MSBA Contractor Roundtable

Geothermal Systems & Lessons Learned

December 9, 2021
Welcome

Contractor Roundtable Agenda

9:30 AM – Welcome and Introduction
   o Jack McCarthy, Executive Director, Massachusetts School Building Authority

9:35 AM – 10:20 AM – Presenters
   o Arlington HS
      o Jim Burrows, Senior Project Manager, Skanska USA Building (OPM Services)
   o Belmont HS
      o Mike Loring, Senior Project Manager, Skanska USA Building (CM Services)
      o Tom Gatzunis, Section Manager, CHA Companies
   o Acton – Boxborough
      o Jim Burrows, Senior Project Manager, Skanska USA Building (OPM Services)
      o Jeremiah Driscoll – Project Manager, Consigli Construction
   o Westborough
      o Steve Theran, Senior Project Manager, The Vertex Companies
      o Kevin Jones, Project Executive, Gilbane Building Company

10:35 - 11:00 AM – Discussion

11:00 AM – Meeting Conclusion
December 2021
MSBA Contractor Roundtable

Geothermal Well Design &
Test Well Operation –
Arlington High School Project
Arlington, MA

Project Team:

SKANSKA

Consigli

Est. 1905

HMFH Architects

McPHAIL
ASSOCIATES, LLC
Arlington HS accepted into the MSBA Feasibility Study Module in 2016

- Arlington community vote in 2019 approved the 408,590-sf phased-occupied new school.

- $290M phased-occupied project to rebuild the school on the existing site

- New school to be complete in 2024, field and final site improvements complete in 2025
Early in the Feasibility Study, the AHS Building Committee established a Sustainability Subcommittee. This group brought a range of relevant technical expertise as well as a passion for sustainability and a strong desire to make the new AHS a net-zero energy building.

The subcommittee developed a list of recommended sustainability goals for the project. These cover issues related to:

- Energy production and use
- Managing the flows of waste within the building (e.g., recycling and organics separation, such as food scraps)
- Using the building as a teaching tool
- Quality of the indoor environment
- Transportation
It was determined that 330 Geothermal Wells were needed to reach the sustainability goals for the project.

The primary geothermal design of 330 wells made use of the entire site, while avoiding the contamination site cap at the existing athletic fields.
Unanticipated construction costs triggered ~$25M in value engineering cuts

Cost Premium for 330 geothermal wells: ~$7M

The premium was associated with the need to drill a network of wells (6-inch holes each approximately 500 feet deep) for a closed loop piping system to transfer heat to/from the building. For the AHS site, the price premium was further compounded by the need to manage contaminated soil.

The Arlington HS Building Committee reduced to 130 wells and supplemented the HVAC design with a VRF system.

The design changes implemented estimated to increase total building energy use by only about 3-4%, while resulting in several million dollars in up-front savings.
On February 24, 2020, while drilling the first test wells, the presence of an unexpected contaminant, Naphthalene (NAPL), was discovered in the bedrock at a depth of approximately 160 feet and drilling was immediately halted.
When unanticipated contaminants were discovered during geothermal test well drilling in February, all test well drilling was halted and the project team performed an analysis of options:

• Proceed with the geothermal well field as designed in its current location = high risk
• Move the geothermal well field to another location on-site and redesign portions of the system = medium to high risk
• Forego a geothermal system, and redesign the building’s mechanical systems = low risk
The Design Team recommended redesigning the project with no geothermal wells because it posed:

- the least risk to impacting/increasing the project budget, the least risk of any future environmental impacts, and the least risk of negatively impacting the project
- Schedule

The redesign would be included in the upcoming 90% CD package, but there would be a 4-week delay.

At its March 24, 2020, meeting, the Arlington HS Building Committee voted to remove geothermal wells from the project and directed HMFH to redesign the HVAC system.
HMFH Architects made adjustments to the design of the new school to use a combination of VRF systems, Chilled Beams, and Solar Panels for a 100% electric powered building.

**Key Features of the Final Design Include:**
- Passive design
- Reduced lighting and plug loads
- Heat pumps for efficient heating and cooling
- Rooftop and ground-mounted solar
- Integrated energy management & user engagement
- Energy and user management
Redesign Schedule Impacts

Due to the 4-week redesign delay of the 90% CD’s, the construction start date and perspective project dates were impacted.

Several schedule options were presented by Consigli that aligned with the phase turn over dates and school vacations. The School Building Committee preferred option 1A.

<table>
<thead>
<tr>
<th>PHASE</th>
<th>CONSTRUCTION FINISH DATE</th>
<th>SCHOOL START DATE</th>
<th>SCHOOL VACATION ALIGNMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>As Planned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 1</td>
<td>12/23/2021</td>
<td>1/6/2022</td>
<td>Christmas/New Year</td>
</tr>
<tr>
<td>Phase 2</td>
<td>8/4/2023</td>
<td>9/8/2023</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 3</td>
<td>8/26/2024</td>
<td>9/6/2024</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 4</td>
<td>5/6/2025</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OPTION 1A</th>
<th>Phase 1 February vacation 2022</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>2/11/2022</td>
<td>2/21/2022</td>
<td>February</td>
</tr>
<tr>
<td>Phase 2</td>
<td>9/11/2023</td>
<td>9/18/2023</td>
<td>Delayed school start</td>
</tr>
<tr>
<td>Phase 3</td>
<td>9/10/2024</td>
<td>9/17/2024</td>
<td>Delayed school start</td>
</tr>
<tr>
<td>Phase 4</td>
<td>5/8/2025</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Redesign Schedule Impacts Analysis

<table>
<thead>
<tr>
<th>Phase</th>
<th>As Planned</th>
<th>Option A</th>
<th>Option B</th>
<th>Option 2</th>
<th>Accelerate</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12/21/2021</td>
<td>1/1/2023</td>
<td>1/1/2023</td>
<td>1/1/2023</td>
<td>1/1/2023</td>
<td></td>
</tr>
<tr>
<td>Phase 1</td>
<td>1/6/2023</td>
<td>February</td>
<td>1/1/2023</td>
<td>1/6/2023</td>
<td>1/6/2023</td>
<td>1/6/2023</td>
</tr>
<tr>
<td>Phase 2</td>
<td>8/1/2023</td>
<td>Summer</td>
<td>8/1/2023</td>
<td>Summer</td>
<td>8/1/2023</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 3</td>
<td>8/16/2023</td>
<td>Summer</td>
<td>8/16/2023</td>
<td>Summer</td>
<td>8/16/2023</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 4</td>
<td>5/31/2023</td>
<td>Summer</td>
<td>5/31/2023</td>
<td>Summer</td>
<td>5/31/2023</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 5</td>
<td>3/1/2022</td>
<td>February</td>
<td>3/1/2022</td>
<td>February</td>
<td>3/1/2022</td>
<td>February</td>
</tr>
<tr>
<td>Phase 6</td>
<td>4/1/2022</td>
<td>April Vacation</td>
<td>4/1/2022</td>
<td>April Vacation</td>
<td>4/1/2022</td>
<td>April Vacation</td>
</tr>
<tr>
<td>Phase 7</td>
<td>11/1/2022</td>
<td>Thanksgiving</td>
<td>11/1/2022</td>
<td>Thanksgiving</td>
<td>11/1/2022</td>
<td>Thanksgiving</td>
</tr>
<tr>
<td>Phase 8</td>
<td>12/28/2022</td>
<td>Christmas/New Year</td>
<td>12/28/2022</td>
<td>Christmas/New Year</td>
<td>12/28/2022</td>
<td>Christmas/New Year</td>
</tr>
<tr>
<td>Phase 9</td>
<td>1/1/2023</td>
<td>Winter</td>
<td>1/1/2023</td>
<td>Winter</td>
<td>1/1/2023</td>
<td>Winter</td>
</tr>
<tr>
<td>Phase 11</td>
<td>8/1/2023</td>
<td>Summer</td>
<td>8/1/2023</td>
<td>Summer</td>
<td>8/1/2023</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 12</td>
<td>8/16/2023</td>
<td>Summer</td>
<td>8/16/2023</td>
<td>Summer</td>
<td>8/16/2023</td>
<td>Summer</td>
</tr>
<tr>
<td>Phase 13</td>
<td>5/31/2023</td>
<td>Summer</td>
<td>5/31/2023</td>
<td>Summer</td>
<td>5/31/2023</td>
<td>Summer</td>
</tr>
</tbody>
</table>

**Notes:**
- **As Planned:**
  - 4 week redesign delay of the 90% CD's, 100% CD/s, GMP and construction start date was in turn delayed.
  - Additional General requirements for winter protection and conditions range ($400K to $600K).

- **Option A:**
  - Phase 1: February vacation 2022
  - Delayed school start.
  - Additional General requirements for winter protection and conditions range ($400K to $600K).

- **Option B:**
  - Phase 3: April vacation 2022
  - Phase 5: Thanksgiving
  - Additional General requirements for winter protection and conditions range ($400K to $600K).

- **Option 2:**
  - Phase 1: Accelerate
  - This may not be possible if COVID-19 enhanced.
  - Additional General requirements for winter protection and conditions range ($400K to $600K).

- **Phase 1 (only) COVID-19 enhanced Impact:**
  - 20% efficiency, delays start of day verification, & separation, longer task durations.
  - Total Impact: $1,000,000.
Other Information:

**Energy Usage**

- **Electricity**
  - Current: about 1,385,000 kWh/year
  - New AHS: about 4,000,000 kWh/year (original estimate with 330 geothermal wells, will be higher with geothermal eliminated)
- **Gas**
  - Current: 225,000 therms
  - New AHS: Zero
- **EUI (Existing school: 66)**
  - With 330 geothermal wells: 30
  - With zero geothermal wells, all ASHP: 37

**Some Key Energy Features**

- Passive design (very efficient building envelope)
- Reduced lighting and plug loads
- Heat pumps for efficient heating and cooling
- Rooftop & ground-mount solar
- Good energy management & user engagement
Belmont Middle & High School

Geothermal Wells – Lessons Learned
Project Information

- Belmont Middle and High School
- CM - Skanska USA Building
- Subcontractor – Chesapeake Geosystems Inc.
- CV - $5.7MM, SCOs - $350k

Scope of Work:
- 280 Wells per Design
- 500 feet in depth per well
- 1000 ft 1¼” HDPE Piping Loop per well
- (3) “Fields” with single vault and (1) Main Vault before connection into Building
- Thermal Conductivity 1.40 Btu/ft/hr

- 6 Month Schedule (February – July)
- At max production, 3 Drill Rigs onsite drilling 3 Wells per day
Lessons Learned - Skanska

- Procurement
  - Utility and Well Coordination
  - Water Management, Treatment and Discharge

- Design
  - Thermal Conductivity
    - Testing, Range, Products
  - Water Quality – Ground Loop vs. Building Loop

- QA/QC
  - Drilling Operation
  - Loop Installation
  - Grout Operation
    - 3rd Party Testing
  - Lateral Piping
Well Field Layout
Lessons Learned - CHA

- Local Permitting
  - Board of Health
- Conservation Commission
- Noise By-Law
December 9th, 2021

MSBA Contractor Roundtable

Geothermal Well Design &
Test Well Operation –
Douglas-Gates ES School Project
Acton-Boxborough, MA

Project Team:
Douglas-Gates ES School Project Overview

- Douglas-Gates Elementary School accepted into the MSBA Feasibility Study Module in 2017
- Acton-Boxborough community vote in 2019 approved the 174,800 sf new consolidated school
- $114M project to build the consolidated school on the Gates site
- New school to be complete in August 2022
GROUNDSOURCE HEAT PUMPS
FEASIBILITY CONSIDERATIONS

1. Set EUI early and then target for number of geothermal wells. You will refine well count after test wells.
2. Well fields are 20ft x 20ft grid
3. Define potential site areas for well field(s) coordinate with other site design strategies
4. Allow appropriate space for interior mechanical equipment
5. Schedule:
   - Onboard geothermal design consultant
   - Plan for test wells in SD or early DD
   - Create float in construction schedule for installation
   - Consider early package for the geothermal wells
GROUND SOURCE HEAT PUMPS
SITING GEOTHERMAL WELLS

- Building SOE & setbacks
- Property setbacks
- Buffer zones
- Existing structures
- Distance to mechanical room
- Ease of construction impacts (ground water, ledge)
- Phasing
- Construction staging
Douglas Gates Elementary Case Study

Existing School

New School

Geothermal Well Field

Existing School

New School
It was determined that 65 wells were required located in back of the new school.
The 65 wells were broken up into two well fields, A and B. A has 7 circuits and B has 6. Each circuit has 4 to 5 wells. Circuit piping runs to a vault designated for that field to combine them.
Geothermal Closed Loop System

Main Components of System:
- Individual Well
- Circuit
- Vault
- Supply & Return
Considerations

Noise & Vibration
- 80-90 dB Avg
- Long Durations
- Effect on Neighbors & Owner

Site Feasibility & Design
- Early Test Wells needed to verify typical Water Inflows
- Arch/Engineer to need to Ensure Ext Geothermal is coordinated w/Int MEP

Cost
- Carry cost for High GPM Mgmt
- Buy GT Scope with Site Subcontractor
Geothermal Closed Loop System
Prior to construction two test wells were installed to determine how many wells would be required to heat and cool the new school.
A great deal of underground water was discovered during the drilling process making the drilling more complicated.
When the underground water was too powerful for the drilling to continue, the workers would plug the area where the water was escaping using cement, after the cement hardened, they drilled through the cemented well without any more water problems.
Once wells were drilled to 600’ 4 lengths of piping called loops were inserted into the well. Two supplies and two returns called a quad well.
Two 8” lines from each of the two vaults are being run into the building.
The circuit piping is connected to the well field vaults
Annie E. Fales Elementary School Project
MSBA Contractor Roundtable - Geothermal Installation
<table>
<thead>
<tr>
<th>Role</th>
<th>Company/Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner</td>
<td>Westborough Public Schools</td>
</tr>
<tr>
<td>OPM</td>
<td>The Vertex Companies, Inc.</td>
</tr>
<tr>
<td>Designer</td>
<td>HMFH Architects, Inc.</td>
</tr>
<tr>
<td>Geothermal Design</td>
<td>McPhail Associates, LLC</td>
</tr>
<tr>
<td>Construction Manager</td>
<td>Gilbane Building Company</td>
</tr>
<tr>
<td><strong>Scope:</strong></td>
<td>Two phase project; build new behind existing; demo old; <strong>Net Zero building</strong></td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td><strong>Phase 1 Schedule:</strong></td>
<td>April 2020 – November 2021</td>
</tr>
<tr>
<td><strong>Occupied:</strong></td>
<td>November 15, 2021</td>
</tr>
<tr>
<td><strong>Geothermal:</strong></td>
<td>40-well design</td>
</tr>
<tr>
<td><strong>Well depth:</strong></td>
<td>600’</td>
</tr>
</tbody>
</table>
Fales Elementary School - Geothermal Piping Manifold
Fales Elementary School - Site Topography
• During backfill process to ensure and establish a protocol to keep the circuit under pressure. This would allow an immediate identification of any issues that may have caused by the back fill process.

• Establish a protocol if leaks are discovered. Reporting protocol with timeframe. Procedure based on size of leak, location, timeframe. Product submissions, etc.

• Establish an order of precedence when exterior and interior systems are comingled – i.e. water quality, glycol products, deionized water.

• Work plan and upfront conversations on how drill tailings are controlled, filtered etc.
Fales Elementary School – OPM’s Lessons Learned

• Drilling noise for abutters

• Set performance expectations for # of wells
  o Plan and expectations for duration of work and what to do with added cost from added time
  o Schedule: Site disruption due to well installation is significant. Extended time with drilling creates numerous collateral impacts including delaying the stabilization and completion of grading, drainage, landscape (plantings and hardscape) and area play structures
  o Site team needs clear understanding of earthwork sequencing i.e., stockpiles, filling, cutting, working grade, etc.
  o Gas service: backup boiler - propane
Questions

- Thank you for Attending!
- If you would like to host a future roundtable or if you have a suggestion for a topic, please contact Patrick.deangelo@massschoolbuildings.org