&gt;1000 mg/L</td>
<td>Electrolytic corrosion &amp; mineral precipitation</td>
</tr>
<tr>
<td>Total suspended solids (TSS)</td>
<td>&gt; 10 mg/L</td>
<td>Increased bacterial activity</td>
</tr>
<tr>
<td>Hardness (as CaCO3)</td>
<td>&gt;180 mg/L</td>
<td>Calcium incrustation</td>
</tr>
<tr>
<td>Alkalinity (as CaCO3)</td>
<td>&lt; 100 mg/L</td>
<td>Corrosion potential</td>
</tr>
<tr>
<td>Total organic carbon (TOC)</td>
<td>&gt; 2mg/L</td>
<td>Supports bacterial growth</td>
</tr>
</tbody>
</table>

Table continues & includes microbial constituents
Example: Method to Assess Site & GHX Options

Large-Scale GHP Suitability Assessment (LS-GSA)

**Stage 1 LS-GSA: Desktop & Option Screening**

1. Review owner’s Project Description and basic GHX Acceptance Criteria. Compile and review site background information.
2. List all potential GHX options; if in doubt, KEEP marginal options on the list.
3. Visit site.
4. Apply acceptance criteria for each GHX option.
5. Select short list of GHX options.
7. Prepare design commentary.
8. Assess constructability.
9. Assess GHX capital costs.
10. Report to owner with recommended next steps.

**Stage 2 LS-GSA: Intrusive Study & Options Evaluation**

1. Carry out intrusive work (e.g., drilling, testing and sampling) to determine site conditions needed to evaluate each GHX option short-listed from Stage 1 LG-GSA;
2. Conduct an Options Decision Analysis with these steps:
   a. Define qualitative ranges or numeric scores for each GHX option;
   b. Evaluate suitability for each GHX option;
   c. Determine a preferred GHX option for the site.
3. Report to owner.

Possible work scope for the intrusive investigation of different GHX options is detailed in Appendix C. The Options Decision Analysis process is described below.
Process & Timeline

• National Ground Water Association announcement & invitations to volunteers (Fall 2011)
• Committee formed (Winter 2012)
• Review of existing documents (Spring 2012)
• Iterative drafts & review (Summer 2012)
• Draft 4 being prepared for broader review (Fall 2012)
  – Will be posted by NGWA for public comment
• Anticipated completion Spring 2013
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