A CONTRACTORS PERSPECTIVE OF REGULATORY OVERSIGHT OF GEOTHERMAL HEAT PUMP SYSTEM INSTALLATIONS
Most Regulators do not Understand Geothermal

- Big G Little G
- Closed Loop
  - Pond\Lake Loops
  - DX
- Open Loop
  - Pump and Dump
  - Pump and Recharge
  - Standing Column
Grouting is the Standard

- National Ground Water Association
  NGWA’s First priority relative to Geothermal Heat Pumps is the protection of the resource
- International Ground Source Heat Pump Association
  Industry and IGSHPA Standards require geoexchange boreholes to be grouted completely from *Bottom to Top*
Borehole Grouting

- Prevents leakage downward along the Ground Heat Exchanger from surface or near surface contamination sources.
- Prevents the migration of water between aquifers.
- Seals off formations that are known to be contaminated.
- Preserves the hydraulic characteristics of artesian formations and prevent leakage upward along the Ground Heat Exchanger
- Can improve VHE performance
Grout Properties

- High Thermal Conductivity
- Reasonably Low Viscosity During Grout Placement
- High Viscosity Upon Placement – Little or no shrinkage of the grout material during settling.
- Low Permeability
Upward Leakage Around an UngROUTed GHEX in a Confined Aquifer

Static Water Level

Relative Pressure

UngROUTed Annular Space Around GHEX

Trench

Water Table Aquifer

Upper Confining Bed

Leakage Upward

Borehole Wall

Confined Aquifer

Topsoil

Backfill

Lower Confining Bed
Downward Leakage Around an Ungrounded GHEX in a Confined Aquifer – Adjacent Well Being Pumped
Leakage from Surface into Water Table Aquifer

- Topsoil
- Downward Leakage
- Borehole Wall
- Trench
- Ungrouted or Improperly Grouted Annular Space Around GHEX
- Static Water Level
- Water Table Aquifer
- Confining Bed
Leakage from Shallow Fractured Bedrock into Bedrock Aquifer

Contamination Enters Fractures

Thin Glacial Drift

Contamination Enters Annulus

Surface Water Travels Down Annulus

Trench

Fractured Bedrock

Ungrounded Annulus Around GHEX

Borehole Wall

Static Water Level

Bedrock Aquifer
**Grouting Methods**

**Not Recommended:**

- Shoveling drill-cuttings, sand or gravel into the mud filled annulus.
- Relying on the drilling mud slurry in the borehole to act as a proper grout.

**Recommended:**

- Grouting vertical boreholes from bottom to top with bentonite based grouting materials through a tremie line.
Bridging of Cuttings in an Annular Space

- Bridging of Cuttings
- Static Water Level
- Trench
- Upper Confining Bed
- Upward Leakage
- Borehole Wall
- Confined Aquifer
- Lower Confining Bed
- Topsilt
Grouting Methods

- Grout is to be placed in the annulus via a tremie pipe under pumping pressure (Pressure Tremie Method).
- Grout is to be pumped into annulus from the bottom of the borehole.
- Pouring of grout material into the borehole is unacceptable.
  - Dilutes the grout
  - Separates the solids contained in the grout
- Placing the tremie pipe less than all of the way to the bottom is also considered pouring.
Settling of Bentonite Solids in an Annular Space

- Initial Mud Level
- Water Loss
- Dilute Drilling Mud
- Mud Level in Annulus Drops Due to Water Loss Into Permeable Formations
- Borehole Wall
- Settled Bentonite Solids
- Lower Confining Bed
- Upper Confining Bed
- Trench
- Confined Aquifer

T-8.10
Subsidence

- Top Off
- Stage Grout
- Reduce Water
Subsidence
## Circulating Fluids

<table>
<thead>
<tr>
<th></th>
<th>Methanol</th>
<th>Ethanol</th>
<th>Propylene Glycol</th>
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<tbody>
<tr>
<td><strong>Toxicity</strong></td>
<td>High</td>
<td>Med</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Flammability</strong></td>
<td>High</td>
<td>Med-High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Corrosivity</strong></td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Viscosity</strong></td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Heat Transfer (#)</strong></td>
<td>High</td>
<td>Med</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Volatility</strong></td>
<td>High</td>
<td>High</td>
<td>Low</td>
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<tr>
<td><strong>Pressure Drop</strong></td>
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<td>Med</td>
<td>High</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
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<td>Med</td>
<td>High</td>
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<tr>
<td><strong>Acceptability (Code)</strong></td>
<td>Not in Ontario</td>
<td>Acceptable</td>
<td>Acceptable</td>
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</table>
## Circulating Fluids

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Used only in highly cooling dominated climates &amp; low heating loads <em>(Not in Canada!)</em></td>
</tr>
<tr>
<td>Ethylene Glycol</td>
<td>Not allowed in most areas because of toxicity</td>
</tr>
<tr>
<td>Sodium Chloride</td>
<td>Not recommended by manufacturers because of corrosiveness</td>
</tr>
<tr>
<td>Calcium Chloride</td>
<td>Not recommended by manufacturers because of corrosiveness</td>
</tr>
<tr>
<td>Potassium Acetate (GS4)</td>
<td>Don’t even go there!! <em>(corrosive when air is present, low viscosity – leaks easily)</em></td>
</tr>
</tbody>
</table>
Regulatory Issues

- When we found our wells not filled completely they wanted to use some #9 stone but I insisted on stone mixed with sand. When they realized it was more work to try and fill the existing holes they re-drilled. They did tell me at first if they hit water they would have to use some #9 stone to fill where the water was since the dust wouldn't sink into the water. I went ahead with extra well capacity and enhanced grout. In fact it just got hooked up yesterday.
Regulatory Issues

- Grouting Regulations Inconsistent Nationwide
  - Mix 111
  - Neat cement grout - MN
  - Bentonite grouts
  - Minimum Grout Thicknesses
  - When should a borehole be grouted
  - Shovel cuttings, pearock
REGULATORY OVERSIGHT

And Too What Extent Should You Be Involved With Consumer Protection?
ACKNOWLEDGEMENTS

NGWA
IGSHPA
Practical GeoExchange Solutions
Thank You

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