Massachusetts School Building Authority

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Executive Director

MSBA Contractor Roundtable

Geothermal Systems & Lessons Learned

December 9, 2021

www.MassSchoolBuildings.org

Welcome

Contractor Roundtable Agenda

9:30 AM – Welcome and Introduction

- Jack McCarthy, Executive Director, Massachusetts School Building Authority

9:35 AM – 10:20 AM – Presenters

- **Arlington HS**
  - Jim Burrows, Senior Project Manager, Skanska USA Building (OPM Services)
- **Belmont HS**
  - Mike Loring, Senior Project Manager, Skanska USA Building (CM Services)
  - Tom Gatzunis, Section Manager, CHA Companies
- **Acton – Boxborough**
  - Jim Burrows, Senior Project Manager, Skanska USA Building (OPM Services)
  - Jerimiah Driscoll – Project Manager, Consigli Construction
- **Westborough**
  - Steve Theran, Senior Project Manager, The Vertex Companies
  - Kevin Jones, Project Executive, Gilbane Building Company

10:35 - 11:00 AM – Discussion

11:00 AM – Meeting Conclusion

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December 2021
MSBA Contractor Roundtable

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

Project Team:

SKANSKA

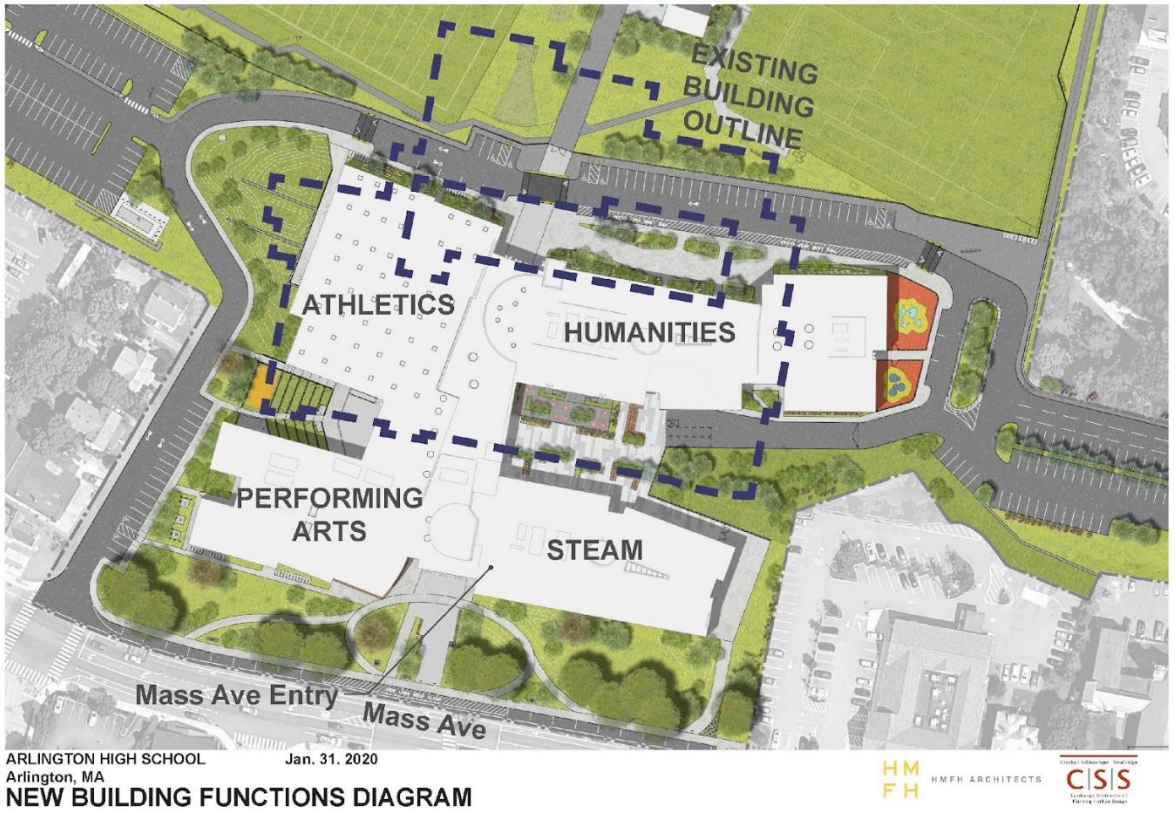
CONSIGLI
Est. 1905

HMFH ARCHITECTS

McPHAIL ASSOCIATES, LLC

Arlington HS Building Project Overview

- 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



Sustainability Goals Set Early On

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.

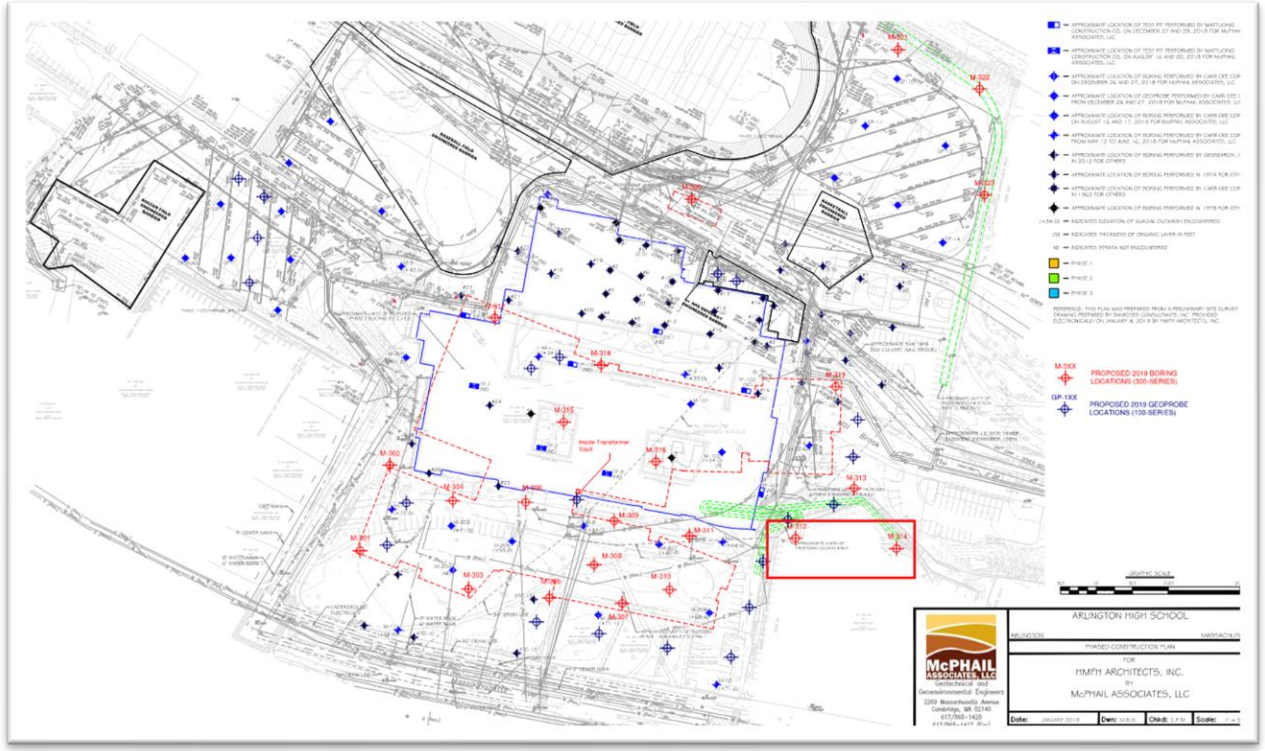
The subcommittee developed a list of recommended sustainability goals for the project. These cover issues related to:

- 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

Geothermal Design Process

It was determined that 330 Geothermal Wells were needed to reach 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.



Value Engineering

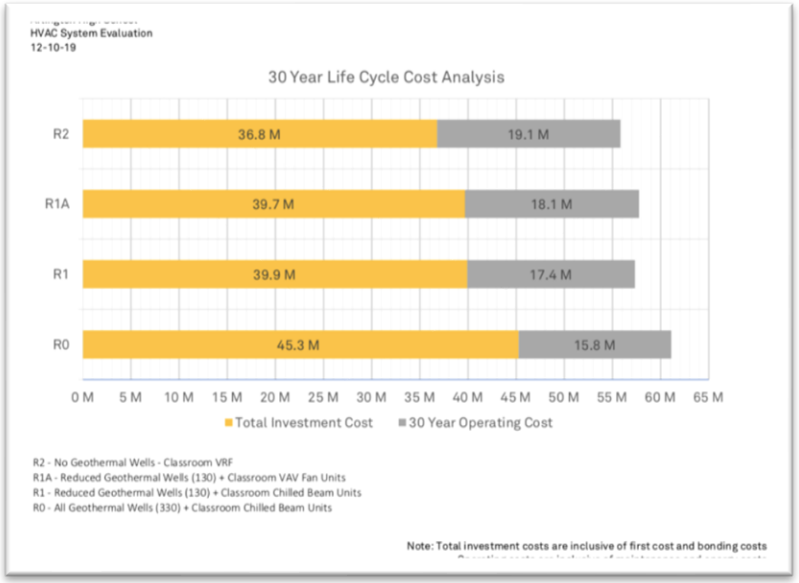
Unanticipated construction costs triggered ~$25M in value engineering cuts

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.



Test Well Operation Halted

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.

The Path Forward

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 Path Forward

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.

The New All-Electric Design

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.

	PHASE	CONSTRUCTION FINISH DATE	SCHOOL START DATE	SCHOOL VACATION ALIGNMENT
As Planned				
	Phase 1	12/23/2021	1/6/2022	Christmas/New Year
	Phase 2	8/4/2023	9/8/2023	Summer
	Phase 3	8/26/2024	9/6/2024	Summer
	Phase 4	5/6/2025		
OPTION 1A	Phase 1 February vacation 2022			
	Phase 1	2/11/2022	2/21/2022	February
	Phase 2	9/11/2023	9/18/2023	Delayed school start
	Phase 3	9/10/2024	9/17/2024	Delayed school start
	Phase 4	5/8/2025		

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Redesign Schedule Impacts Analysis

Job #: 2153
Project: Arlington High School
Location: Arlington , MA
Date: 5/11/2020
Proposal: Schedule Options
Gross Area (SF): 408,000

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	PHASE	CONSTRUCTION FINISH DATE	SCHOOL START DATE	SCHOOL VACATION ALIGNMENT		NOTES	Description	ESTIMATED VALUE
As Planned								
	Phase 1	12/23/2021	1/6/2022	Christmas/New Year				
	Phase 2	8/4/2023	9/8/2023	Summer				
	Phase 3	8/26/2024	9/6/2024	Summer				
	Phase 4	5/6/2025						
OPTION 1A	Phase 1 February vacation 2022							
	Phase 1	2/11/2022	2/21/2022	February	8 Weeks		Additional General requirements for winter protection and conditions range ($200K to $400K)	400,000
	Phase 2	9/11/2023	9/18/2023	Delayed school start				
	Phase 3	9/10/2024	9/17/2024	Delayed school start				
	Phase 4	5/8/2025						
OPTION 1B	Phase 1 April vacation 2022							400,000
	Phase 1	4/15/2022	4/18/2022	April Vacation	15 Weeks		Additional General Conditions and General requirements for winter protection and conditions range ($400K to $800K)	1,400,000
	Phase 2	11/17/2023	11/17/2023	Thanksgiving			Skanaka & HMFH support staffing	425,000
	Phase 3	12/20/2024	12/22/2024	Christmas/New Year				
	Phase 4	10/21/2025						
OPTION 2	Phase 1 Accelerate					This may not be possible if COVID-19 enhanced		1,825,000
	Phase 1	12/23/2021	1/6/2022	Christmas/New Year Vacation		6 days week - Saturday Schedule. 6 mos. (March - Sept. 2021) Veneer, roof,winter conditions, MEP/FP Co collaboration, MEP/FP rough in, drywaller.	Trade over time	1,152,000
	Phase 2	8/4/2023	9/8/2023	Summer			Winter conditions (slabs, fire proofing, veneer)	500,000
	Phase 3	8/5/2024	9/6/2024	Summer			Full time MEP/FP Subcontractor co-collaboration	300,000
	Phase 4	4/2/2025					GC's Supervision (Saturdays) & GR's (5) months	156,500
	Phase 1 (only) COVID-19 enhanced Impact					20% Inefficiency, Daily start of day verification, 6' separation, longer task durations		2,108,500

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

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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 1 ¼” 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


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CAT

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

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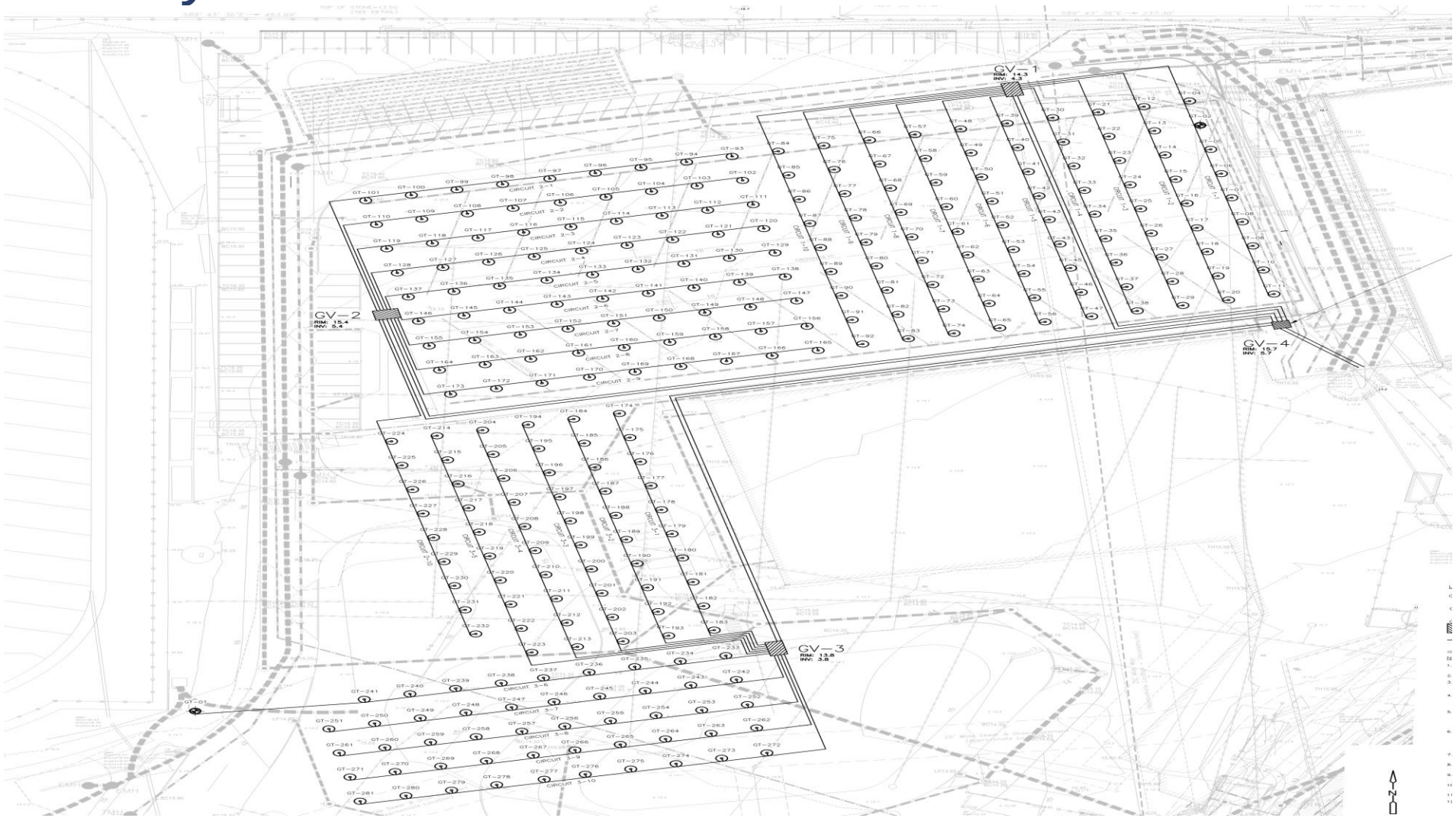
Well Field Layout



Lessons Learned - CHA

- Local Permitting
  - Board of Health
- Conservation Commission
- Noise By-Law

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December 9th, 2021

MSBA Contractor Roundtable

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

Project Team:

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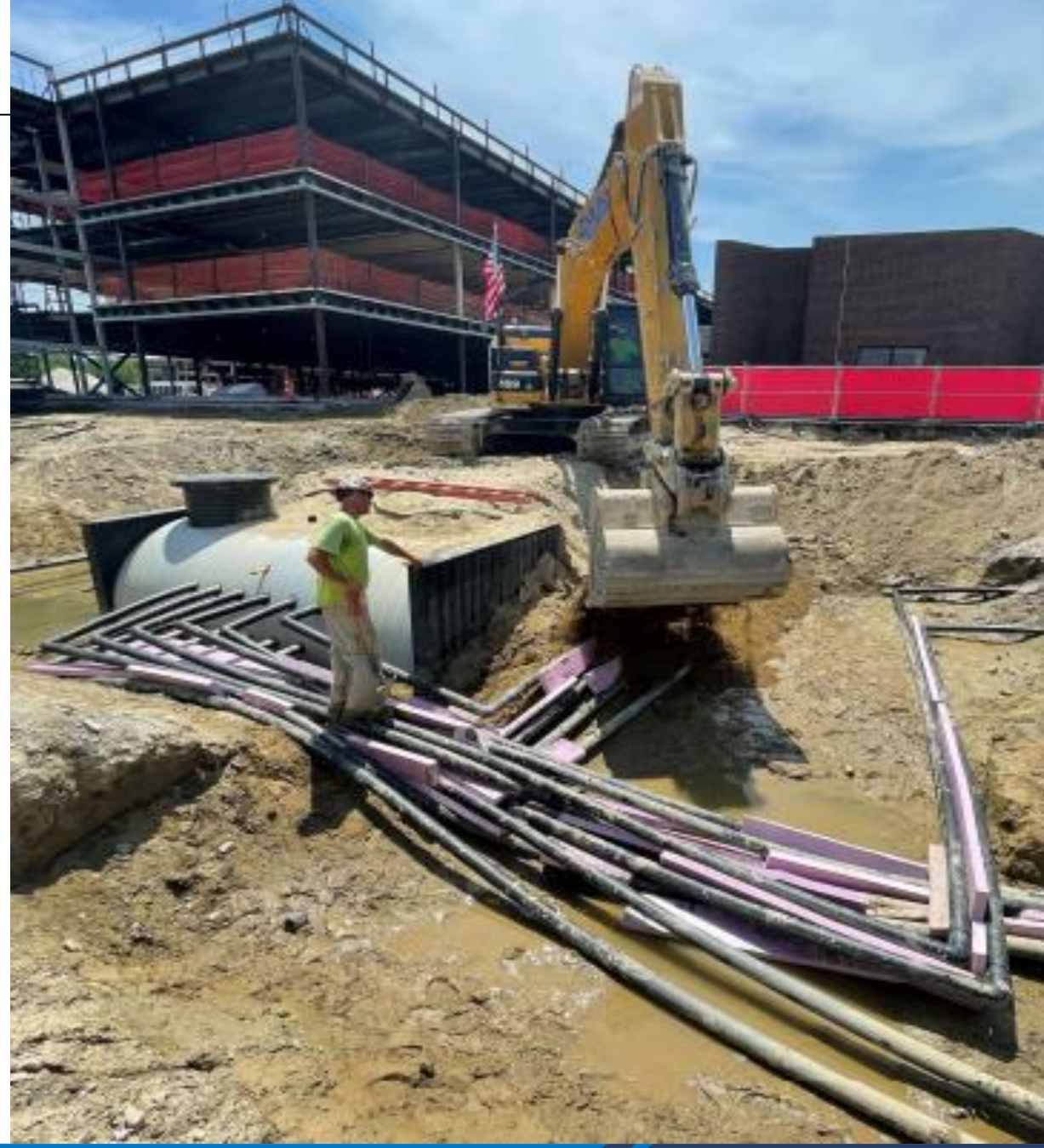
ARROWSTREET
ARCHITECTURE & DESIGN



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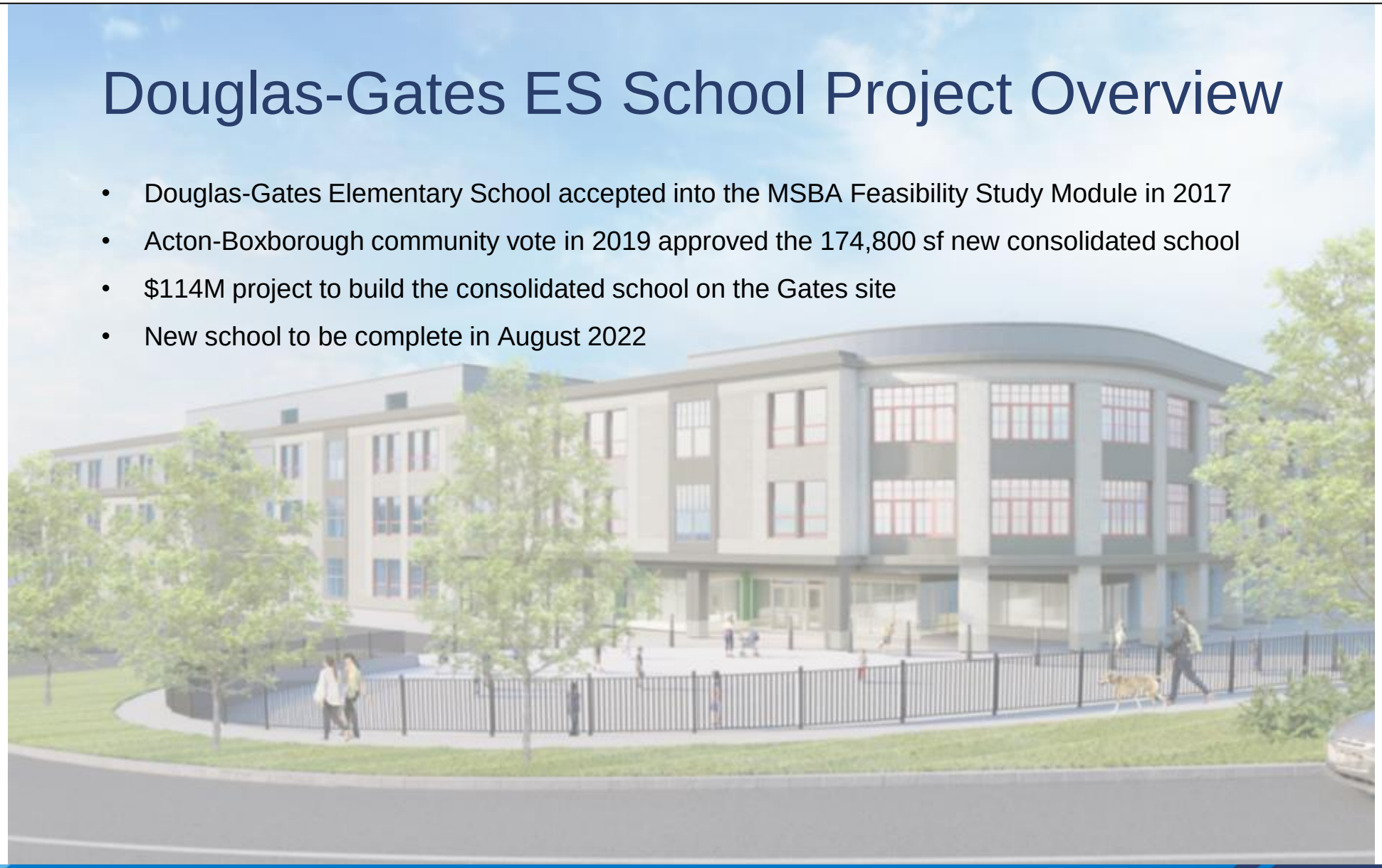
Douglas-Gates ES School Project Overview

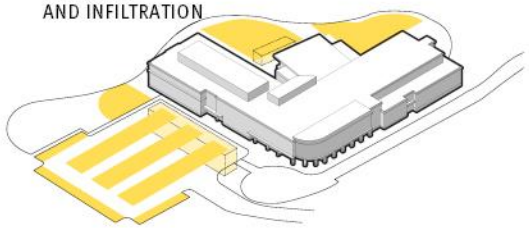
- Douglas-Gates Elementary School accepted into the MSBA Feasibility Study Module in 2017
- Acton-Boxborough community vote in 2019 approved the 174,800 sf new consolidated school
- $114M project to build the consolidated school on the Gates site
- New school to be complete in August 2022



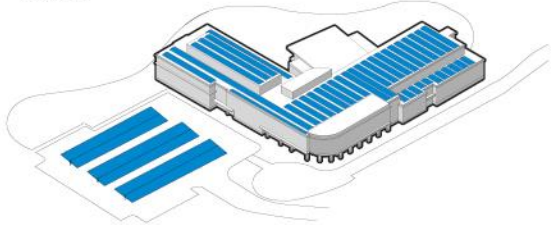
GROUNDSOURCE HEAT PUMPS
FEASIBILITY CONSIDERATIONS

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

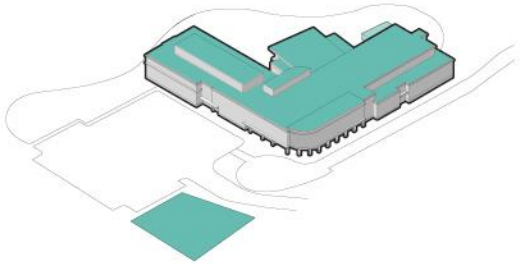
STORMWATER RETENTION AND INFILTRATION



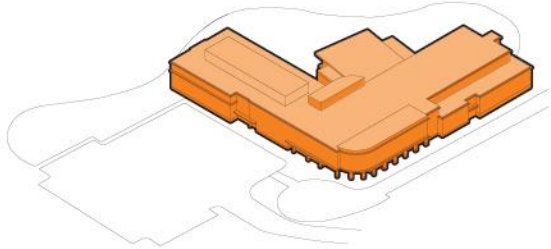
PHOTOVOLATIC PANELS



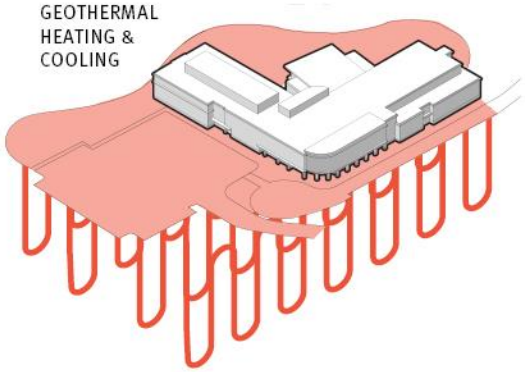
RAINWATER HARVESTING



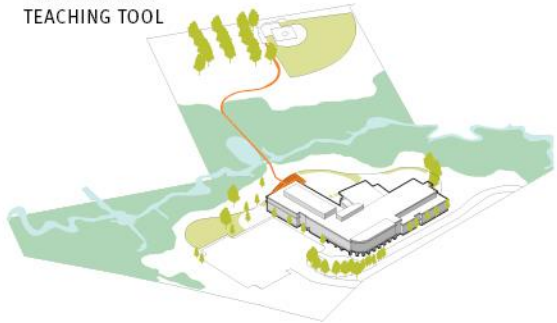
HIGH PERFORMING ENVELOPE



GEOTHERMAL HEATING & COOLING

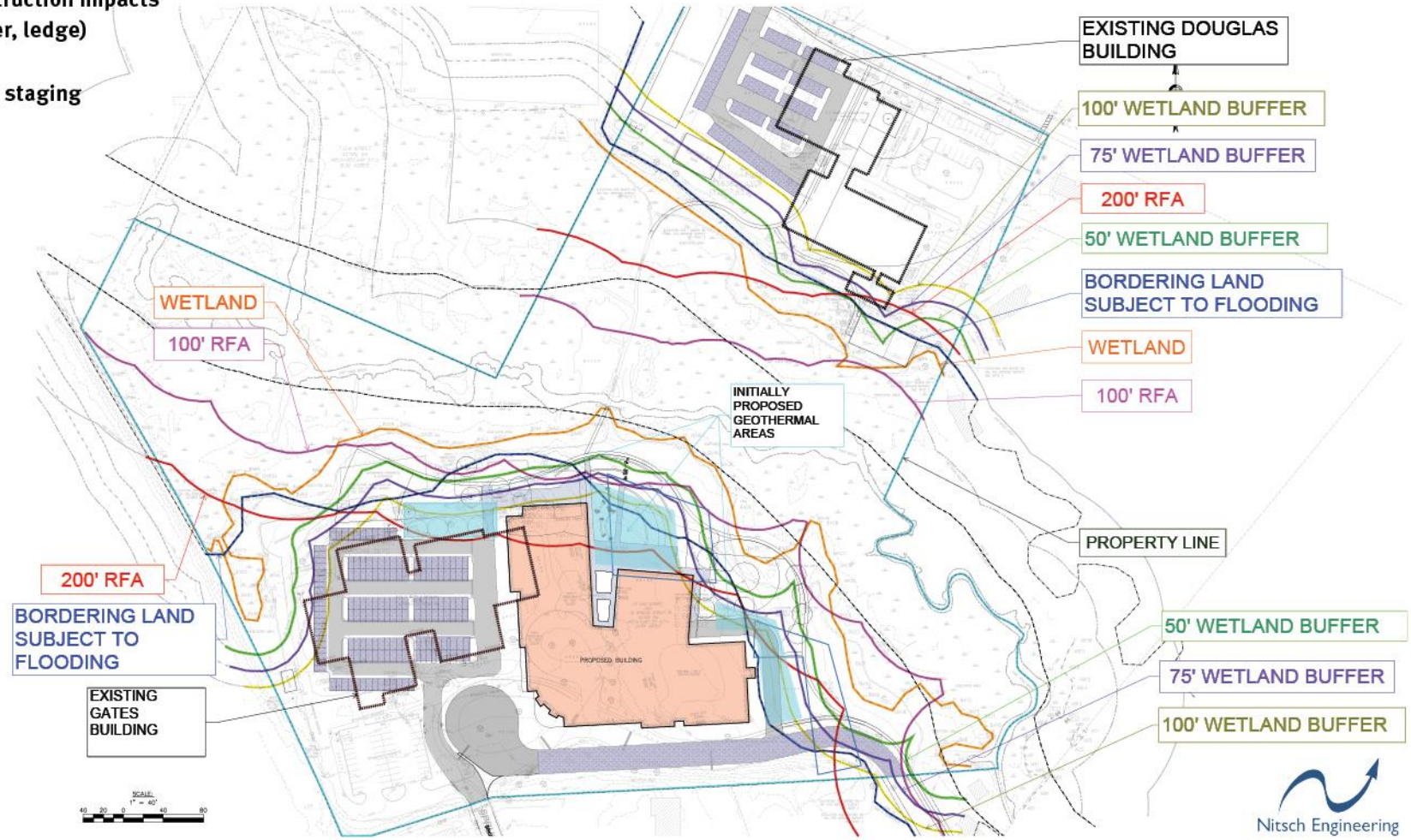


LANDSCAPE AS TEACHING TOOL



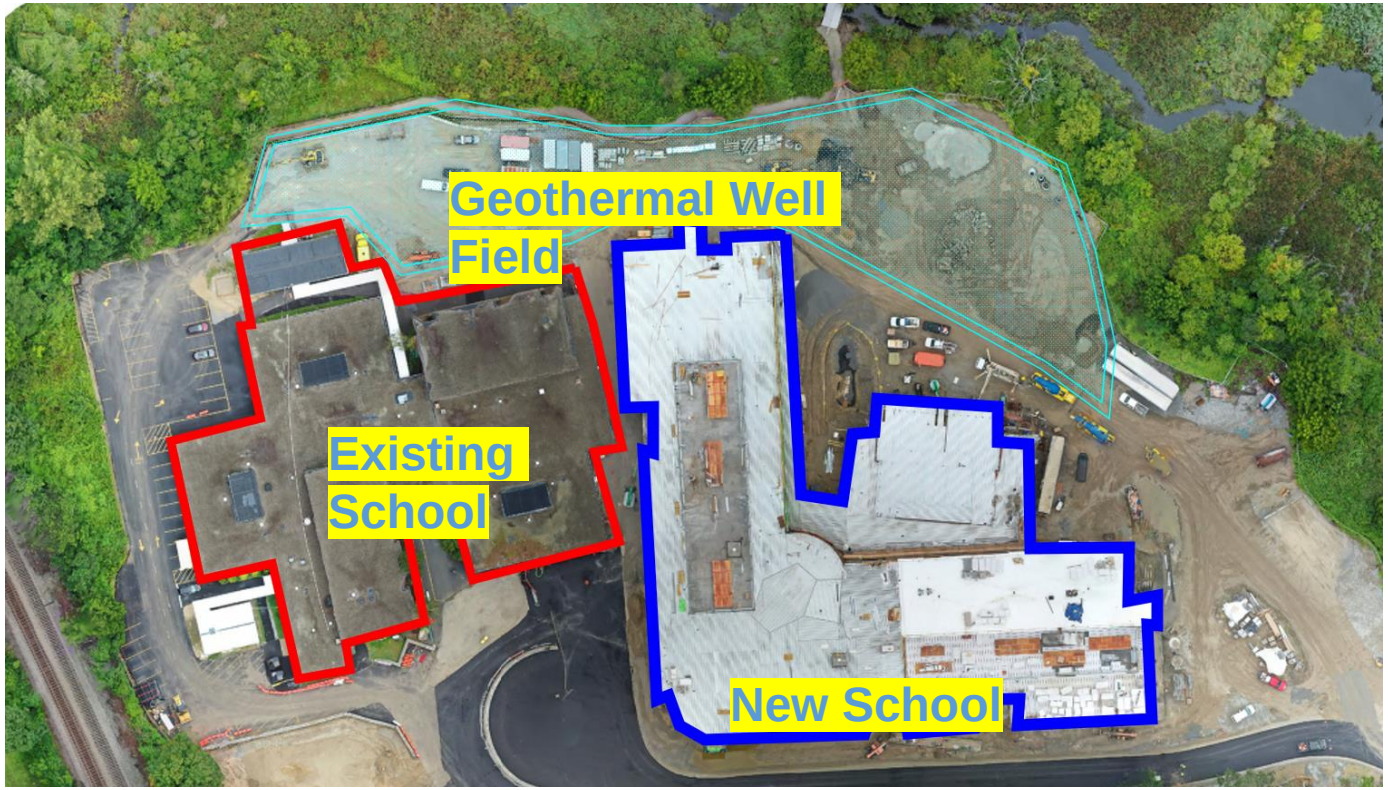
GROUNDSOURCE HEAT PUMPS
SITING GEOTHERMAL WELLS

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



Nitsch Engineering

Douglas Gates Elementary Case Study



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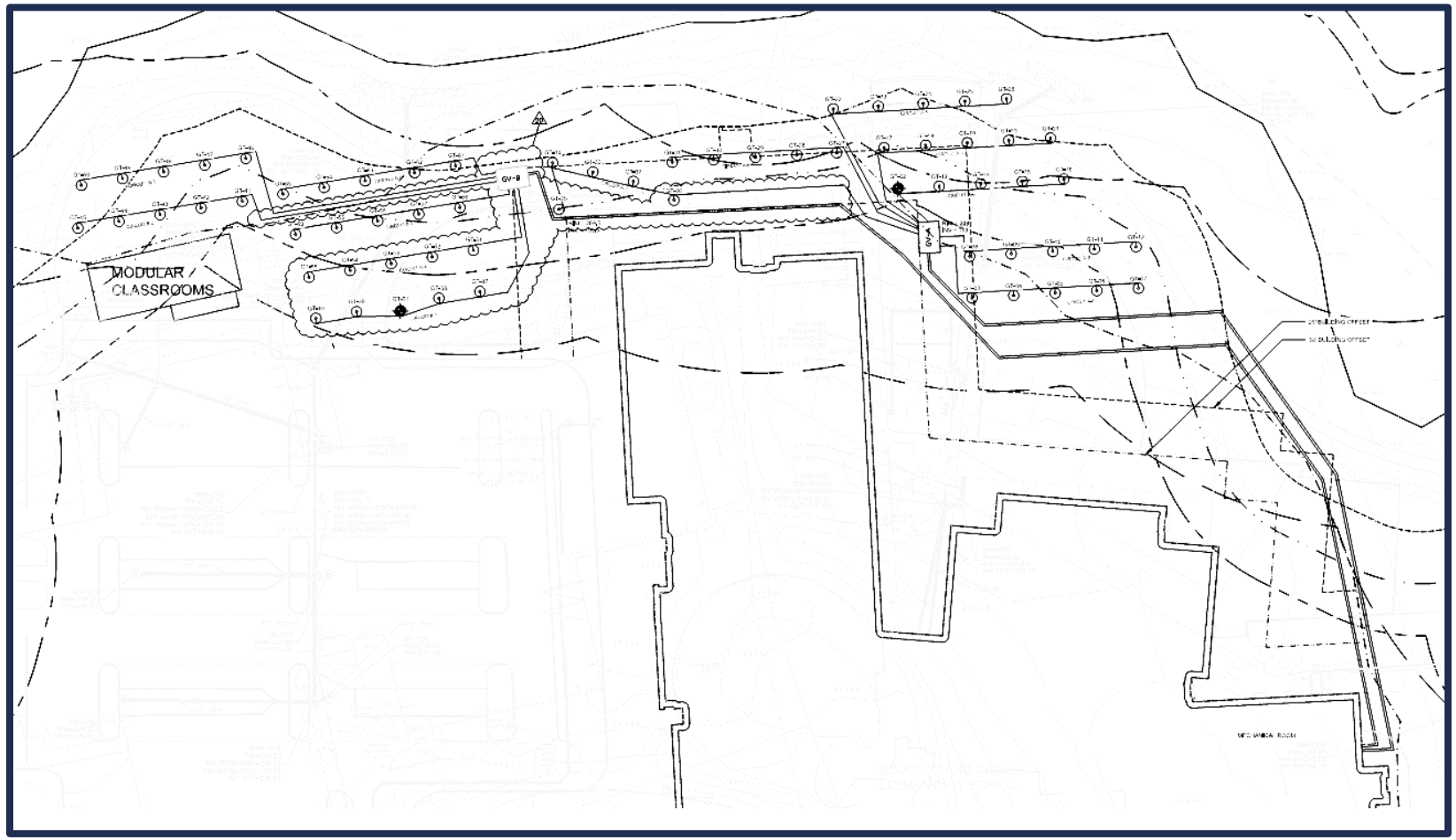
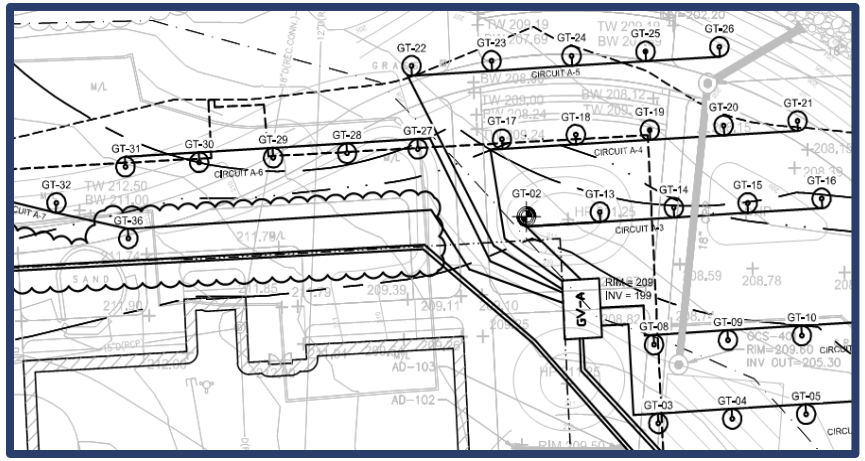
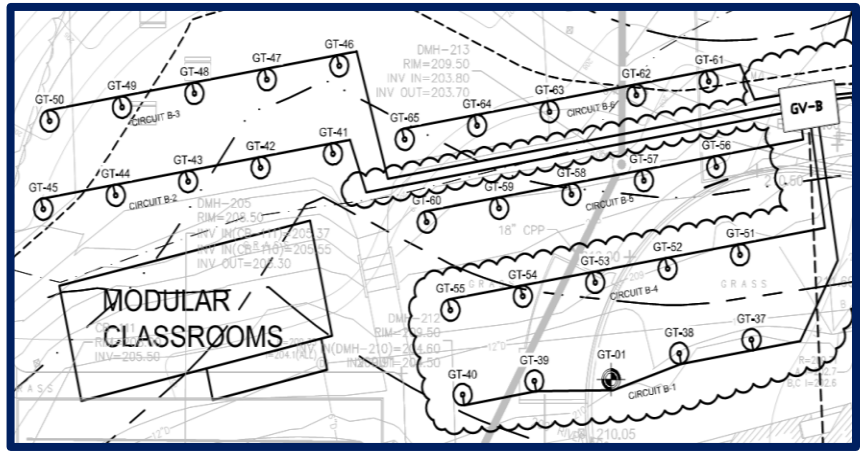
It was determined that 65 wells were required located in back of the new school



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.



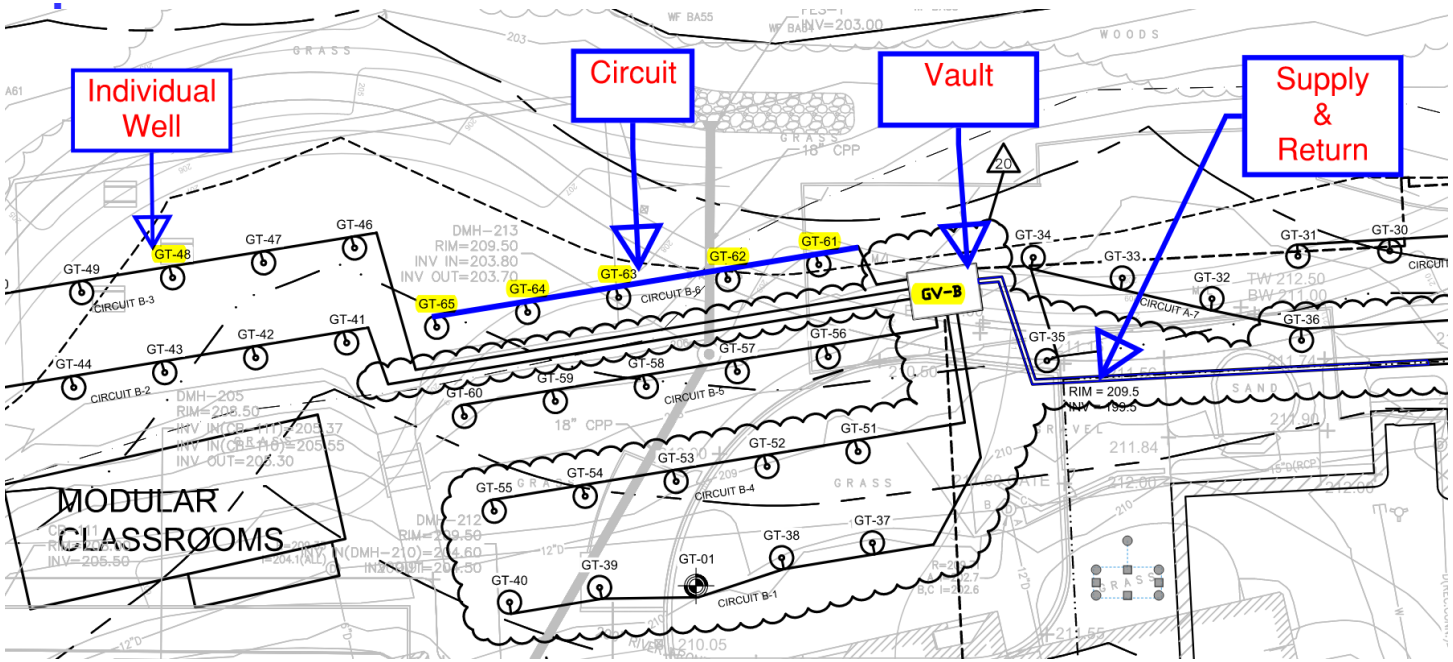
Well Field A



Well Field B

Geothermal Closed Loop System

Main Components of System



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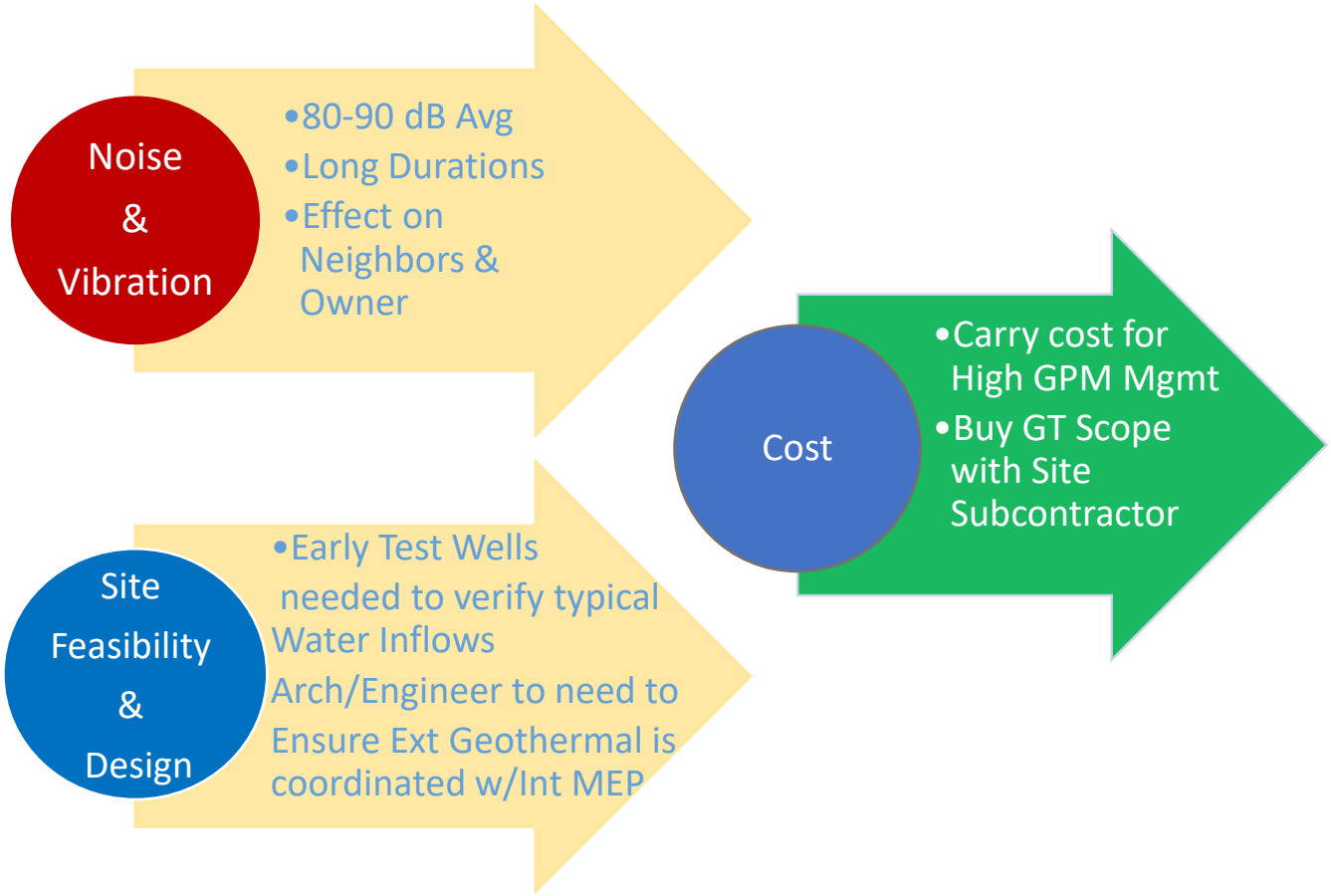
Considerations



Geothermal Closed Loop System

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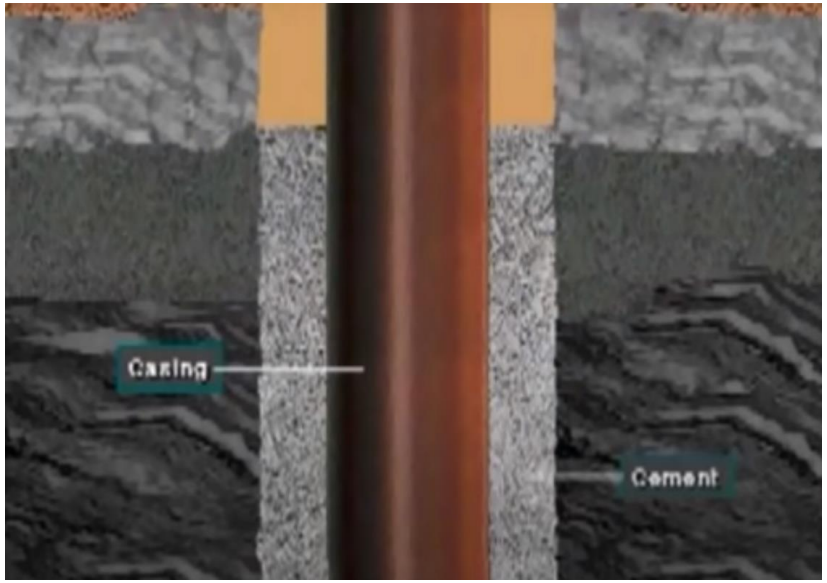
Prior to construction two test wells were installed to determine how many wells would be required to heat and cool the new school.

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.

Cementing in progress



Cemented well

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.

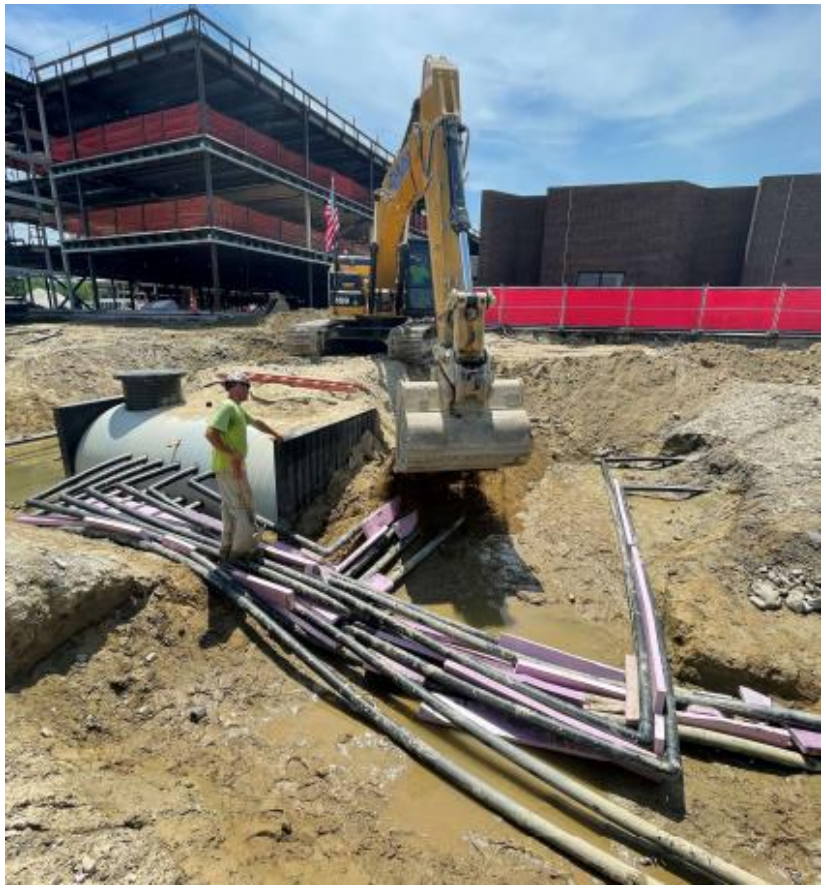
A Loop Wheel is used to install piping

Quad loop completed & grouted

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

Circuit piping



Circuit piping connected to the vault

VERTEX

Fales Elementary School - Westborough, MA

Fales Elementary School – Project Team

Owner:	Westborough Public Schools
OPM:	The Vertex Companies, Inc.
Designer:	HMFH Architects, Inc.
Geothermal Design:	McPhail Associates, LLC
Construction Manager:	Gilbane Building Company

Fales Elementary School – Project Information

Scope:	Two phase project; build new behind existing; demo old; Net Zero building
Phase 1 Schedule:	April 2020 – November 2021
Occupied:	November 15, 2021
Geothermal:	40-well design
Well depth:	600’

VERTEX

Fales Elementary School - Geothermal System Layout

VERTEX

Fales Elementary School - Geothermal Well Installation

VERTEX

Fales Elementary School - Geothermal Piping

VERTEX

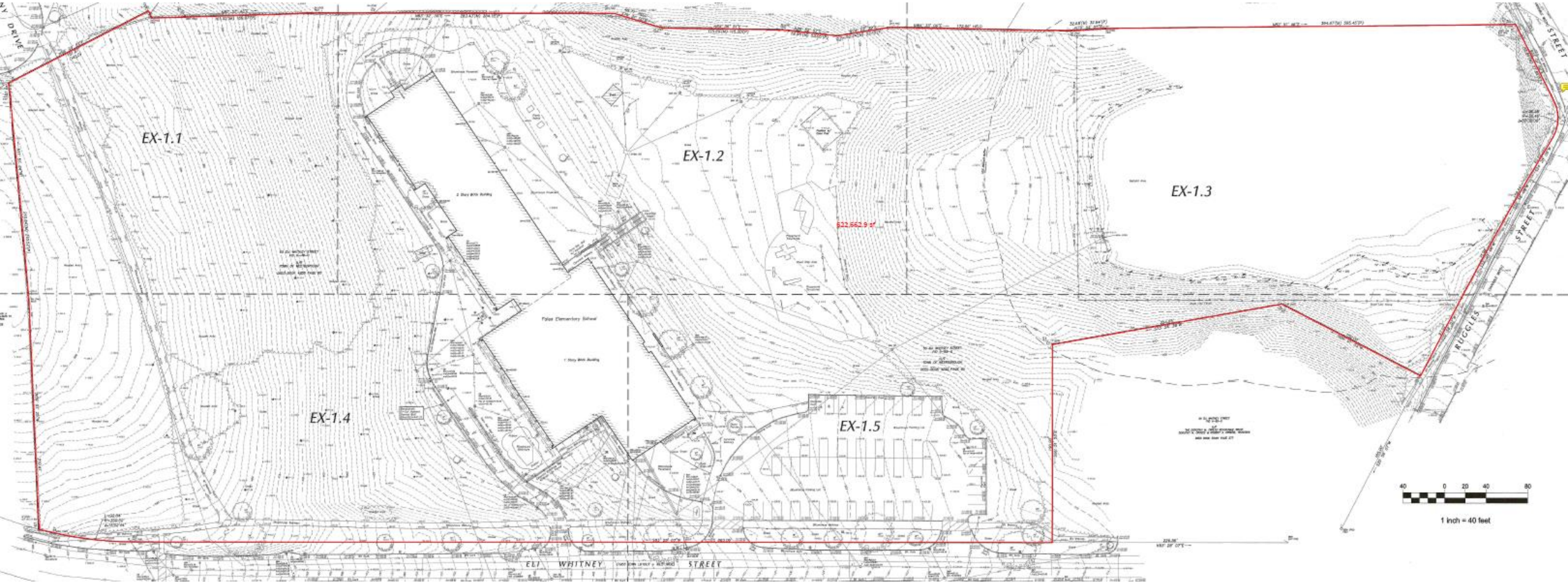
Fales Elementary School - Geothermal Piping

VERTEX

Fales Elementary School - Geothermal Piping Manifold

VERTEX

Fales Elementary School - Site Topography



Fales Elementary School – CM's Lessons Learned

- 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
  - Plan and expectations for duration of work and what to do with added cost from added time
  - 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
  - Site team needs clear understanding of earthwork sequencing i.e., stockpiles, filling, cutting, working grade, etc.
  - 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