2024 Top Jobs Application

GEOSTAR

AFFORDABLE RENEWABLE CLEAN

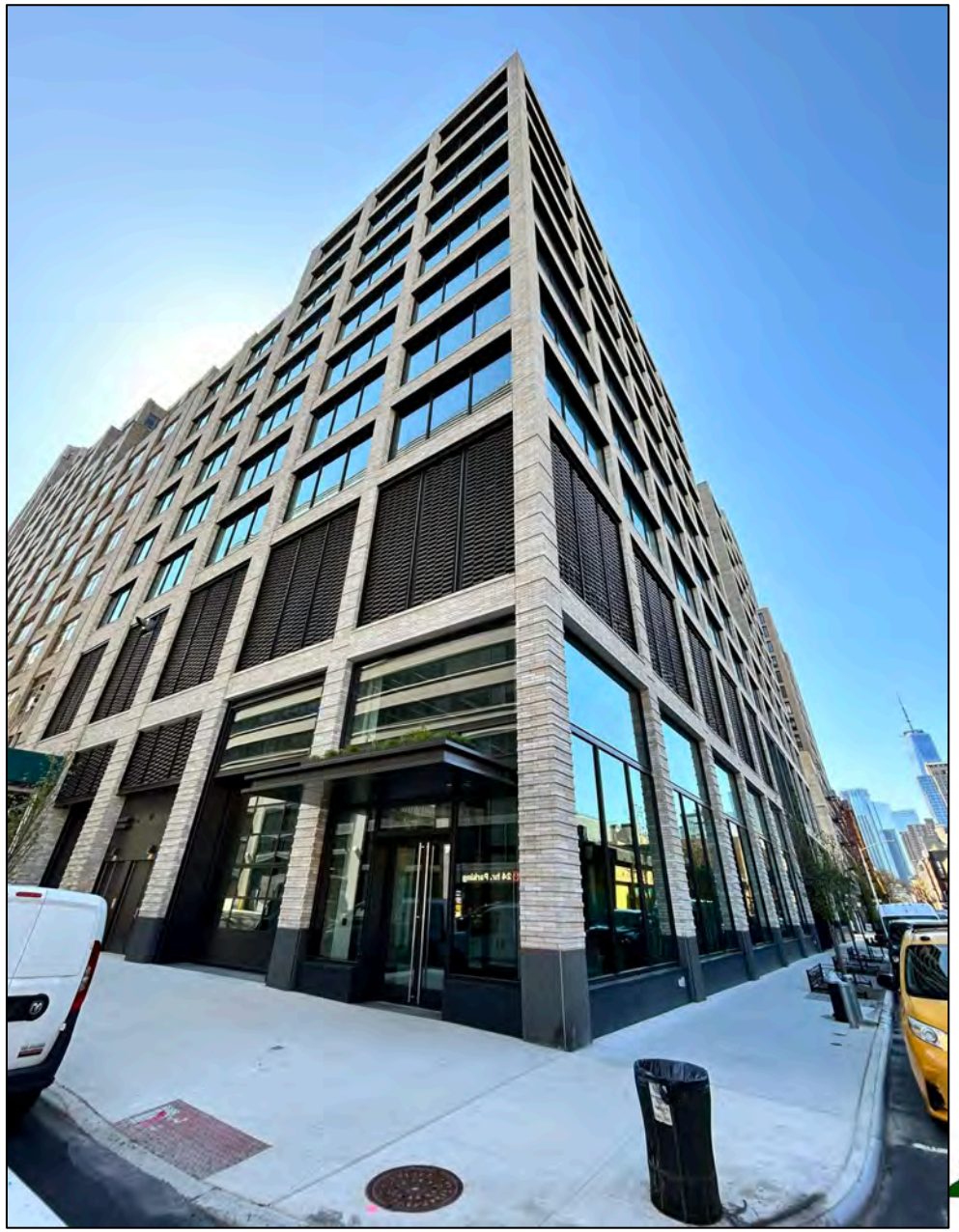
PRESENTER NAME: Tony Amis

ORGANIZATION NAME: Endurant Energy

PROJECT NAME: 555 Greenwich

PROJECT LOCATION: New York, NY

555 Greenwich Street – Project Overview



- Hudson Square Rezoning
- 270,000 ft² commercial space, 17-story building
- Highly contaminated site transformed into highly sustainable, all-electric building
- Structurally tied to neighboring building at 345 Hudson Street (combined 1.2 million GSF)
- 25% less electricity than other Class A office buildings of similar size
- Reduce emissions by 45% over NYC's 2030 climate targets and become carbon neutral by 2032

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Project Team

Building Owners: HUDSON SQUARE PROPERTIES

Norges Bank Investment Management

TRINITY CHURCH WALL STREET

Hines

Design Team

COOKFOX

Thornton Tomasetti

LANGAN

JB&B

Construction Team

AECOM TISHMAN

endurant

URBAN

GEOptimize

FMC FRESH MEADOW MECHANICAL CORP

Salas O'Brien

PACE

GEO INSTRUMENTS

MASTERS BUILDING SOLUTIONS

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555 Greenwich Commercial Building, New York, NY

Design & Construction

Delivering Ingenuity & Efficiency

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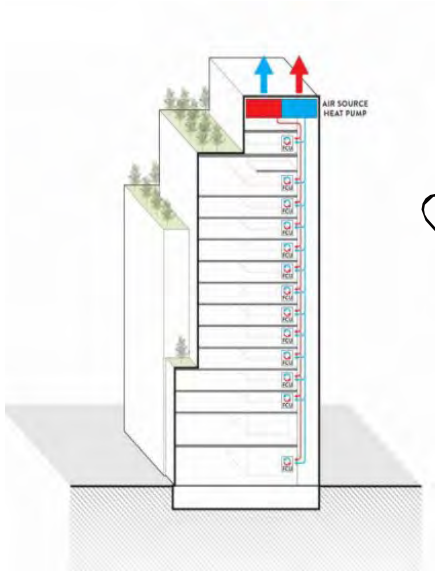
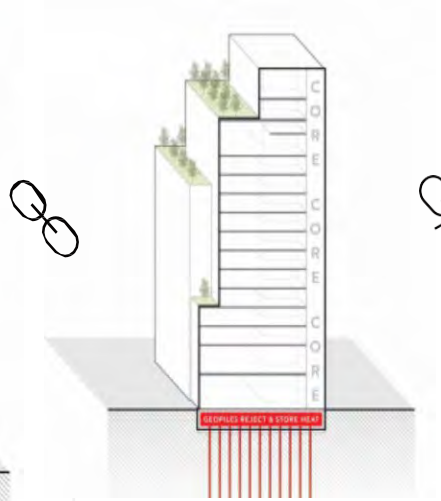
Greenwich NY – Design Approach

All Electric (Heat Pumps/Heat Recovery)

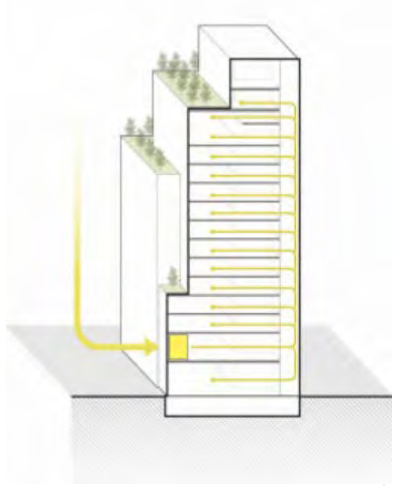


Geothermal Energy Piles (Thermal Storage)



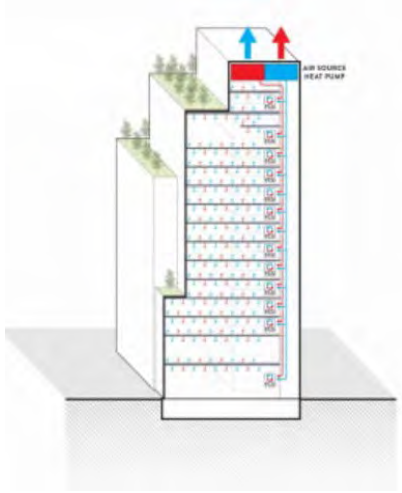
40%
of Heating and Cooling

DOAS (Direct Outside Air System) Ventilation w/ Heat Recovery

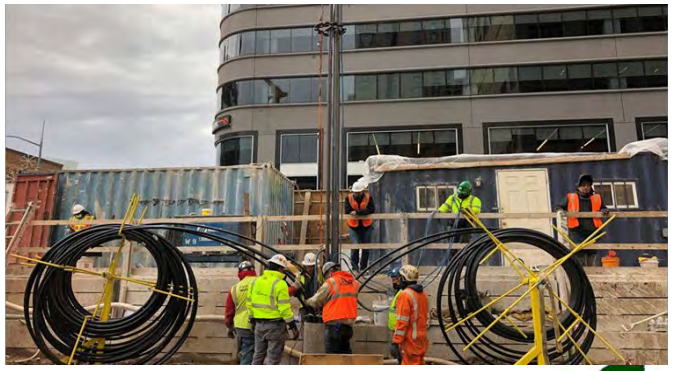


Better
Indoor Air Quality

Thermally Active Structure (Radiant Heating & Cooling)



16%
Greater Comfort



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Improvement Over Business As Usual

25%
Reduction in electricity consumption

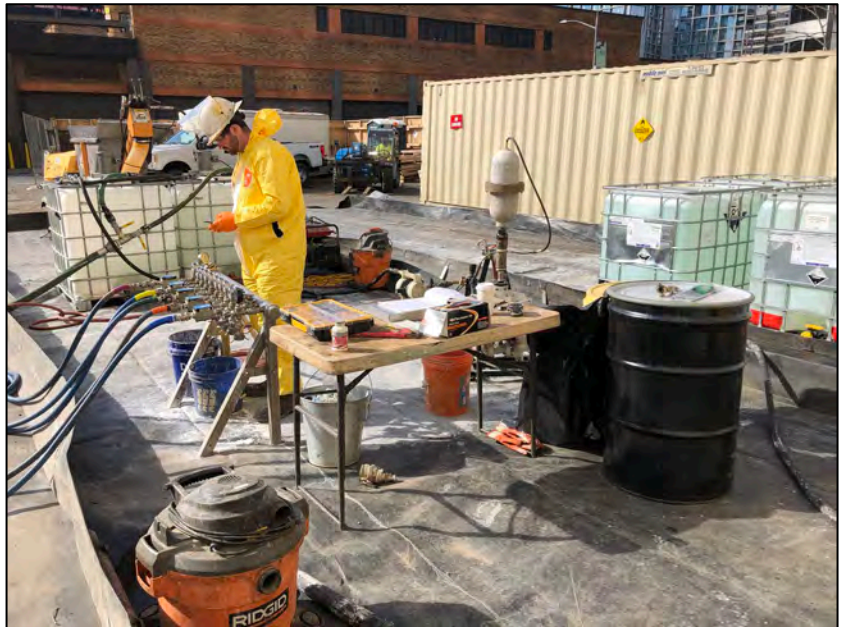
800k
Gallons of water saved per year

45%
Operational carbon reduction

No
Fossil fuels burning on-site

1.2%
Cost premium

The site prior to commencing work..



Geotechnical and environmental challenges

- Loose alluvial soils (liquefiable?)
- Differential settlement between 555 Greenwich and 345 Hudson
- Caisson foundations + deep bedrock
- Large diameter caissons to reduce drilling spoils (blessing in disguise for geothermal looping)
- Site wide remediation through Brownfield Cleanup Program
  - 10,200 tons of hazardous lead impacted soil removed
  - 19,100 tons of petroleum impacted soil removed
  - 13,000,000+ gallons of petroleum impacted GW treated and discharged

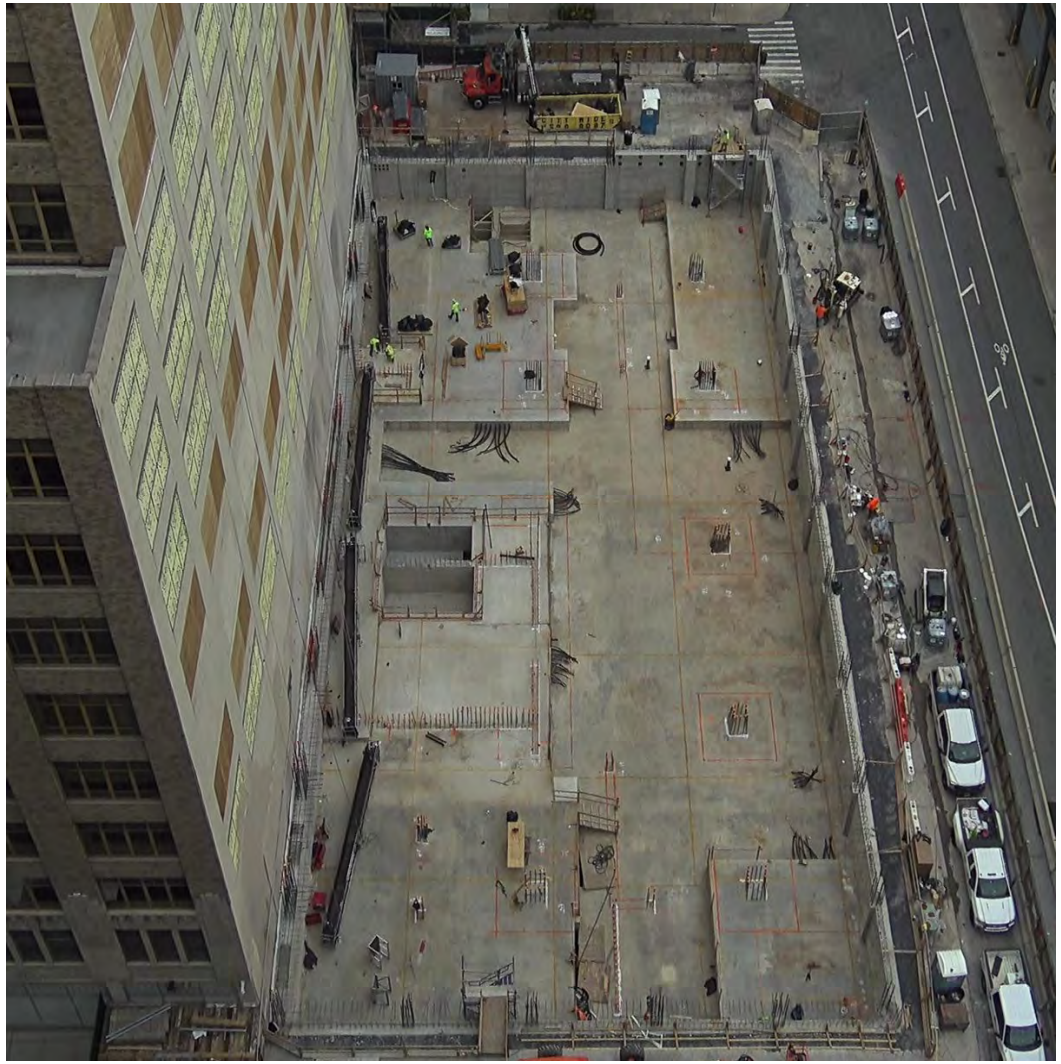
Energy piles in dense urban areas

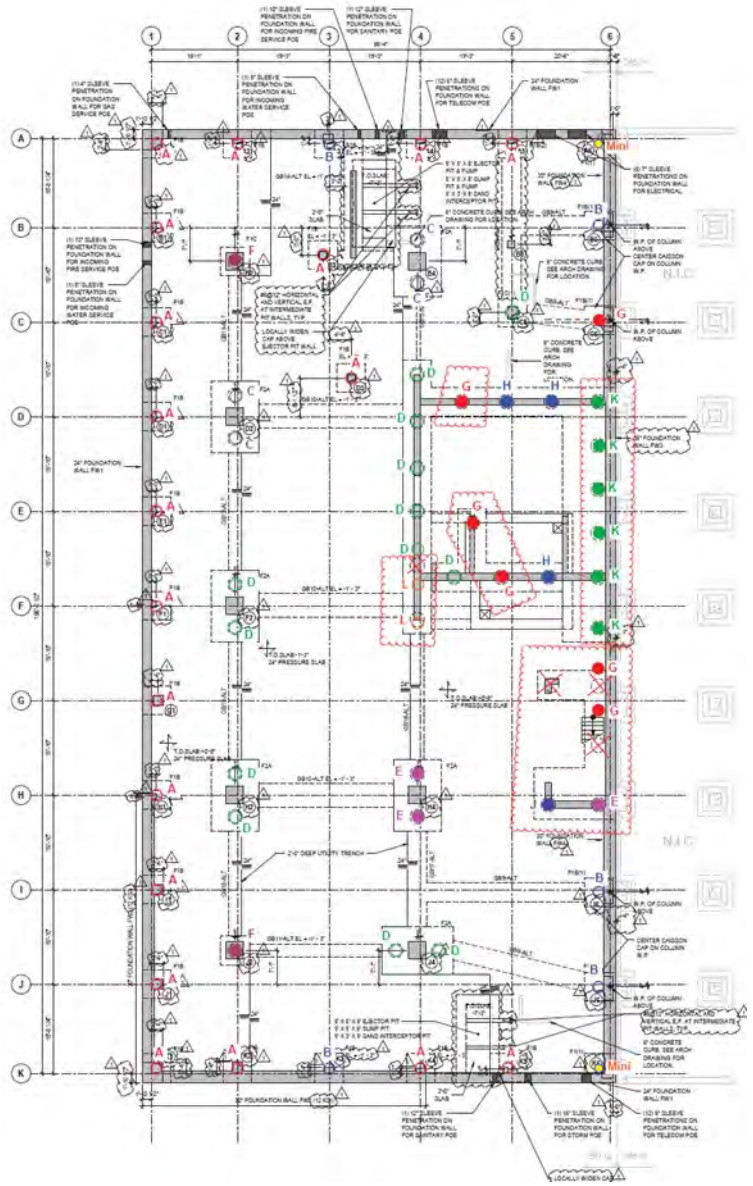
- Options to transfer energy to and from the ground are limited in dense urban areas where the building footprint extends to the entire site
- Optimal building for energy foundation solution is a 15-storey building with 100’ deep foundations
- Contaminated site will add significant environmental costs and schedule impact to drill geo boreholes
- GSHP delivering base heating and cooling load combined with ASHP to deliver top upload is a neat solution that will help deliver an all-electric building

Greenwich Office Building, New York NY

- 270,000ft² commercial space
- 300 T of peak cooling load
- 70 T of peak heating load
- Radiant slab heating & cooling

Foundation layout at Greenwich, New York, NY





Foundation Details

- 2 13” dia piles 120’ deep
- 23 24” dia piles 120’ deep
- 40 36” dia piles 120’ deep

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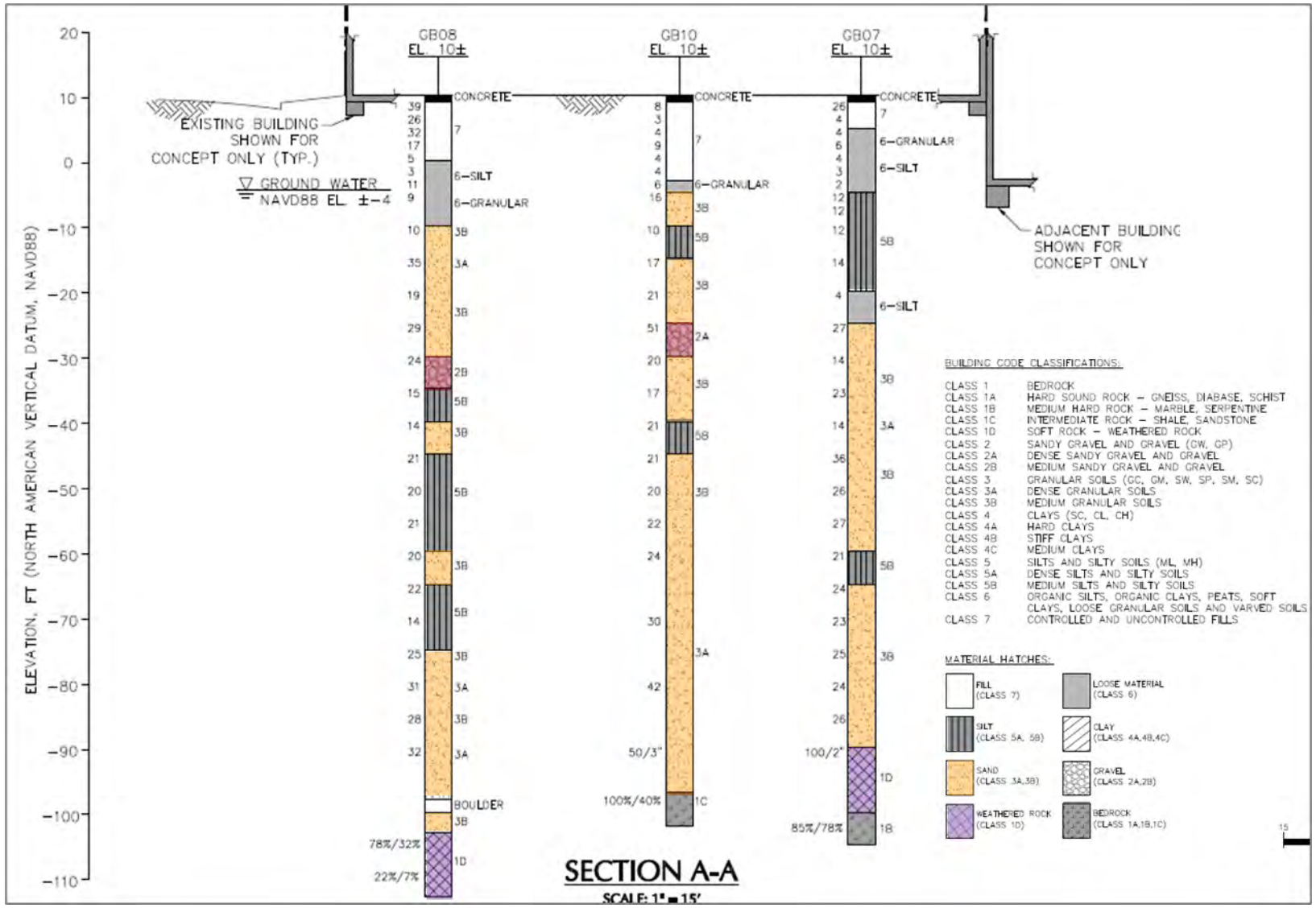
Review / estimate thermal properties of soil / rock



Geotechnical information reviewed to estimate thermal transfer properties of formation. Water table and ground water movement influences heat transfer.

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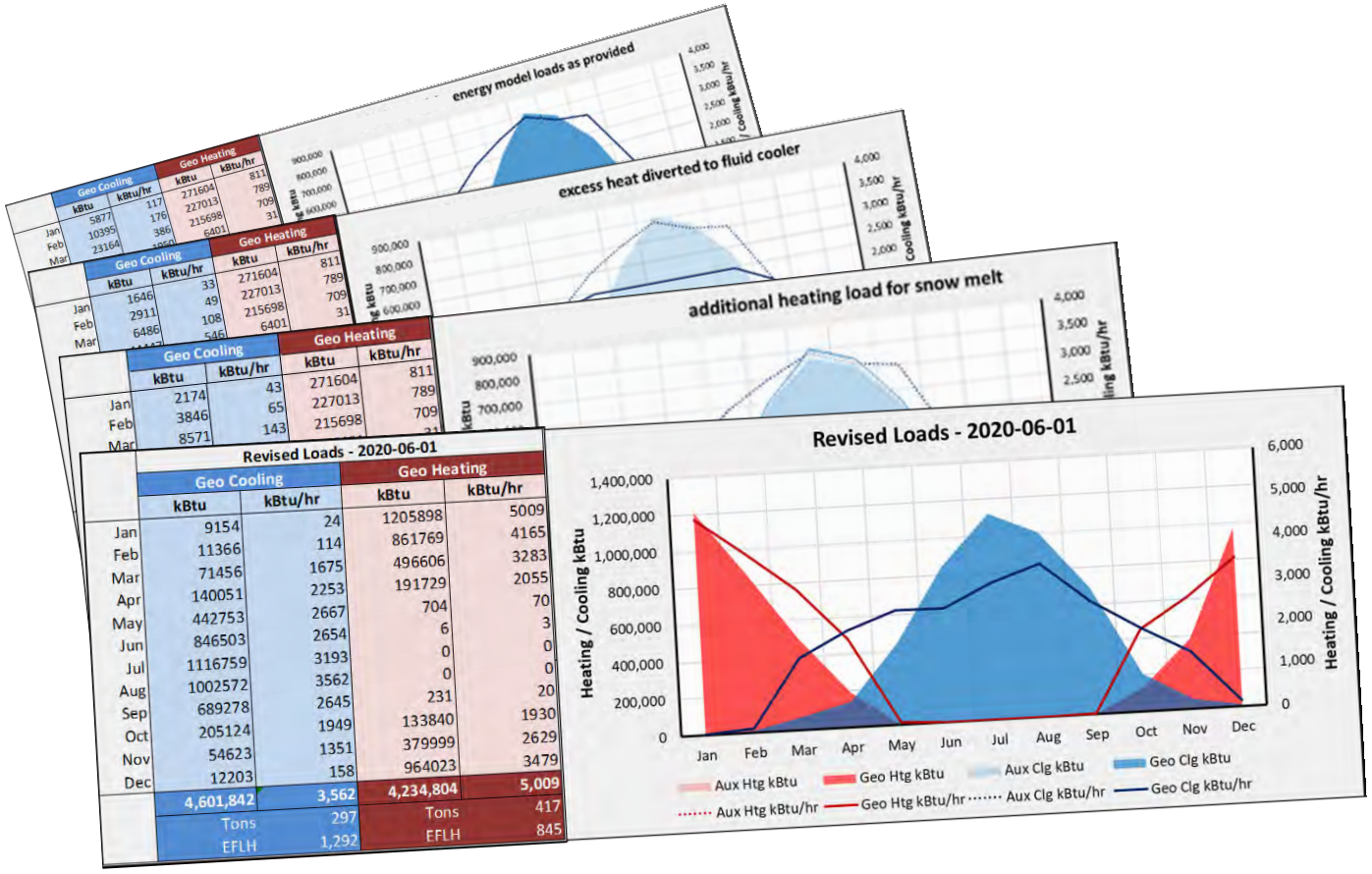
Energy modeling



- Understanding energy loads to and from the ground is the starting point for cost-effective, efficient and reliable ground source heat pump system design.
- Numerous iterations of hourly energy models allow a designer to balance energy loads to and from the GHX…lowering CAPEX and OPEX
- Also provides the basis for long term monitoring and performance verification

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Foundation layout at 555 Greenwich, New York, NY

Energy Piles

- 3 Geo loops in each 24” & 36” piles = 192 u-tubes 120 ft. deep
- 13” piles not used

Geothermal loop arrangement

- 3 Loops (u-tubes) connected in series per pile.
- 1 13” pile fitted with thermistor used for monitoring temperature
- 2 piles to be fitted with thermistor and strain gauges

Geothermal loops to be equally spaced around perimeter

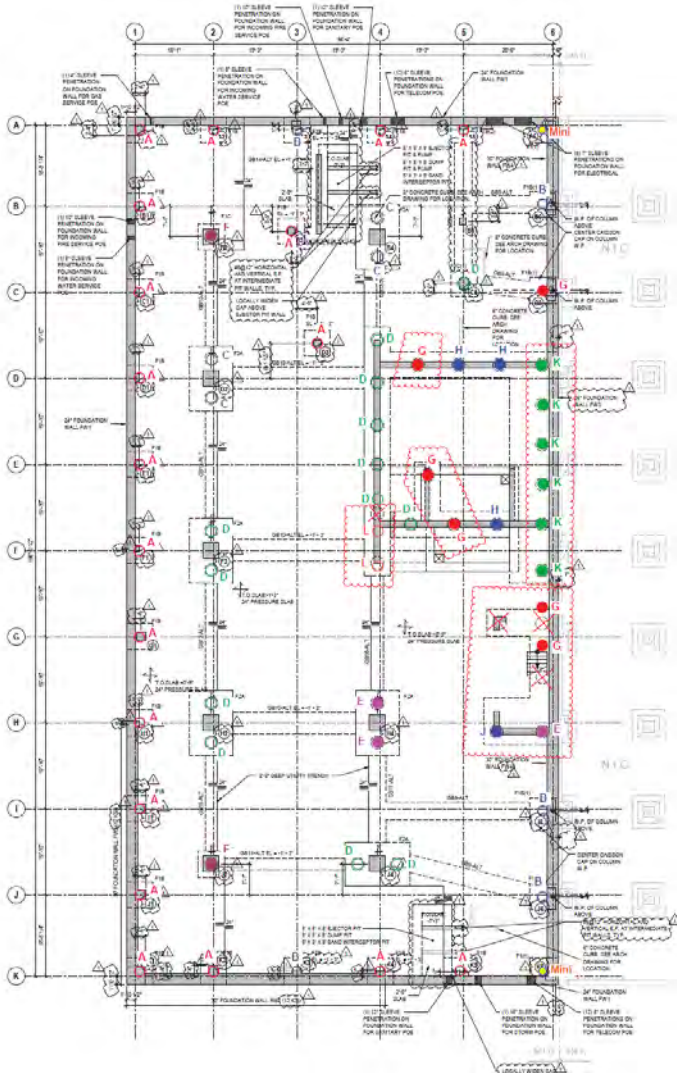
- 24" piles, the u-tubes spaced at 1’
- 36" piles, the u-tubes spaced by 1.6’

Headering Arrangement

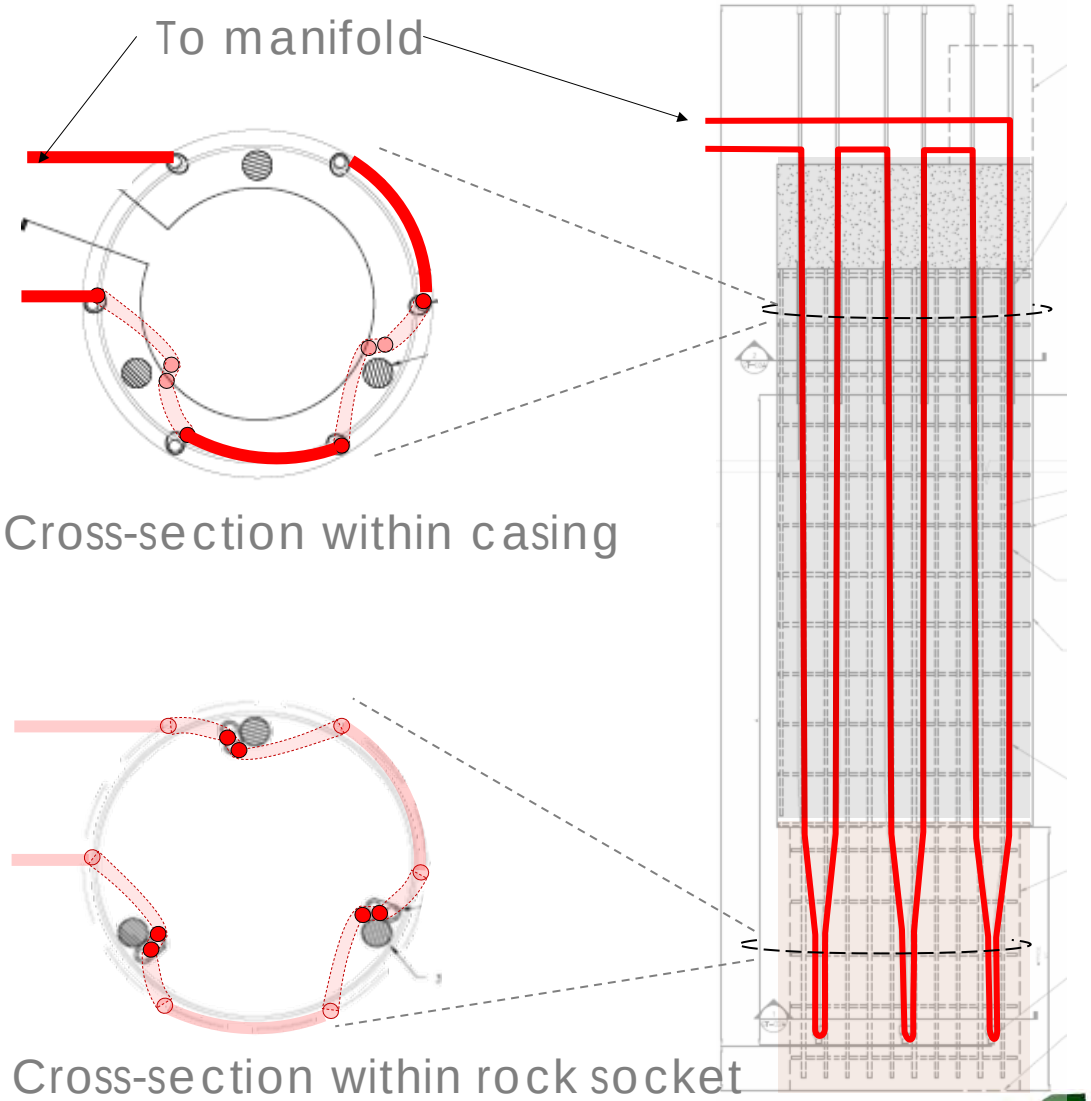
3 U-tubes in series represents 1 circuit.

8 circuits will connect to 1 sub-manifold

8 sub-manifolds connecting to 1 main manifold.



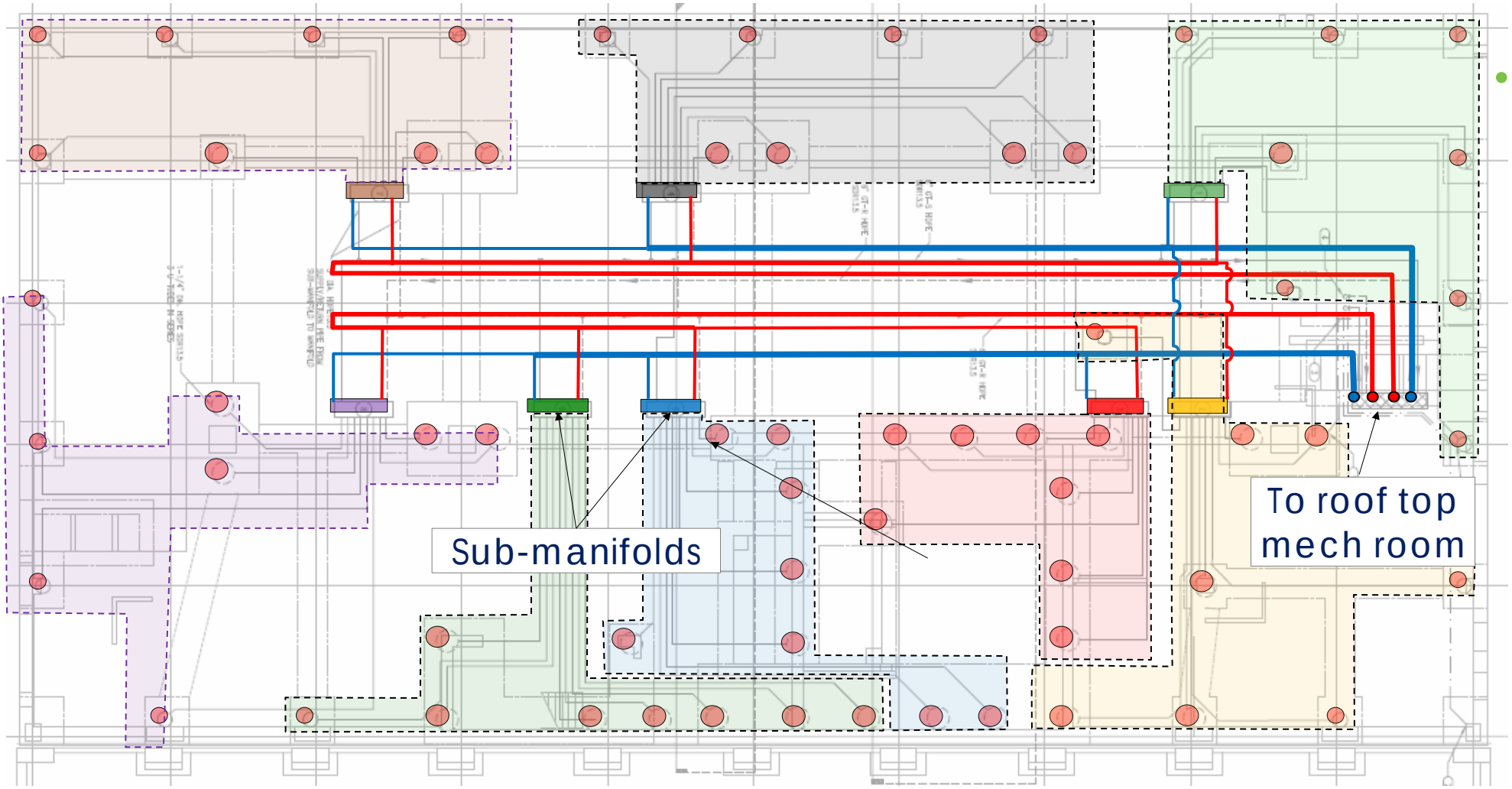
GHX piping in large diameter piles



Three U-tubes installed in each 2’ and 3’ diameter pile.

- Within casing, pipe equally spaced outside of reinforcement cage to maximize energy transfer to ground
- Within rock socket, piping attached inside of reinforcement to protect pipe
- Three U-tubes connected in series to maximize heat transfer and minimize pressure drop through piping based on design flow rates

63 Large diameter piles



- Eight piles (24 U-tubes) connected to each manifold

Greenwich NY – Anticipated energy pile capacity

Energy piles will deliver:

- 92 T (31%) of the cooling loads
- 1903 kBtu/hr (38%) of the heating loads
- Remaining heating and cooling load delivered by ASHP

Results | Fluid | Soil | Bore | Pattern | Extra kW | Information

	COOLING	HEATING
Total Bore Length (ft):	23040.0	23040.0
Borehole Number:	192	192
Borehole Length (ft):	120.0	120.0
Ground Temperature Change (°F):	N/A	N/A
Peak Unit Inlet (°F):	85.4	37.2
Peak Unit Outlet (°F):	91.3	30.7
Total Unit Capacity (kBtu/Hr):	1104.2	1903.4
Peak Load (kBtu/Hr):	1104.2	1903.4
Peak Demand (kW):	72.3	122.2
Heat Pump EER/COP:	15.2	4.5
Seasonal Heat Pump EER/COP:	18.0	5.1
Avg. Annual Power (kWh):	8.04E+4	9.23E+4
System Flow Rate (gpm):	276.1	475.9

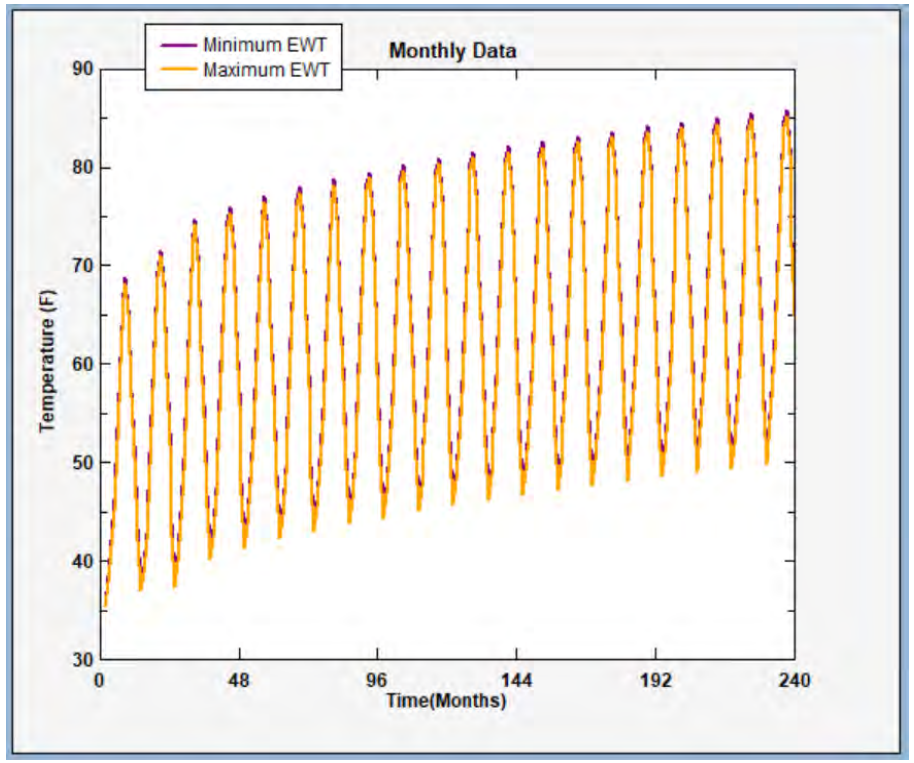
Optional Hybrid System: On

Update | Reset | Summary

Peaks: Cooling 69% Heating 62%

Totals: Cooling 69% Heating 62%

	Geo Cooling		Geo Heating	
	Clg kWh	Clg kW	Htg kWh	Htg kW
Jan	9154	24	458241	1903
Feb	11366	114	327472	1903
Mar	22151	1104	188710	1903
Apr	43416	1104	72857	1903
May	137253	1104	704	70
Jun	262416	1104	6	3
Jul	346195	1104	0	0
Aug	310797	1104	0	0
Sep	213676	1104	231	20
Oct	63588	1104	50859	1903
Nov	16933	1104	144400	1903
Dec	12203	158	366329	1903
	1,449,148	1,104	1,609,809	1,903
	Tons	314	Tons	541
	EFLH	1,313	EFLH	846



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Loop Installation – 555 Greenwich New York - December 2020

Energy Foundation solution delivered with..

- No schedule impact
- No excavated material removed
- No modification to foundation design
- No additional reinforcement
- Minimal additional cost compared to other geo solutions

System will deliver 30 - 40% of the buildings heating and cooling requirements possibly much more!

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Ensuring Quality At Every Stage Is Essential

Loop Installation into Pile 40 at Greenwich site

Loops equally spaced around circumference

Protection to loops in pile trim zone

QA/QC Flow & Pressure test

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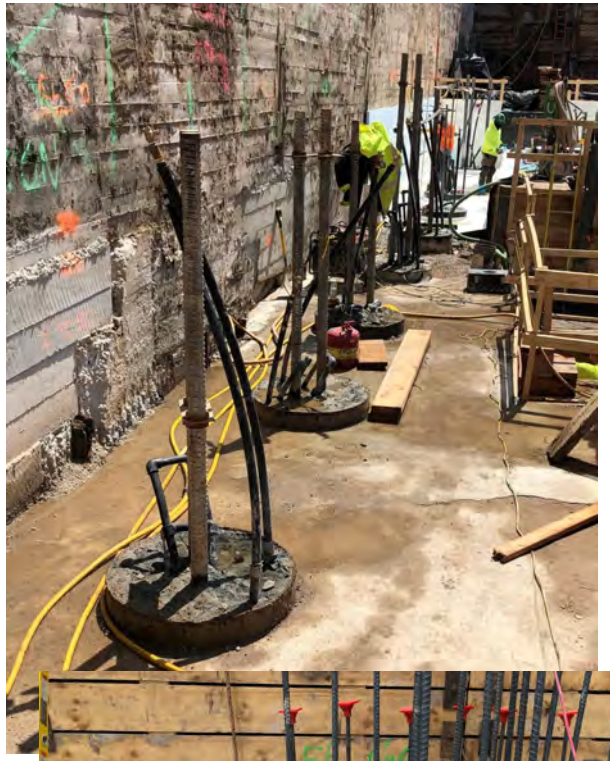
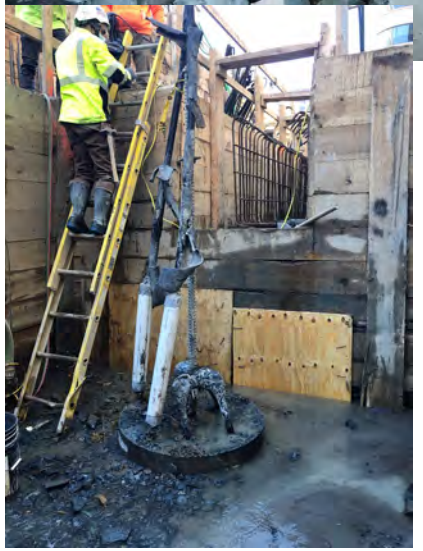
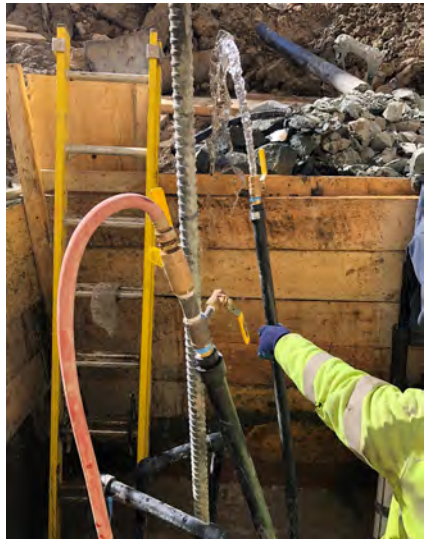
Energy Pile to Pile Cap – Flow Test Pressure Test Each Key Stage







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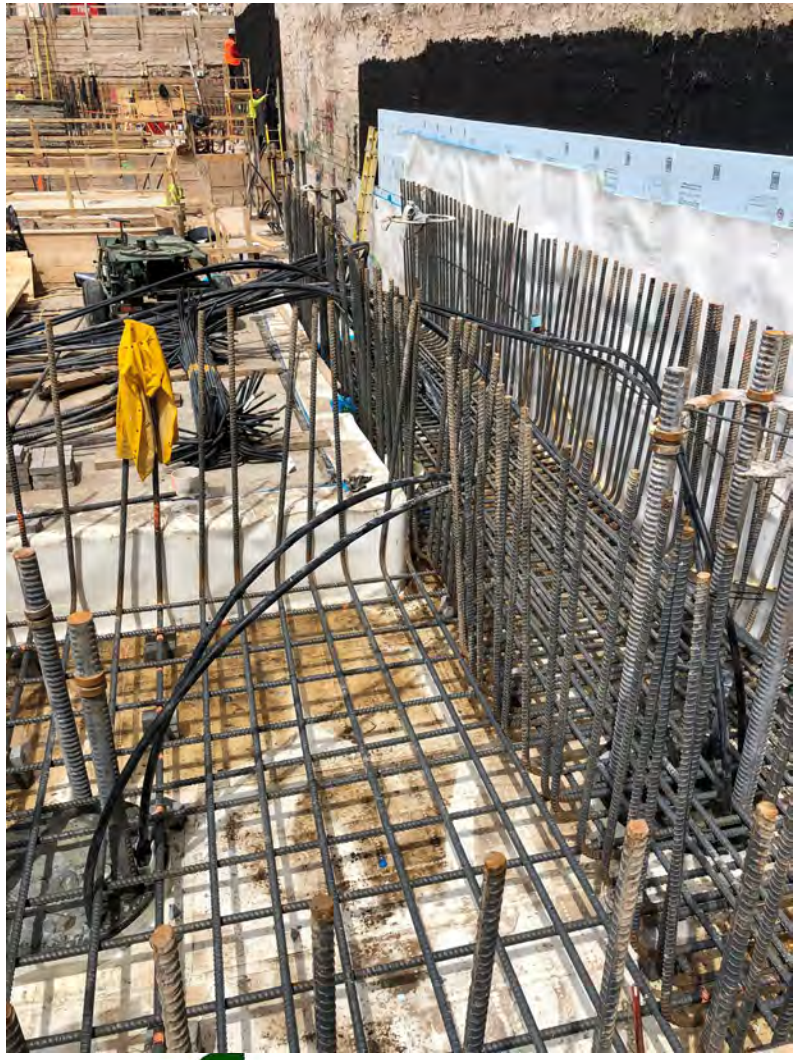
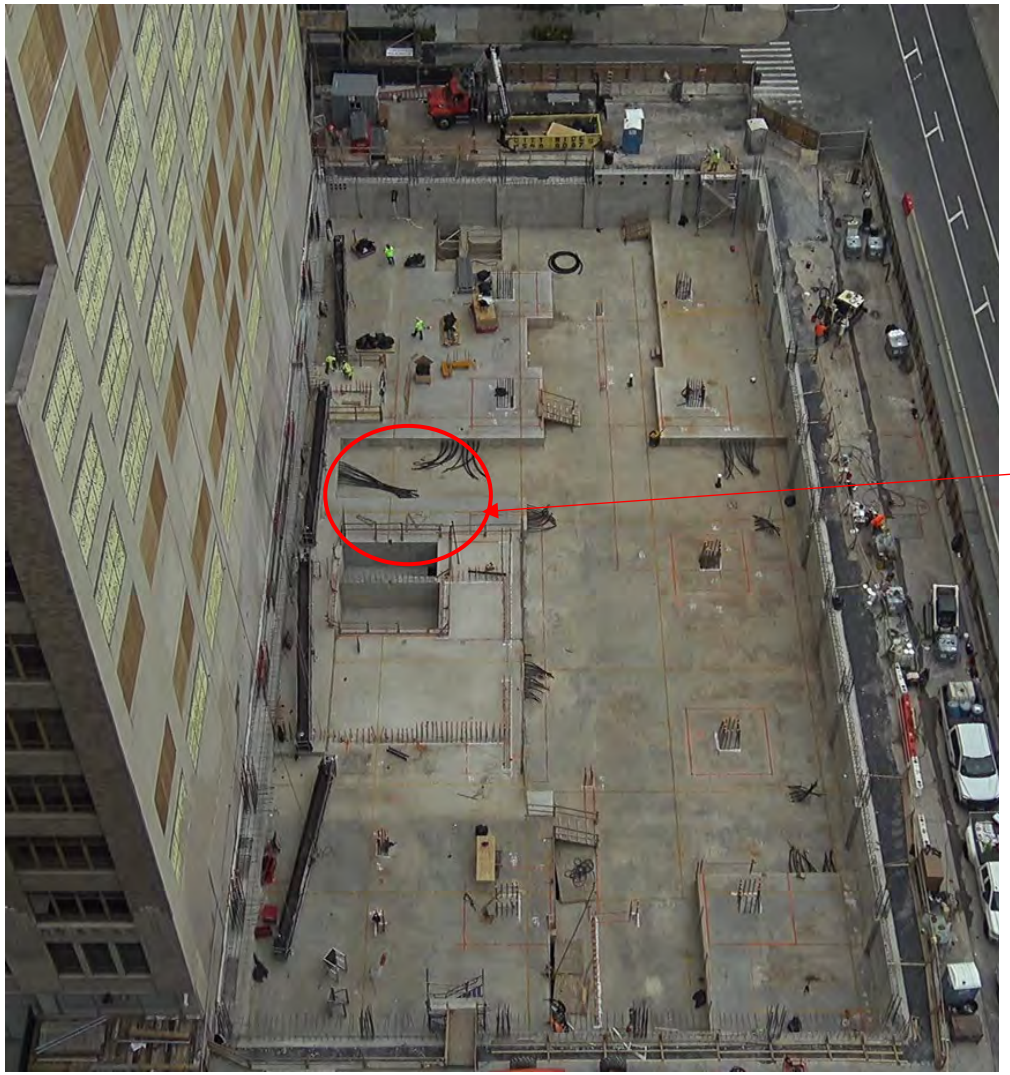
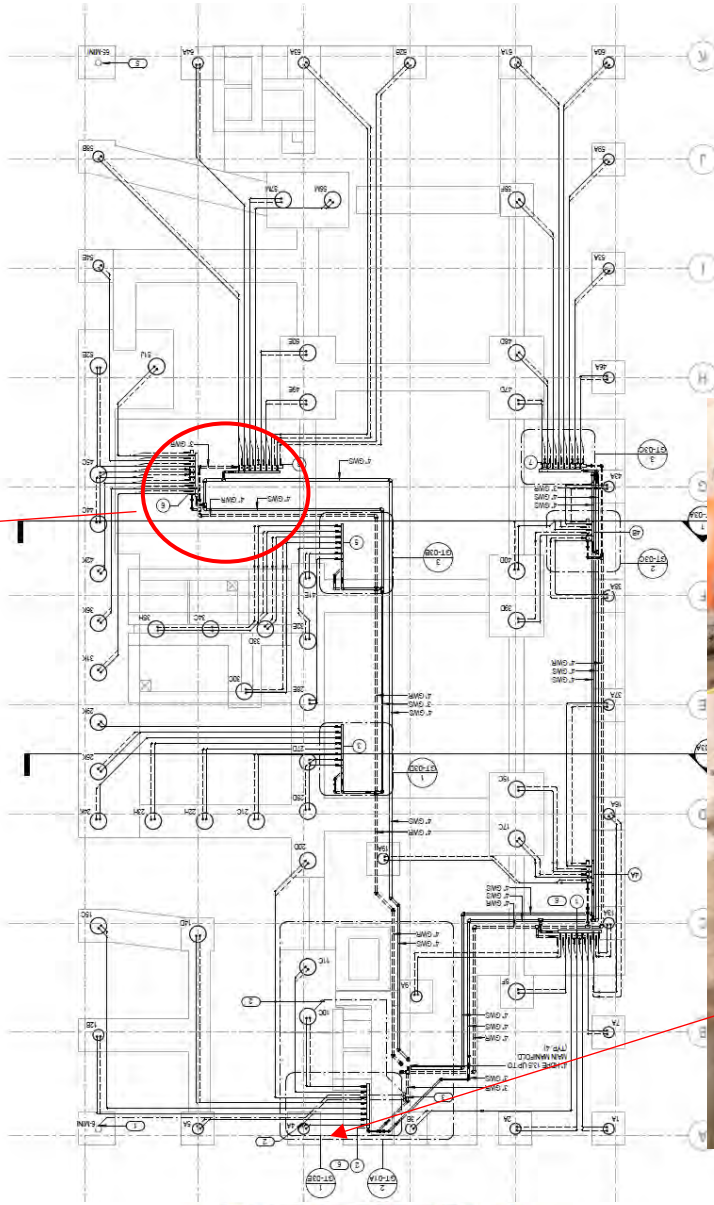
Energy pile to sub- manifold



- Utilizing pile caps and structural beams to run geo-loops to sub manifolds means no additional excavation and backfilling of trenches.
- Good coordination with contractors ensures no schedule impacts.
- Each additional stage finishes with flow test and pressure being locked into confirm and verify system integrity

Completed basement – Reverse returns & sub manifolds in progress





Each geo loop fitted with pressure gauges to verify system until next stage

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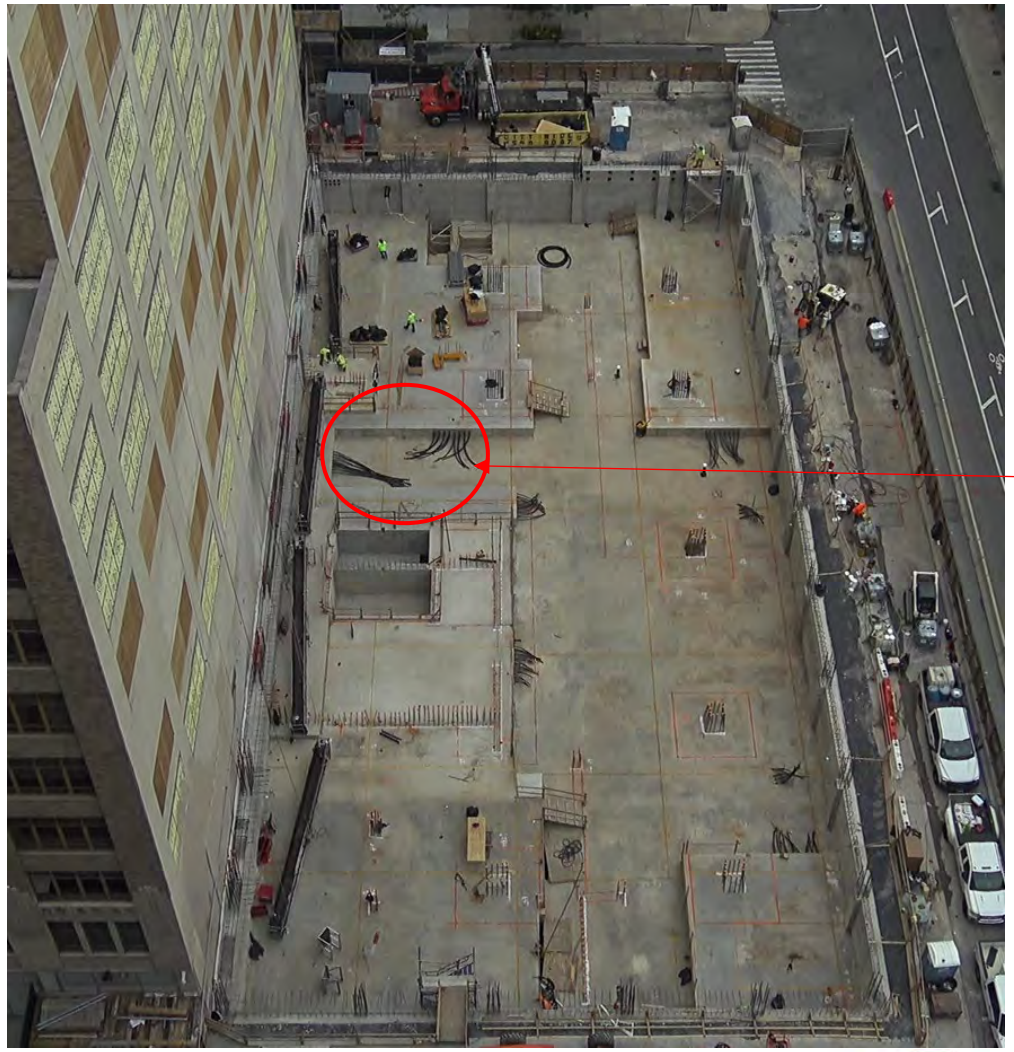
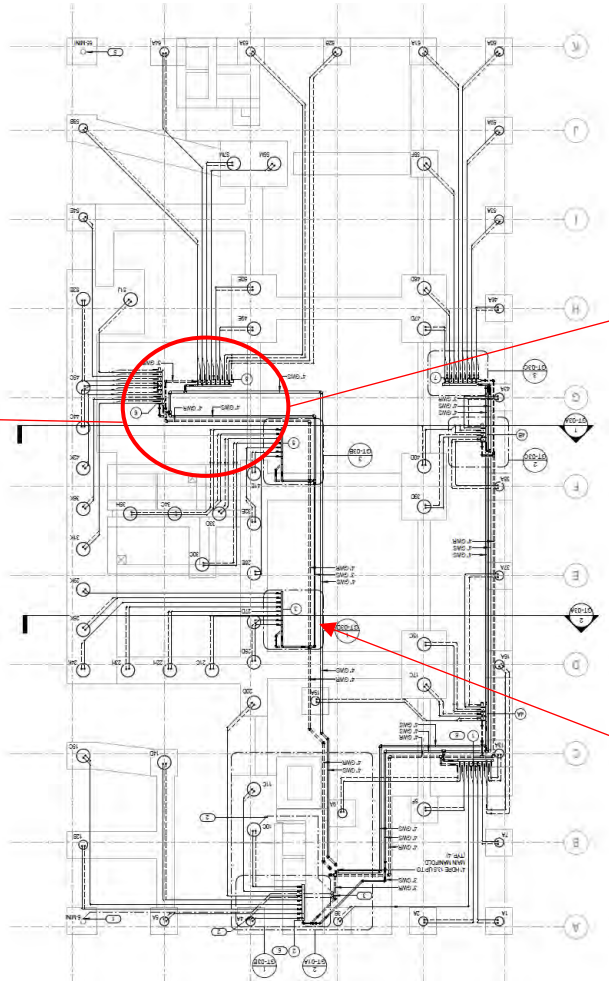
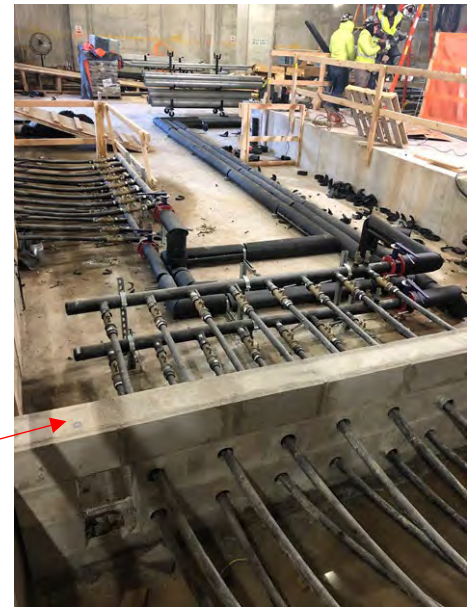
Completed basement – Reverse returns & sub manifolds in progress

Sub Manifolds enable 100% resilience – If 1 Energy Pile fails it can be isolated







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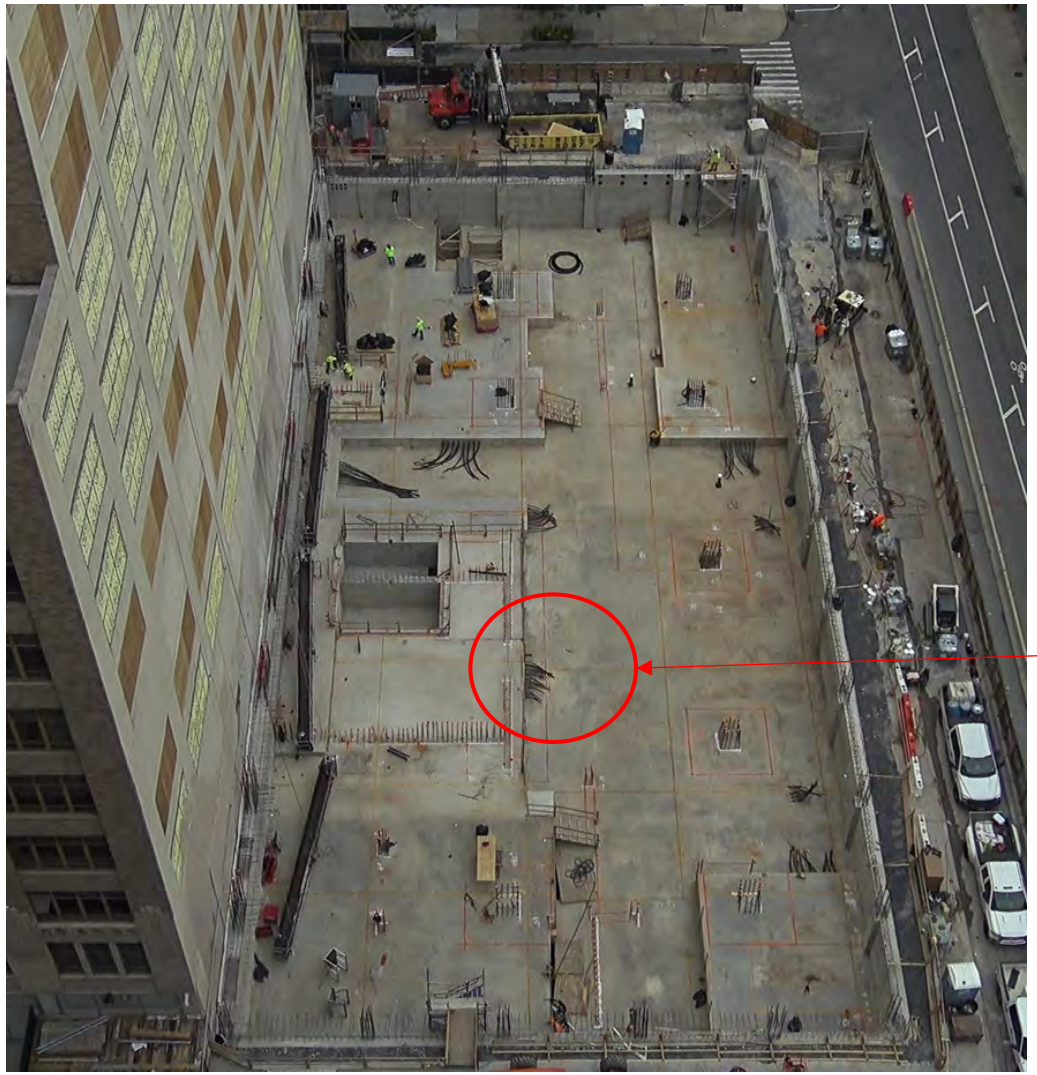
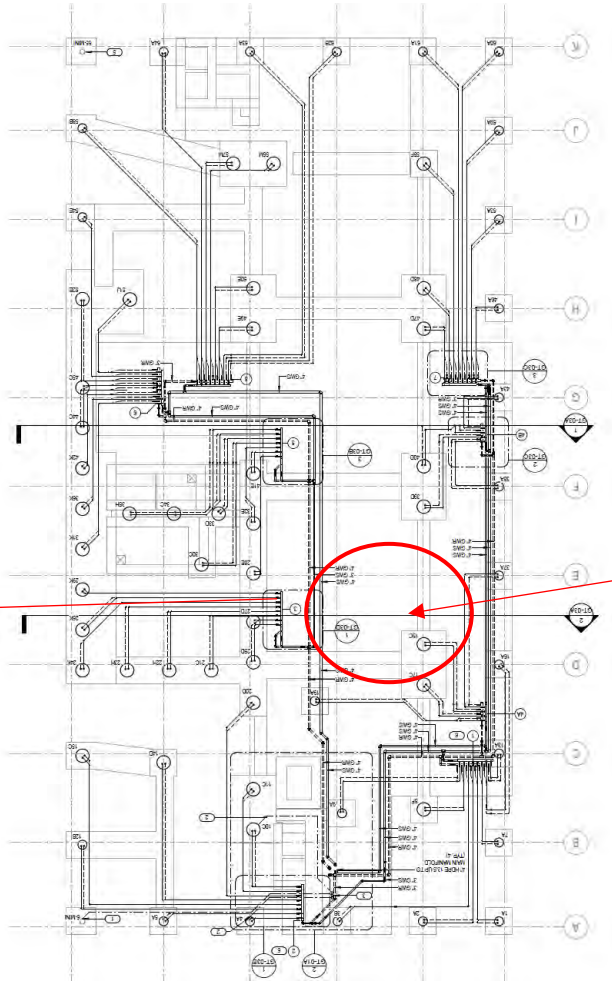
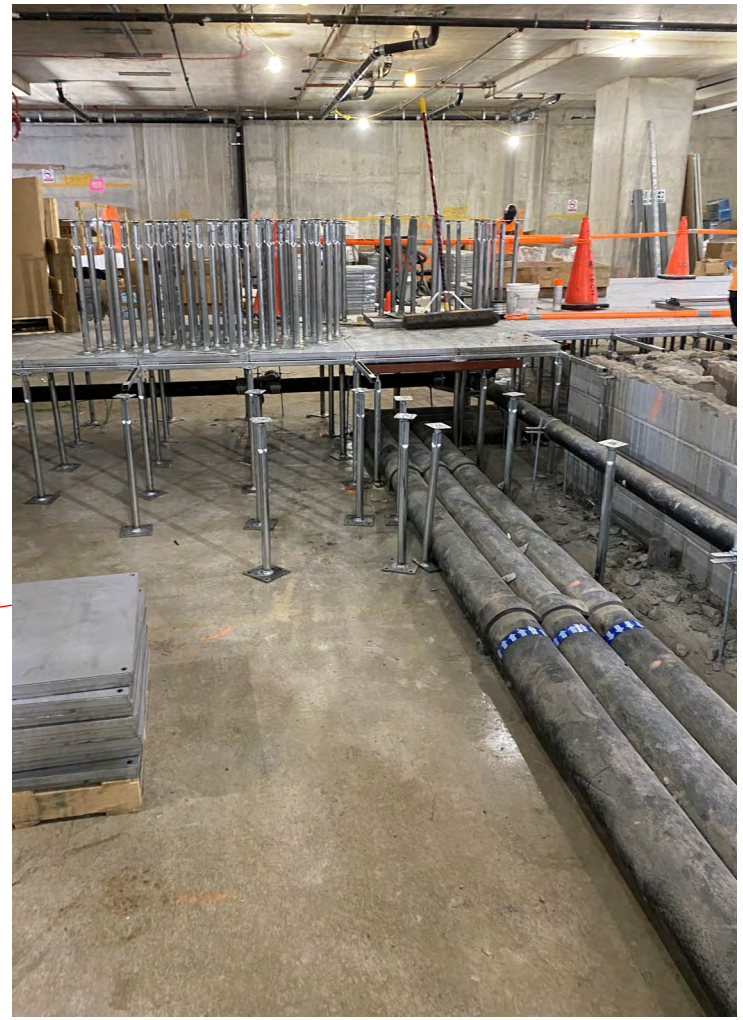
Completed basement – Reverse returns & sub manifolds in progress

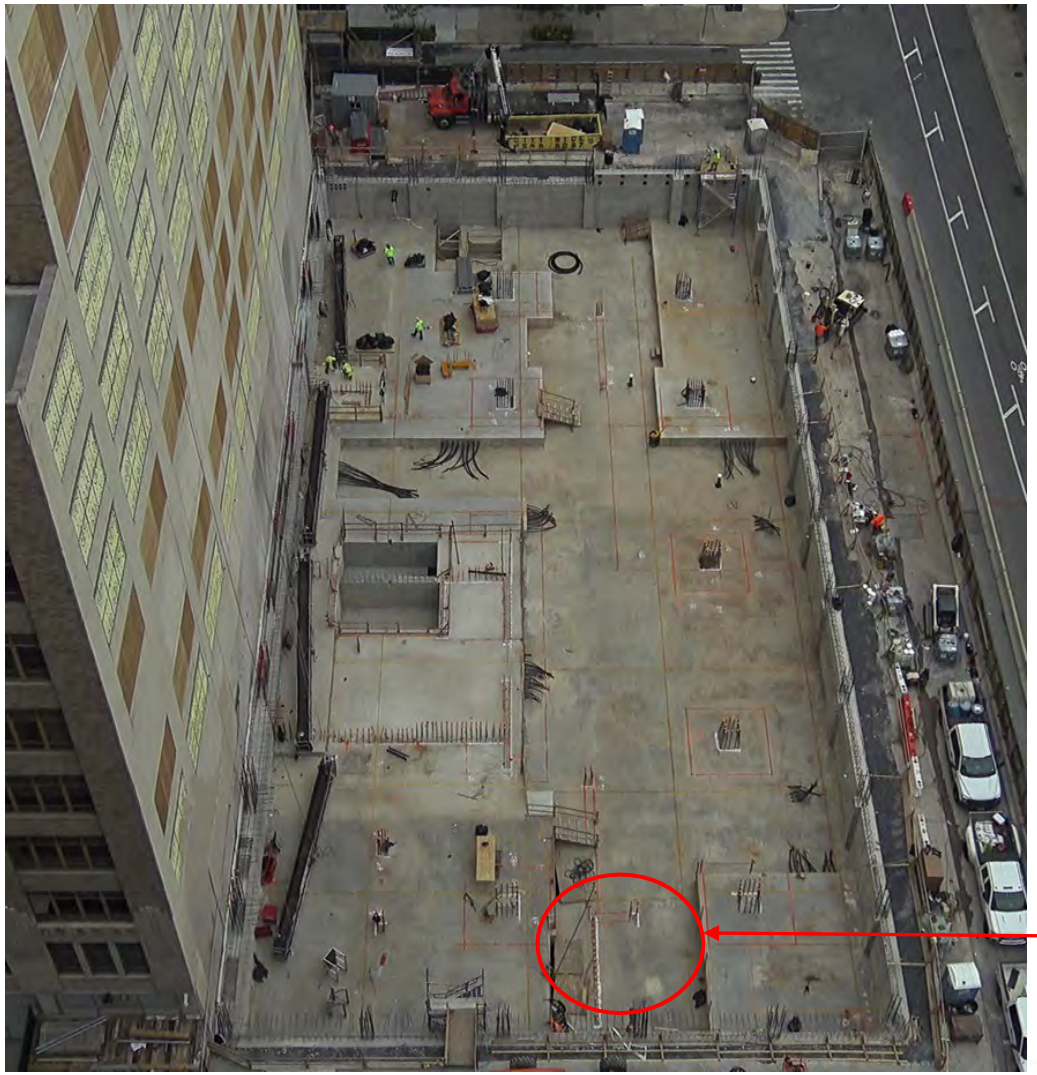


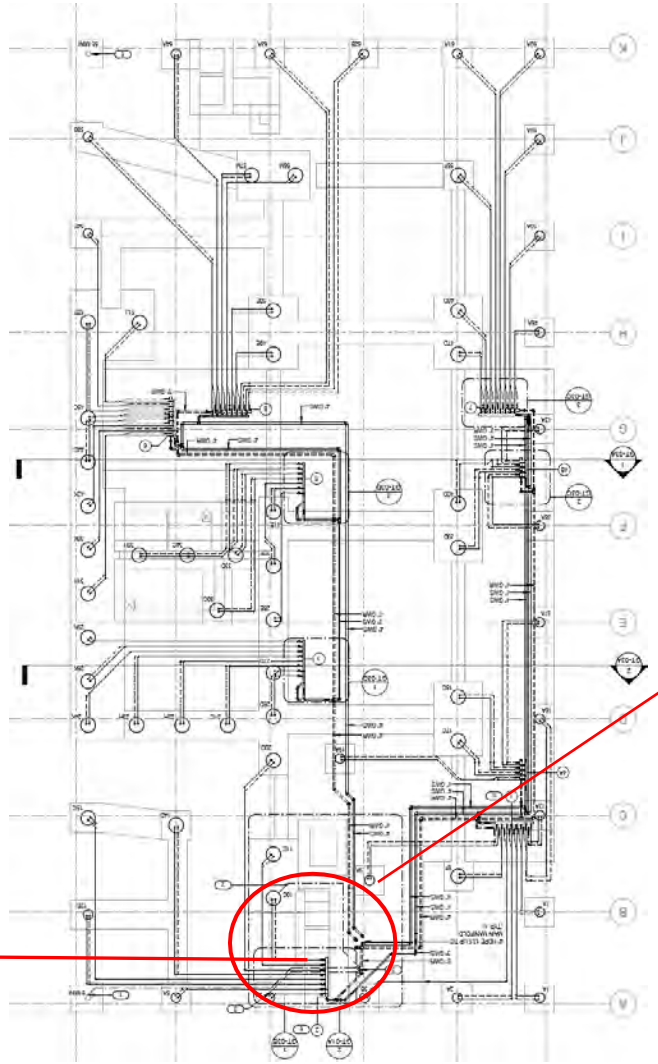




Removable flooring being installed

Main Manifold Flushing & Purging Undertaken





Purging & flushing to remove air and debris in loops

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Rooftop Ground and Air-Source Heat Pumps

Multistack Roof top heat pumps operate in either ASHP, GSHP or simultaneous mode saving rooftop space and providing system resilience.
GSHP Delivers 40% of the Buildings Heating and Cooling ASHP makes up remaining heating and cooling load

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Financial Benefits

Benefits of an Energy Foundation solution

Financial & Schedule

1. Zero schedule impact related to
   - No additional excavation works associated with drilling
   - No additional trenching operations required
   - No additional drilling equipment on an already congested site
2. Minimal cost addition to foundation works as
   - Foundation design remains unchanged
   - Geo Loops installed within structural floors and beams
   - No additional excavated material removed from site
3. Geo loop damage – Nil as concrete protects loops

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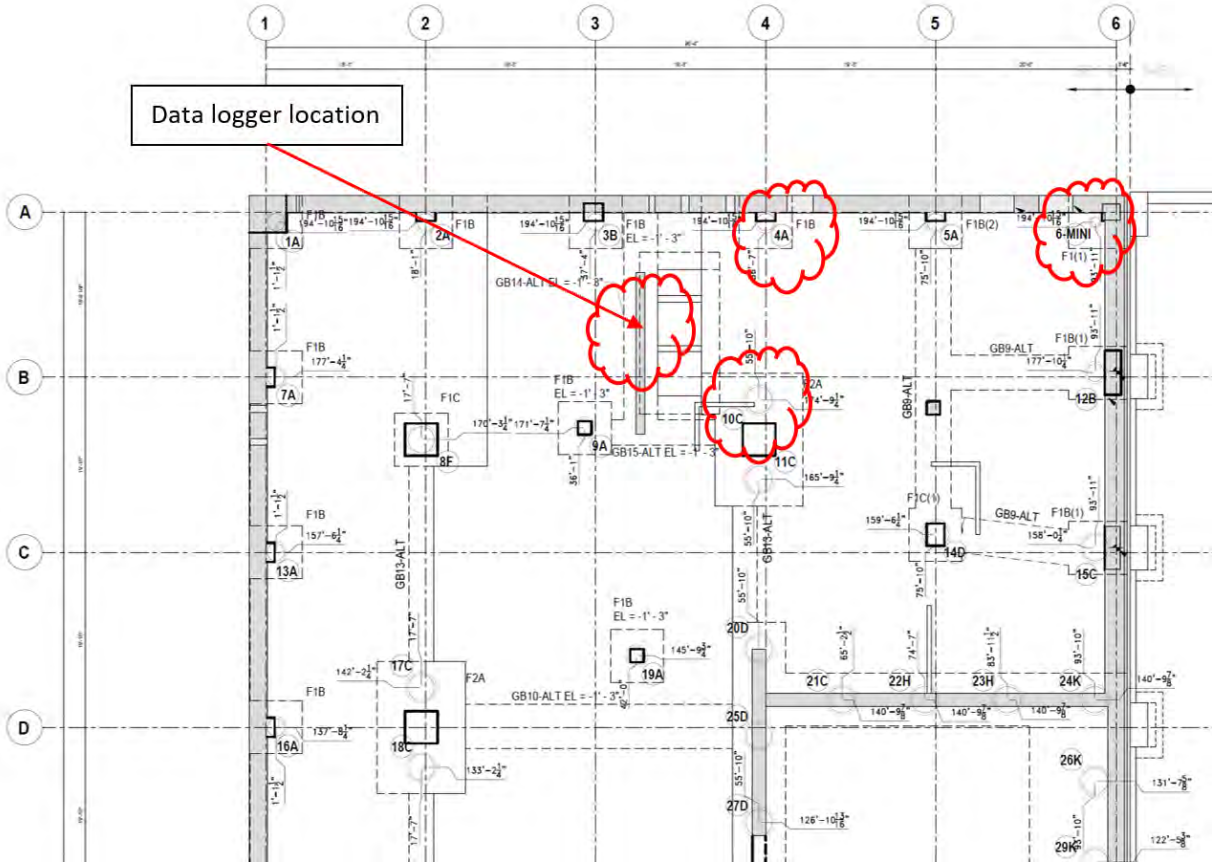
Greenwich Office Building, New York, NY

Designing & Building for the future!

Long Term Management & System Optimization

Monitoring & Controls System Installed – With The support of NYSERDA



Pile 4A & 10C - 20VW & 14 Temperature sensors (Pile 10C Conductivity test pile)
Pile 6 Mini – 14VW sensors
Instrumentation positioned at 2, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 95, 98 ft below pile cut off

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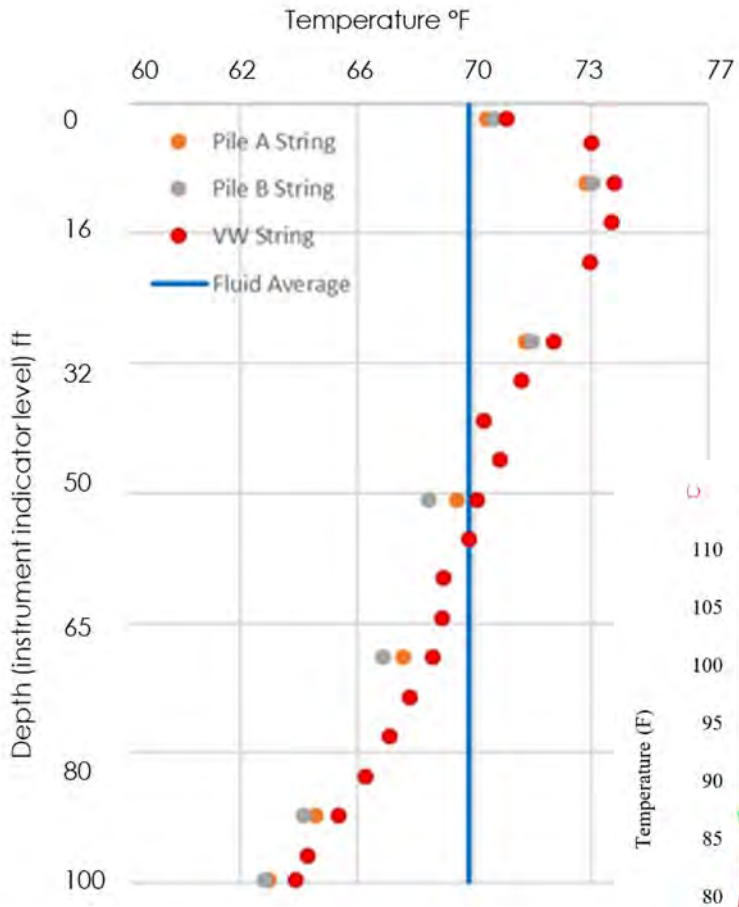
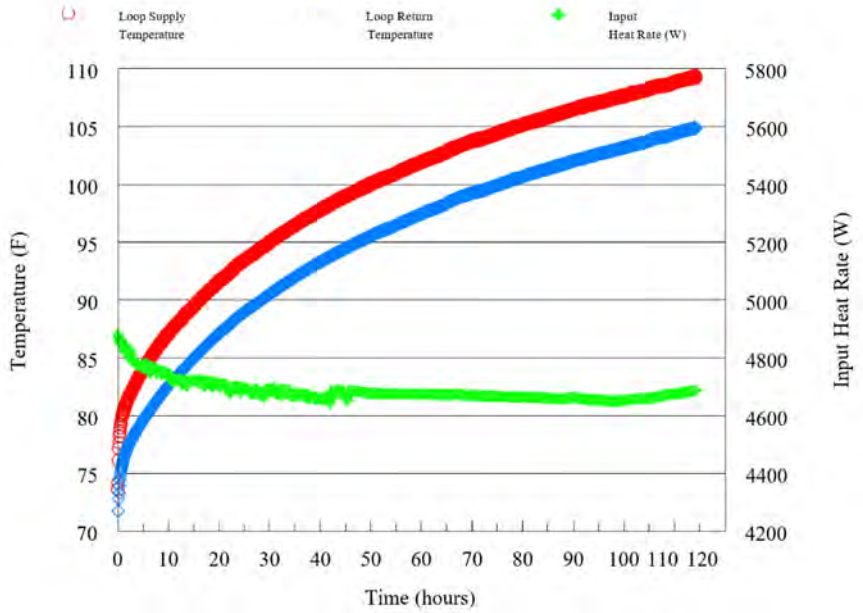
Conductivity Testing – Energy piles



Higher than expected ground temperatures noted during conductivity testing demonstrate depth of NYC's "urban heat island" effect

Test duration 114 hours



Undisturbed Formation Temperature – Approx. 66.6-73.0°F

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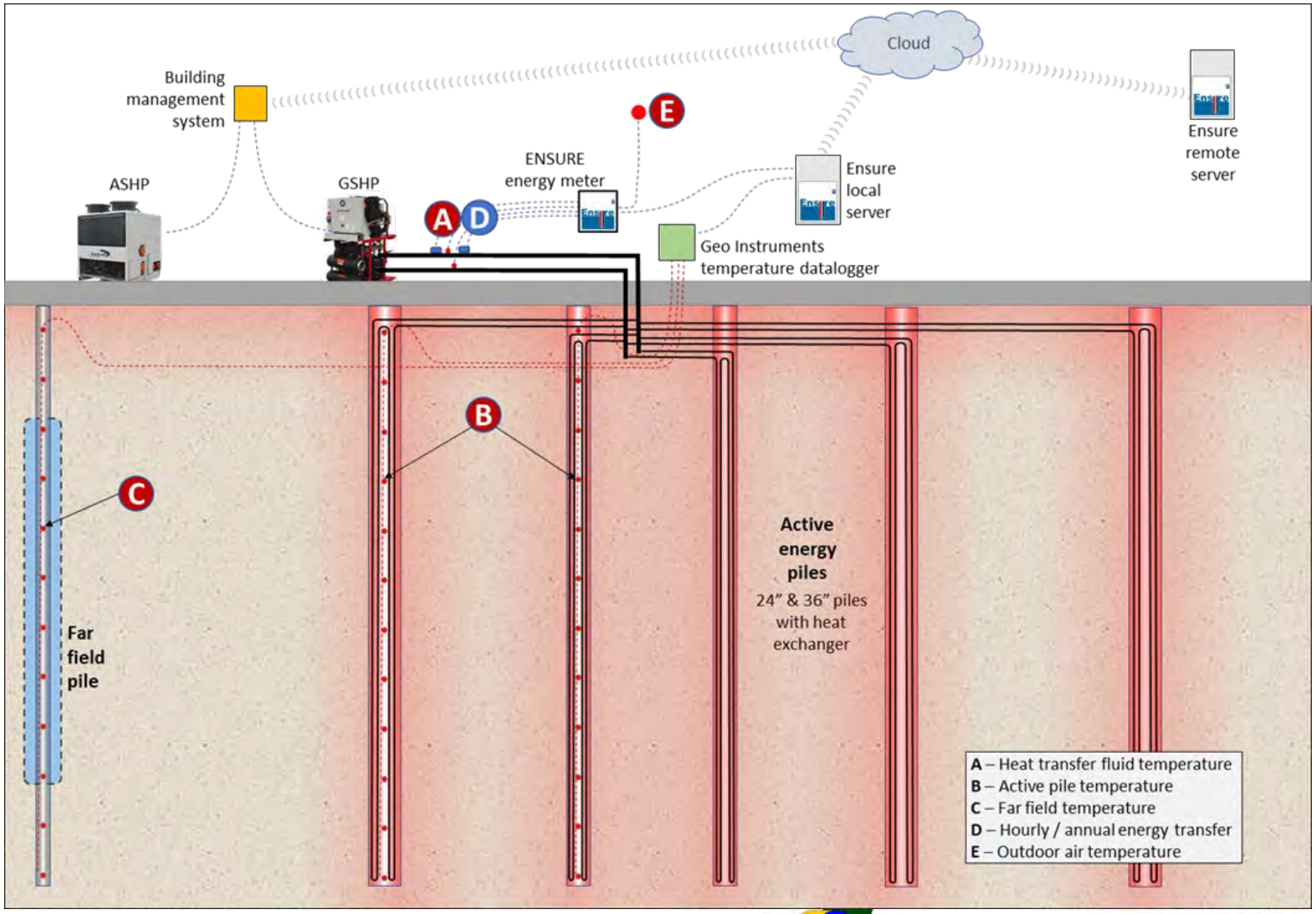
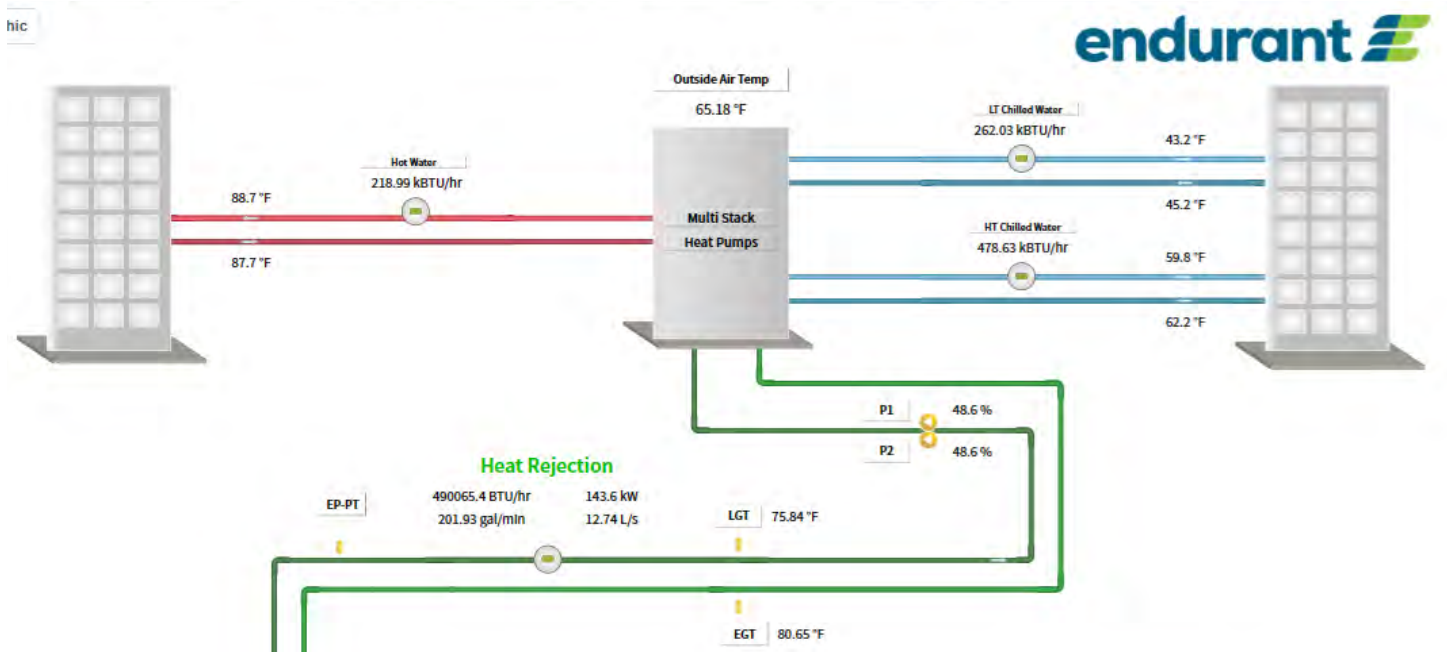
Long term monitoring and system controls

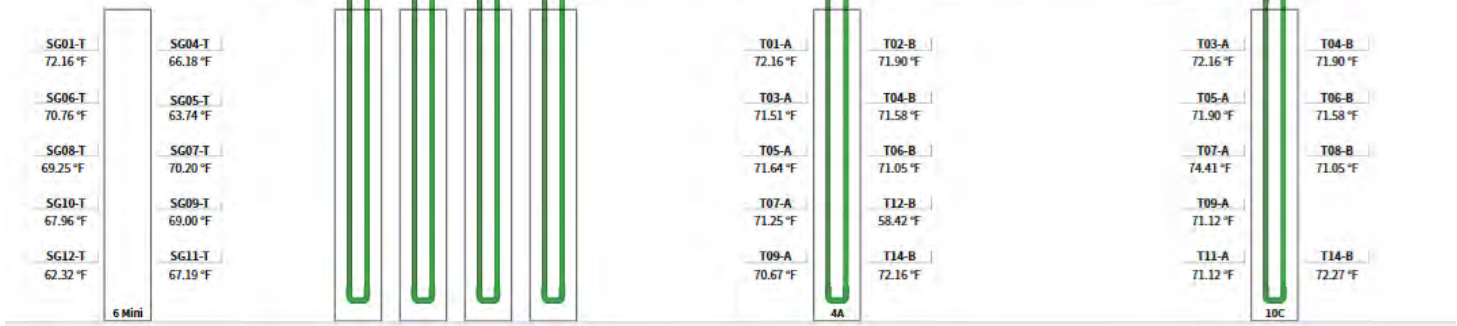


Predictive control system

- Determines most economic means of delivering heating and cooling to building
- GSHP V ASHP
- Record & adapt system to meet true building energy model
- Enables system optimisation

View of Monitoring System at 561 Greenwich – October 2023





Controls system enables

- Verification of design heating and cooling loads
- Ground loop and system are maintained within design parameters
- Management of thermal battery
- Long term performance monitoring
- System optimization

Thermal Battery
40F target - summertime
90F target - wintertime

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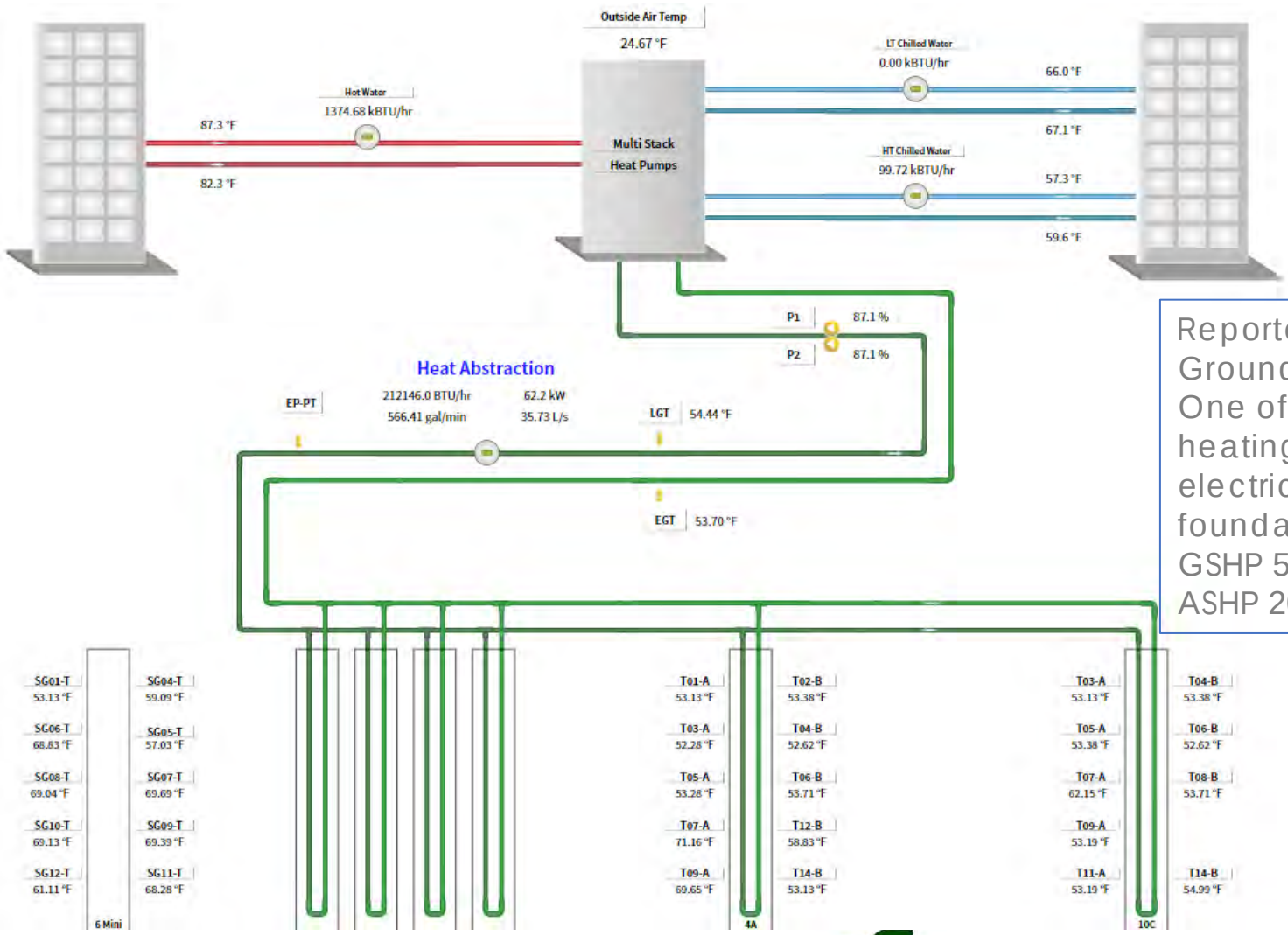
View of Monitoring System at 555 Greenwich - February 2024

Wintertime goal is to allow ground loop temperatures to cool down to enable efficient summertime cooling



Reported Outside Air Temperature 24.7F
Ground loop temperature 54.4F
One of the coldest days of the year! An ASHP delivering heating to the building would be using twice as much electrical energy as the GS solution connected to energy foundations
GSHP 55°F = 5.7
ASHP 20°F = 2.9

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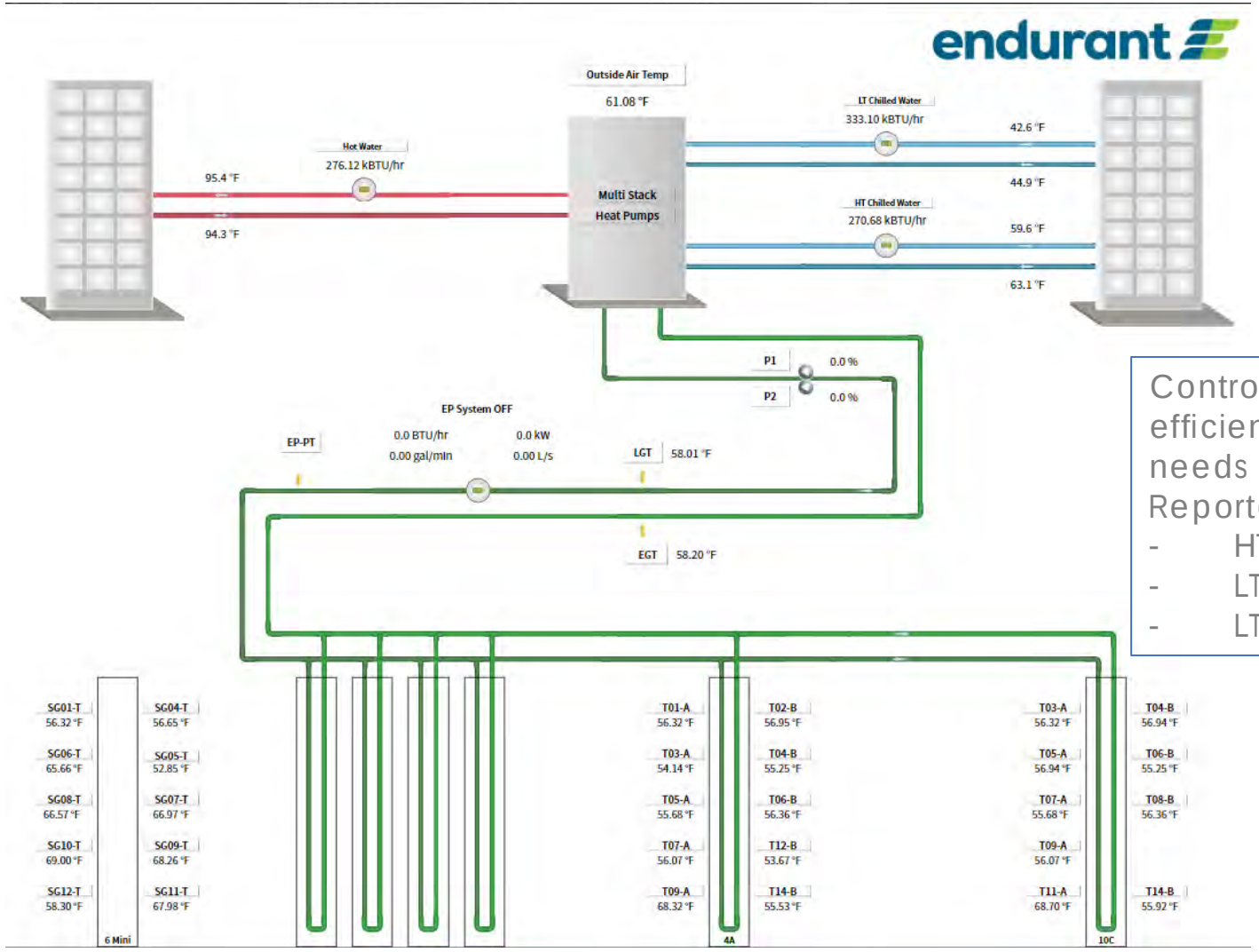
View of Monitoring System at 555 Greenwich – April 30 2024



Control algorithms use simultaneous heat pumps for energy efficiency – Heat from cooling being used to deliver heating needs

Reported COP's Outside Air Temperature 61F

- HT Cooling Only COP (OA @ 61F): 6.5
- LT Cooling Only COP (OA @ 61F): 5.0
- LT Heating COP from Simultaneous Heating/Cooling: 9.4

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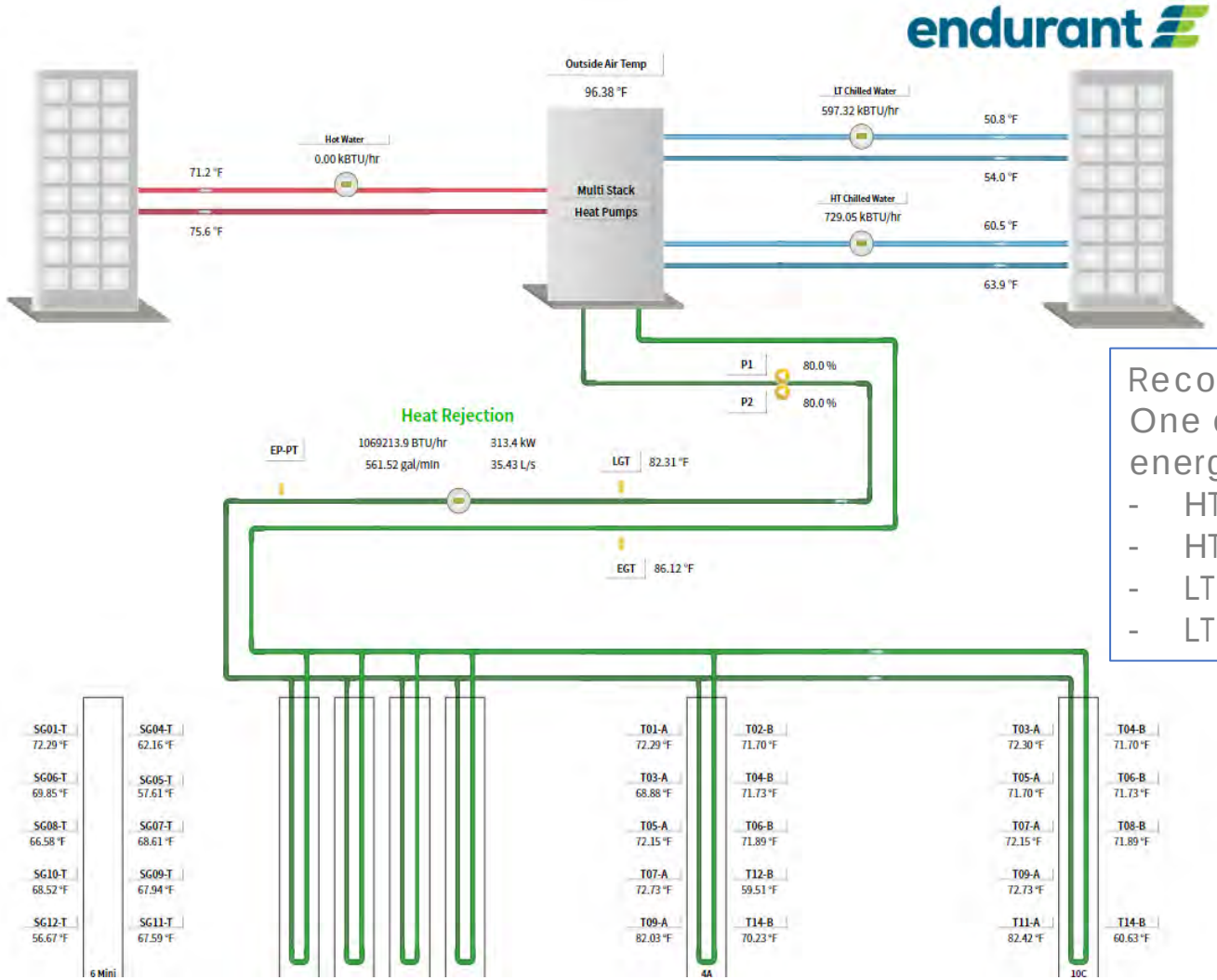
View of Monitoring System at 555 Greenwich – July 8 2024

Summertime goal is to allow ground loop temperatures to warm up to enable efficient wintertime heating



Recorded COP's Outside Air Temperature 96F
One of the Hottest days of the year and the GS solution using energy foundations delivers cooling with 35 - 40% less electricity

- HT Cooling Only COP (GS@ 82F): 6.5 **GSHP**
- HT Cooling Only COP (OAT @ 96F): 3.7 ASHP
- LT Cooling Only COP (GS@ 82F): 4.5 **GSHP**
- LT Cooling Only COP (OAT @ 96F): 2.9 ASHP

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Key Findings to date

First year data gathering ongoing – Actual vs. Design energy model being assessed

- Design Energy Model – Very conservative compared to actual – possibly due to occupation of building currently not being at capacity
- Algorithms working well in terms of heat pump mode selection and OpEx
- Energy foundations (thermal battery) performing as expected
  - Geo loop temperature reached 45-50°F before summer season cooling started
  - Geo loop temperature currently at 85-90°F being primed for winter season..
- Quality data being recorded to compare actual building model with design and enable performance enhancement over next few years

With NYSERDA support - Data from temperature and strain instrumentation is being used for education and improving knowledge on energy foundation performance when being heated and cooled

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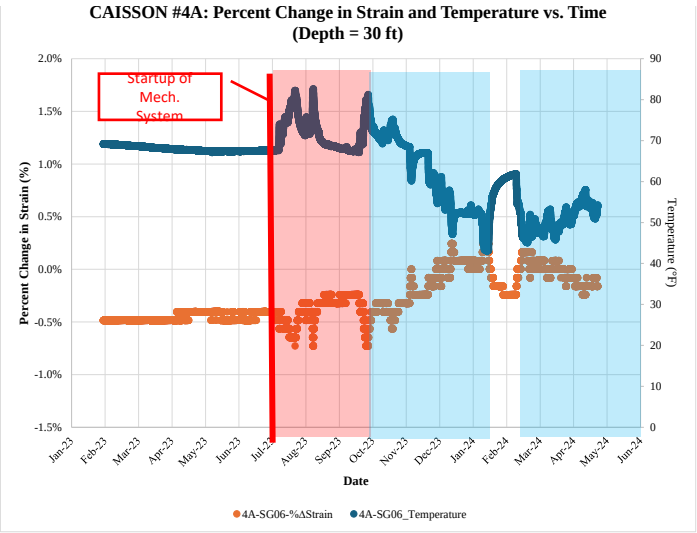
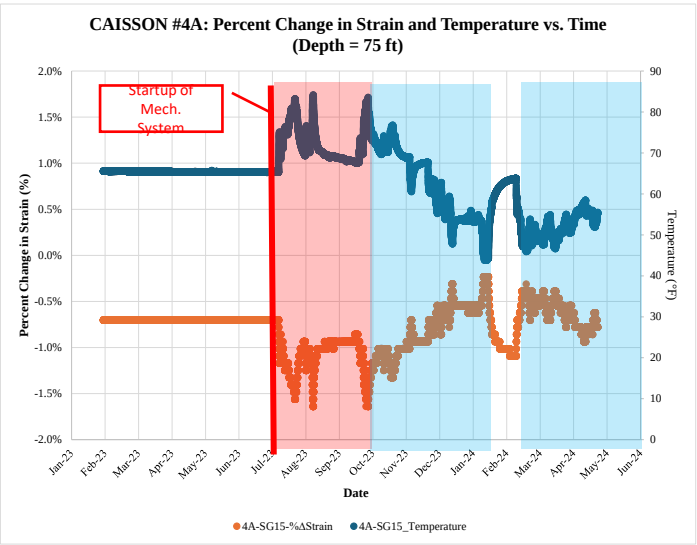
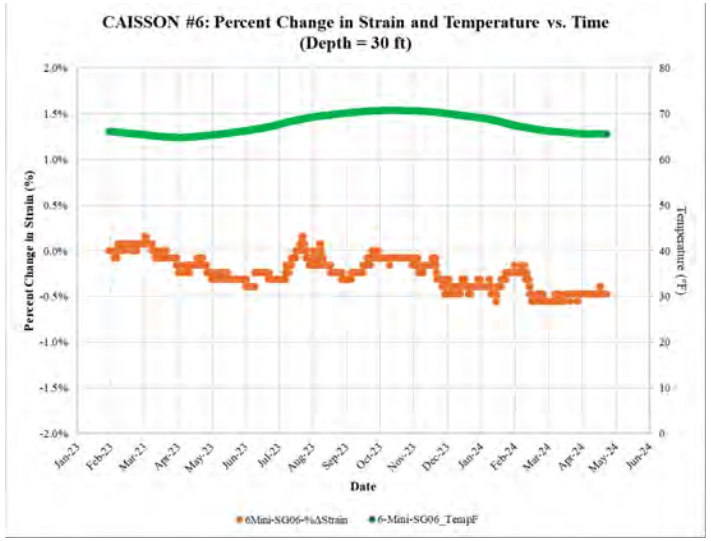
Initial Monitoring Results – Caisson with Geothermal Loop

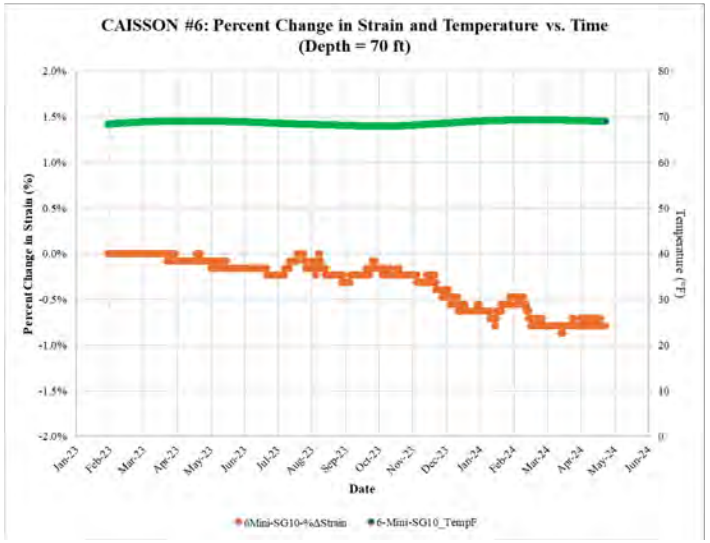
WITH GEOLOOP





NO GEOLOOP





Ground Heats up (Cooling Mode – Heat Absorption)

Ground Cools down (Heating Mode – Heat Extraction)

With GEOLOOP

Percent change in strain ranges from about **-1.64% to +0.65%,** indicating a very small expansion and contraction of the pile is occurring during thermal cycles.

NO GEOLOOP

Percent change in strain range from about **-0.87% to +0.16%**, indicating a very small expansion and contraction of the pile is occurring during thermal cycles.

Conclusion

Very minimal effect of about a 0.5% to 1% change (+/-) in strain from a geothermal loop observed when comparing caissons with and without GEO loops.

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Energy Foundation Solution Key Takeaways

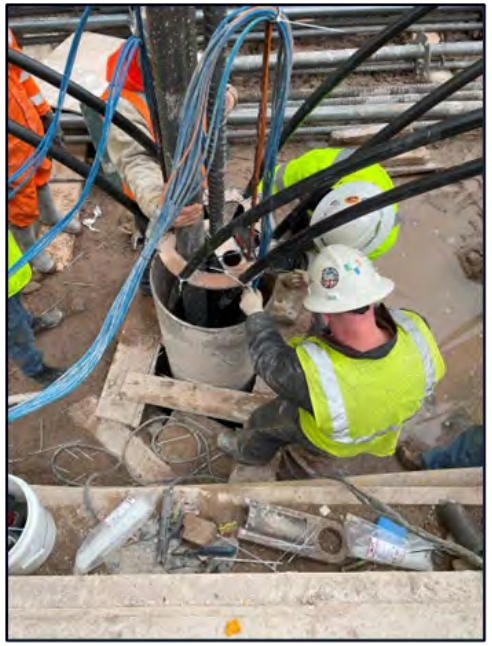
Energy Foundations

1) Eliminate additional spoils removal from drilling and trenching compared to conventional boreholes especially on highly contaminated sites
2) Larger diameter foundation elements reduce spoils and allow for geothermal loops to be placed more easily
3) Can be installed with minimal to zero impact on construction schedule
4) Provide significant cost benefits
5) Over 50ft to 60 ft can be considered for geothermal foundations. The deeper the better for energy capacity
6) Full time field oversight of geothermal energy foundations is highly critical
7) No major impacts noted to stress/strain behavior of foundation elements with geothermal loops

As with all Geo Systems

1) Evaluate geothermal early in design process
2) Control, monitor and maintain ground loop once operational

A closing thought – is it time for some new building code legislation?



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Thank you!

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