REQUEST FOR QUALIFICATIONS (RFQ) NO. S-P26603-00017412

A&E SERVICES: GEOTHERMAL & ENERGY RESILIENCE
Parkrose School District No. 3

1.0 INTRODUCTION & PROJECT OVERVIEW

Parkrose School District (the "District") is soliciting Statements of Qualifications (SOQ) for professional Architectural and Engineering (A&E) services for geothermal conversions at Russell Elementary and Shaver Elementary Schools.

This project is funded by the Portland Clean Energy Community Benefits Fund (PCEF). The District intends for these designs to support a future Oregon Community Renewable Energy Grant (CREP) application for microgrid resilience.

This solicitation is conducted in accordance with ORS 279C.110 (Qualifications-Based Selection). No pricing information shall be submitted with SOQs.

The District intends this project to be a collaborative partnership. While the District has established clear expectations regarding budget, schedule, grant compliance, and technical performance, it recognizes that successful delivery requires open communication, early identification of risks, and cooperative problem-solving among the District, Consultant, CM/GC, Commissioning Agent, and other project participants.

<u>Project Locations</u>:

Russell Elementary 2700 NE 127th Ave, Portland, OR 97230

Shaver Elementary 3701 NE 131st Place, Portland, OR 97230

1.1 Project Budget & Design-to-Ceiling Strategy

The total available grant funding from the Portland Clean Energy Community Benefits Fund (PCEF) for all aspects of this project—including design, permitting, construction, and commissioning—is $8,422,807. The District has established an estimated Maximum Allowable Construction Cost (MACC) ceiling of $7,500,000 for the core geothermal scope. The Consultant shall utilize Target Value Design principles to design a system that fits safely within this MACC ceiling, leaving appropriate reserves for soft costs, third-party commissioning, and regulatory permits.

The Consultant shall design the project to align with the MACC and shall provide cost estimates at each design phase. If cost estimates exceed the MACC:

- The Consultant shall promptly notify the District whenever it appears the project scope or market conditions may jeopardize the MACC so that corrective action may be taken at the earliest practical stage.
- The Consultant shall recommend scope adjustments, phasing strategies, and/or additive alternates
- The Consultant shall participate in reasonable redesign efforts without additional compensation to the extent that cost overruns are primarily attributable to design decisions that do not meet the applicable professional standard of care.
- The Consultant shall identify value engineering opportunities that preserve system performance, energy efficiency, maintainability, and life-cycle value.

If cost escalation is due to documented extraordinary market conditions beyond the Consultant's control, the District and Consultant will work collaboratively to adjust scope or identify additional funding.

2.0 TRANSPARENCY & PRELIMINARY WORK DISCLOSURE

The District discloses that the following firms performed preliminary feasibility studies, thermal conductivity testing, and conceptual design work:

- Interface Engineering (Feasibility & Conceptual Design)
- Arrow Drilling (Thermal Conductivity Testing)

Reports generated by these firms are provided as Reference Documents (see Appendix B). All Proposers are encouraged to review these materials.

These firms are not precluded from submitting a proposal; however, no preference will be given in the evaluation process.

The selected Consultant shall review the preliminary materials and identify any apparent errors, omissions, or areas requiring additional investigation within 30 days of contract execution. The Consultant's design shall be based on information reasonably available and consistent with the applicable professional standard of care. Nothing in this section relieves the Consultant of its responsibility to perform professional services consistent with the applicable standard of care

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3.0 SCOPE OF SERVICES & TECHNICAL STANDARDS

3.1 Resilience & Critical Load Isolation

The Consultant shall identify and electrically isolate critical mechanical loads (including pumps, controls, and designated resilience zones) to support functionality during grid outages.

The Consultant shall design Points of Interconnection (POI) for future solar photovoltaic (PV) and battery storage systems and develop a preliminary critical load schedule and one-line diagram.

3.2 CM/GC Coordination & Schedule

The District anticipates utilizing a CM/GC delivery method.

The Consultant shall:

- Participate in preconstruction coordination with the CM/GC
- Support cost estimating, constructability review, and bid packaging strategies
- Participate in collaborative schedule development

The project shall target Summer 2027 substantial completion, and phasing strategies shall reflect the constraints of occupied K–12 facilities.

3.3 Quality Control & Commissioning

The District will employ a third-party Commissioning Agent (CxA).

The Consultant shall:

- Coordinate with the CxA at key design milestones (30%, 60%, 90%)
- Respond to CxA review comments
- Provide site observations during construction
- Provide photographic documentation of geothermal wellfield connections and other critical system components prior to concealment

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3.4 Construction Phasing & Site Logistics (K–12)

The Consultant shall demonstrate an understanding of the logistical challenges of occupied school environments and develop phasing strategies that minimize disruption to students and staff.

The Consultant shall provide a training plan for District personnel addressing system operation, controls, and maintenance.

3.5 Owner's Project Requirements (OPR) & Design Validation

- Early in Schematic Design, the Consultant shall facilitate an Owner's Project Requirements (OPR) workshop with District representatives to confirm project goals, operational priorities, energy performance objectives, resilience strategies, maintenance expectations, phasing considerations, and budget priorities. The Consultant shall document the agreed-upon project requirements and utilize them as the basis for subsequent design decisions. The OPR shall be reviewed and updated at major design milestones as appropriate.
- The Consultant shall maintain a Project Decision Log documenting significant design decisions, alternatives considered, and the basis for major recommendations throughout the design process.

3.6 Technical Requirements

The Consultant shall:

- Demonstrate experience with OWRD low-temperature geothermal permitting
- Include a qualified geologist or Certified Water Rights Examiner (CWRE)
- Design systems compatible with and fully integrated into the District's existing Building Automation System, including sequences of operation, alarms, trending, graphics, and operator functionality.
- Develop additive and deductive alternates to support scope prioritization within available funding

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4.0 PCEF COMPLIANCE & PAYMENT TERMS

4.1 Wage Floor & Reporting

Work is subject to BOLI Prevailing Wage and the PCEF 180% wage floor.

Proposers shall submit a Wage Oversight Memo describing their process for ensuring compliance by all sub-consultants.

4.2 Quarterly Compliance Gate

To maintain grant eligibility, the District requires quarterly workforce and demographic reporting.

Invoices for work performed during the final month of any calendar quarter (March, June, September, December) shall be held until all required PCEF reporting data for that quarter has been submitted and verified.

The District will not unreasonably withhold payment for delays in documentation beyond the Consultant's control.

4.3 Final Payment

Final payment may be contingent upon completion of required PCEF reporting and project closeout documentation.

5.0 SOQ SUBMITTAL REQUIREMENTS

5.1 Format

- Maximum length: 25 pages (excluding cover letter and resumes)
- PDF format preferred

5.2 Required Contents

SOQs shall include the following:

1. Firm Overview
2. Relevant Project Experience (GSHP, K–12, Oregon permitting) & relevant experience of proposed subconsultants.
3. Key Personnel (roles and relevant experience)
4. Project Approach (including geothermal design, phasing, and CM/GC coordination)
5. Design-to-Ceiling Strategy (cost control, alternates, phasing)
6. Energy & Funding Strategy (IRA, CREP familiarity, lifecycle considerations)
7. Equity & PCEF Strategy (including Wage Oversight Memo)
8. Capacity and Availability

6.0 EVALUATION CRITERIA (100 TOTAL POINTS)

- **Specialized Firm and Key Personnel Experience (35 points)**
  GSHP retrofits, OWRD permitting, and K–12 engineering

- **Project Approach & Design-to-Ceiling Strategy (25 points)**
  Phasing, constructability, cost management, and alternates
- **Equity & PCEF Strategy (20 points)**
  DMWESB utilization and wage compliance approach
- **Resilience, Commissioning, & CM/GC Coordination (20 pts)**: Approach to load isolation, proactive coordination with the 3rd-party CxA, and collaborative contractor integration

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7.0 SELECTION PROCESS

The District will evaluate SOQs and may shortlist firms for interviews.

Firms will be ranked based on qualifications in accordance with QBS procedures. The District will enter into negotiations with the highest-ranked firm to establish a mutually acceptable contract.

If the District is unable to reach agreement with the top-ranked firm, negotiations will be formally terminated and initiated with the next-ranked firm.

8.0 SCHEDULE

- RFQ Issued: 7/7/26
- Mandatory Site Walk: 7/21/26 @10am - start at Russell Elementary followed by Shaver Elementary
- Deadline for Questions: 8/4/26
- SOQs Due: 8/20/26 @ 2pm
- Interviews (if conducted): TBD

The District reserves the right to modify the schedule as necessary.

9.0 COMMUNICATIONS

Point of Contact:
Robyn Stolin
Supervisor of Maintenance

Questions may be submitted via:

- OregonBuys (preferred)
- Email to the District

Responses to all substantive questions will be issued via formal addenda to ensure all proposers have access to the same information.

Proposers shall not contact other District staff regarding this solicitation.

10.0 SUBMISSION INSTRUCTIONS

SOQs may be submitted via:

- Electronic submission through OregonBuys
  OR
- Sealed hardcopy delivered to:

Parkrose School District
10636 NE Prescott St
Portland, OR 97220

SOQs must be received by the stated deadline. Late submissions will not be accepted.

11.0 GENERAL CONDITIONS

- The District reserves the right to reject any or all SOQs
- The District may waive informalities or minor irregularities
- The District is not responsible for costs incurred in proposal preparation
- Proposers are responsible for monitoring OregonBuys for addenda
- All work shall comply with applicable Oregon laws and PCEF requirements

11.1 Minimum Insurance Requirements

The selected Consultant shall maintain, at its own expense, the following minimum insurance coverages throughout the duration of the contract, as fully detailed in the Sample Contract (Appendix C):

- **Professional Liability / Errors & Omissions:** $2,000,000 per claim / $4,000,000 aggregate
- **Commercial General Liability:** $1,000,000 per occurrence / $2,000,000 aggregate.
- **Pollution / Environmental Liability:** $1,000,000 per claim

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APPENDIX A: PROPOSER CERTIFICATION

Conflict Disclosure:
Does your firm have a relationship with the preliminary contractors (Interface/Arrow)?
☐ NO ☐ YES

Payment Terms:
We acknowledge the Quarterly Compliance Gate for payment processing.
☐ YES

Independence:
We acknowledge we are ineligible for the construction/installation contract.
☐ YES

Contract Acceptance:
We have reviewed Appendix C (District Personal Services Contract) and accept the terms.
☐ YES

Authorized Signature: ___________________________
Date: ______________________

Interface Engineering, Inc.
100 SW Main Street, Suite 1600
Portland, OR 97204
TEL 503.382.2266
www.interfaceengineering.com

Parkrose - Russell ES Geoexchange Study

Parkrose SD Russell Academy ES Geoexchange Study
2024-1214

Prepared by:
Shem Heiple, PE, LEED AP

Prepared for:
Parkrose School District

October 10, 2024

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Executive Summary

Introduction

Russel Elementary School was used as a case study and is one of nine existing schools in the Parkrose school district with plans to upgrade to a geoexchange ground source heat pump system that will profoundly reduce the district building's energy use and carbon emissions and move from fossil fuel heating to predominantly all electric buildings. The purpose of this study was to assess one of the schools for geoexchange / ground source heat pump system upgrades that could be used as a prototype for applying to other schools. The study

- Assess energy and carbon emissions savings potential with geoexchange upgrades.
- Identify additional cost-effective energy efficiency measures.
- Assess existing building for geoexchange upgrade feasibility.
- Provide recommended geoexchange system configuration.
- Design narrative and concept drawings for cost estimation.
- Assess site area requirements for geo-field system.

Summary

Performance

The school's current energy usage based on utility bills is 48.5 (kbtu/h/sf/yr) EUI, which is comparable to a national average school EUI of 47 (kbtu/h/sf/yr). Sixty-five percent of the energy use is fossil fuel (natural gas) with the remainder being electricity.

By upgrading to a geoexchange system, the building's heating and domestic hot water system is converted to all electric heat pump technology with consistent high operating efficiencies near 4 COP. By including air-to-air energy recovery and demand control ventilation in addition to the geoexchange upgrade the following is achieved:

- **53%** total building energy reduction
- **22 EUI** (kbtu/h/sf/yr)
- **35%** total building carbon emissions reduction
- All-electric heating
- Possible to reach net zero energy and emission with roof mounted PV array

Other benefits with the geoexchange and HVAC upgrades:

- Improved **indoor air quality** is achieved with the addition of MERV 13 filters and demand control ventilation.
- Improved **thermal comfort** is achieved by adding mechanical cooling to the existing building.
- **Education** is improved by reducing school closure with geoexchange system cooling that can maintain occupant comfort in extreme heat climate events.

- **Climate change resiliency** is improved with ground coupled cooling that is resistant to high air temperature events compare to air-source cooling systems.

Recommendations

District Level

- Vertical well, closed loop geo-field system is recommended for district level implementation and for initial budgeting.
- Horizontal well (bore) configuration that is less common may also be considered in lieu of a vertical well configuration but may require more site area than what is available for all schools. Additionally, horizontal drilling contractor availability could be limited.
- Building HVAC ground source heat pump system type: optimal system type must be assessed for each school. Either centralize or distributed depending on building condition and configuration. Larger schools should consider 6-pipe central ground source heat pump with heat recovery.
- Ground source domestic hot water heat pumps.
- Provide conductivity test bore at each school for geo-field sizing.

Russel Elementary

- Centralized ground source heat pump system with a 2-pipe changeover system.
- New unit ventilators and new air handler units with MERV 13 filter. Note that MERV 13 filters are not available for water source heat pump unit ventilators.
- New unit ventilators should be provided with demand control ventilation and full air-side economization for each classroom.
- Air-to-air energy recovery (ER) and demand control ventilation (DCV) is recommended.
- Net-Zero Energy can be achieved with a 15,000 sf, 257 kW roof mounted PV array.

Performance

Based on the natural gas and electricity utility bills from 2022 through 2023, the existing school has an EUI of 47 (kbtu/h/sf/year) which is below the national average EUI of 48.5 for existing K-12 schools. Over 65% of the building's energy is natural gas that is primarily associated with building heating.

The school was assessed for cost effective building energy and carbon emission reduction strategies beyond the geoexchange upgrade including envelope, lighting and HVAC system measures. Of the available energy measures, demand control ventilation (DCV) and air-to-air energy recovery (ER) had the highest potential for energy cost effectiveness.

By upgrading the natural gas boiler and domestic hot water systems to ground source heat pumps, 49% energy reduction can be achieved. This is done by utilizing all electric geo heat pump technology that operates at efficiencies consistently above a 4 COP compared to the existing natural gas boiler efficiencies that operate at 85%-90% thermal efficiency. The geoexchange upgrade shifts from natural gas fossil fuel use to all electric. However, natural gas equivalent carbon emissions at 399 lb/MWh is less that PGE electricity equivalent carbon emissions of 759 lb/MWh and the resulting total building carbon emissions reduction potential is 27%.

Mechanical cooling will be available with the geoexchange upgrade. Additional cooling energy will be small with ground source heat pump cooling efficiency and will be offset by improved building HVAC systems such as EC fan motors replacing older constant volume unit ventilator fans.

Demand Control Ventilation (DCV)

The building's existing high temperature heating water system will be required to be replaced with a new low temperature system to operate with ground source heat pumps that are limited to lower supply water temperatures. New unit ventilators that have dedicated outdoor air damper modulation are supplied with demand control ventilation (DCV) that can modulate outdoor air rates base on classroom space CO_2 sensors. DCV will ensure ventilation requirements are provided while reducing outside air rates by 20% - 40% resulting in significant heating energy reduction. DCV could provide 5% additional energy reduction with the geoexchange upgrade.

Air-to-Air Energy Recovery (ER)

Increased ventilation rates for high occupant density classrooms results in high preheat outside air heating energy. Air-to-air energy recovers energy from the exhaust air stream to reduce the preheat energy by up to 80%. However, with extremely high geo system heating efficiency and ventilation air reduction through demand control ventilation, the cost savings is slightly lower than a standard efficiency heating building with an annual energy cost savings of less than $1,000 a year and a 3% annual energy reduction. By adding air-to-air energy recovery, the required geoexchange capacity is reduced by approximately 20%.

Renewables for Net-Zero Energy & Carbon Emission (PV)

The school's EUI can be reduced from 47 to 22 with geoexchange systems and minor demand control ventilation upgrades. With this dramatic reduction in energy use the building is within reach of net-zero energy and emissions through renewable systems. With the school being a single-story building, the school has over 40,000 sf of roof area for a roof mounted PV array. Approximately 15,000 sf of PV array panel area is needed to offset 100% of the building energy.

Project Name	**Russell ES - NZE**
Building Square Footage	44,232
Solar PV System Cost ($/W)	3.0
Basis of Design PV Module	SPR-X21-470-COM
PV Module Wattage	470
Energy Production per Module (kWh/yr)	517
Module Area (sq. ft.)	23.3
Quantity	548
Solar PV Array Size (kW)	257
Min. Roof Area (sq. ft.)	12,760
Spacing Factor (1.2) (sq. ft.)	15,312
Total Energy Production (kWh/yr)	283,126
Estimated Cost	$772,163

Figure 1: PV sizing for net-zero energy

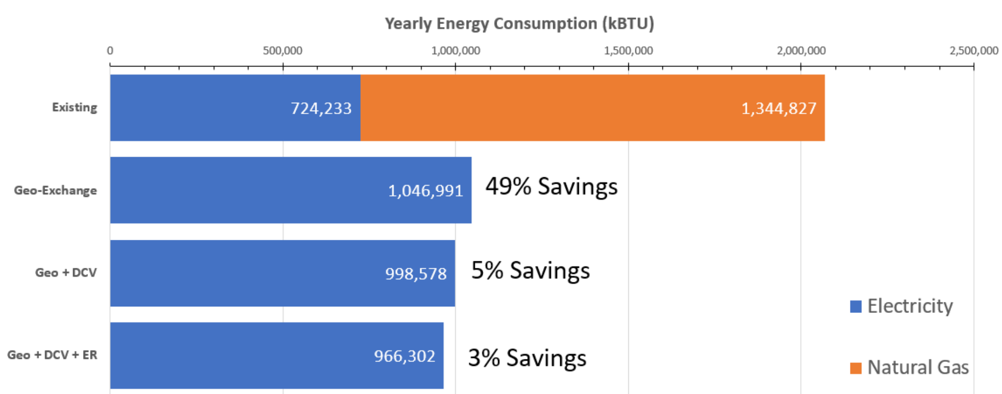


Figure 2: Energy Savings

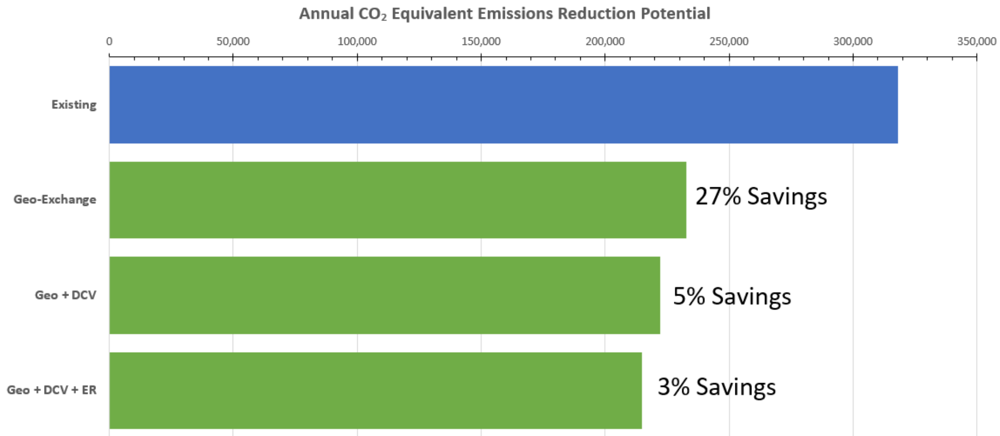


Figure 3: Emissions Reduction

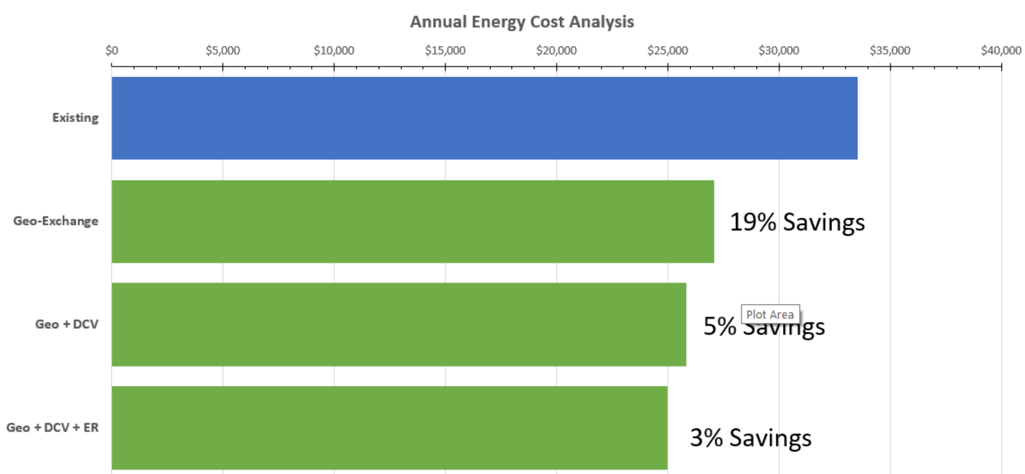


Figure 4: Energy Cost Savings

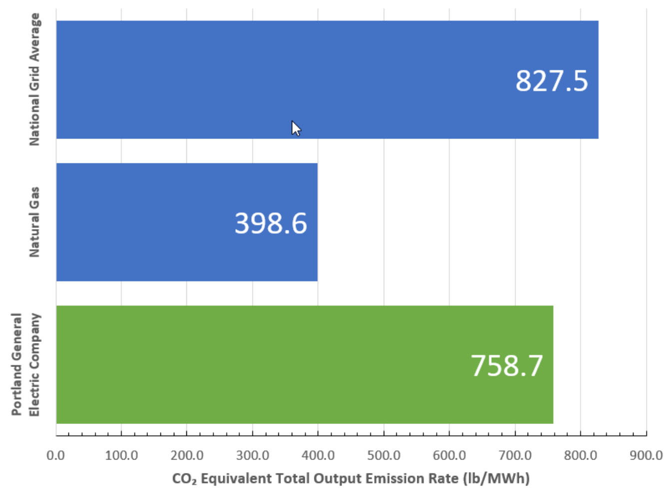


Figure 5: CO2 equivalent emission rate by fuel consumption

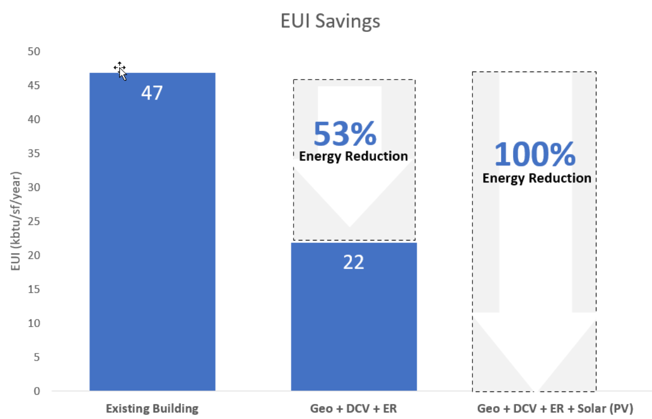


Figure 6: Proposed EUI reduction

Month	Electric Use (kWh) @ 0.0882 $/kWh			NG Use (therms) @ 1.10 $/therm		
	2022	2023	2-year Average[1,3]	2022	2023	2-year Average
January	21,351	22,880	22,116	2,680	2,857	2,769
February	20,654	20,400	20,527	2,238	2,375	2,307
March	17,534	18,240	17,887	1,627	1,876	1,752
April	18,894	19,200	19,047	1,399	1,572	1,486
May	19,431	18,800	19,116	1,035	635	835
June	14,887	14,960	14,924	272	162	217
July	11,450	10,800	11,125	99	99	99
August	11,200	11,840	11,520	91	51	71
September	18,400	16,960	17,680	129	58	94
October	19,680	17,760	18,720	157	122	140
November	22,640	18,960	20,800	1,928	1,170	1,549
December	20,960	16,640	18,800	2,479	1,792	2,136
Annual Energy Usage						
Annual Energy Usage	217,081	207,440	212,261	14,134	12,769	13,452
Annual Energy Usage (kBtu)	740,680	707,785	724,233	1,413,061	1,276,594	1,344,827
Total Energy Cost[1] ($)	$19,147	$18,296	$18,721	$15,547	$14,046	$14,797
Energy Performance of the Facility						
Total Building Area			**44,232**			
Total Energy Use (kBtu per year, based on 2-year Average)			**2,069,060**			
Energy Use Intensity, EUI (kBtu/sqft/year)			**47**			
Median EUI for Facility Type in the US[2]			48.5			

1. Using industry average values of $0.0882/kWh and $1.10/therm.
2. Please refer to this link to obtain the Median EUI for various facility types - https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/what-eui

Table 1: Historical Energy Use

Existing Condition

Russell Elementary School was built in 1963 and consists of 1 level buildings with a total building area of 44,000 square feet. The existing building is served by a condensing boiler heating water system with equipment and piping replacement that occurred between 2011-2013. The classrooms are served by unit ventilators installed in original construction that are well past their useful life. Heat ventilators (HV-1 and HV-2) serve the office area and cafeteria and are well past their useful life. There is no mechanical cooling at the school except for a new multi-purpose area with gym and classroom built in 2013. The multi-purpose addition cooling and heating is provided by an air-to-water source heat pump connected to a hydronic heated and cooled radiant slab.

All original windows were replaced with enhanced energy performance window systems. The envelope insulation appears to be of the original build in 1963. Wall and roof insulation is likely well below current energy code standards. Low insulation levels correlates to the relatively high heating energy that is over 50% of the buildings energy use.

Design

Geo-Field System

A new central closed-loop ground-coupled geoexchange system will serve the entire school except for the multi-purpose addition. The approximate geo-field cooling capacity is 80-tons and is sized to provide full heating capacity of the original school building. The direct buried ground loop is made up of high-density polyethylene (HDPE) tubing. Lateral headers feeding 10 vertical loops are connect to main geo piping at underground header vaults. Each lateral header loop is provided with isolation valves at the header vaults. Reverse-return pipe configuration used to auto balance individual vertical loops. Refer to M1 for the geo-field configuration and 3/M5, 4/M5 for geo header vault and vertical well construction.

Vertical wells: 125 vertical wells, fully grouted, 320 feet deep, 20-foot spacing, 5-inch diameter bore with 1 inch HDPE pipe, target grout thermal conductivity of 1.0 Btu/(hr-ft-F). Refer to detail 4/M5.

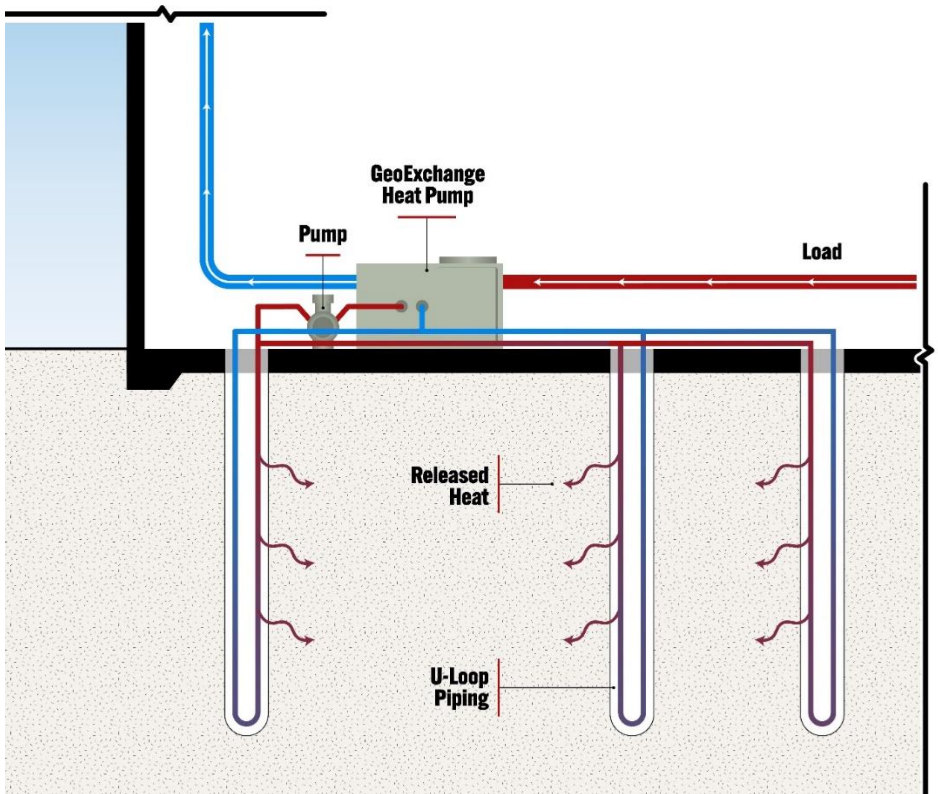


Figure 7: Closed loop, vertical well geo-field with centralized ground source heat pump

Performance Criteria

- Geo-Field to meet full heating demand with a 25% safety factor.
- Conduct a site well conductivity test and size capacity and configuration based on soil performance parameters.
- Maintain full heating capacity for 30 years with field thermal drift.
- Final configuration and well depth based on well conductivity test.

Building HVAC System

Centralized Ground Source Heat Pump (Base System)

All existing heating ventilators (HV-1 and HV-1), unit ventilators and unit heaters are replaced with new 2-pipe coils that retains the same equipment type and function as existing. Existing heating water piping, heating water pumps and valving is demolished. One existing boilers and pump remain for backup heating. Existing exhaust and supply air distribution ductwork to remain.

A 4-pipe 100-ton modular water-to-water geoexchange heat pump located in the existing mechanical room provides heating water or chilled water to a 2-pipe change over loop. The change-over loop is connected to new 2-pipe coil unit ventilators, unit heater and AHU's replacing like existing equipment. All new hydronic coils are sized for low heating water temperature of 120 deg F.

Change-over loop sized for a 12 deg F temperature difference. Pipping constructed with copper or schedule 40 black steel. Refer to floor plan drawings for pipe lengths. Refer to piping diagram for configuration. Total system flow: 250 gpm. Pumps with variable flow operation.

Geo field loop sized for a 10 deg F temperature difference. Indoor piping constructed with copper of schedule 40 black steel. Refer to floor plan drawings for pipe lengths. Refer to piping diagram for configuration. Geo field loop provided with auxiliary hydronic equipment including expansion tank, air separator, pot feeder. Total system flow: 300 gpm. Pumps with variable flow operation.

A new water-to-water domestic hot water ground source heat pump located in the mechanical room supplies all the domestic hot water for the school.

Design Note:
A ground source heat pump system with a 2-pipe change-over system is used in instead of a 6-pipe ground source heat pump system (4-pipe fan coil) capable of simultaneous heating/cooling and heat recovery for Russell Elementary for the following reasons:

- A 6-pipe system increases operation complexity and equipment sequencing failure.
- The building has a low simultaneous heating and cooling load for heat recovery that does not justify the added equipment cost.
- Unit ventilators and AHUs are equipped with full air-side economization that can provide cooling during change-over seasons when both heating and cooling is required.
- 6-pipe system installed cost for piping is significantly higher because it requires both a heating water and chilled water loop compared to just one building loop for a 2-pipe change-over system.

Performance Criteria

- Unit ventilators
    - 2-pipe change-over coil.
    - MERV 13 filters
    - ECM fans
    - Low sound equipment
    - Air-side economizers
    - CO2 demand control ventilation with outside air damper modulation.
- Hydronic coil sized for change-over 2-pipe operation for heating and cooling. Heating coil operation sized for 120 deg F supply temperature.
- Heating Ventilators (replacing HV-1 and HV-2)
    - 2-pipe change-over coil.
    - MERV 13 filters
    - ECM fans
    - Air-side economizers
- Centralized Ground Source Heat Pumps
    - 4-pipe, heating or cooling mode

- Low GWP refrigerant – R454B
- VFD compressor
- Modular configuration with scroll compressors

Major Equipment

Equipment Type	Manufacturer	Quantity	Capacity	Description
Unit Ventilator: 2-pipe coil (UV)	Trane -VUV 125	22	1250 cfm	2-pipe coil, floor mounted
Unit Ventilator: 2-pipe coil (UV)	Trane -VUV 075	12	750 cfm	2-pipe coil, floor mounted
Consule: (UH)	Trane -Unitrane	6	500 cfm	2-pipe coil, floor mounted
Indoor AHU (HV-1)	---	1	8000 cfm	2-pipe coil, indoor
Indoor AHU (HV-2)	---	1	4000 cfm	2-pipe coil, indoor
Base Mounted Pump	---	2	7.5 HP	Geo/Condenser water pump
Base Mounted Pump	---	2	5 HP	Primary building pump
Modular Ground Source HP	Climacool - UWTS50A (2)	1	100 ton	Two 50 ton banked modules
Domestic Hot Water Heat Pump	Aegis W - 250	1	199 MBH output	CO2 (R744) water source DHW heat pump

Table 3: Major equipment for cost estimation

Alternate #1 – Distributed Water Source Heat Pump

This alternate replaces the Centralized Ground Source Heat Pump (Base System).

Benefits:
- Simultaneous heating/cooling
- Condenser loop energy recovery
- Potential lower cost
- Simple operation
- Distributed compressor results in minimal impact with compressor failure compared to centralized heat pump system

Drawbacks:
- MERV 13 filtration is not available with water-source heat pump unit ventilators
- Potentially higher sound levels with compressor operation in unit ventilators.
- Higher maintenance with multiple compressors

The building side systems connected to the geo-field system consists of geo/condenser water loop sized for a 10 deg F temperature difference. Indoor pipping constructed with copper or schedule 40 black steel. Refer to floor plan drawings for pipe lengths. Refer to piping diagram for configuration. Geo/condenser water loop provided with auxiliary hydronic equipment including expansion tank, air separator, pot feeder. Total system flow 300 gpm. Pumps with variable flow operation.

Performance Criteria

- Unit Ventilators
    - Water-Source Heat Pumps
    - ECM Fans
    - Low-Sound Equipment
    - Air-Side Economizers
    - CO2 demand control ventilation with outside air damper modulation.
- Heating Ventilators (replacing HV-1 and HV-2)
    - Water-Source Heat Pumps
    - 2-Pipe Change-Over Coil.
    - MERV 13 Filters
    - ECM Fans
    - Air-Side Economizers

Major Equipment

Equipment Type	Manufacturer	Quantity	Capacity	Description
Unit Ventilator: WSHP (UV)	Daikin - GRQ 040	22	1250 cfm	Water-source HP inverter compressor, floor mounted
Unit Ventilator: WSHP (UV)	Daikin - GRQ 024	12	750 cfm	Water-source HP inverter compressor, floor mounted
Consule: WSHP (UH)	Daikin - Infinity Consule	6	500 cfm	Water-source HP inverter compressor, floor mounted
Indoor AHU - WSHP (HV-1)	Daikin - Infinity LVW	1	20 tons	Water-source HP, Vertical, Indoor
Indoor AHU - WSHP (HV-2)	Daikin - Infinity LVW	1	10 tons	Vertical, Indoor
Base Mounted Pump	---	2	7.5 HP	Geo/Condenser water pump
Domestic Hot Water Heat Pump	Aegis W - 250	1	199 MBH output	CO2 (R744) water-source DHW heat pump

Table 3: Alternate #1 - Major equipment for cost estimation

Air-to-Air Energy Recovery Ventilators (ER)

Energy recovery ventilators serve the north and south classrooms. Units are provided with high sensible and latent efficiency so that post energy recovery heat is not required. Ventilators are sized to provide 2/3 of the required ventilation rate in the classrooms. Unit ventilator with demand control ventilation will open normally closed outside air damper when space CO2 concentration exceeds an upper limit. Refer to M4 for configuration and equipment criteria.

Performance Criteria

- Energy Recover Ventilators
  - Post energy recovery core electric heat
  - ECM Fans
  - Energy core with sensible efficiency above 80%

Cost Estimates

Cost estimation for building HVAC system should utilize the provided design narrative, equipment list and concept drawings. Two options are presented for the building HVAC system. The base system with central ground source heat pump is the recommended base option. Alternate #1 – Distributed Water Source Heat Pump is provided for alternative pricing comparison. The air-to-air energy recovery system is independent of the building base system and alternate and can be added to either option.

Geo-Field:

- (100) 320 ft vertical well: $960,000
- Lateral header piping: $110,000
- (1) Header vault: $80,000
- Total Cost: $1,150,000

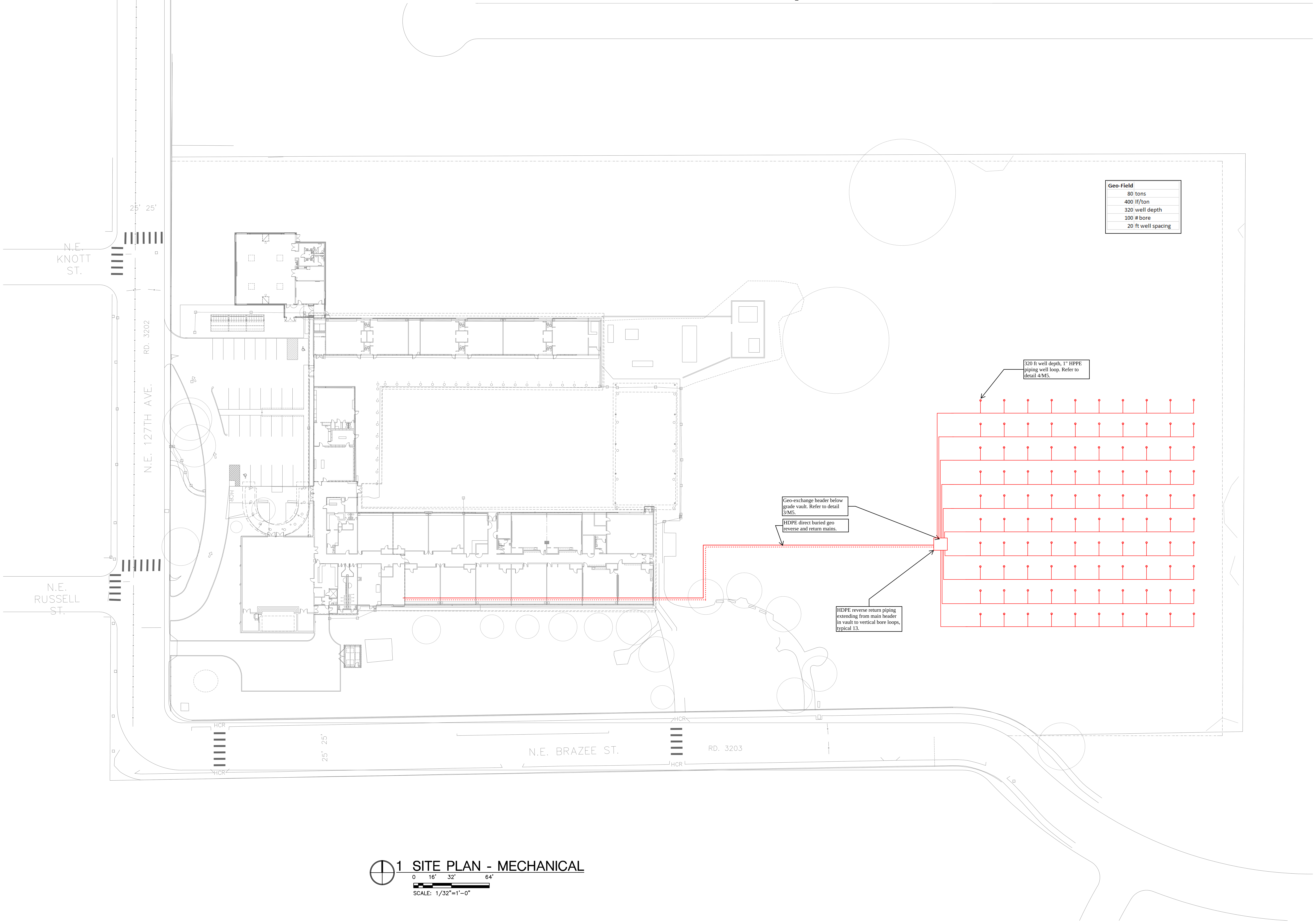
Geo-Field cost estimates are based on previous project cost averages and are not intended to be used for final budgetary purposes. A cost estimate from a geoexchange contractor is recommended.

The cost for the geo-field is highly influenced by the required heating capacity for the geo-field and the ground thermal properties. Ground thermal properties derived from a well conductivity test nor peak heating loads were available for capacity sizing. For this study the block heating load was estimated based on the existing heating water plant capacity and the building size and compared with the estimated block cooling load. The geo-field sizing was based on lower performance ground properties with the intention to reflect the higher range of required geo-field size. With additional analysis and test data the geo-field sizing and configuration can be further refined with the potential to reduce overall size. Additional geo-field analysis is required for construction level design as follows:

- Heating and cooling load analysis through metered data or modeled load analysis.
- Well conductivity test.
- Geo-field performance simulation with measured ground properties and building load data.

Appendix A – Concept Drawings

Vertical Well, Closed Loop Geo-Field



Geo-Field	
80	tons
400	lf/ton
320	well depth
100	# bore
20	ft well spacing

1 SITE PLAN - MECHANICAL

0 16' 32' 64'

SCALE: 1/32"=1'-0"

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100 SW Main Street, Suite 1600
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TEL 503.382.2266
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SHEET TITLE

SITE PLAN - MECHANICAL

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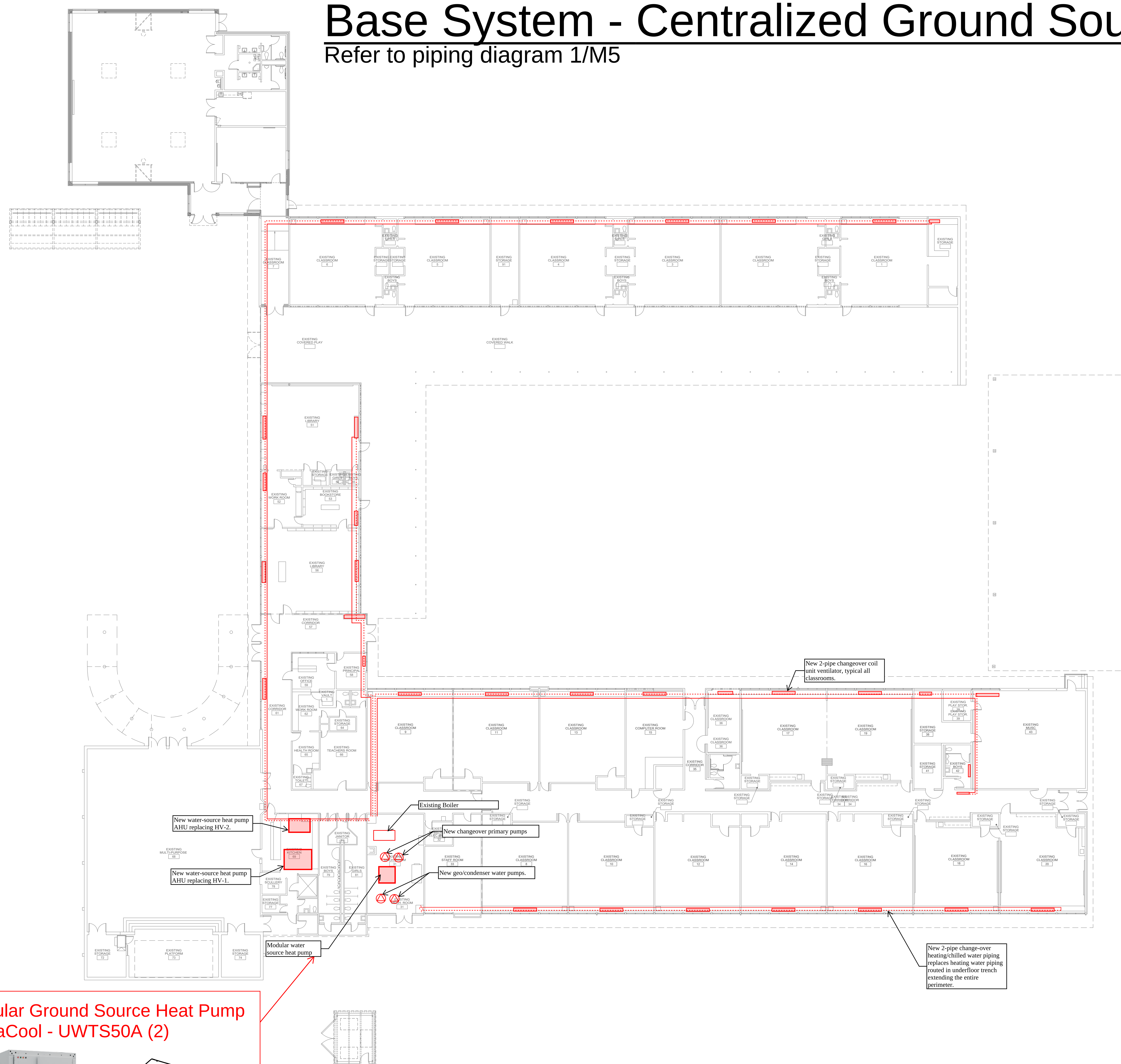
DATE

SHEET NUMBER

M1

Base System - Centralized Ground Source Heat Pump

Refer to piping diagram 1/M5

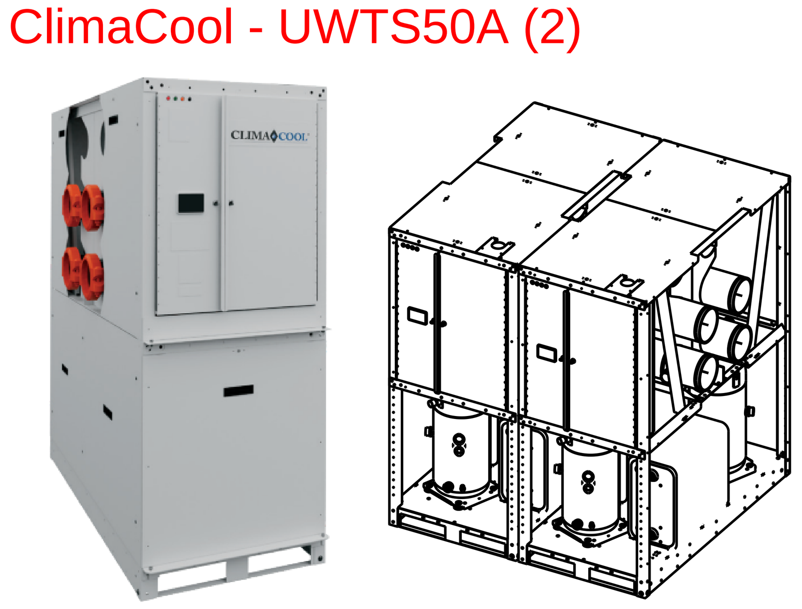


1 OVERALL PLAN - MECHANICAL

0 8' 16' 32'

SCALE: 1/16"=1'-0"

Modular Ground Source Heat Pump
ClimaCool - UWTS50A (2)



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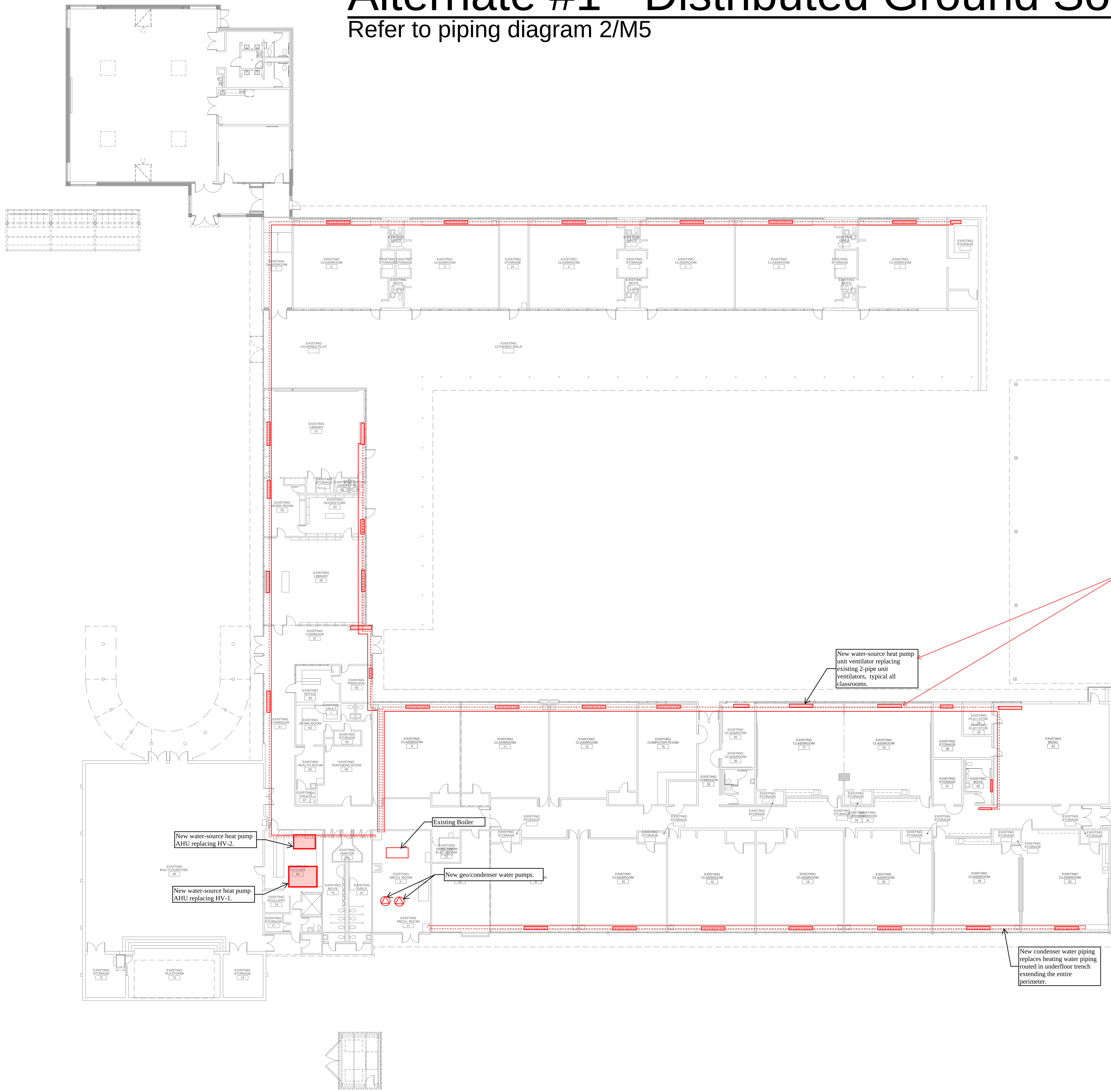
M2

Alternate #1 - Distributed Ground Source Heat Pump

Refer to piping diagram 2/M5



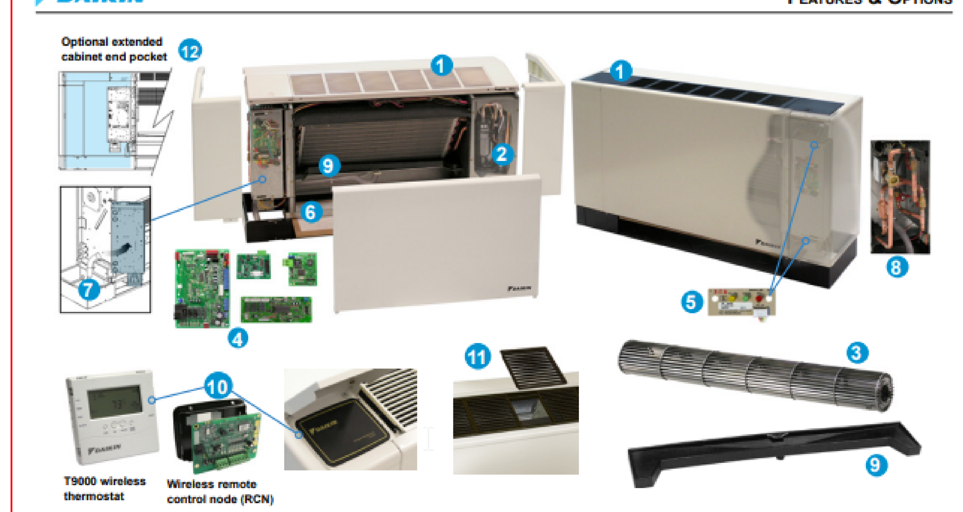
1 OVERALL PLAN - MECHANICAL

0 8' 16' 32'

SCALE: 1/16"=1'-0"

Unit Ventilator Water Source Heat Pump

DAIKIN — FEATURES & OPTIONS



1. **Cabinets**
   - Design flexibility with slope top or flat top configurations and directional grille options
   - Service accessible with removable top, front, and end panels
2. **Compressor**
   - Increased energy savings using high efficiency rotary design
   - Zero ozone depleting R-410A refrigerant with no phase-out date
3. **Gentleflo™ fan**
   - High efficiency and quiet multi-speed tangential fan system
4. **MicroTech® III unit controller**
   - Streamlined network controls using LonWorks® or BACnet® communication modules
   - I/O expansion module for electric heat and multiple fan speeds
5. **LED status lights**
   - Easy diagnosis and troubleshooting of fault condition indicators
6. **Filter**
   - Easily accessible and serviceable 1/2" standard disposable filter
7. **Hinged control box**
   - Increases service access to plumbing end compartment for fast installation and maintenance
8. **2-way motorized valve packages (optional)**
   - Factory-installed or field-installed choice for variable pumping applications.
   - Reduced operating costs with two-way isolation valves
9. **Double-sloped drain pan**
   - Easily removable and cleanable, non-corrosive polymer design promotes maintenance and superior Indoor Air Quality (IAQ)
10. **T9000 wireless temperature controller (option)**
    - Precise temperature control without installation and wiring expenses
    - Factory-installed or field-installed choice for 24V thermostat controlled units

Remote control node (RCN)
- Easy integration with unit and temperature controls

11. **Multi-directional grilles (option)**
    - Discharge air directional control using rotatable grilles
12. **High sill extended end pocket (option)**
    - Increases service access 11" for piping or field-installed pump

Outside air dampers (option - not shown)
- Increased ventilation air control - motorized or manual operation

7" high sub base (option - not shown)
- Increases piping arrangement flexibility

2", 4", 6" cabinet rear extension (option - not shown)
- Extends space behind unit for piping (high sill units only)

Expanded paint colors – for any decor.

Cupola White | Off White | Putty Beige | Soft Gray | Antique Ivory | Oxford Brown (Discharge Grille & Subbase)

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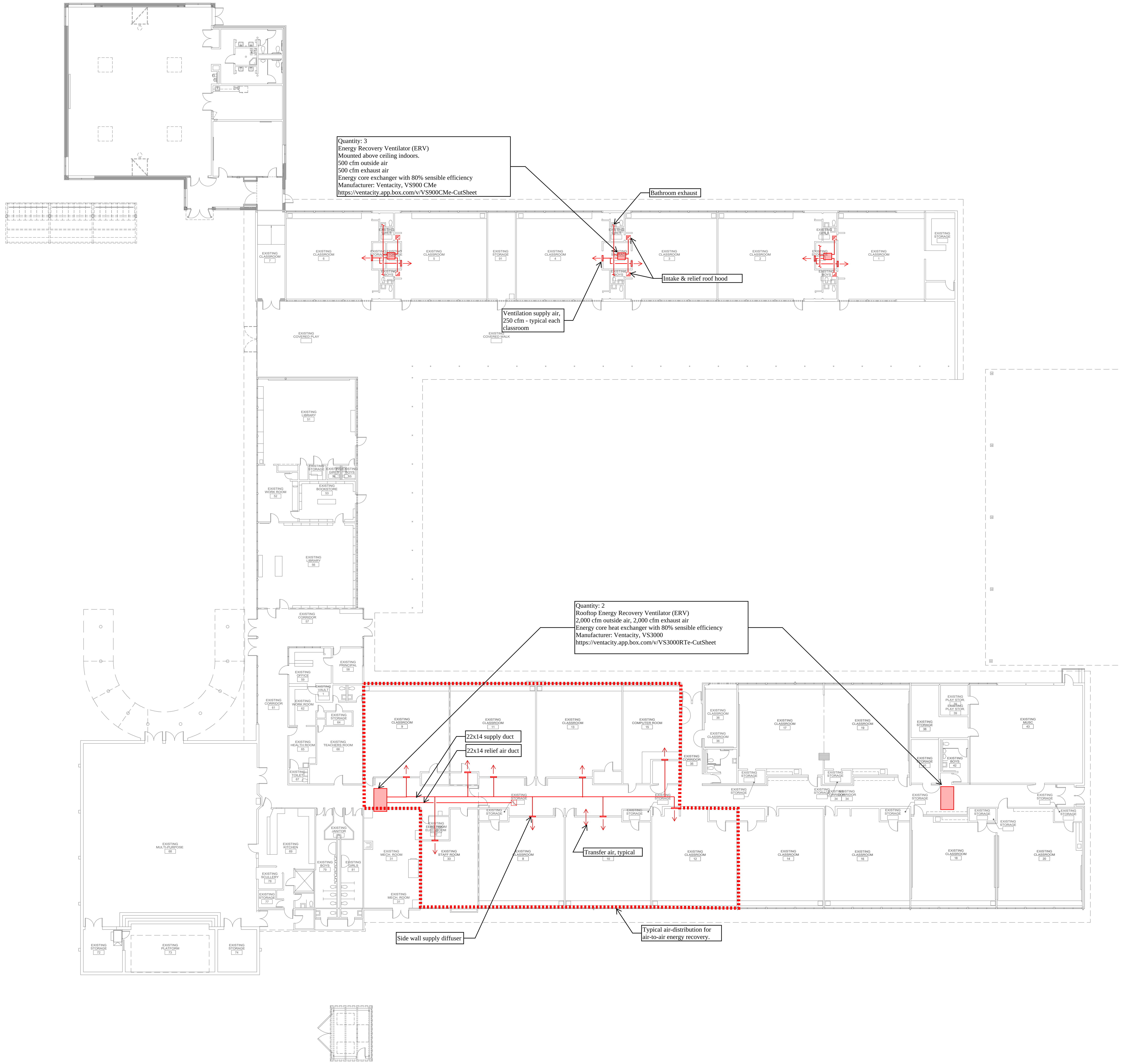
M3

Air-to-Air Energy Recovery (ER)



1 OVERALL PLAN - MECHANICAL

0 8' 16' 32'

SCALE: 1/16"=1'-0"

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OVERALL PLAN - MECHANICAL

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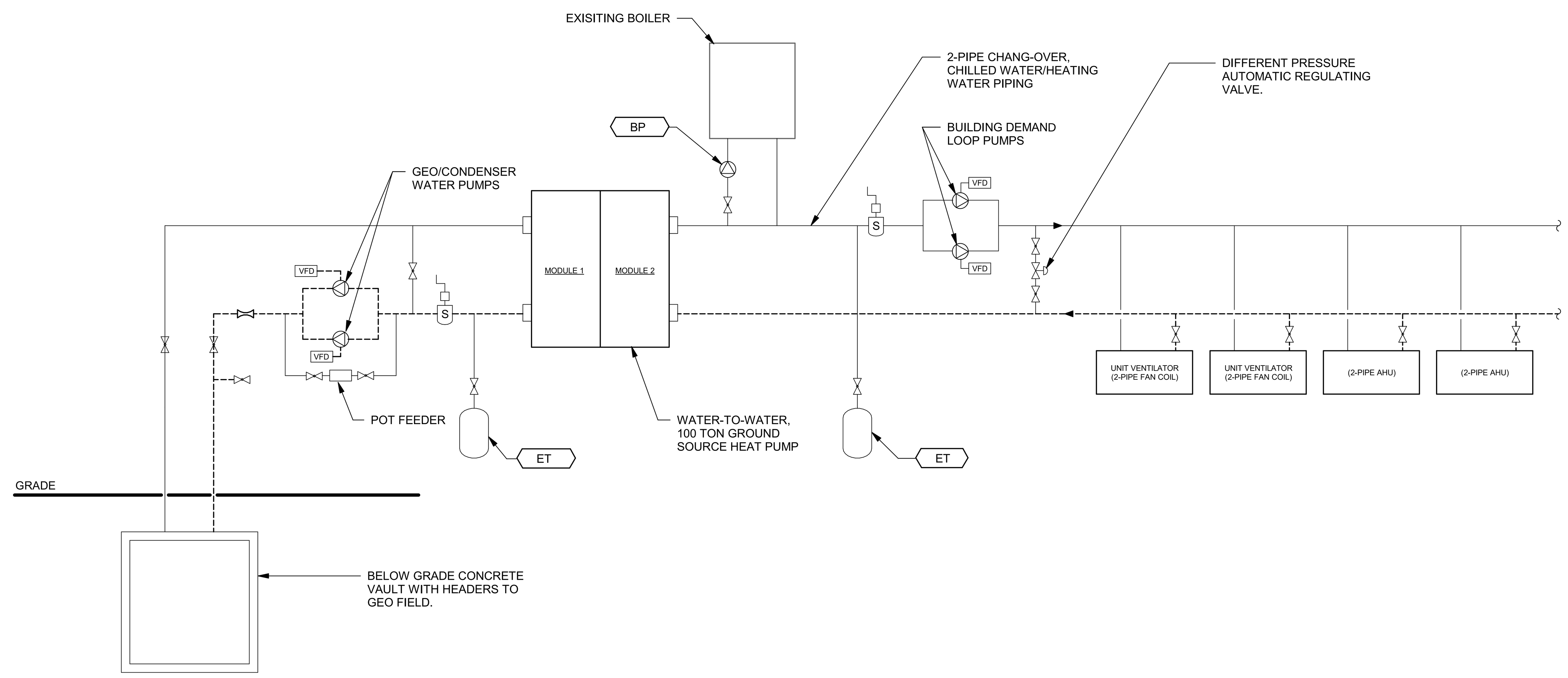
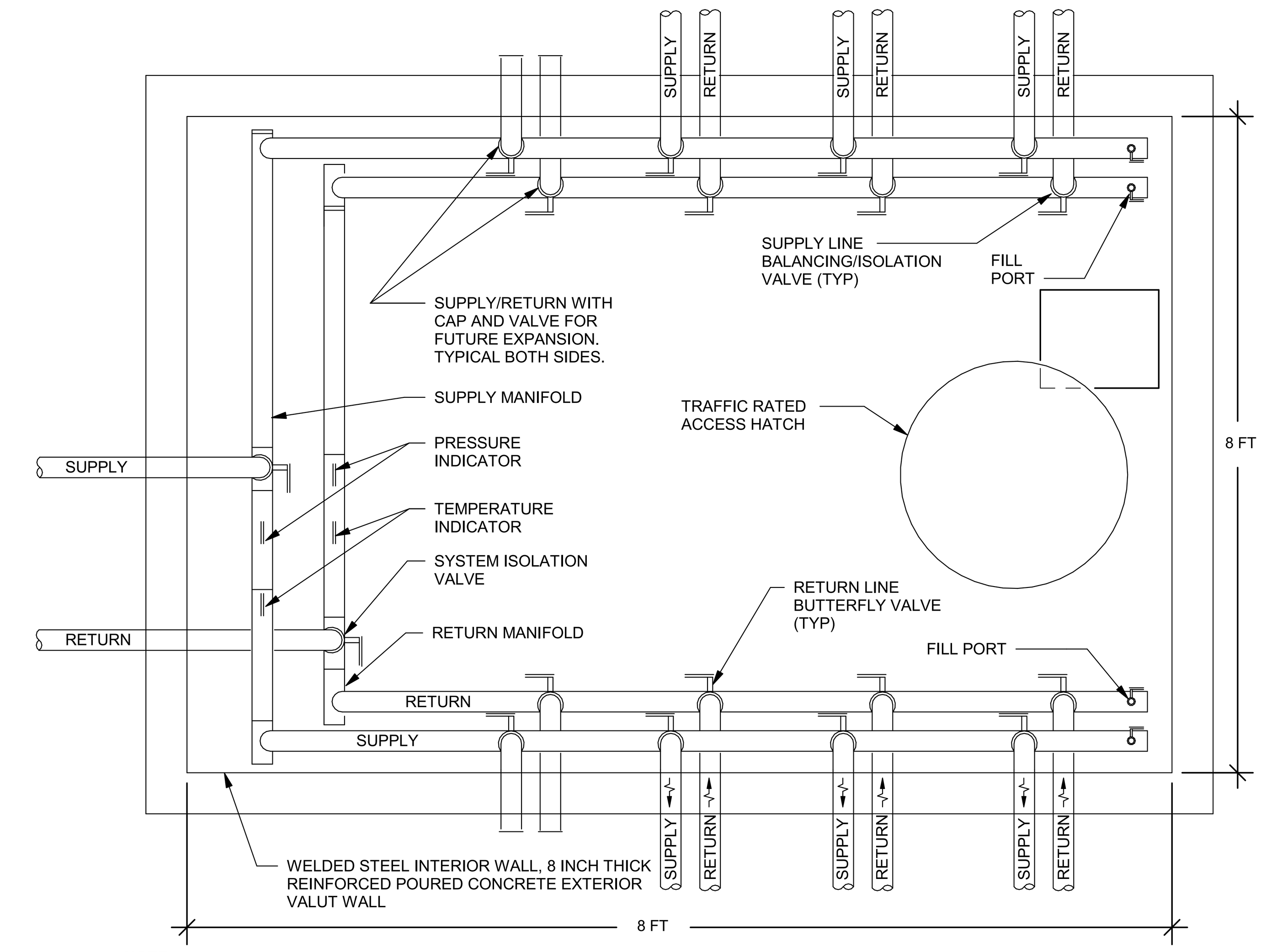
M4

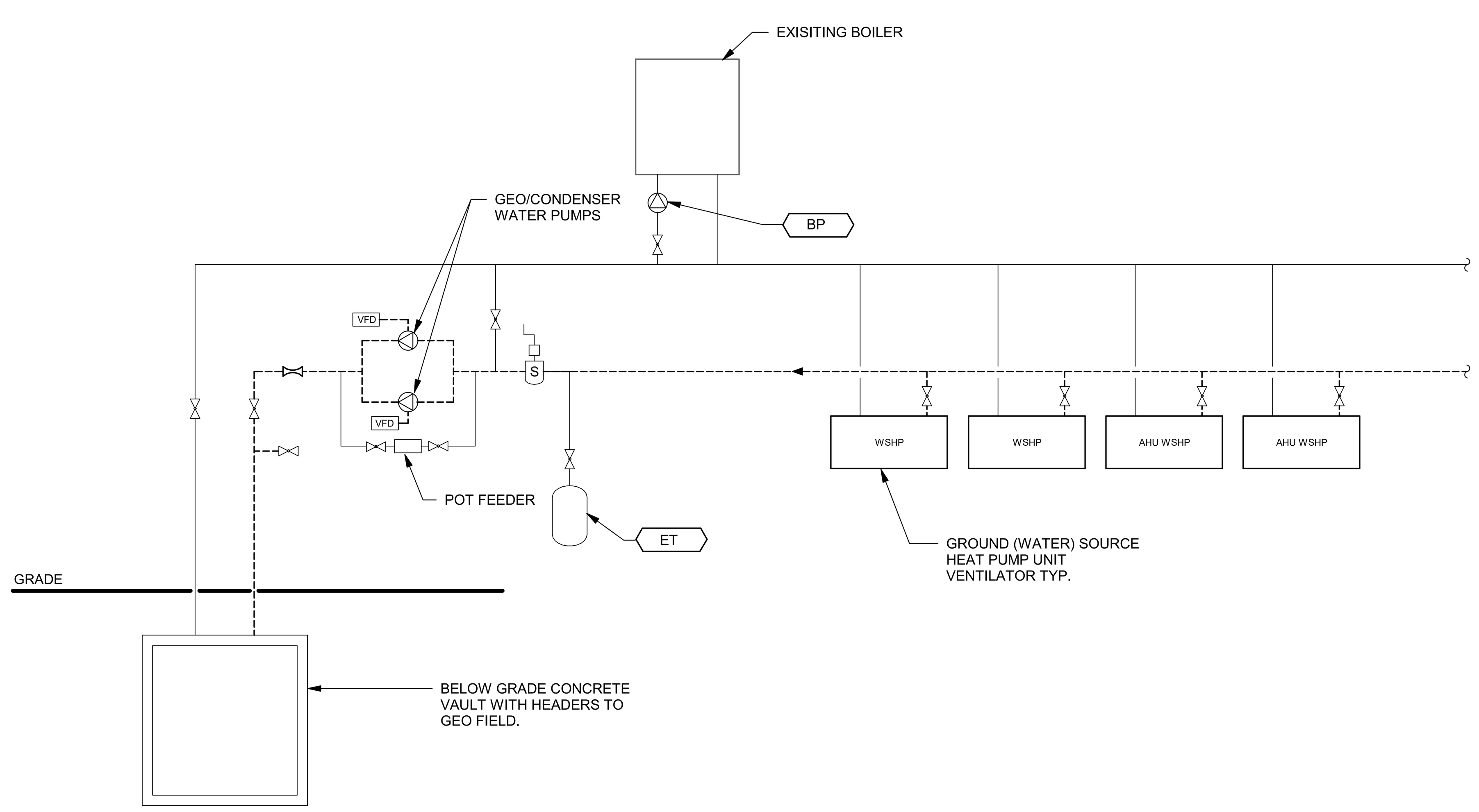


1 BASE SYSTEM: CENTRALIZED GROUND SOURCE HEAT PUMP SYSTEM
NO SCALE

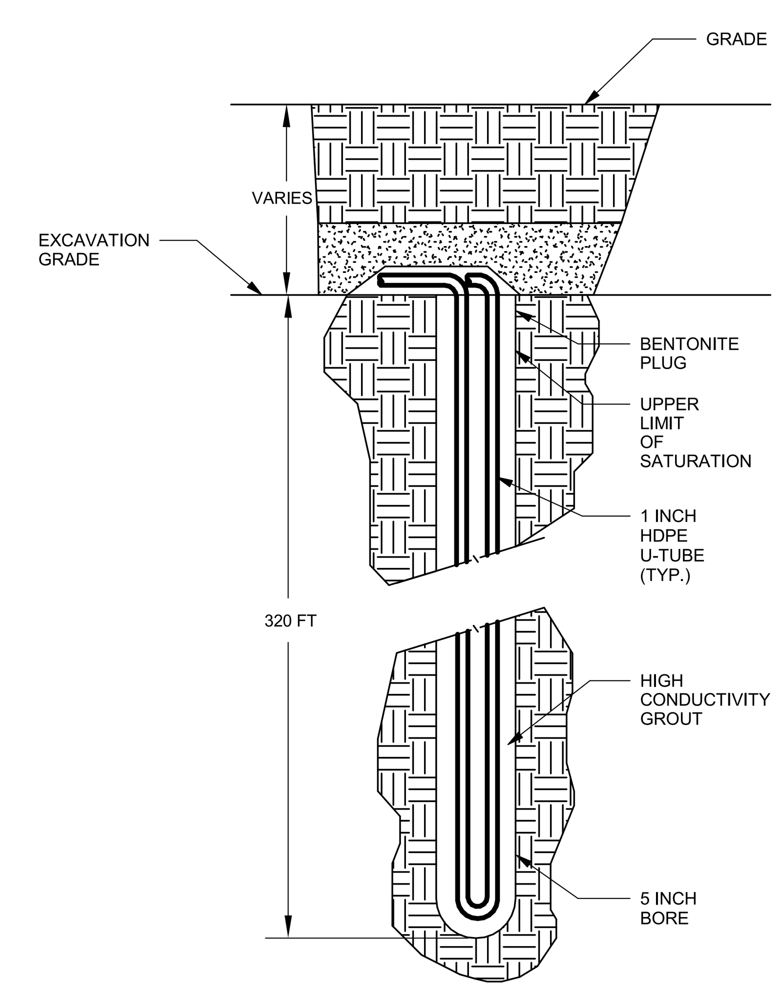


NOTE:
ALL PIPE PENETRATIONS THROUGH VAULT WALLS SHALL BE SEALED WATER TIGHT WITH A LINK SEAL TYPE MECHANICAL SEAL.

3 GEO-THERMAL HEADER VAULT
NO SCALE



2 ALTERNATE #1: DISTRIBUTED GROUND SOURCE HEAT PUMP SYSTEM
NO SCALE



4 GROUND LOOP BORE SECTION
NO SCALE

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SHEET TITLE
DETAILS - MECHANICAL

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DATE
SHEET NUMBER
M5

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Parkrose - Shaver ES Geoexchange Study

Parkrose SD Shaver ES Geoexchange Study
2024-1214

Prepared for:

Parkrose School District

January 31, 2025

Prepared by:

Shem Heiple, PE, LEED AP
Blake Reynolds, PE

Table of Contents

Executive Summary

Introduction

Shaver Elementary School was used to expand upon an earlier case study as one of nine existing schools in the Parkrose School District with plans to upgrade to a geoexchange ground source heat pump system that will profoundly reduce the district building's energy use and carbon emissions and move from fossil fuel heating to predominantly all electric buildings. The purpose of this study was to assess the school for geoexchange / ground source heat pump system upgrades. The study

- Assess energy and carbon emissions savings potential with geoexchange upgrades.
- Identify additional cost-effective energy efficiency measures.
- Assess existing building for geoexchange upgrade feasibility.
- Provide recommended geoexchange system configuration.
- Design narrative and concept drawings for cost estimation.
- Assess site area requirements for geo-field system.

Summary

Performance

The school's current energy usage based on utility bills is 52 (kbtu/h/sf/yr) EUI, which is comparable to the national average school EUI of 47 (kbtu/h/sf/yr). Sixty-four percent of the energy use is fossil fuel (natural gas) with the remainder being electricity.

By upgrading to a geoexchange system, the building's heating and domestic hot water system is converted to all electric heat pump technology with consistent high operating efficiencies near 4 COP. By including air-to-air energy recovery and demand control ventilation in addition to the geoexchange upgrade the following is achieved:

- **53%** total building energy reduction
- **25 EUI** (kbtu/h/sf/yr)
- **26%** total building carbon emissions reduction
- All-electric heating
- Possible to reach net zero energy and emission with roof mounted PV array

Other benefits with the geoexchange and HVAC upgrades:

- Improved **indoor air quality** is achieved with the addition of MERV 13 filters at room level fan coil units and demand control ventilation.
- Improved **thermal comfort** is achieved by adding mechanical cooling to the existing building.
- **Education** is improved by reducing school closure with geoexchange system cooling that can maintain occupant comfort in extreme heat climate events.

- **Climate change resiliency** is improved with ground coupled cooling that is resistant to high air temperature events compared to air-source cooling systems.

Recommendations

District Level

- Vertical well, closed loop geo-field system is recommended for district level implementation and for initial budgeting.
- Horizontal well (bore) configuration that is less common may also be considered in lieu of a vertical well configuration but may require more site area than what is available for all schools. Additionally, horizontal drilling contractor availability could be limited.
- Building HVAC ground source heat pump system type: optimal system type must be assessed for each school. Either centralize or distributed depending on building condition and configuration. Larger schools should consider 6-pipe central ground source heat pump with heat recovery.
- Ground source domestic hot water heat pumps.
- Provide conductivity test bore at each school for geo-field sizing.

Shaver Elementary

- Centralized ground source heat pump system with a 2-pipe changeover system.
- New hydronic 2-pipe changeover fan coils with MERV13 filters serving most of the building including classrooms.
- New fan coil units provided with demand control ventilation and air-side economization.
- Centralized Air-to-air energy recovery (ER) unit sized to provide additional air side economization.
- Utilize existing below slab air tunnels for centralized relief and ventilation air distribution.
- Net-Zero Energy can be achieved with a 20,000 sf, 327 kW roof mounted PV array.

Performance

Based on the natural gas and electricity utility bills from 2022 through 2023, the existing school has an EUI of 52 (kbtu/h/sf/year) which is above the national median EUI of 48.5 for existing K-12 schools. Over 64% of the building's energy is natural gas that is primarily associated with building heating.

The school was assessed for cost effective building energy and carbon emission reduction strategies beyond the geoexchange upgrade including envelope, lighting and HVAC system measures. Of the available energy measures, demand control ventilation (DCV) and air-to-air energy recovery (ER) had the highest potential for energy cost effectiveness. Fan energy savings is achieved by upgrading from a centralized air distribution system to dedicated outside air/decentralized air distribution system with hydronic energy transport.

By upgrading the natural gas boiler and domestic hot water systems to ground source heat pumps, 49% energy reduction can be achieved. This is done by utilizing all electric geo heat pump technology that operates at efficiencies consistently above a 4 COP compared to the existing natural gas boiler efficiencies that operate at 85%-90% thermal efficiency. The geoexchange upgrade shifts from natural gas fossil fuel use to all electric. However, natural gas equivalent carbon emissions at 399 lb/MWh is less than PGE electricity equivalent carbon emissions of 759 lb/MWh and the resulting total building carbon emissions reduction potential is 26%.

Mechanical cooling will be available with the geoexchange upgrade. Additional cooling energy will be small with ground source heat pump cooling efficiency and will be offset by improved building HVAC systems such as EC fan motors replacing older constant volume unit ventilator fans.

Dedicated Outside Air with Hydronic Energy Distribution (fan energy reduction)

The school's centralized variable air volume (VAV) dual duct air distribution system provides the heating and free cooling. A new dedicated outside air system will replace the centralized dual duct system that will be sized for ventilation and free cooling supply air that will decrease the central building airflow and fan energy by 60%. Fan coils with EC motors will provide low fan energy air delivery at the space.

Demand Control Ventilation (DCV)

The building's dual duct VAV system will be replaced with a new dedicated outdoor air unit and fan coil units at the space level that will be capable of modulating the outside air ventilation rates based on space CO_2 levels. DCV will ensure ventilation requirements are provided while reducing outside air rates by 20% - 40% resulting in significant heating energy reduction. DCV could provide 5% additional energy reduction with the geoexchange upgrade.

Air-to-Air Energy Recovery (ER)

Increased ventilation rates for high occupant density classrooms results in high preheat outside air heating energy. Air-to-air energy recovers energy from the exhaust air stream to reduce the preheat energy by up to 80%. However, with extremely high geo system heating efficiency and ventilation air reduction through demand control ventilation, the cost savings is slightly lower than a standard efficiency heating building with an annual energy cost savings of less than $1,000 a year and a 3% annual energy reduction. By adding air-to-air energy recovery, the required geoexchange capacity is reduced by approximately 20%.

Renewables for Net-Zero Energy & Carbon Emission (PV)

The school's EUI can be reduced from 52 to 25 with geoexchange systems and minor demand control ventilation upgrades. With this dramatic reduction in energy use the building is within reach of net-zero energy and emissions through renewable systems. With the school being a single-story building, the school has approximately 40,000 sf of roof area for a roof mounted PV array. Approximately 20,000 sf of PV array panel area is needed to offset 100% of the building energy.

Project Name	**Shaver ES - NZE**
Building Square Footage	49,585
Solar PV System Cost ($/W)	3.0
Basis of Design PV Module	SPR-X21-470-COM
PV Module Wattage	470
Energy Production per Module (kWh/yr)	517
Module Area (sq. ft.)	23.3
Quantity	697
Solar PV Array Size (kW)	327
Min. Roof Area (sq. ft.)	16,235
Spacing Factor (1.2) (sq. ft.)	19,481
Total Energy Production (kWh/yr)	360,226
Estimated Cost	$982,435

Figure 1: PV sizing for net-zero energy

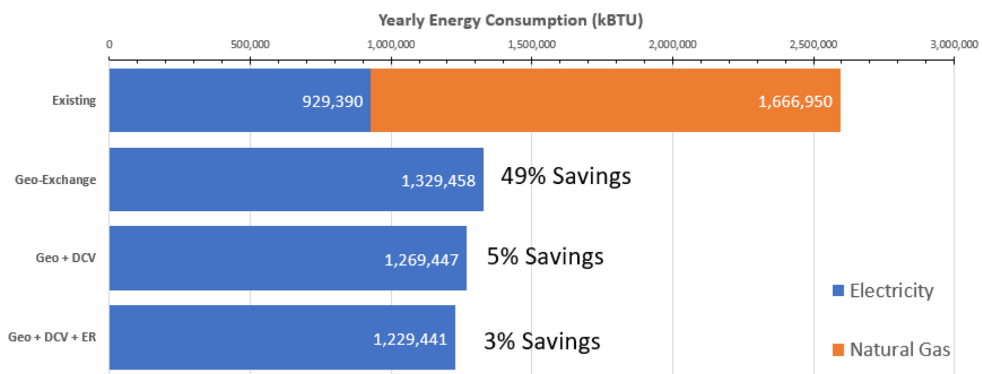


Figure 2: Energy Savings

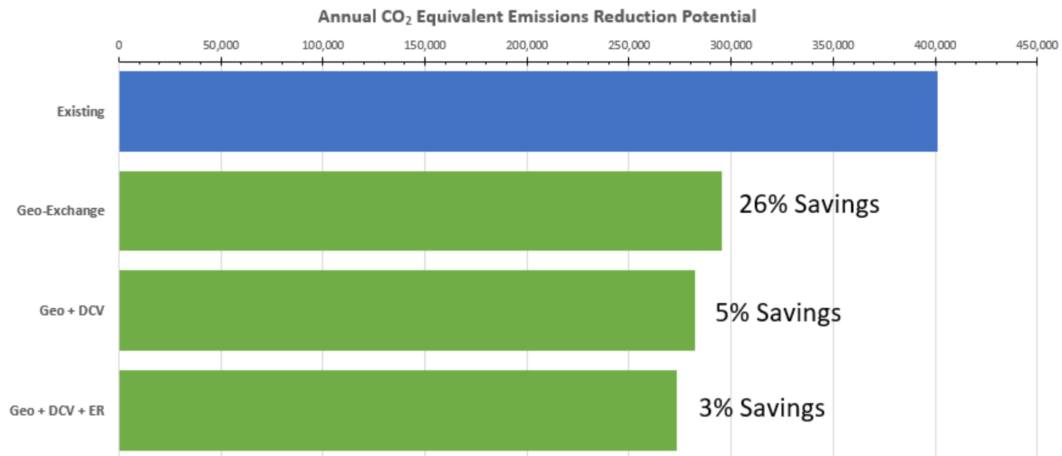


Figure 3: Emissions Reduction

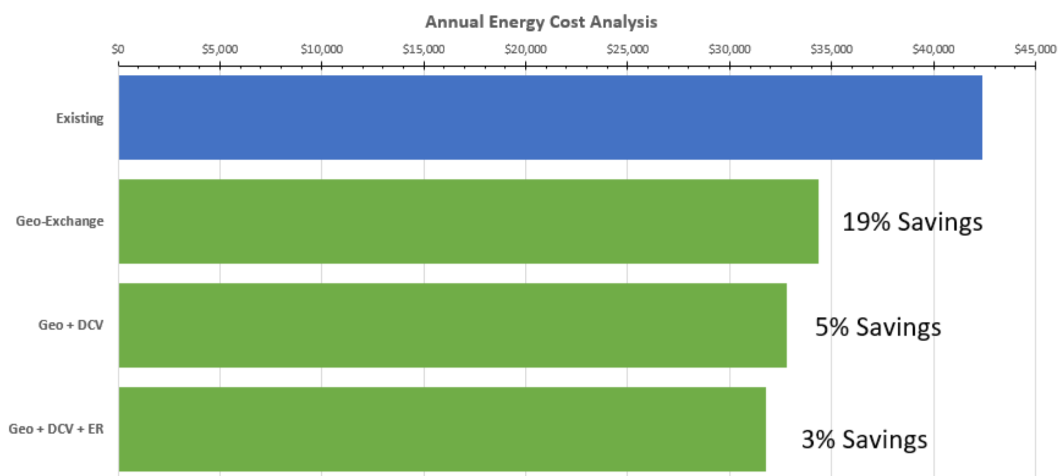


Figure 4: Energy Cost Savings

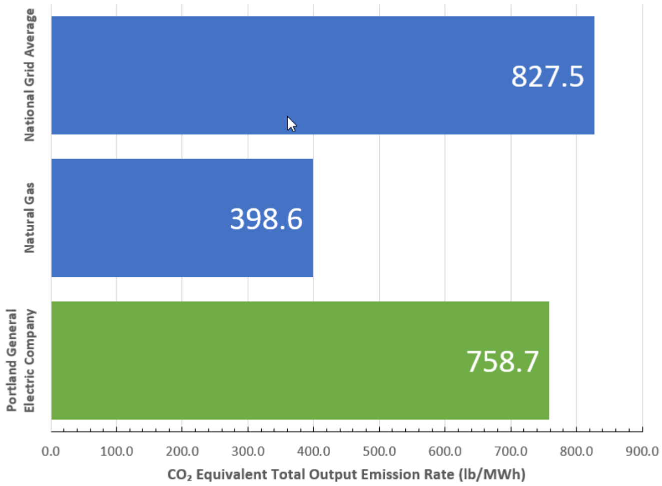


Figure 5: CO2 equivalent emission rate by fuel consumption

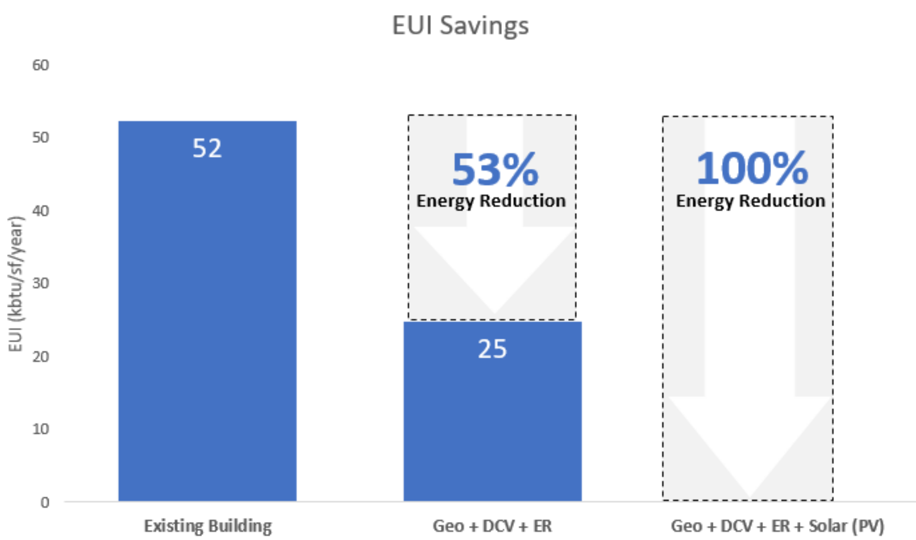


Figure 6: Proposed EUI reduction

Month	Electric Use (kWh) @ 0.0882 $/kWh			NG Use (therms) @ 1.10 $/therm		
	2022	2023	2-year Average[1,3]	2022	2023	2-year Average
January	26,118	29,940	28,029	3,086	2,249	2,668
February	26,968	25,160	26,064	2,591	2,323	2,457
March	23,868	23,380	23,624	2,432	1,633	2,033
April	25,808	23,960	24,884	2,057	714	1,386
May	23,858	21,000	22,429	585	283	434
June	20,538	19,080	19,809	163	90	127
July	17,248	16,980	17,114	44	38	41
August	18,578	14,760	16,669	75	102	89
September	22,588	21,300	21,944	131	218	175
October	23,788	18,600	21,194	2,341	1,370	1,856
November	29,368	21,240	25,304	2,782	1,901	2,342
December	29,949	20,700	25,325	3,154	2,985	3,070
Annual Energy Usage						
Annual Energy Usage	288,677	256,100	272,389	19,441	13,906	16,674
Annual Energy Usage (kBtu)	984,966	873,813	929,390	1,943,633	1,390,266	1,666,950
Total Energy Cost[1] ($)	$25,461	$22,588	$24,025	$21,385	$15,297	$18,341
Energy Performance of the Facility						
Total Building Area			**49,585**			
Total Energy Use (kBtu per year, based on 2-year Average)			**2,596,339**			
Energy Use Intensity, EUI (kBtu/sqft/year)			**52**			
Median EUI for Facility Type in the US[2]			48.5			

1. Using industry average values of $0.0882/kWh and $1.10/therm.
2. Please refer to this link to obtain the Median EUI for various facility types - https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/what-eui

Table 1: Historical Energy Use

Existing Condition

Shaver Elementary School was built in 1963 and consists of 1-level buildings with a total building area of 44,000 square feet. Most of the original mechanical equipment is from the original construction. A mechanical improvement project occurred in 2014 that included admin area new cooling systems, multi-purpose room expansion, boiler replacement and existing equipment and controls refurbishment. The school is served by a built-up central dual duct variable air volume system. Heating air and ventilation air is distributed via below grade air tunnels that feed into dual duct terminal units. Condensing boilers installed in 2014 provide the heating for the centralized air-handling unit. The multi-purpose addition cooling and heating is provided by an air-to-water source heat pump connected to a hydronic heated and cooled radiant slab.

There is no active mechanical cooling at the school except at the new multi-purpose and administration areas. Free cooling (air-side economization) is provided by the centralized dual duct system for the remainder of the building.

All original windows were replaced with enhanced energy performance window systems. The envelope insulation appears to be of the original build in 1963. Wall and roof insulation is likely well below current energy code standards. Low insulation levels correlate to the relatively high heating energy that is over 50% of the building’s energy use.

Design

Geo-Field System

A new central closed-loop ground-coupled geoexchange system will serve the entire school including the multi-purpose addition. The approximate geo-field cooling capacity is 99-tons and is sized to provide full heating capacity of the original school building. The direct buried ground loop is made up of high-density polyethylene (HDPE) tubing. Lateral headers feeding 12-13 vertical loops are connect to main geo piping at an underground header vault. Each lateral header loop is provided with isolation valves at the header vaults. Reverse-return pipe configuration used to auto balance individual vertical loops. Refer to M1 for the geo-field configuration and 3/M5, 4/M5 for geo header vault and vertical well construction.

Vertical wells: 125 vertical wells, fully grouted, 320 feet deep, 20-foot spacing, 5-inch diameter bore with 1 inch HDPE pipe, target grout thermal conductivity of 1.0 Btu/(hr-ft-F). Refer to detail 4/M5.

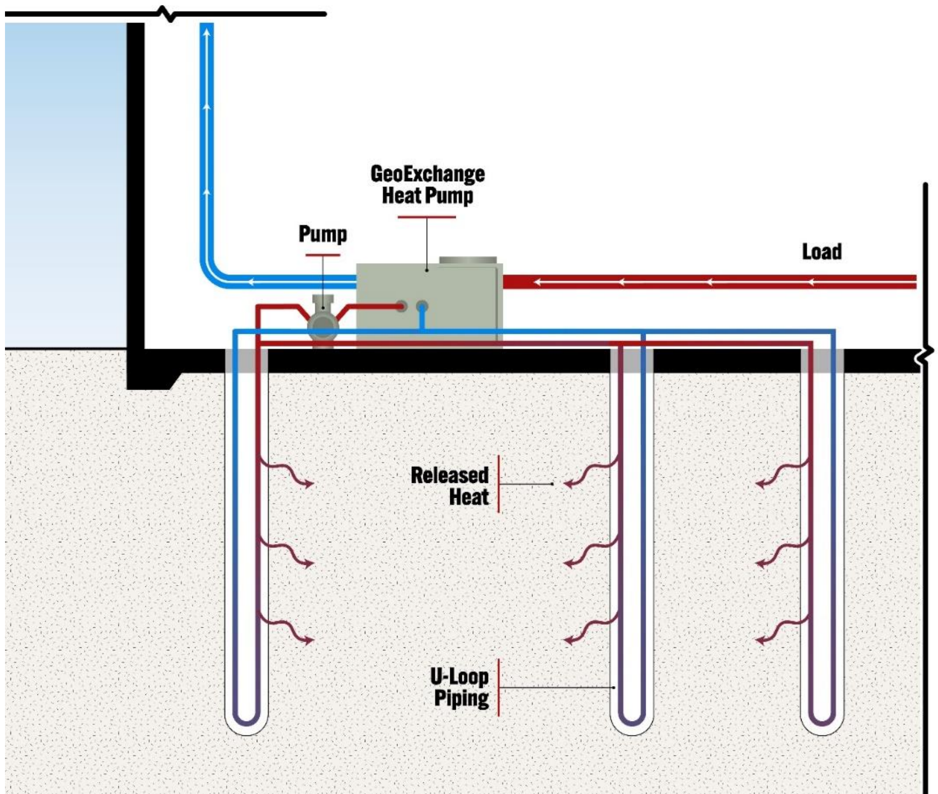


Figure 7: Closed loop, vertical well geo-field with centralized ground source heat pump

Performance Criteria

- Geo-Field to meet full heating demand with a 25% safety factor.
- Conduct a site well conductivity test and size capacity and configuration based on soil performance parameters.
- Maintain full heating capacity for 30 years with field thermal drift.
- Final configuration and well depth based on well conductivity test.

Building HVAC System

Centralized Ground Source Heat Pump (Base System)

The existing centralized dual duct system is replaced with a new centralized dedicated outdoor air unit with air-to-air energy recovery and a 2-pipe changeover loop that serves space level fan coil units. Existing boilers and pumps remain for backup heating. Air distribution ductwork downstream of the existing dual duct terminal unit remain and are reconnected to new mechanical equipment. Existing exhaust ductwork to remain.

A 4-pipe 100-ton modular water-to-water geoexchange heat pump located in the existing mechanical room provides heating water or chilled water to a 2-pipe changeover loop. The changeover loop is connected to new 2-pipe fan coil units, a new rooftop unit serving the cafeteria and the multi-purpose area radiant slab system. Fan coil units replace dual duct terminal units and will typically match the same design airflow allowing the existing downstream ductwork to be utilized. All new hydronic coils are sized for low heating water temperature of 120 deg F.

The existing system utilizes underfloor air tunnels for distributing heating air (ducted) and unducted ventilation air. The existing return air tunnel will be repurposed for centralized unducted relief air, fan coil locations (replace existing dual duct terminal units) and localized fan-coil unit return air. The existing heating duct will be demolished. The existing ventilation air duct tunnel will be utilized for the same purpose as the existing equipment - ventilation air and free cooling air. The relief and ventilation air tunnels will not require additional main ductwork back to the central outside air unit. The 2-pipe changeover loop piping will be routed throughout the building through the ventilation air tunnel.

Air side economizer cooling will be required to maintain space temperature set points during the heating-to-cooling changeover periods (shoulder season) when heating is required from the ground source heat pump with simultaneous space cooling loads. The dedicated air handler unit will be sized to provide increased outside air rates for full economizer mode. Fan coil units will be equipped with an economizer mixing box to modulate outside air for free cooling. Additional economizer air will be introduced from the roof for fan coil units located in the ceiling space or on the roof.

The changeover loop is sized for a 12 deg F temperature difference. Piping is constructed with copper or schedule 40 black steel. Refer to floor plan drawings for pipe lengths. Refer to piping diagram for configuration. Total system flow: 260 gpm. Pumps with variable flow operation.

Geo field loop is sized for a 10 deg F temperature difference. Indoor piping is constructed with copper of schedule 40 black steel. Refer to floor plan drawings for pipe lengths. Refer to piping diagram for configuration. Geo field loop provided with auxiliary hydronic equipment including expansion tank, air separator, pot feeder. Total System Flow: 320 gpm. Pumps with variable flow operation.

A new water-to-water domestic hot water ground source heat pump located in the mechanical room supplies all the domestic hot water for the school.

Design Note:
A ground source heat pump system with a 2-pipe changeover system is used in instead of a 6-pipe ground source heat pump system (4-pipe fan coil) capable of simultaneous heating/cooling and heat recovery for Shaver Elementary for the following reasons:

- A 6-pipe system increases operation complexity and equipment sequencing failure.
- The building has a low simultaneous heating and cooling load for heat recovery that does not justify the added equipment cost.
- Full airside economization required for 2-pipe changeover system is capable through the existing air tunnel.

- The 6-pipe system's installed cost for piping is significantly higher because it requires both a heating water and chilled water loop compared to just one building's loop for a 2-pipe changeover system.

Performance Criteria

- Fan Coil Units
    - 2-pipe changeover coil.
    - MERV 13 filters
    - ECM fans
    - Low sound equipment
    - Mixing box with air-side economizer and CO2 demand control ventilation.
- Hydronic coil sized for changeover 2-pipe operation for heating and cooling. Heating coil operation sized for 120 deg F supply temperature.

Dedicated Outside Air Unit (DOAU) with Energy Recovery

- 2-pipe changeover coil.
- MERV 13 filters
- Fan wall with ECM fans
- Air-side economizers
- Airflow monitoring
- Energy recovery wheel with heating effectiveness >80%.
- Variable speed operation
- Energy recovery bypass for airside economizer operation

- Centralized Ground Source Heat Pumps
    - 4-pipe, heating or cooling mode
    - Low GWP refrigerant – R454B
    - VFD compressor
    - Modular configuration with scroll compressors

Major Equipment

Equipment Type	Manufacturer	Quantity	Capacity	Description
Fan Coils: 2-pipe	Trane -BCHE 36	26	1000-1200 cfm	2-pipe coil, ducted horizontal.
Fan Coils: 2-pipe coil	Trane -BCHE 24	10	650 cfm	22-pipe coil, ducted horizontal.
Fan Coils: 2-pipe coil	Trane -BCHE 12	2	350 cfm	2-pipe coil, ducted horizontal.
Indoor AHU (DOAU)	Xetex Custom	1	15000 cfm	2-pipe coil, indoor, Energy recovery, 100% OA, variable volume.
Rooftop Unit Serves cafeteria	Aaon RN	1	5000 cfm	2-pipe coil, packaged rooftop.
Base Mounted Pump	---	2	7.5 HP	Geo/Condenser water pump
Base Mounted Pump	---	2	5 HP	Primary building pump
Modular Ground Source HP	Climacool - UWTS50A (2)	1	100 ton	Two 50 ton banked modules
Domestic Hot Water Heat Pump	Aegis W - 250	1	199 MBH output	CO2 (R744) water source DHW heat pump

Table 3: Major equipment for cost estimation

Alternate #1 – Distributed Water Source Heat Pump

Alternate 1 replaces the Centralized Ground Source Heat Pump (Base System). Refer to detail 2/M5 for alternate system diagram. A condenser water loop is connected to the geo-field and decentralized water source heat pumps within the building. Water source heat pumps with same configuration and capacity replace the base system 2-pipe fan coils. The rooftop unit and the central dedicated outdoor air unit are equipped with water source heat pumps instead of 2-pipe coils in the base system. The condenser loop is routed the same as the base system 2-pipe changeover system.

Benefits:

- Simultaneous heating/cooling
- Condenser loop energy recovery
- Simple operation
- Distributed compressor results in minimal impact with compressor failure compared to centralized heat pump system
- Existing mechanical room size would accommodate new mechanical equipment.

Drawbacks:

- Higher maintenance with multiple compressors
- WSHP fan coils have larger cabinet size than 2-pipe or 4-pipe fan coils and will limit maintenance access in the tunnels.

The building side systems connected to the geo-field system consist of the geo/condenser water loop sized for a 10 deg F temperature difference. Indoor piping constructed with copper or schedule 40 black steel. Refer to floor plan drawings for pipe lengths. Refer to piping diagram for configuration. Geo/Condenser water loop provided with auxiliary hydronic equipment including expansion tank, air separator, and pot feeder. Total system flow 300 gpm. Pumps work with variable flow operation.

Cost Estimates

Cost estimation for building HVAC system should utilize the provided design narrative, equipment list and concept drawings. Two options are presented for the building HVAC system. The base system with central ground source heat pump is the recommended base option. Alternate #1 – Distributed Water Source Heat Pump is provided for alternative pricing comparison

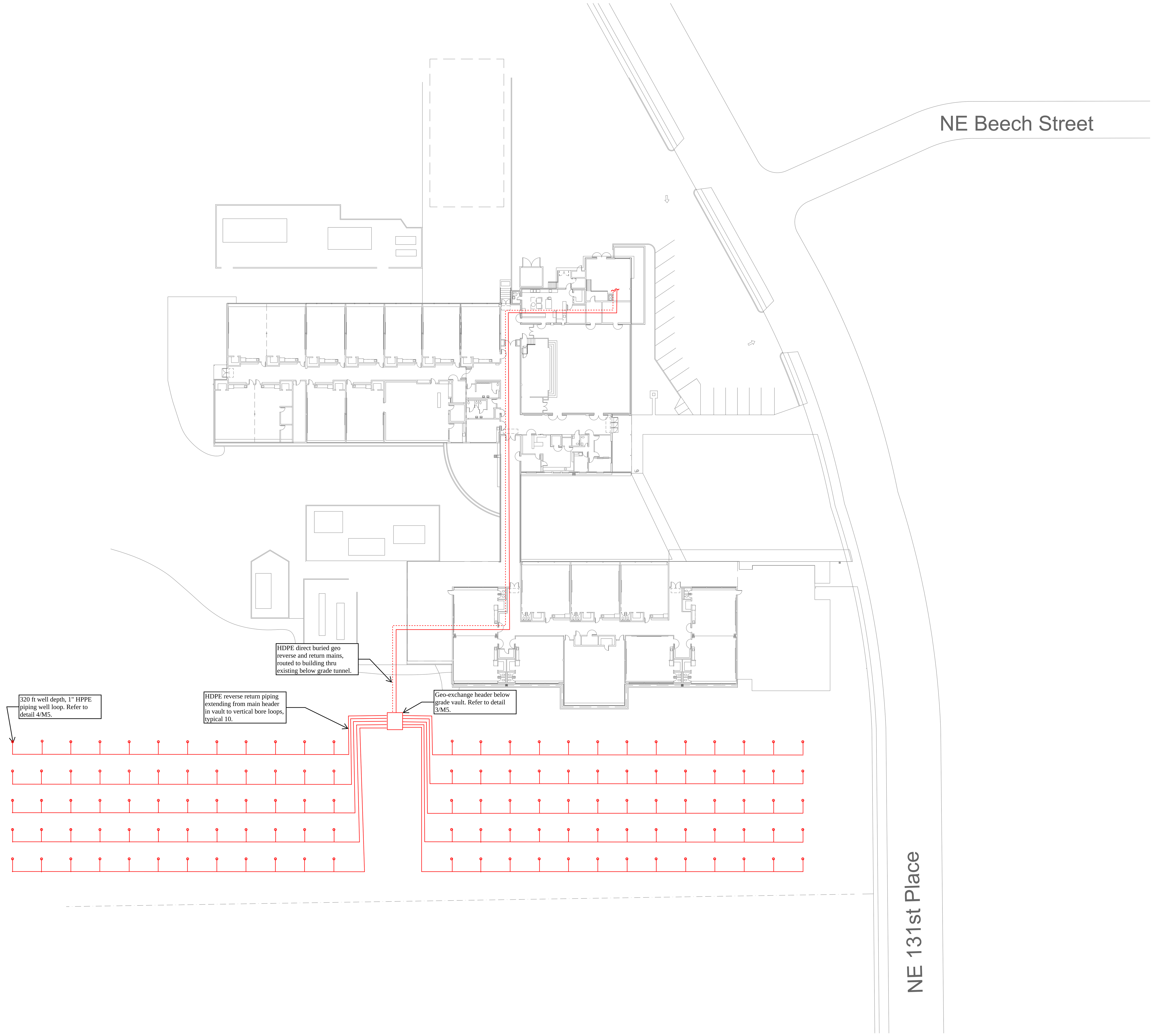
Geo-Field:
- (125) 320 ft vertical well: $1,200,000
- Lateral header piping: $140,000
- (1) Header vault: $80,000
- Total Cost: $1,420,000

Geo-Field cost estimates are based on previous project cost averages and are not intended to be used for final budgetary purposes. A cost estimate from a geoexchange contractor is recommended.

The cost for the geo-field is highly influenced by the required heating capacity for the geo-field and the ground thermal properties. Ground thermal properties derived from a well conductivity test nor peak heating loads were available for capacity sizing. The block heating load for this study was estimated based on the existing heating water plant capacity and the building size and compared with the estimated block cooling load. The geo-field sizing was based on lower performance ground properties with the intention to reflect the higher range of required geo-field size. The geo-field sizing and configuration can be further refined with additional analysis and test data to provide the potential to reduce overall size Additional geo-field analysis is required for construction level design as follows:
- Heating and cooling load analysis through metered data or modeled load analysis.
- Well conductivity test.
- Geo-field performance simulation with measured ground properties and building load data.

Appendix A – Concept Drawings

Vertical Well, Closed Loop Geo-Field



1 SITE PLAN - MECHANICAL

SCALE: 1/32"=1'-0"

INTERFACE ENGINEERING

100 SW Main Street, Suite 1600
Portland, OR 97204
TEL 503.382.2266
www.interfaceengineering.com

SHAVER ELEMENTARY SCHOOL - GEO STUDY

Parkrose School District
10636 NE Prescott Street, Portland, Oregon 97220

SHEET TITLE

SITE PLAN - MECHANICAL

REVISIONS

DRAWN BY BR

CHECKED BY

JOB NO.

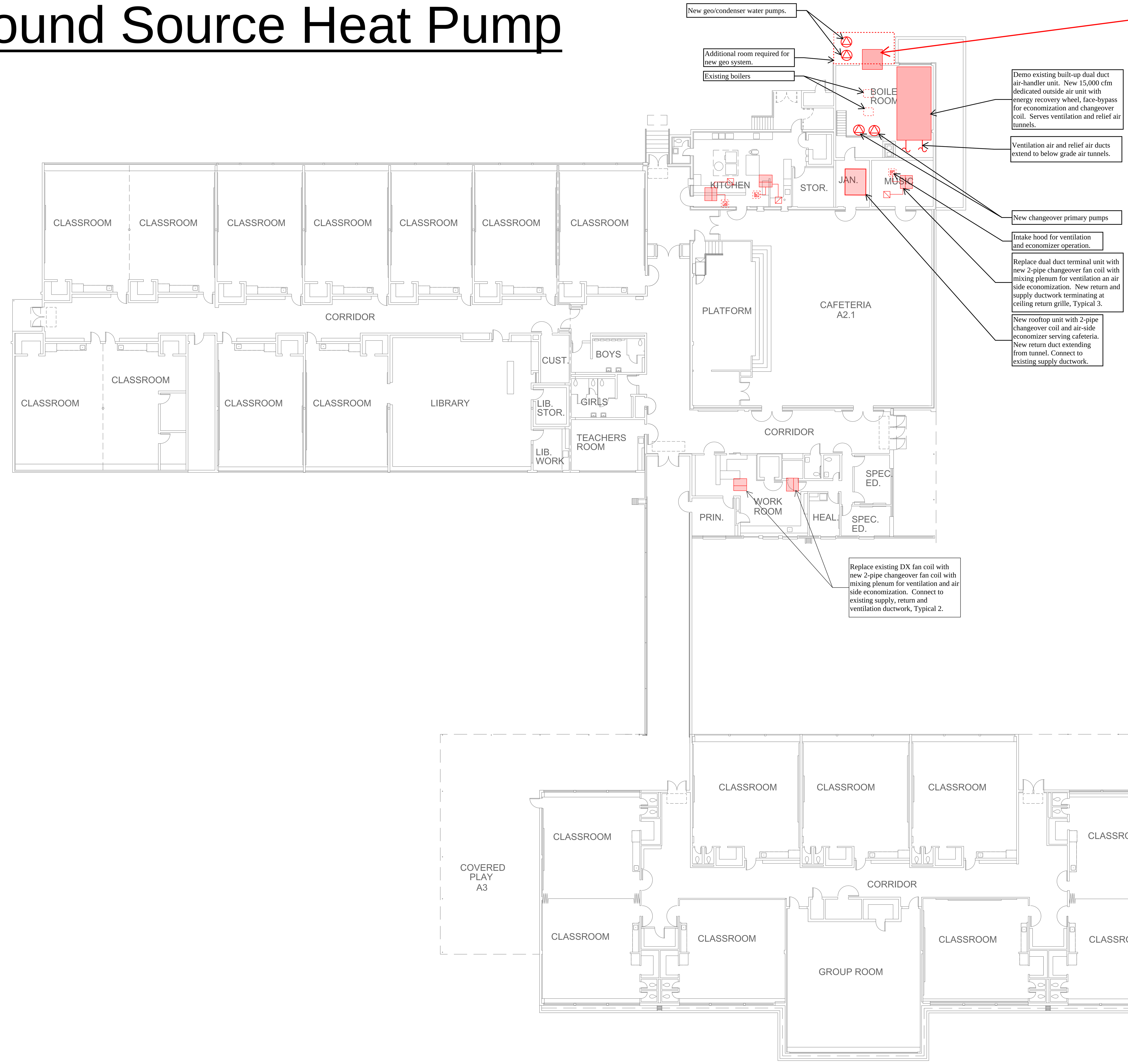
DATE

SHEET NUMBER

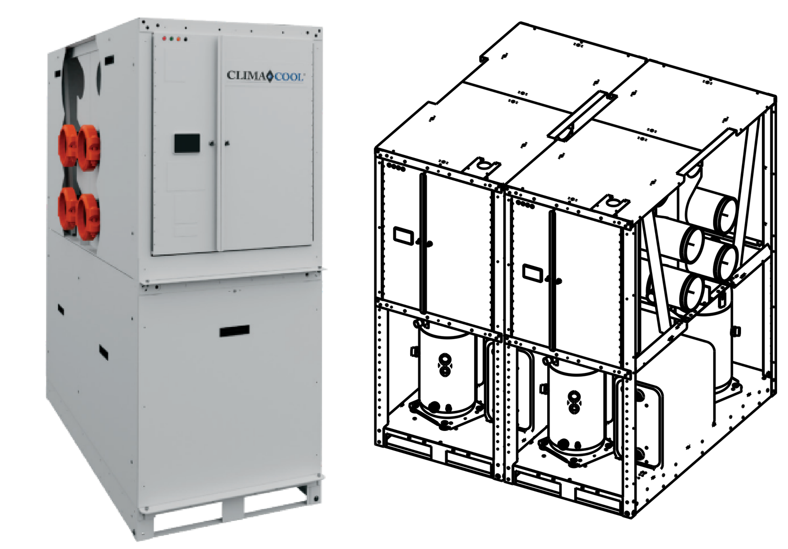
M1

Centralized Ground Source Heat Pump

Refer to piping diagram 1/M5



Modular Ground Source Heat Pump
ClimaCool - UWTS50A (2)



1 OVERALL PLAN - MECHANICAL

0 8' 16' 32'

SCALE: 1/16"=1'-0"

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www.interfaceengineering.com

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Parkrose School District
10636 NE Prescott Street, Portland, Oregon 97220

SHEET TITLE

OVERALL PLAN - MECHANICAL

REVISIONS

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BR

CHECKED BY

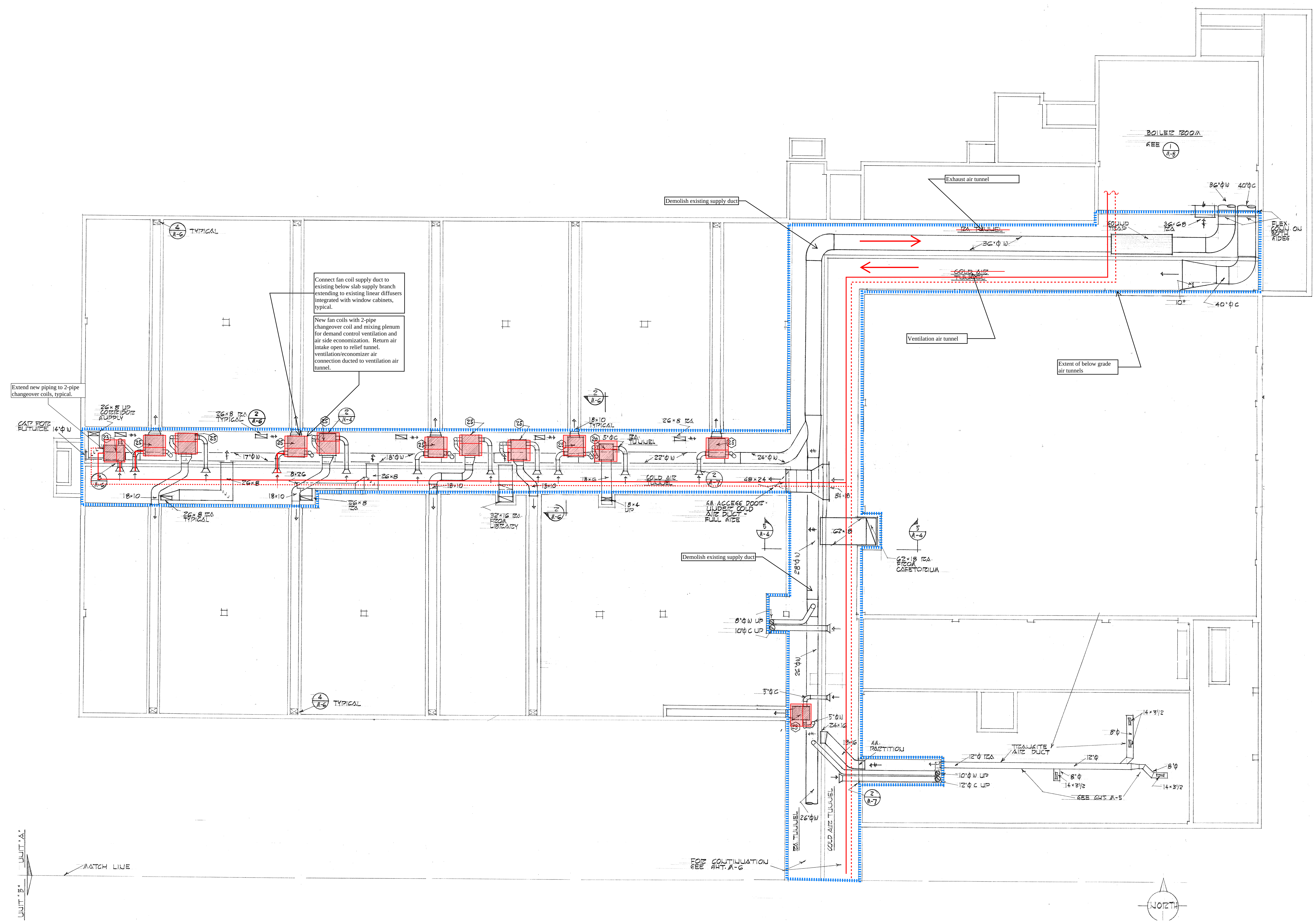
JOB NO.

DATE

SHEET NUMBER

M2

Below Slab - Mechanical North



1 UNIT 'A' FOUNDATION HEATING AND VENTILATION PLAN - MECHANICAL

0 4' 8' 16'

SCALE: 1/8"=1'-0"

FILE: M3.DWG – M3 | EDIT: 1/30/2025 3:18 PM BY JESUSR | PLOT: 1/30/2025 3:20 PM BY JESUS RODRIGUEZ

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Parkrose School District
10636 NE Prescott Street, Portland, Oregon 97220

SHEET TITLE

UNIT 'A' PLAN - MECHANICAL

REVISIONS

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CHECKED BY

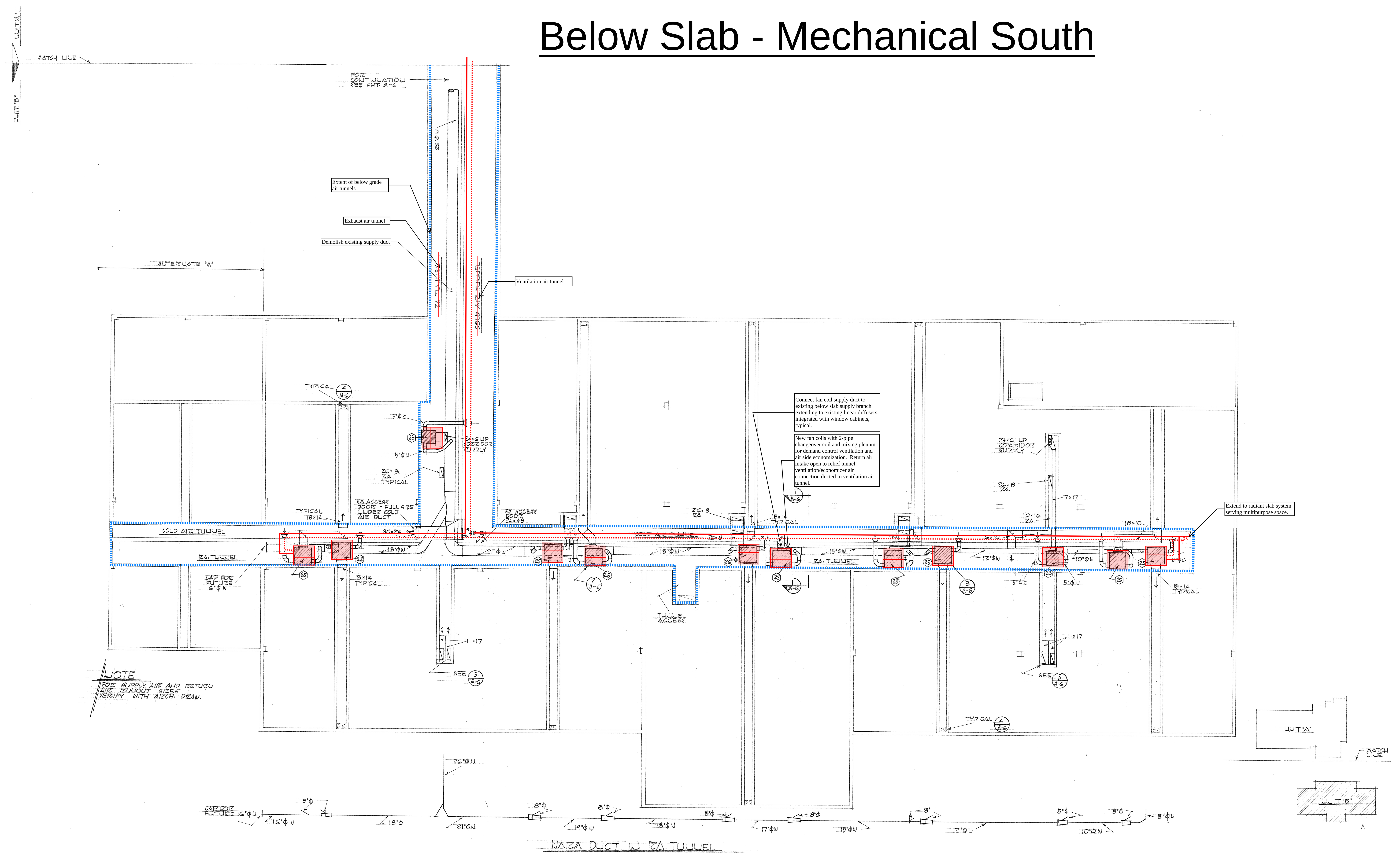
JOB NO.

DATE

SHEET NUMBER

M3

Below Slab - Mechanical South



1 UNIT 'B' FOUNDATION HEATING AND VENTILATION PLAN - MECHANICAL

0 4' 8' 16'

SCALE: 1/8"=1'-0"

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100 SW Main Street, Suite 1600
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TEL 503.382.2266
www.interfaceengineering.com

SHAVER ELEMENTARY SCHOOL - GEO STUDY

Parkrose School District
10636 NE Prescott Street, Portland, Oregon 97220

SHEET TITLE

UNIT 'B' PLAN - MECHANICAL

REVISIONS

DRAWN BY
BR

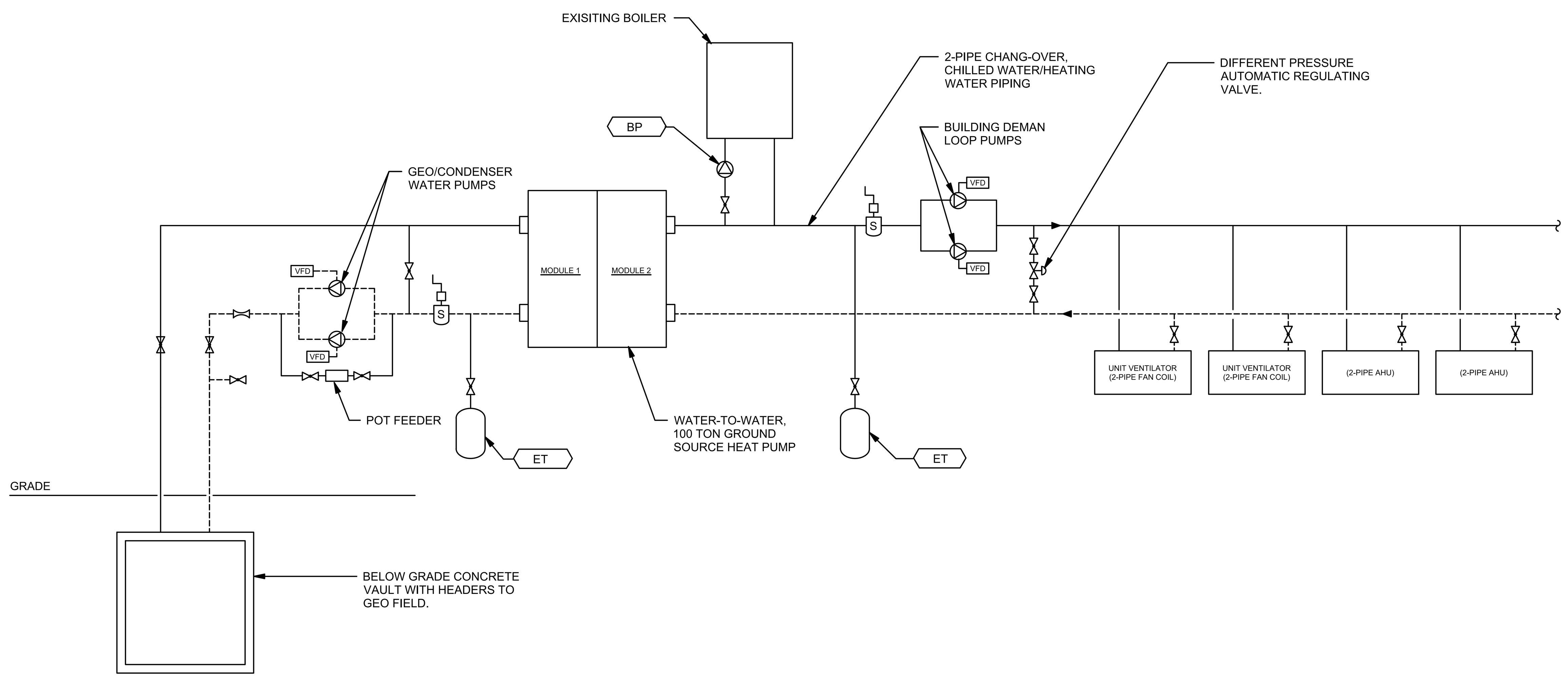
CHECKED BY

JOB NO.

DATE

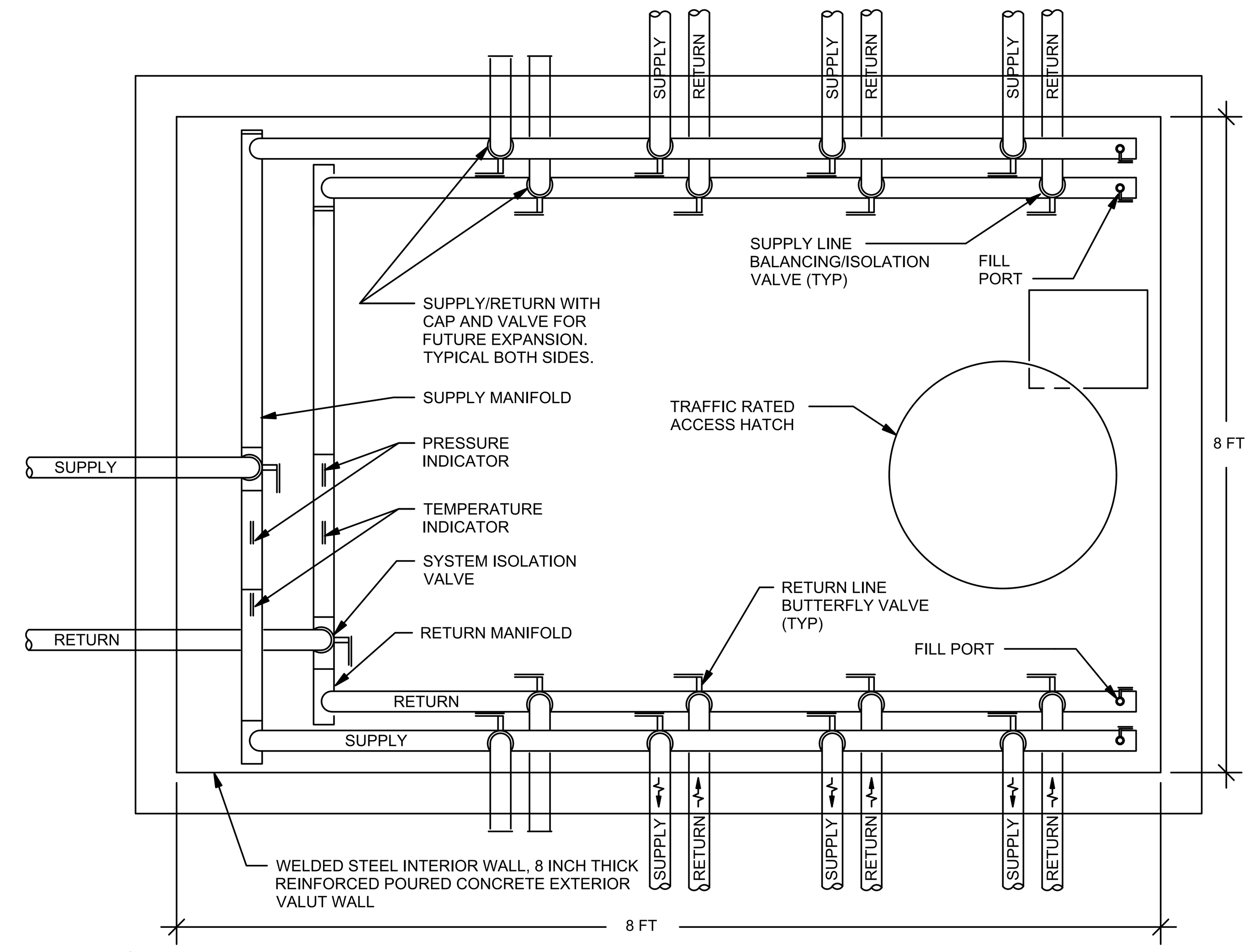
SHEET NUMBER

M4



1 BASE SYSTEM: CENTRALIZED GROUND SOURCE HEAT PUMP SYSTEM

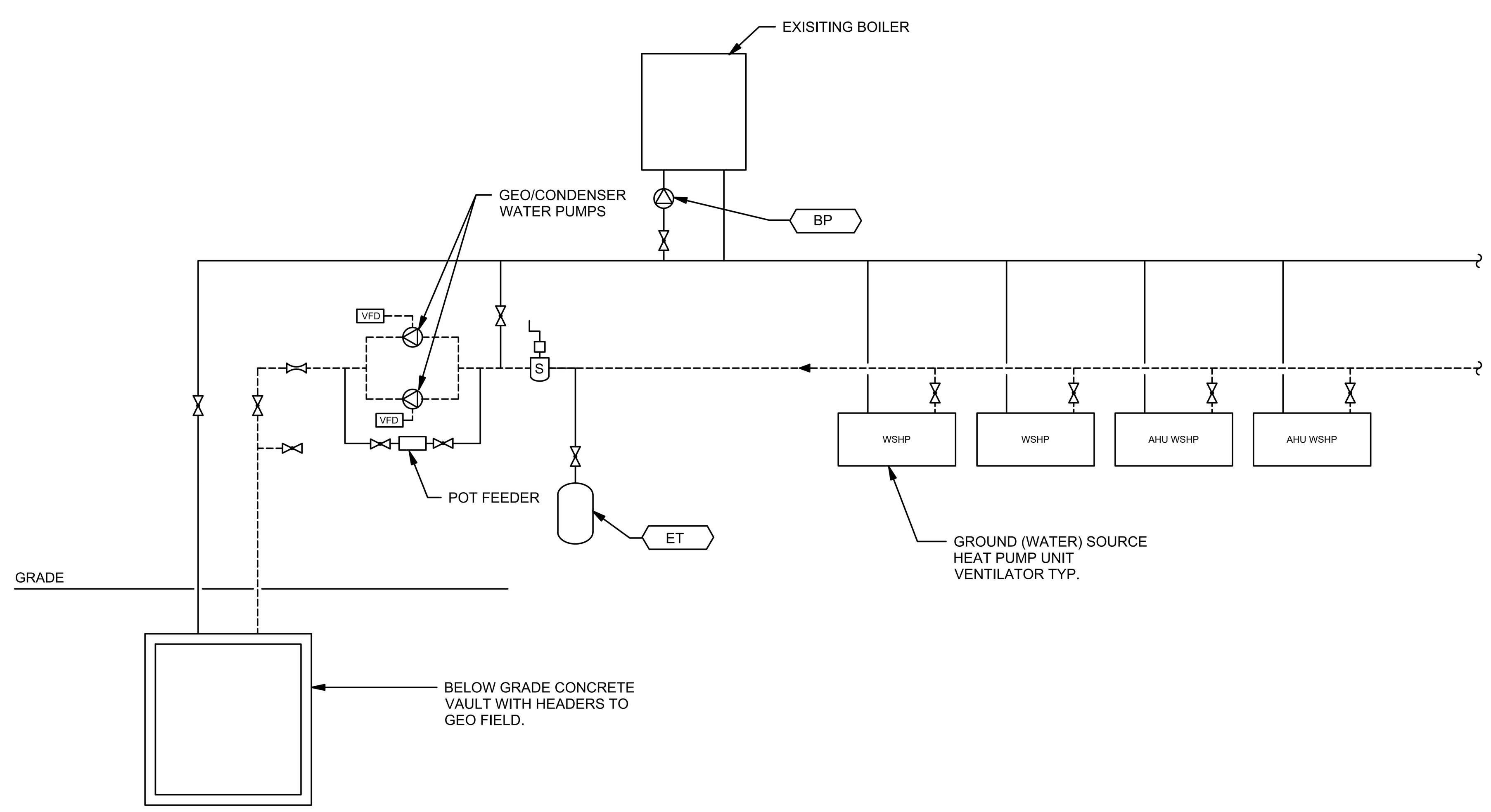
NO SCALE



NOTE:
ALL PIPE PENETRATIONS THROUGH VAULT WALLS SHALL BE SEALED WATER TIGHT WITH A LINK SEAL TYPE MECHANICAL SEAL.

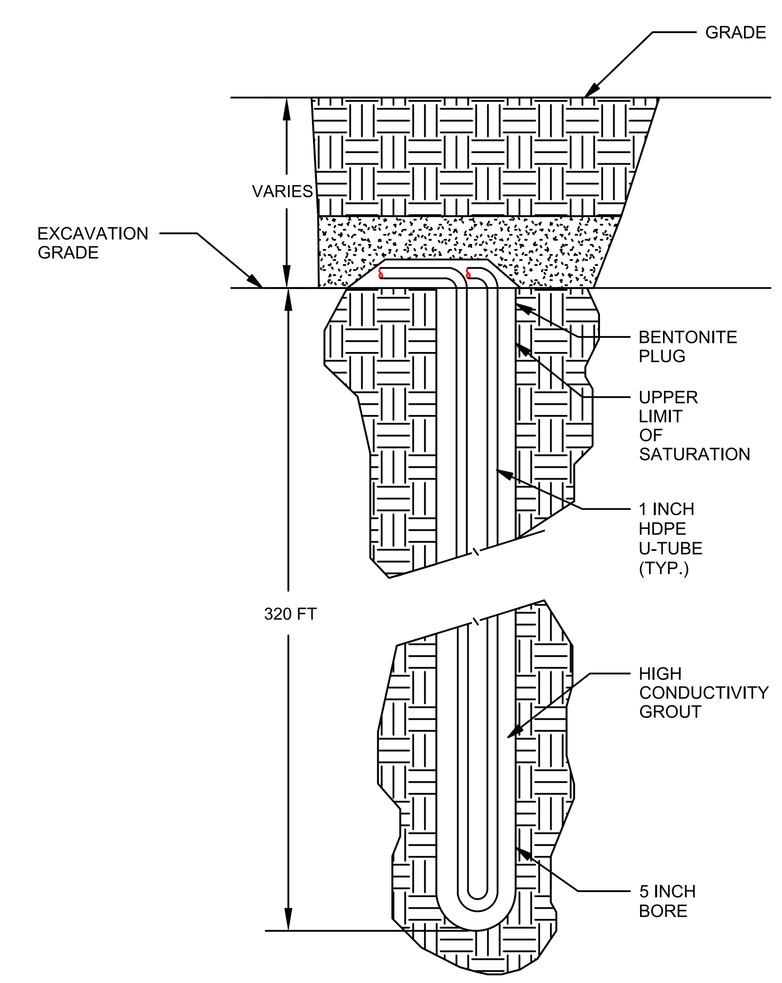
3 GEO-THERMAL HEADER VAULT

NO SCALE



2 ALTERNATE #1: DISTRIBUTED GROUND SOURCE HEAT PUMP SYSTEM

NO SCALE



4 GROUND LOOP BORE SECTION

NO SCALE

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SHEET TITLE
OVERALL PLAN - MECHANICAL

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SHEET NUMBER
M5

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Parkrose Conductivity Test and Analysis

Parkrose School District Conductivity Test Coordination
2025-0514

Prepared for:
Parkrose School District

December 7, 2025

Prepared by:
Shem Heiple, PE, LEED AP

Executive Summary

Project Description

A Formation Thermal Conductivity (FTC) test was performed for four elementary schools in the Parkrose School District (Prescott, Russell, Sacramento, Shaver) during summer 2025. The purpose was to determine suitability for geothermal system upgrades. The drilling was performed by Arrow Drilling, FTC tests by Geonomic Developments, Inc., and analysis by Geothermal Resource Technologies Inc. (GRTI). Results were analyzed using GLD software to assess geo-field performance, capacity, operating temperatures, and long-term operation.

Key Findings

- Based on the conductivity tests and analysis, energy savings reported in initial geothermal studies can be achieved with soil conditions for geothermal.
- All four schools exhibit moderate and consistent soil thermal properties, suitable for geothermal systems.
- Russell and Prescott have the most ideal soil conditions, requiring the least developed geo-field line length per unit heating load.
- Shaver and Sacramento require slightly more geo-field length (3% and 7% more, respectively), but differences are minimal.
- Increasing grout conductivity from 0.85 to 1.2 Btu/hr·ft·°F can improve geo-field performance by up to 8%.
- Utilizing the existing boiler as a backup provides freeze protection and allows a 20–30% reduction in geo-field size.

Summary Table – FTC Results and Soil Thermal Properties

Site	Ground Temp (°F)	Thermal Conductivity (Btu/hr·ft·°F)	Thermal Diffusivity (ft^2/hr)	Impact
Russell	55	0.87	0.68	Most ideal soil; minimal geo-field length required
Shaver	55	0.78	0.6	Slightly lower performance; 3% more geo-field length
Prescott	55	0.87	0.66	Most ideal soil; minimal geo-field length required
Sacramento	55	0.74	0.59	Lowest performance; 7% more geo-field length

Analysis

Purpose and Methodology

The analysis evaluates suitability of four sites for geothermal upgrades using FTC test data and GLD software. A single energy model was applied with soil properties varied per site. FTC tests were performed by Geonomic Developments, Inc., and analyzed by GRTI using ASHRAE and IGSHPA standards.

Inputs and Assumptions

- Bore spacing: 20 ft
- Bore depth: 400 ft
- Soil properties from FTC tests
- Domestic hot water load included
- The same annual heating loads and cooling loads as developed in the preliminary shoebox model was used for each school.

Limitations and Disclaimer

Developed length and bore count are for a test building and do not represent actual geo-field capacity. Full ASHRAE-compliant load and energy analysis required for construction-level design.

Operating Temperature Test Results

Site	Bore Count (40°F)	Bore Count (36°F)	Developed Length (ft)	% Difference
Russell	100	70	28000	1.0
Shaver	100	72	28800	1.03
Prescott	100	70	28000	1.0
Sacramento	100	75	30000	1.07

Explanation: This table shows how bore count and developed length change when target minimum leaving water temperature is lowered to 36°F. Russell and Prescott require the least infrastructure, while Sacramento requires the most. Lowering the leaving water temperature near freezing requires either glycol or a back-up boiler for freeze protection.

Grout Conductivity Impact

Site	Bore Count (Grout U- 0.85)	Bore Count (Grout U- 1.0)	Bore Count (Grout U- 1.2)
Russell	70	67	64
Shaver	72	70	65
Prescott	70	68	64
Sacramento	75	72	70

Explanation: This table illustrates the impact of increasing grout conductivity on bore count. Higher grout conductivity improves heat transfer, reducing required bore count (geo-field capacity) by up to 8%.

Conclusions

All sites are suitable for geothermal upgrades. Russell and Prescott are most ideal; Shaver and Sacramento require minor adjustments. Performance can be optimized by increasing grout conductivity and using boiler backup.

Next Steps

This analysis used a simplified energy model to compare the general geothermal suitability of each school site based on the conductivity tests. To advance the design and ensure accurate system sizing and performance, the following steps are recommended:

1. Perform Detailed ASHRAE Load Calculations: For any school moving forward in the design phase, conduct a comprehensive ASHRAE-compliant load calculation to accurately determine heating and cooling requirements.

2. Develop a Detailed Energy Model: Create a full energy model for each selected school, reflecting the final design and operational schedules. This will enable precise prediction of annual energy performance and system efficiency.

3. Geo-field Sizing and Layout: Use the results of the detailed energy model and load calculations to accurately size the geo-field layout and capacity, addressing both peak and ongoing operational needs.

Appendix A – Formal Thermal Conductivity Tests

FORMATION THERMAL CONDUCTIVITY
TEST & DATA ANALYSIS

TEST LOCATION **Russell Elementary School**
Portland, OR

TEST DATE August 4-6, 2025

ANALYSIS FOR Geonomic Developments, Inc.
6635 N. Baltimore Ave.
Portland, OR 97203
Phone: (503) 734-0123

TEST PERFORMED BY Geonomic Developments, Inc.

Executive Summary

A formation thermal conductivity test was performed on the geothermal bore at Russell Elementary School at 2700 NE 127th Ave in Portland, Oregon. The vertical bore was completed on July 23, 2025 by Arrow Drilling. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the morning of August 4, 2025.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 0.87 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity ≈ 0.68 ft^2/day

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature ≈ 54.7-56.5°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to loop-field design procedures and commercially available software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

Test Procedures

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours**.**

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than ±2%. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

Data Analysis

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. Applying the line source method to a u-bend grouted in a borehole, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In the analysis of the data from the formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger was plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients were calculated that produce a line that fit the data. This procedure was repeated for various time intervals to ensure that variations in the power or other effects did not produce inaccurate results.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

Contact: Galen Streich
Regional Managing Engineer
Elkton, SD
Ph: 866-991-4784
gstreich@grti.com

TEST BORE DETAILS
(AS PROVIDED BY GEONOMIC DEVELOPMENTS, INC.)

Site Name .... Russell Elementary School
Location .... Portland, OR
Driller .... Arrow Drilling
Installed Date .... July 23, 2025
Borehole Diameter .... 6 inches
U-Bend Size .... 1 ¼ inch DR-11 HDPE
U-Bend Depth Below Grade .... 405 ft
Grout Type .... GeoPro TG Lite/PowerTEC
Grout Mixture .... 1200 lb TG Lite, 256 lb PowerTEC, 360 gal water
Grouted Portion .... Entire bore
Note: Holeplug placed in top 4 ft of bore.

DRILL LOG

FORMATION DESCRIPTION	DEPTH (FT)
Topsoil	0'-1'
Gravel and cobbles with brown clay	1'-4'
Gravels and cobbles tight	4'-15'
Silty sand and gravels tight with occasional cobbles	15'-192'
Cobbles and boulders	192'-255'
Soft with occasional rough zones	255'-293'
Rough with occasional easy zones	293'-308'
Boulders with sand and gravel	308'-383'
Smooth clay, grey sticky	383'-413'

THERMAL CONDUCTIVITY TEST DATA

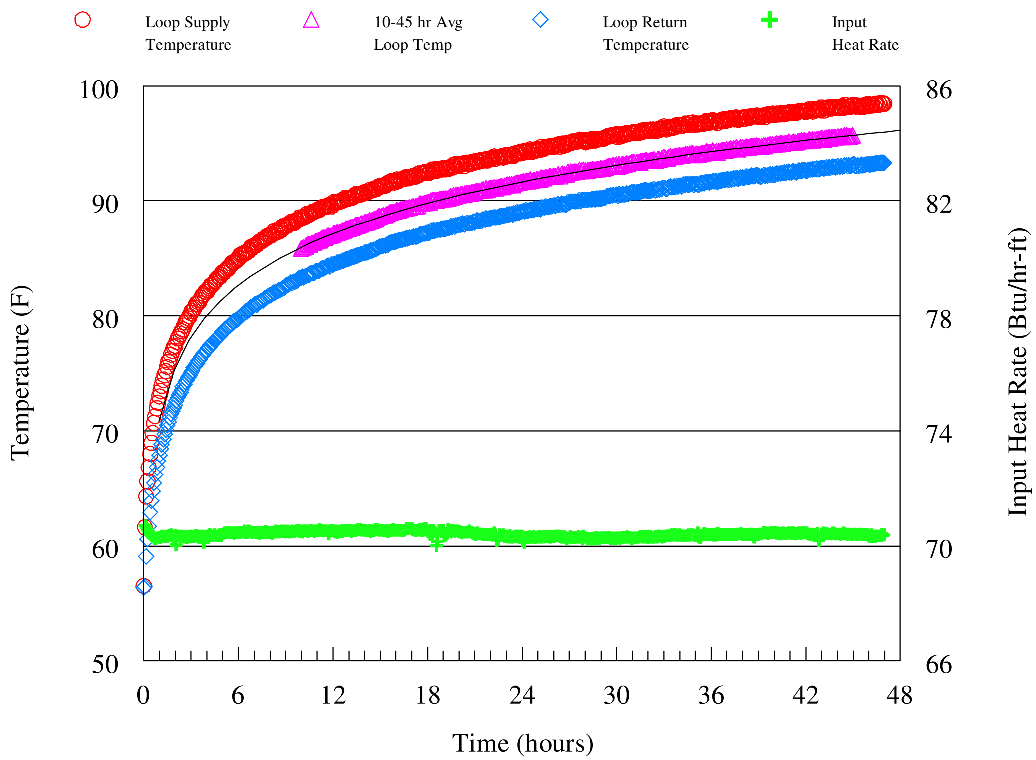


FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

SUMMARY TEST STATISTICS

Test Date	August 4-6, 2025
Undisturbed Formation Temperature	Approx. 54.7-56.5°F
Duration	47.0 hr
Average Voltage	240.2 V
Average Heat Input Rate	28,515 Btu/hr (8,357 W)
Avg Heat Input Rate per Foot of Bore	70.4 Btu/hr-ft (20.6 W/ft)
Circulator Flow Rate	11.0 gpm
Standard Deviation of Power	0.14%
Maximum Variation in Power	0.56%

LINE SOURCE DATA ANALYSIS

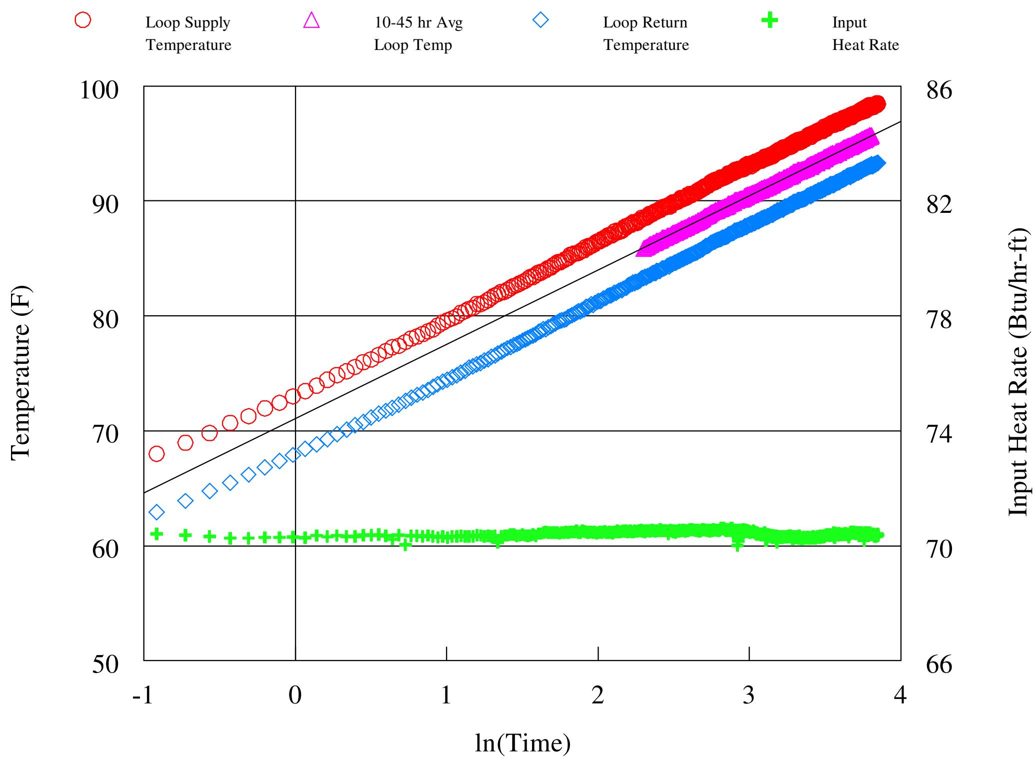


FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 45.0 hours. The slope of the curve fit was found to be 6.48. The resulting thermal conductivity was found to be **0.87 Btu/hr-ft-°F**.

Thermal Diffusivity

The reported drilling log for this test borehole indicated that the formation consisted of clay, sand, gravel and cobbles. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 30.5 Btu/ft^3-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **0.68 ft^2/day**.

CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit 249

DA Unit 34

Primary Equipment	
Component	Calibration Date
Datalogger	9/11/2024
Current Transducer	9/11/2024
Voltage Transducer	9/11/2024

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via a water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

Date	9/30/2024	4/18/2025	7/24/2025	
Thermocouple 1 (°F)	68.3 68.4 68.4	78.7 78.7 78.7	58.7 58.8 58.9	
Thermocouple 2 (°F)	68.3 68.4 68.5	78.8 78.8 78.8	58.6 58.7 58.8	
Thermocouple 3 (°F)	68.3 68.4 68.4	78.7 78.7 78.7	58.6 58.7 58.9	
Thermocouple 4 (°F)	68.3 68.4 68.4	78.7 78.7 78.7	58.7 58.8 58.9	
Digital Thermometer (°F)	68.4 68.5 68.6	78.8 78.8 78.8	58.6 58.7 58.9	

Formation Thermal Conductivity
Test & Data Analysis

Test location: **Shaver Elementary School**
Portland, OR

Test Date: August 11-13, 2025

Analysis For: Geonomic Developments, Inc.
6635 N. Baltimore Ave.
Portland, OR 97203
Phone: (503) 734-0123

Test Performed By: Geonomic Developments, Inc.

Executive Summary

A formation thermal conductivity test was performed on the geothermal bore at Shaver Elementary School at 3701 NE 131st Pl, Portland, Oregon. The vertical bore was completed on August 6, 2025 by Arrow Drilling. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on August 11, 2025.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 0.78 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity ≈ 0.60 ft^2/day

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature ≈ 54.8-57.1°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to loop-field design procedures and commercially available software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

Test Procedures

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours**.**

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than ±2%. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

DATA ANALYSIS

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. Applying the line source method to a u-bend grouted in a borehole, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In the analysis of the data from the formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger was plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients were calculated that produce a line that fit the data. This procedure was repeated for various time intervals to ensure that variations in the power or other effects did not produce inaccurate results.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

CONTACT: Galen Streich
Regional Managing Engineer
Elkton, SD
Ph: 866-991-4784
gstreich@grti.com

TEST BORE DETAILS
(AS PROVIDED BY GEONOMIC DEVELOPMENTS, INC.)

Site Name	Shaver Elementary School
Location	3701 NE 131st Pl, Portland, OR
Driller	Arrow Drilling
Installed Date	August 6, 2025
Borehole Diameter	6 inches
U-Bend Size	1 ¼ inch DR-11 HDPE
U-Bend Depth Below Grade	400 ft
Grout Type	GeoPro TG Lite/PowerTEC
Grout Mixture	1200 lb TG Lite, 256 lb PowerTEC, 360 gal water
Grouted Portion	Entire bore

Note: Hole Plug bentonite placed in top 5 ft.

DRILL LOG

FORMATION DESCRIPTION	DEPTH (FT)
Topsoil	0'-1'
Brown clay silty	1'-13'
Gravels with clay	13'-18'
Gravels with cobbles very loose	18'-76'
Sand and gravels tight	76'-102'
Gravels and cobbles with some boulders	102'-260'
Sand cemented with gray clay	260'-294'
Gravels and cobbles	294'-364'
Gray clay, sticky	364'-400'

Thermal Conductivity Test Data

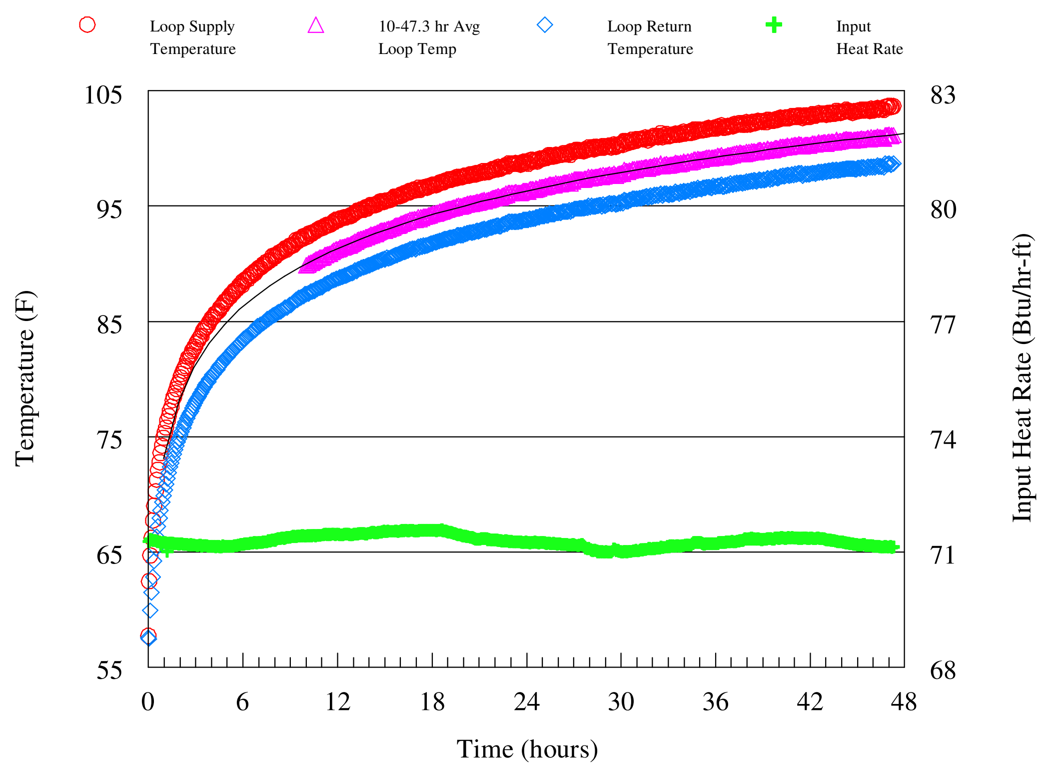


Fig. 1: Temperature & Heat Rate Data Vs Time

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

Summary Test Statistics

Test Date	August 11-13, 2025
Undisturbed Formation Temperature	Approx. 54.8-57.1°F
Duration	47.3 hr
Average Voltage	240.4 V
Average Heat Input Rate	28,517 Btu/hr (8,357 W)
Avg Heat Input Rate per Foot of Bore	71.3 Btu/hr-ft (20.9 W/ft)
Circulator Flow Rate	11.3 gpm
Standard Deviation of Power	0.22%
Maximum Variation in Power	0.42%

LINE SOURCE DATA ANALYSIS

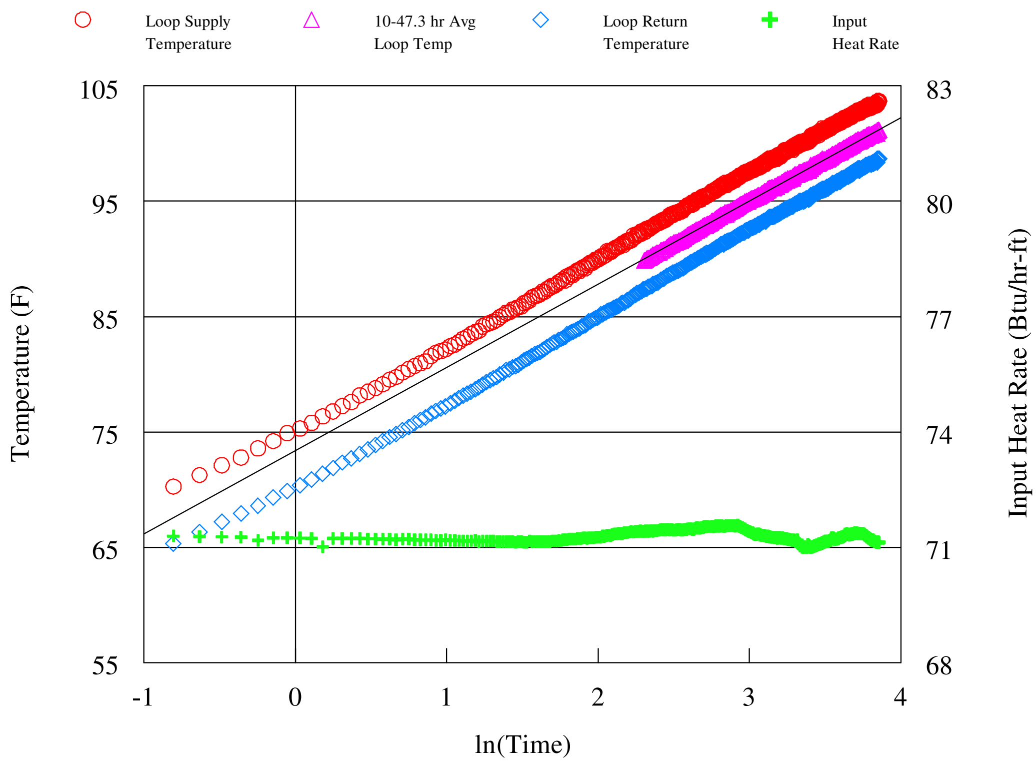


FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 47.3 hours. The slope of the curve fit was found to be 7.23. The resulting thermal conductivity was found to be **0.78 Btu/hr-ft-°F**.

Thermal Diffusivity

The reported drilling log for this test borehole indicated that the formation consisted of clay, sand, gravel and cobbles. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 31.3 Btu/ft^3-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **0.60 ft^2/day**.

Certificate of Calibration

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit 249

DA Unit 34

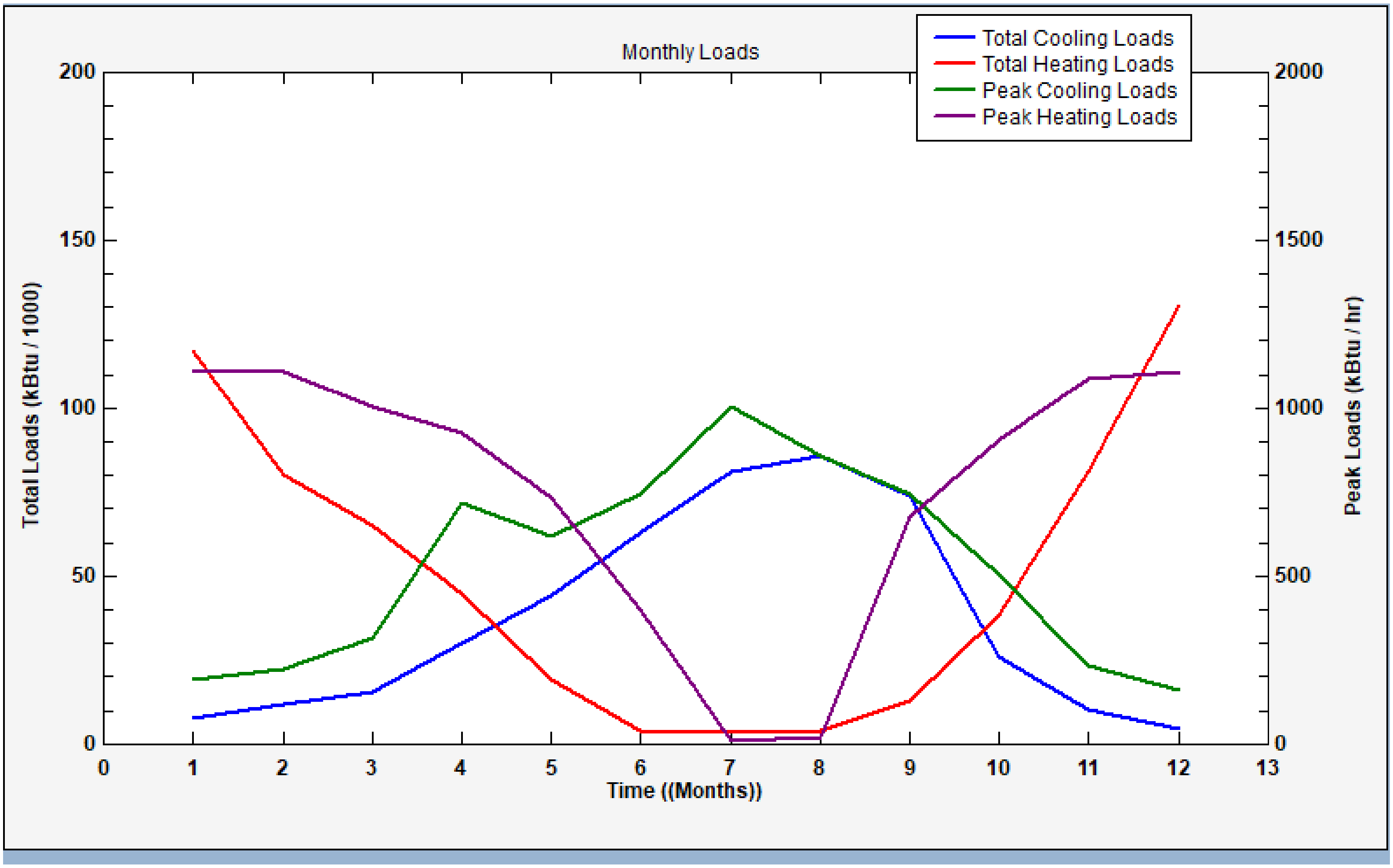
Primary Equipment	
Component	**Calibration Date**
Datalogger	9/11/2024
Current Transducer	9/11/2024
Voltage Transducer	9/11/2024

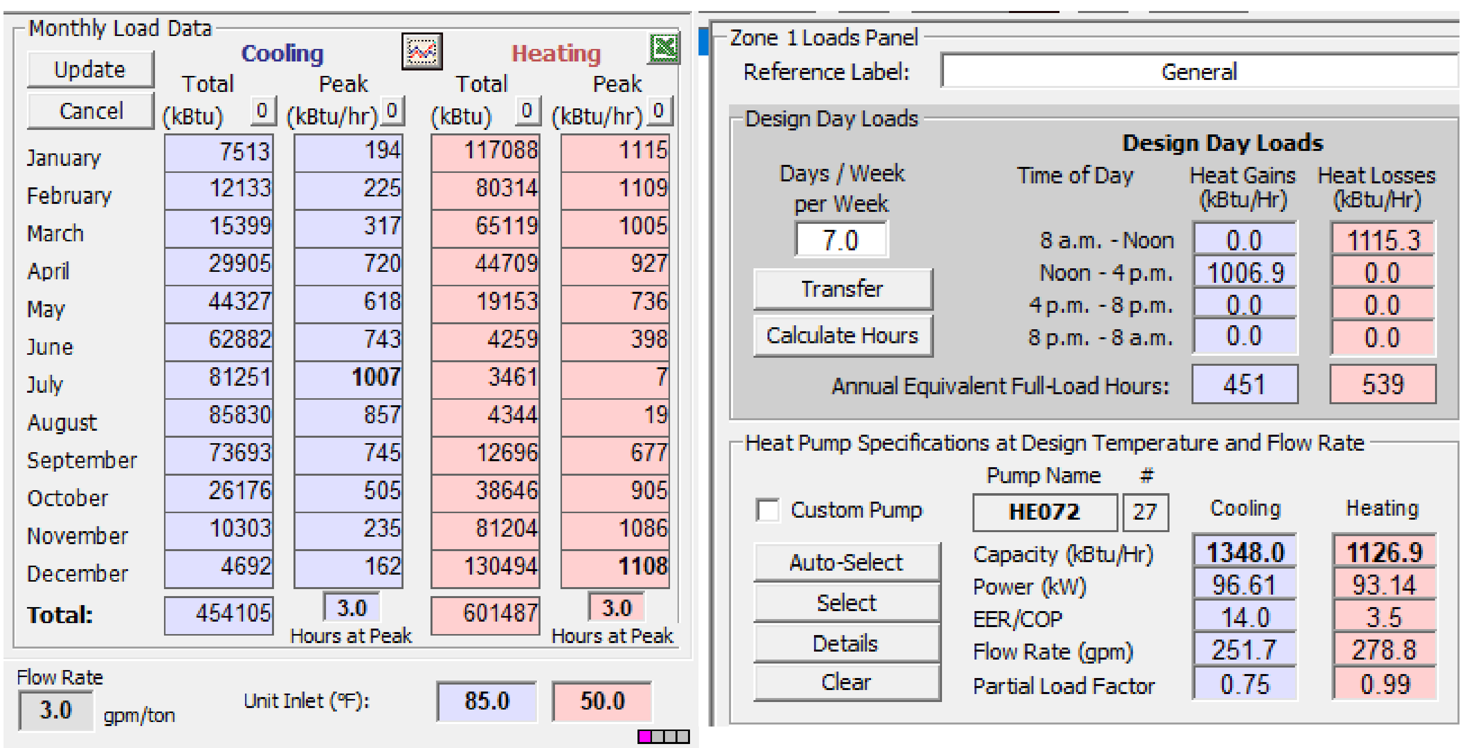
GRTI periodically verifies the combined temperature sensor/datalogger accuracy via a water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

Date	9/30/2024	4/18/2025	7/24/2025	
Thermocouple 1 (°F)	68.3 68.4 68.4	78.7 78.7 78.7	58.7 58.8 58.9	
Thermocouple 2 (°F)	68.3 68.4 68.5	78.8 78.8 78.8	58.6 58.7 58.8	
Thermocouple 3 (°F)	68.3 68.4 68.4	78.7 78.7 78.7	58.6 58.7 58.9	
Thermocouple 4 (°F)	68.3 68.4 68.4	78.7 78.7 78.7	58.7 58.8 58.9	
Digital Thermometer (°F)	68.4 68.5 68.6	78.8 78.8 78.8	58.6 58.7 58.9	

Appendix B – GLD Geo-field Results

General Information





Monthly Load Data

Update | Cancel

	Cooling Total (kBtu)	Cooling Peak (kBtu/hr)	Heating Total (kBtu)	Heating Peak (kBtu/hr)
	0	0	0	0
January	7513	194	117088	1115
February	12133	225	80314	1109
March	15399	317	65119	1005
April	29905	720	44709	927
May	44327	618	19153	736
June	62882	743	4259	398
July	81251	**1007**	3461	7
August	85830	857	4344	19
September	73693	745	12696	677
October	26176	505	38646	905
November	10303	235	81204	1086
December	4692	162	130494	**1108**
Total:	454105	3.0 Hours at Peak	601487	3.0 Hours at Peak

Flow Rate 3.0 gpm/ton

Unit Inlet (°F): 85.0 50.0

Zone 1 Loads Panel

Reference Label: General

Design Day Loads

Days / Week per Week 7.0

Transfer | Calculate Hours

Time of Day	Heat Gains (kBtu/Hr)	Heat Losses (kBtu/Hr)
8 a.m. - Noon	0.0	1115.3
Noon - 4 p.m.	1006.9	0.0
4 p.m. - 8 p.m.	0.0	0.0
8 p.m. - 8 a.m.	0.0	0.0
Annual Equivalent Full-Load Hours:	451	539

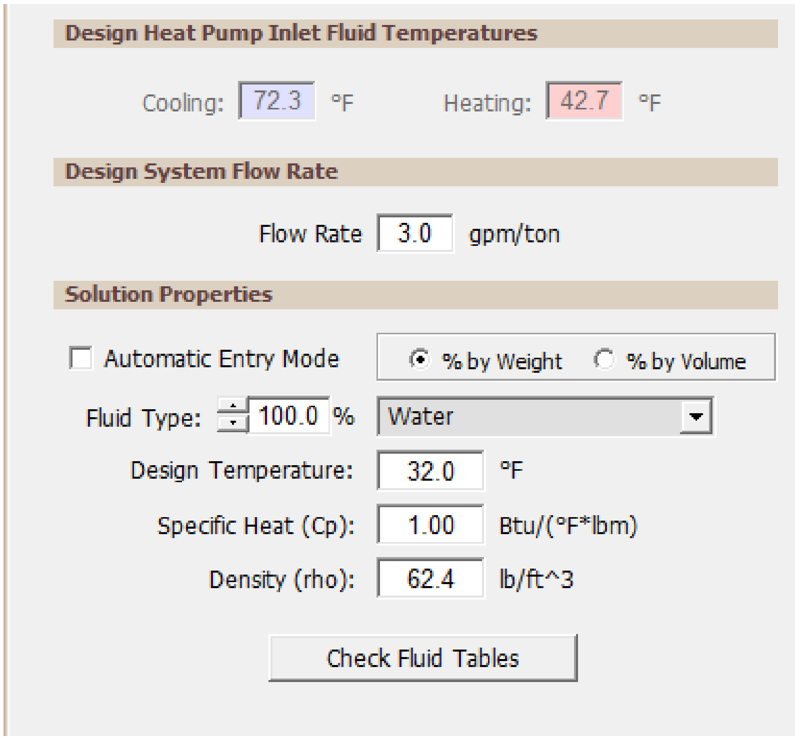
Heat Pump Specifications at Design Temperature and Flow Rate

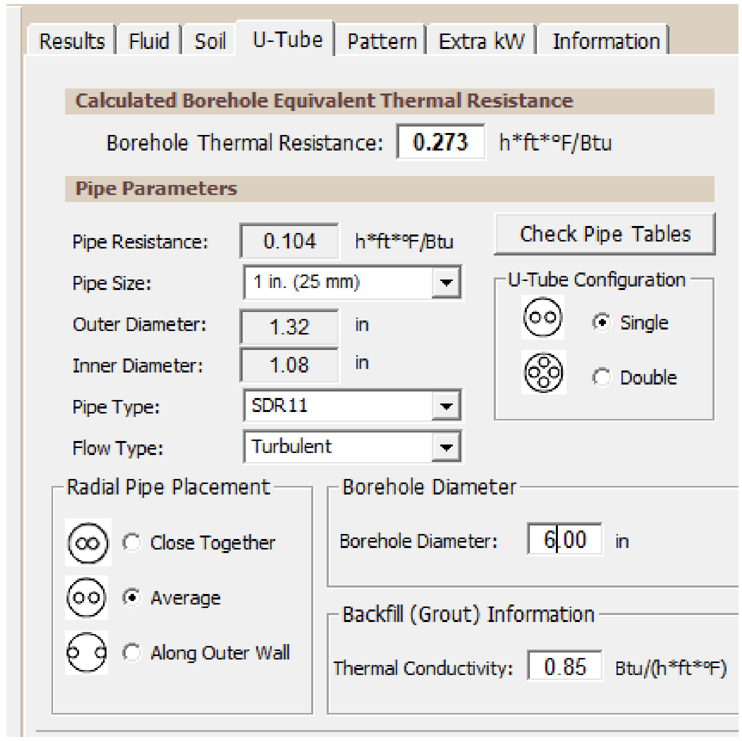
Custom Pump — Pump Name: HE072, #: 27

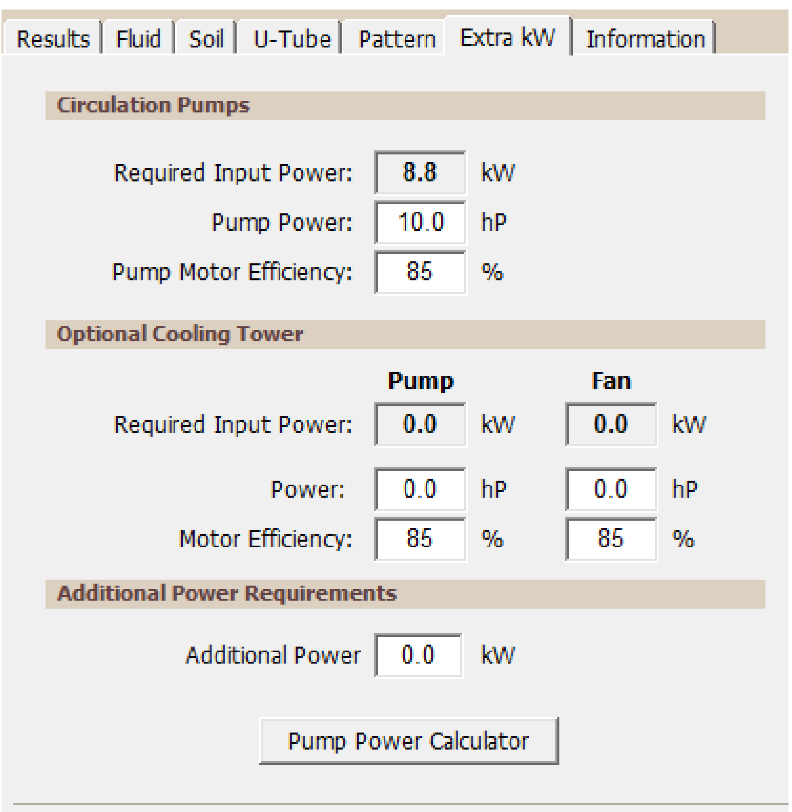
Auto-Select | Select | Details | Clear

	Cooling	Heating
Capacity (kBtu/Hr)	**1348.0**	**1126.9**
Power (kW)	96.61	93.14
EER/COP	14.0	3.5
Flow Rate (gpm)	251.7	278.8
Partial Load Factor	0.75	0.99

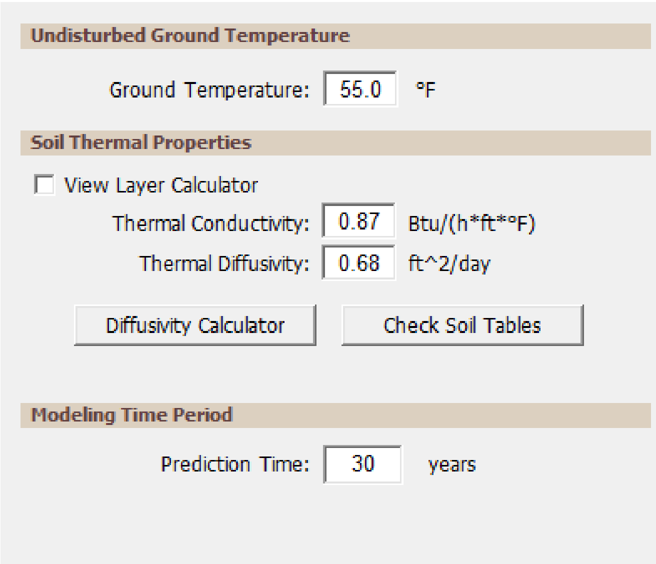
General Information

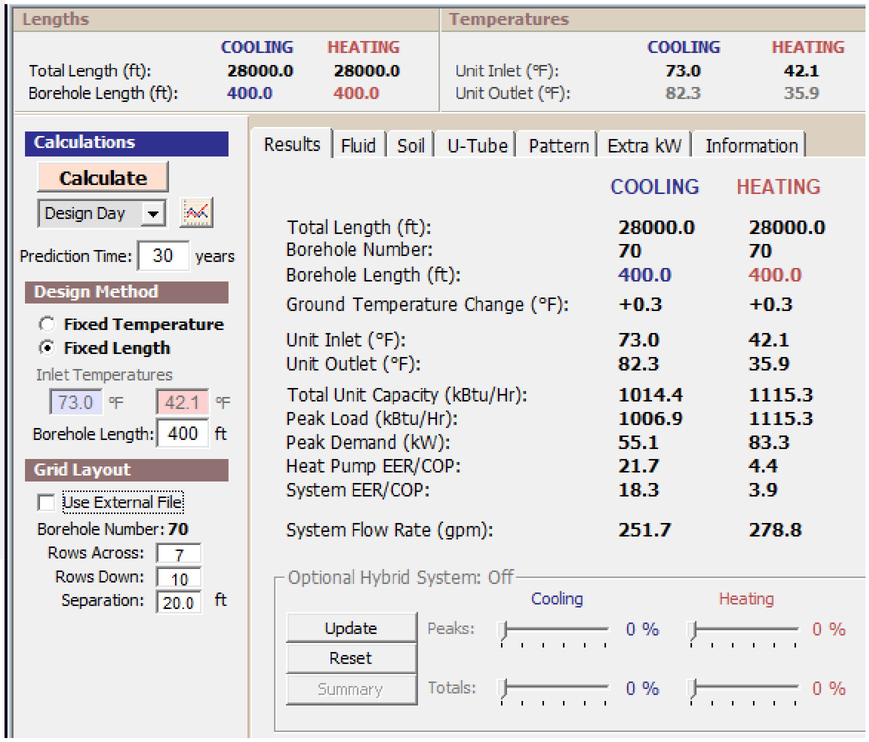


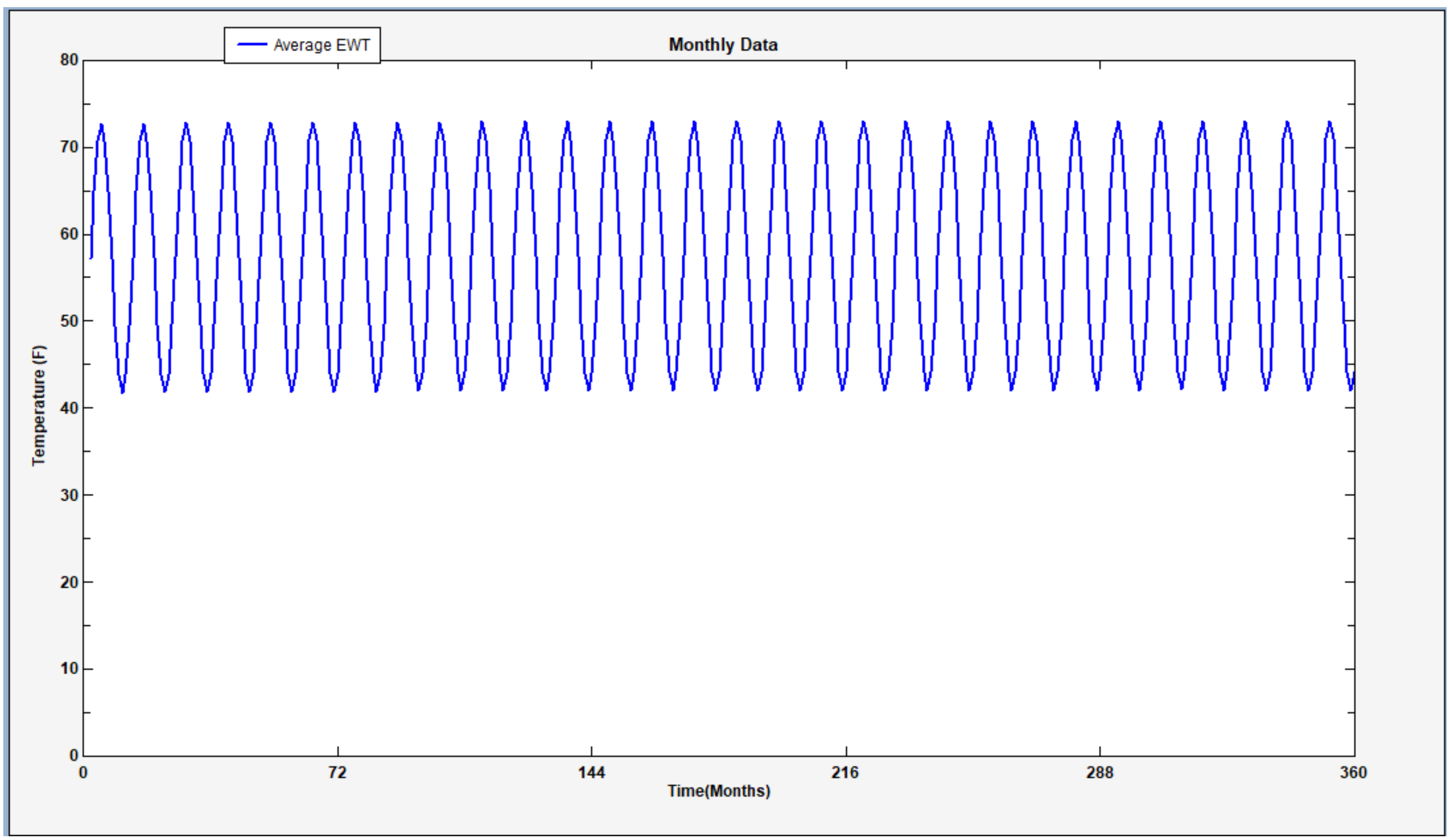




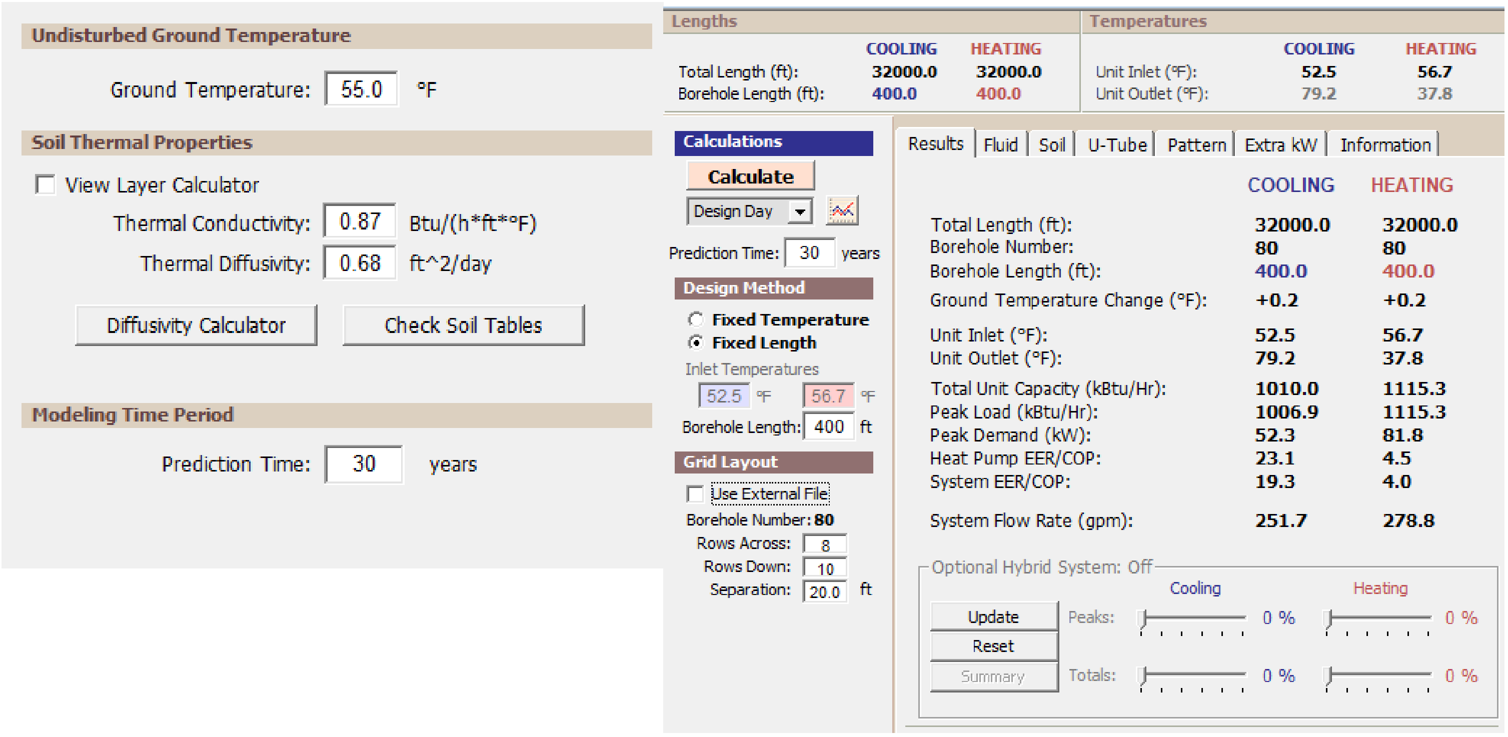
Russell
400' Depth, 70 bores, 20' spacing

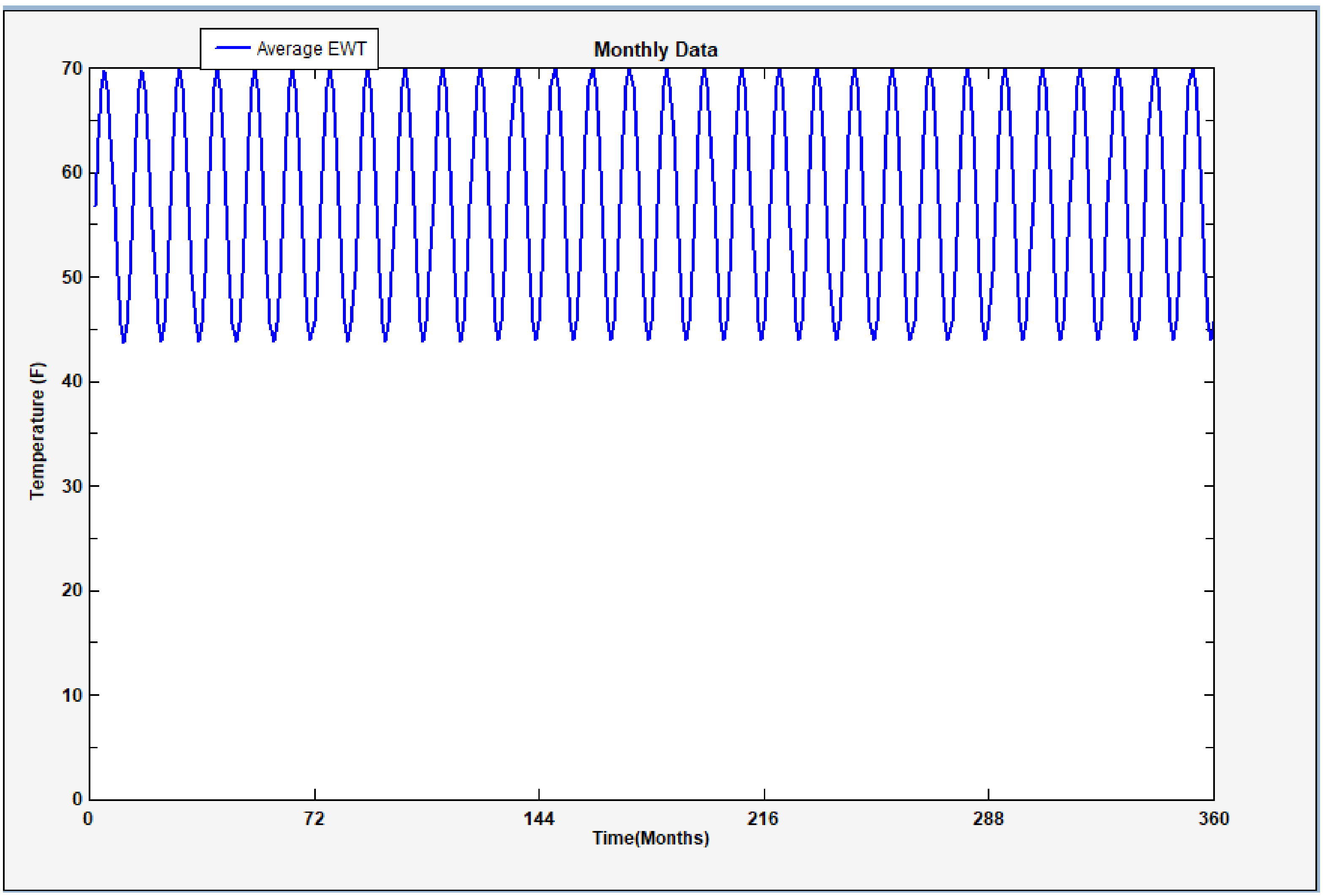




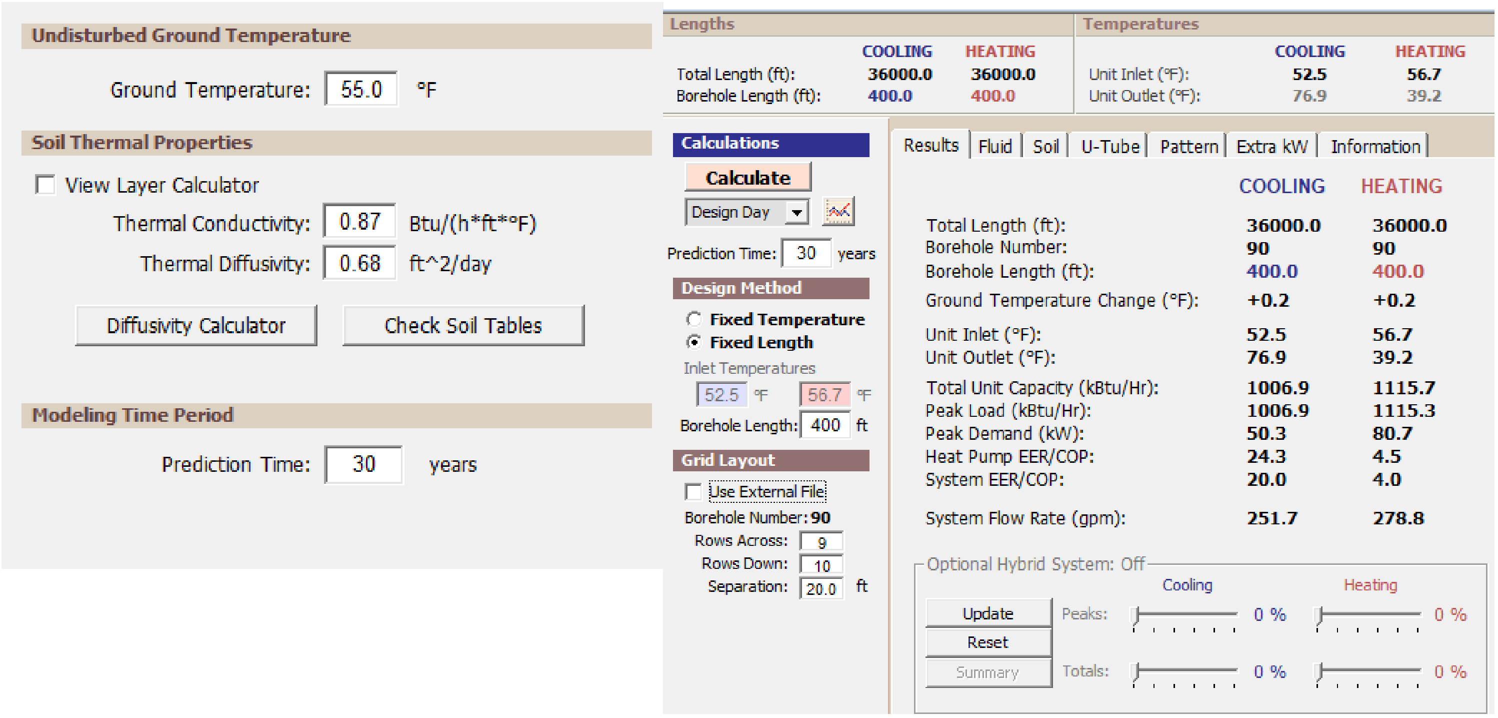


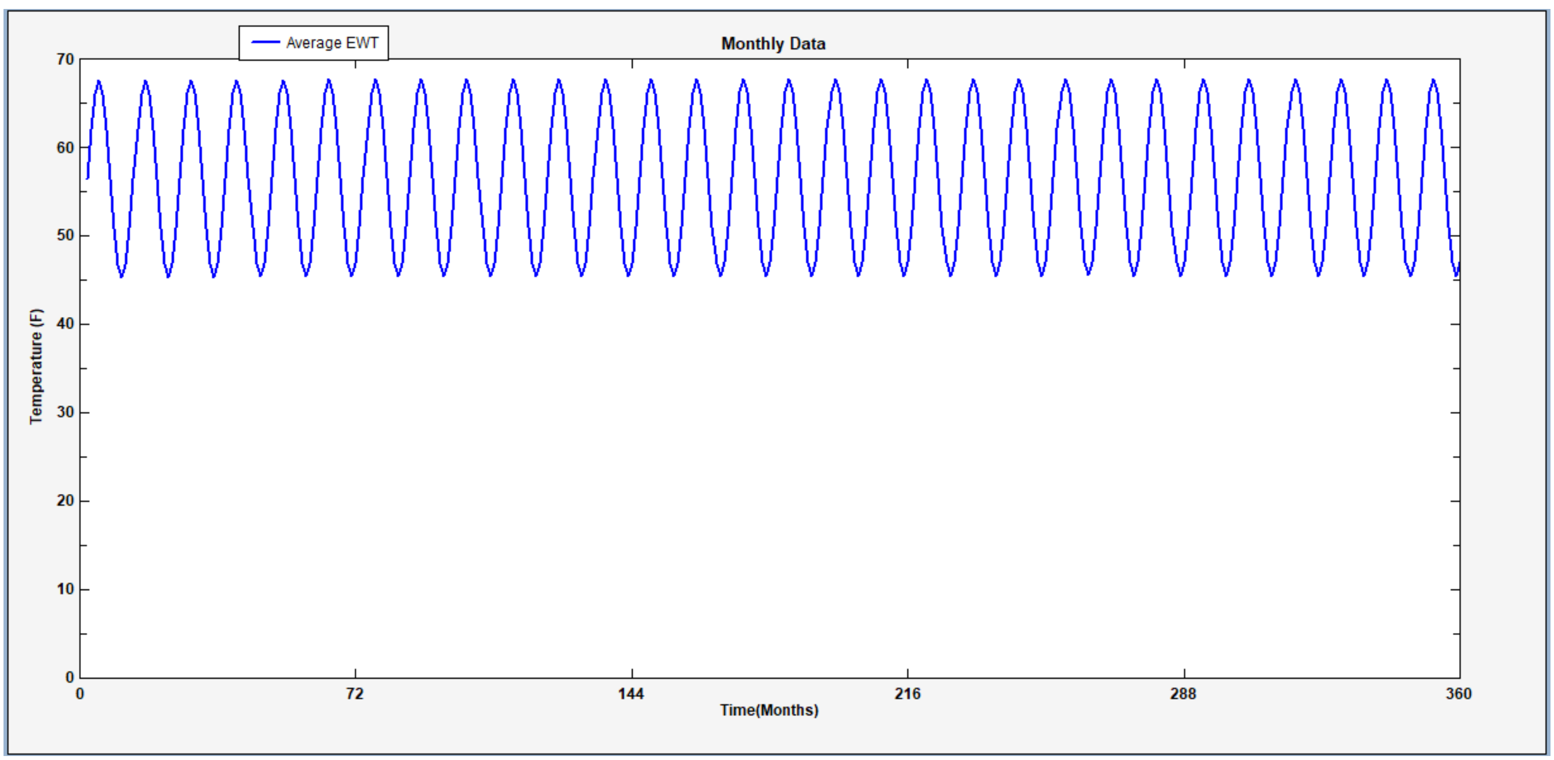
Russell
400' Depth, 80 bores, 20' spacing



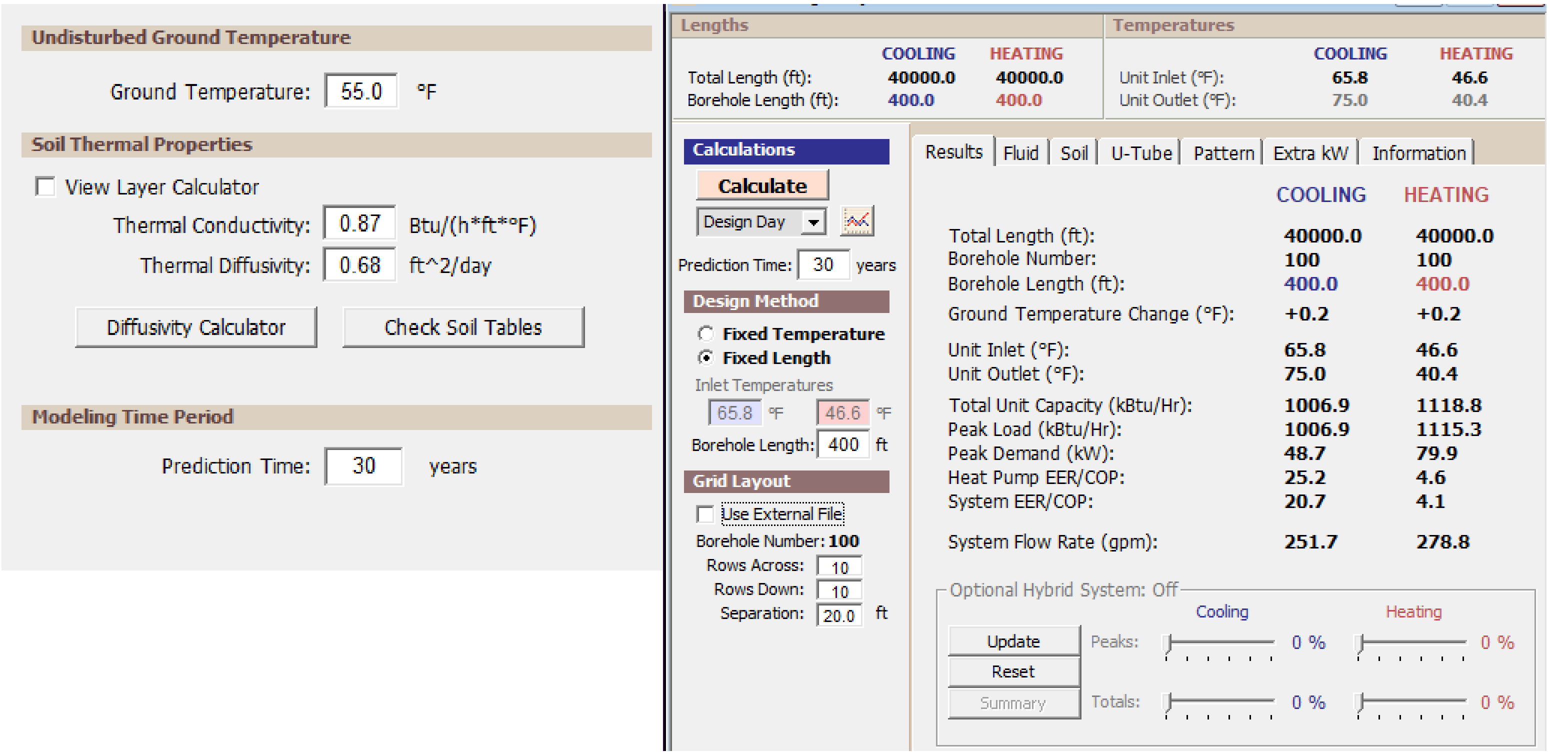


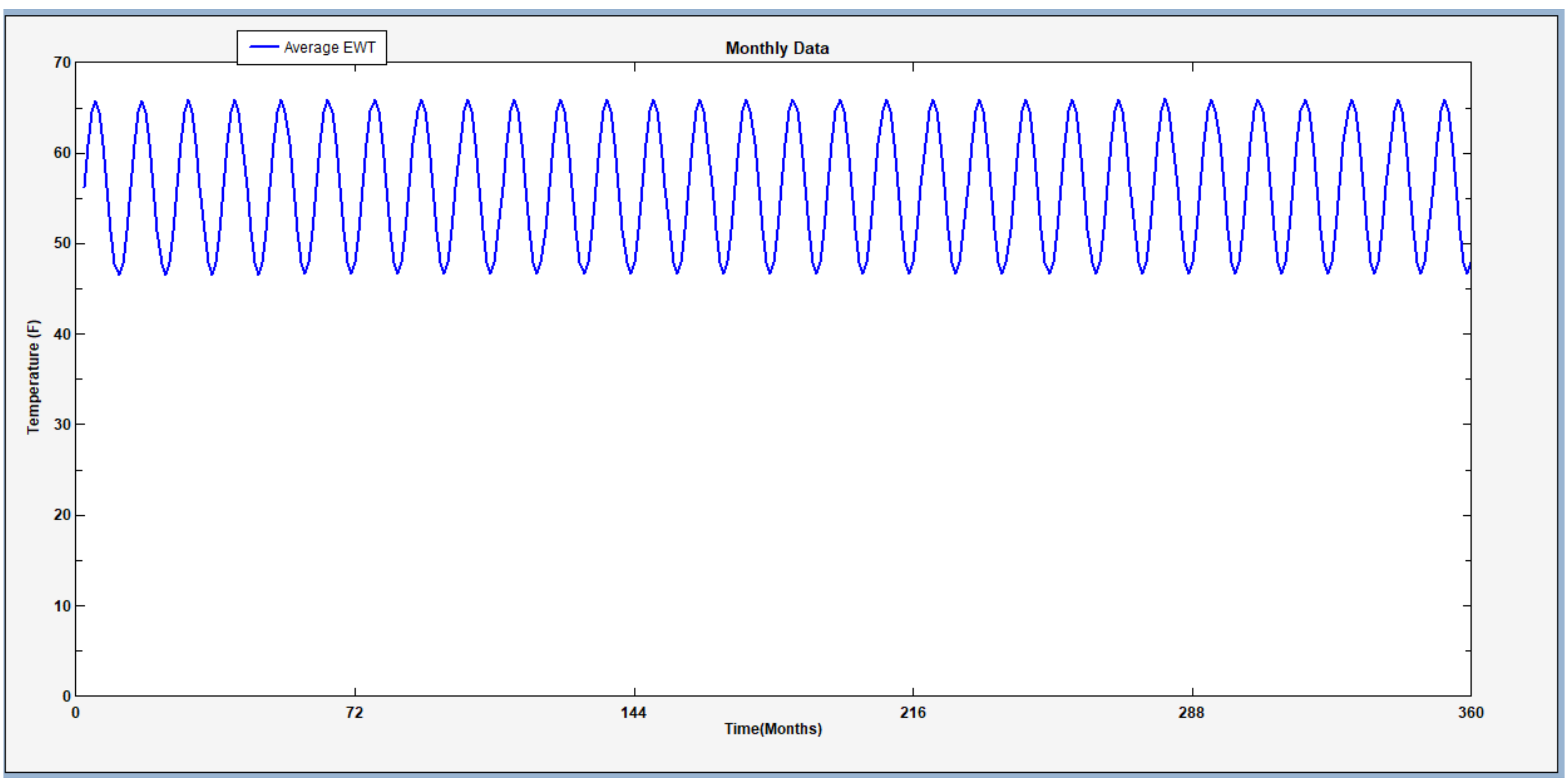
Russell
400' Depth, 90 bores, 20' spacing





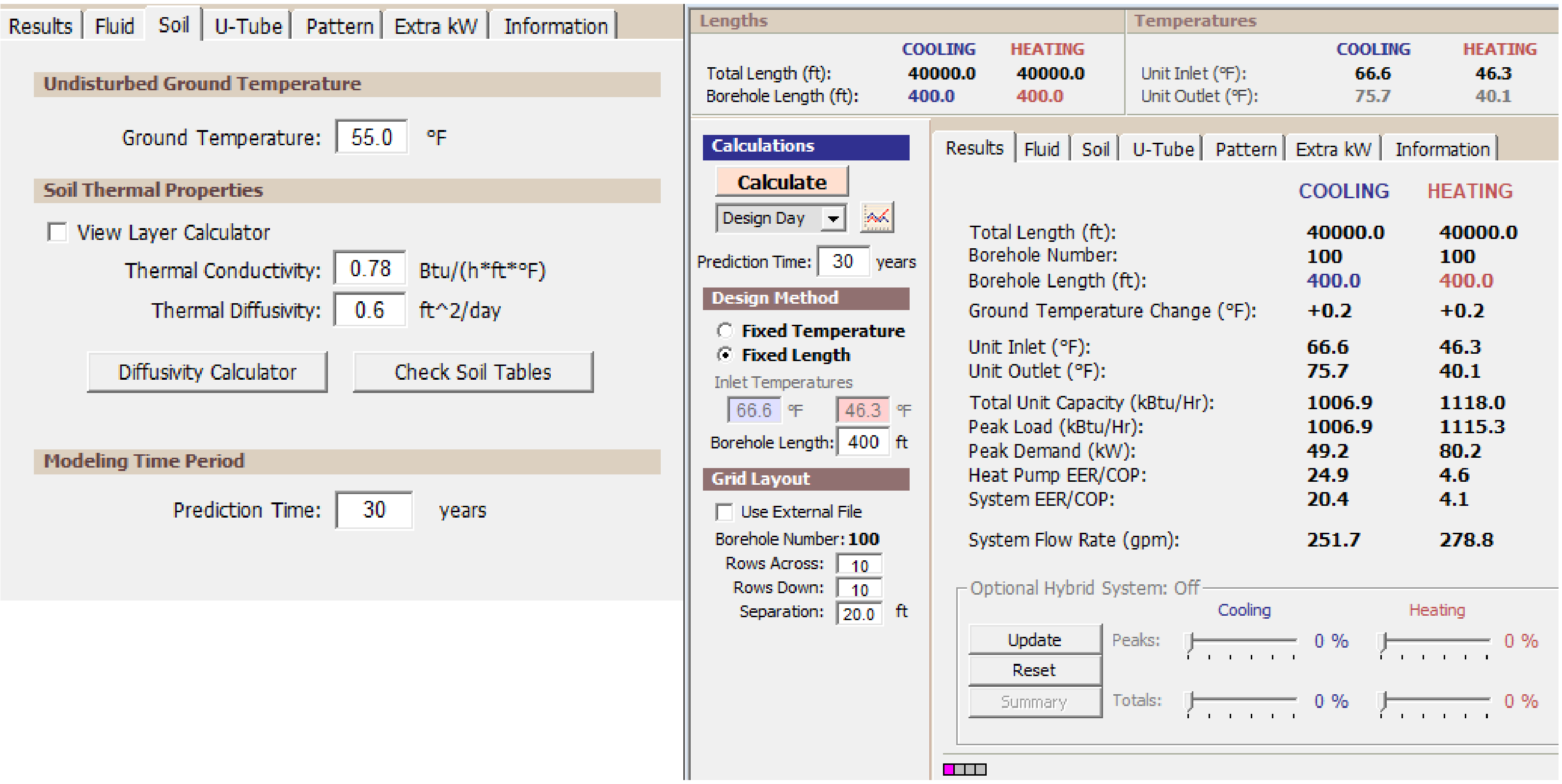
Russell
400' Depth, 100 bores, 20' spacing, .85 grout

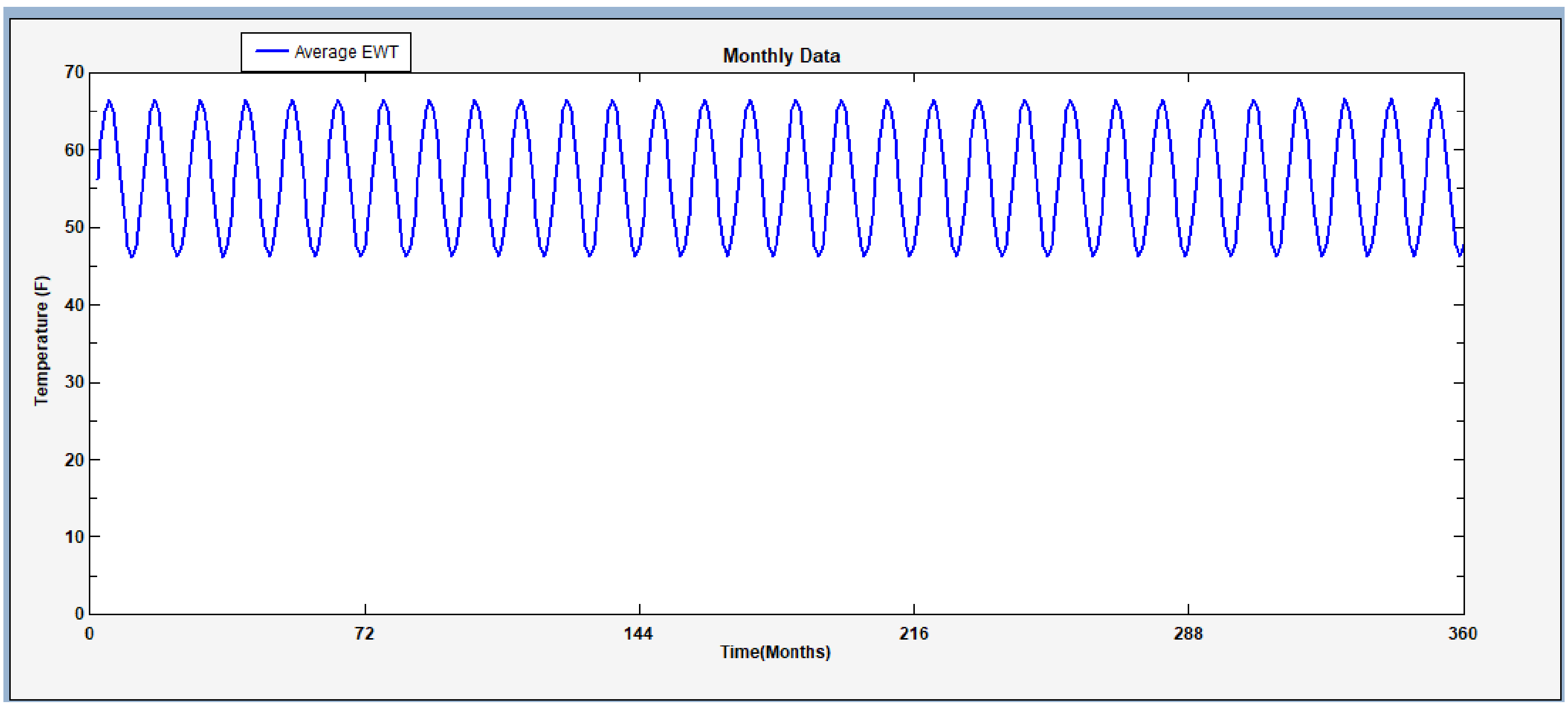




This is preferred field size. HP outlet is greater than 40 degrees in heating. No risk of freezing.

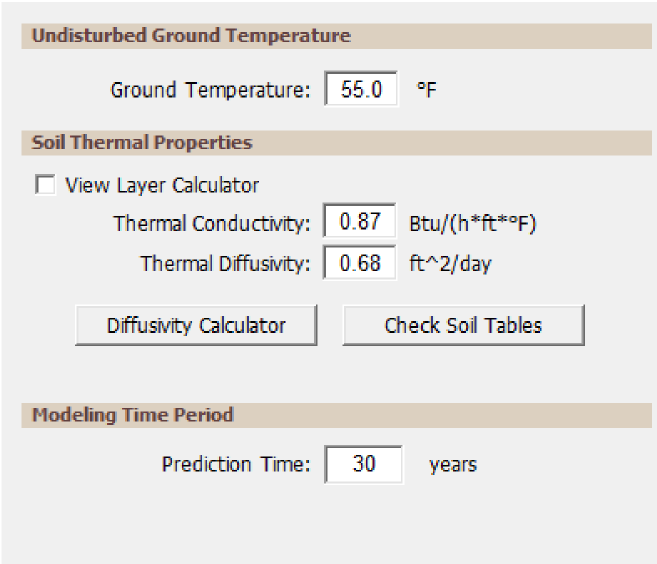
Shaver
400' Depth, 100 bores, 20' spacing

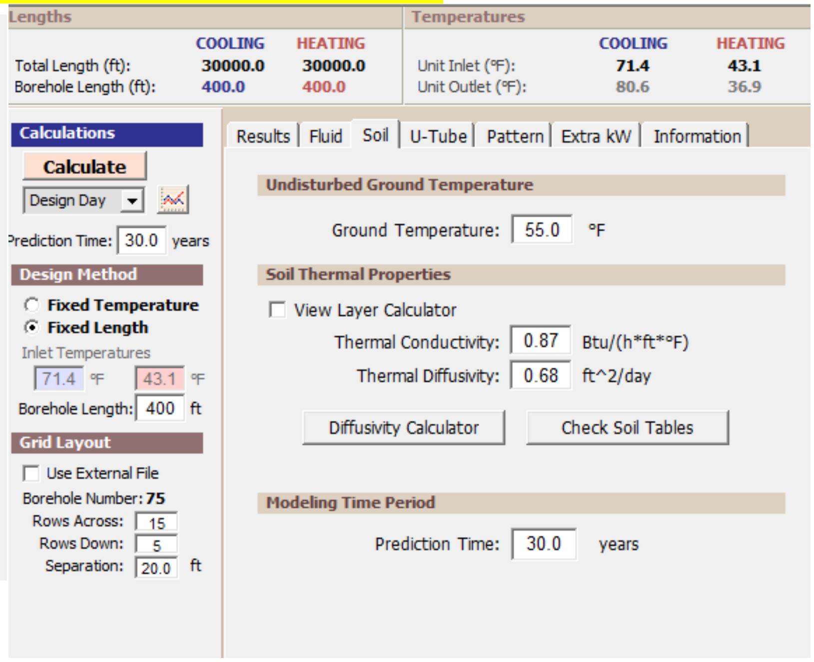


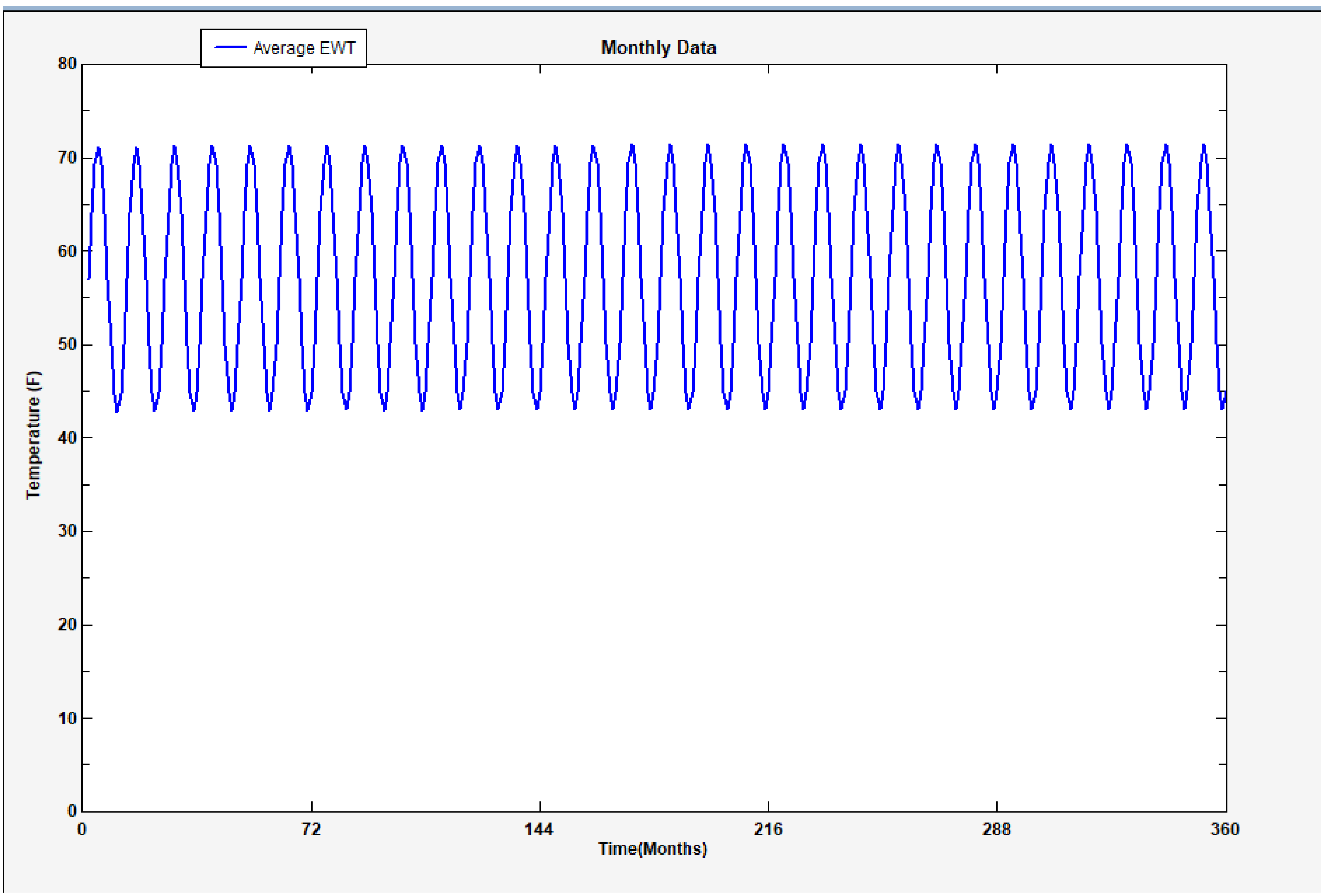


This is preferred field size. HP outlet is greater than 40 degrees in heating. No risk of freezing.

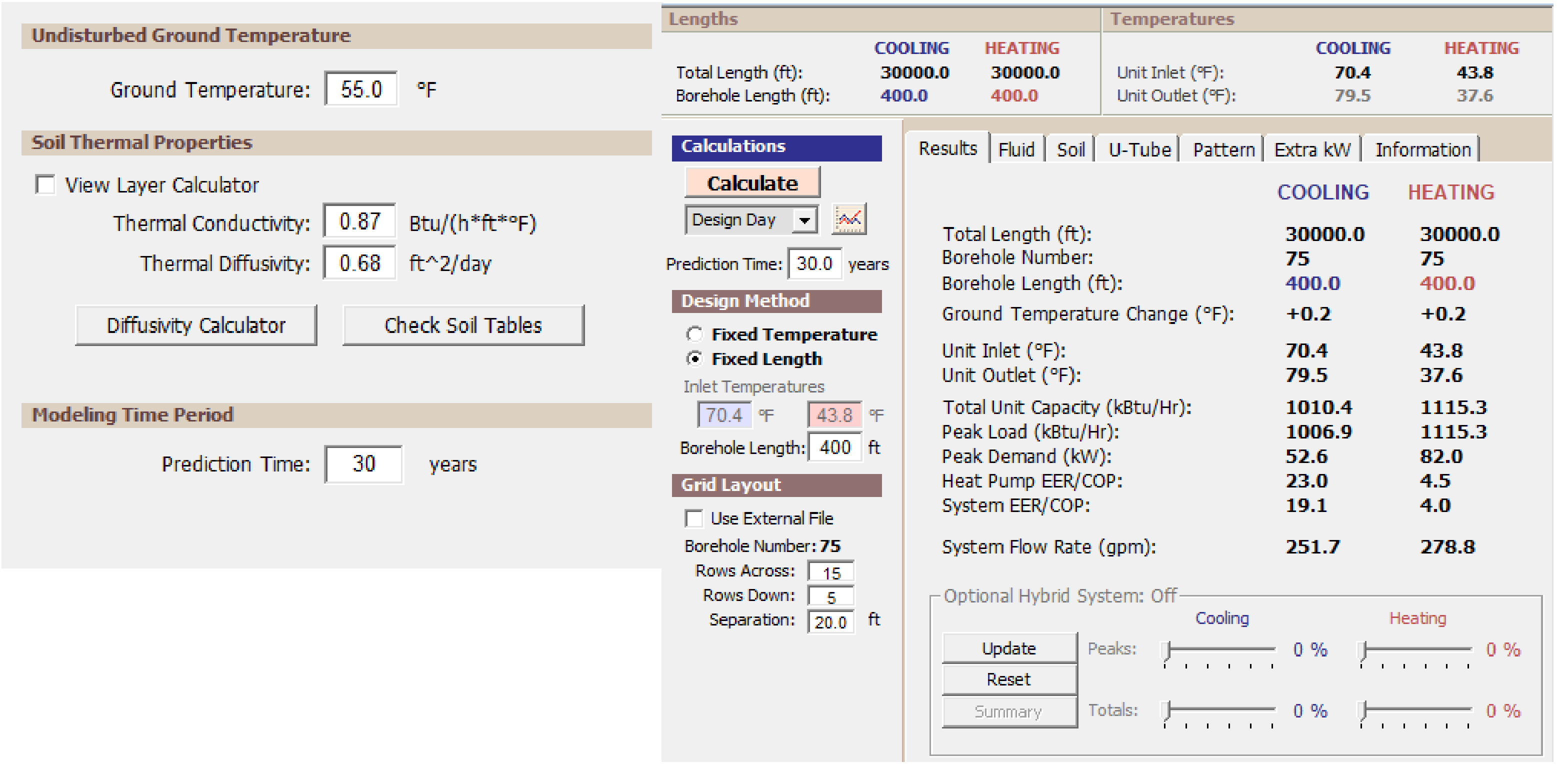
Russell
400' Depth, 75 bores, 20' spacing, .85 grout

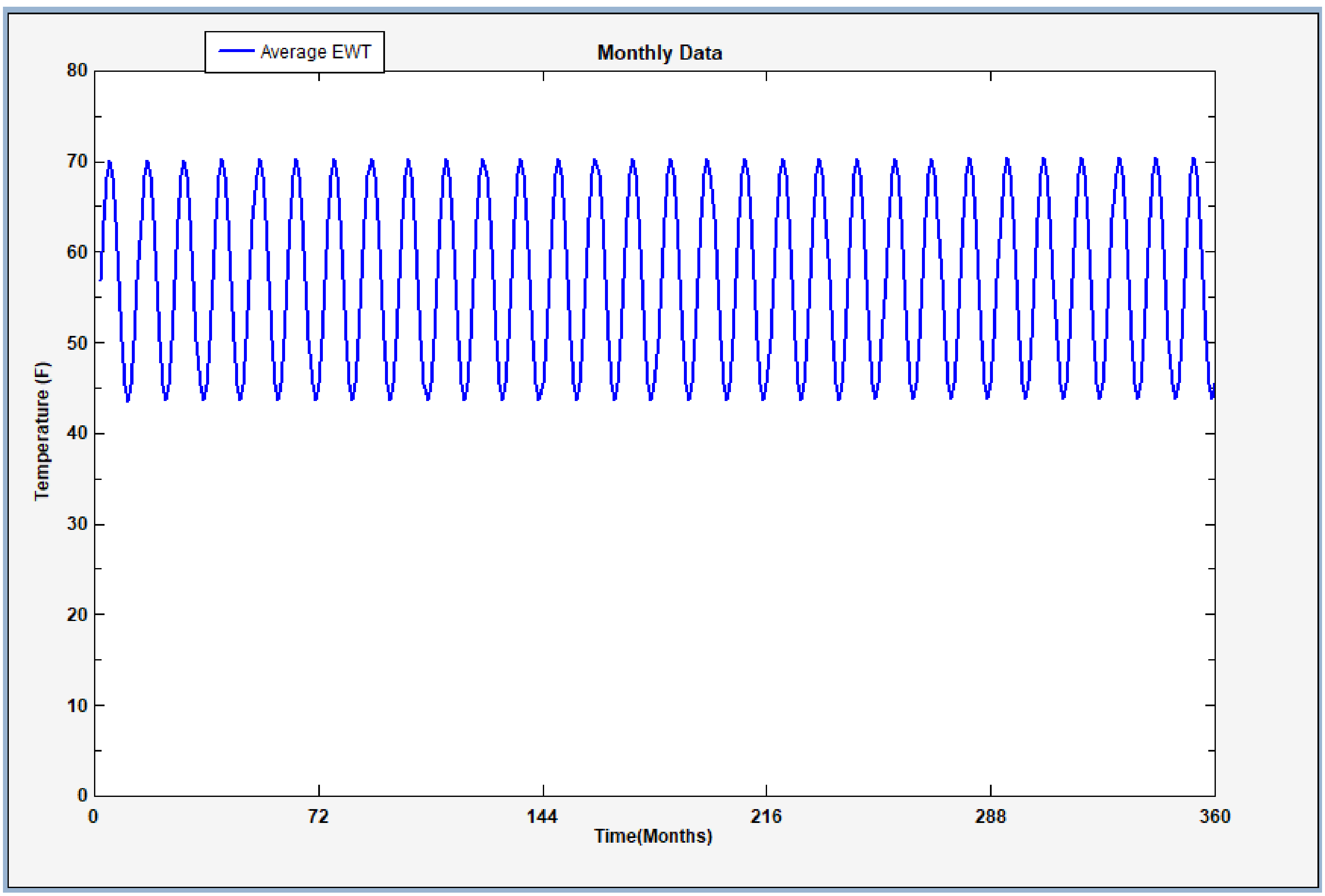




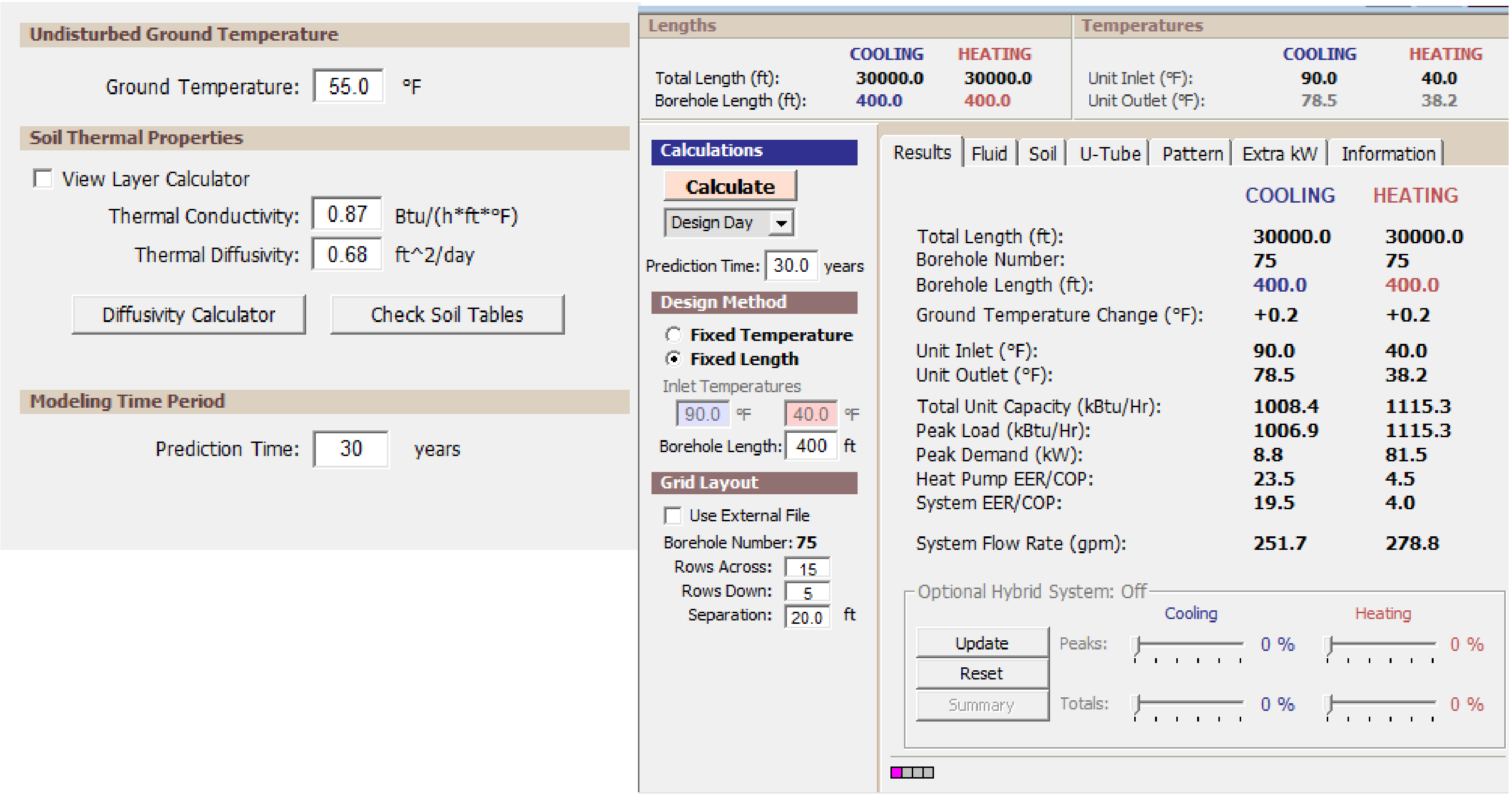


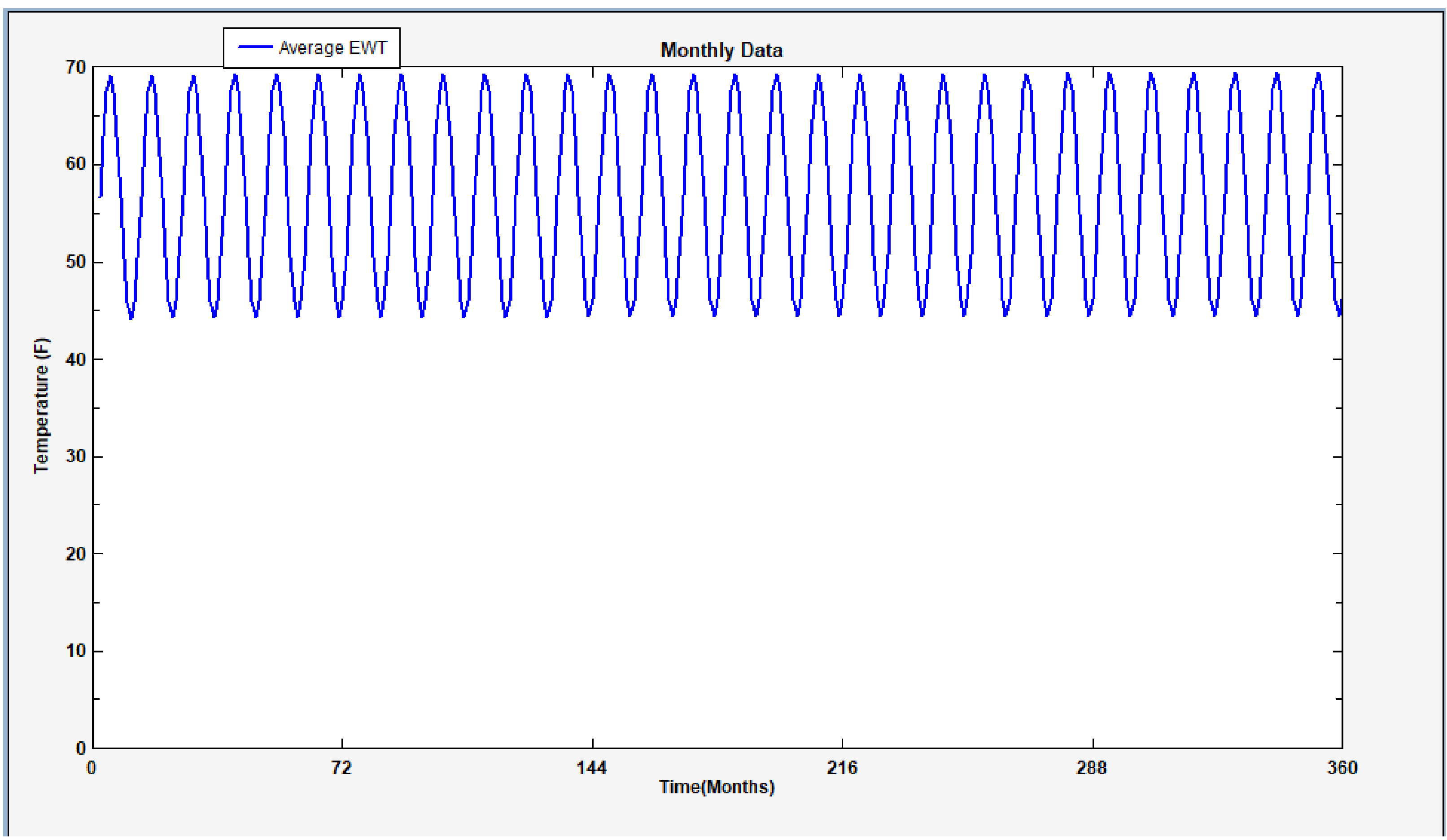
Russell
400' Depth, 75 bores, 20' spacing, 1.0 grout





Russell
400' Depth, 75 bores, 20' spacing, 1.2 grout





Russell
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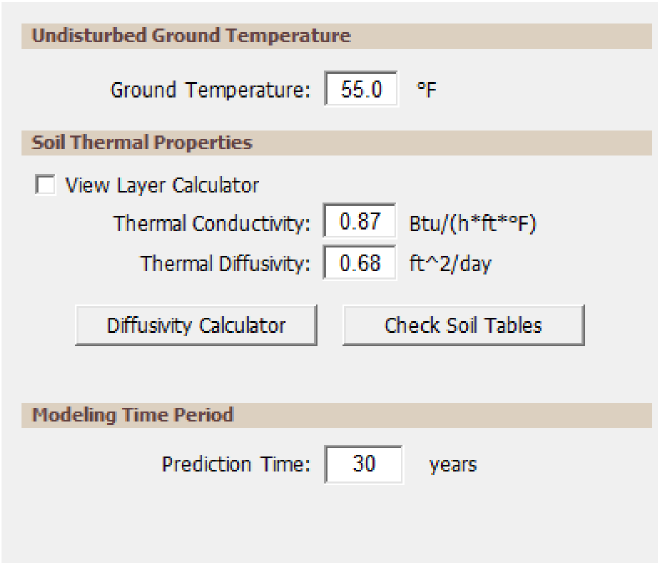
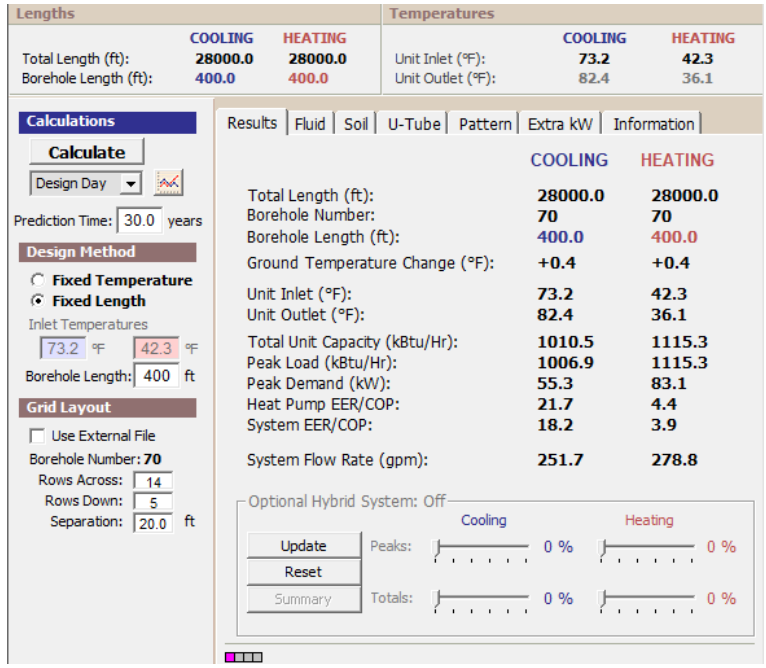
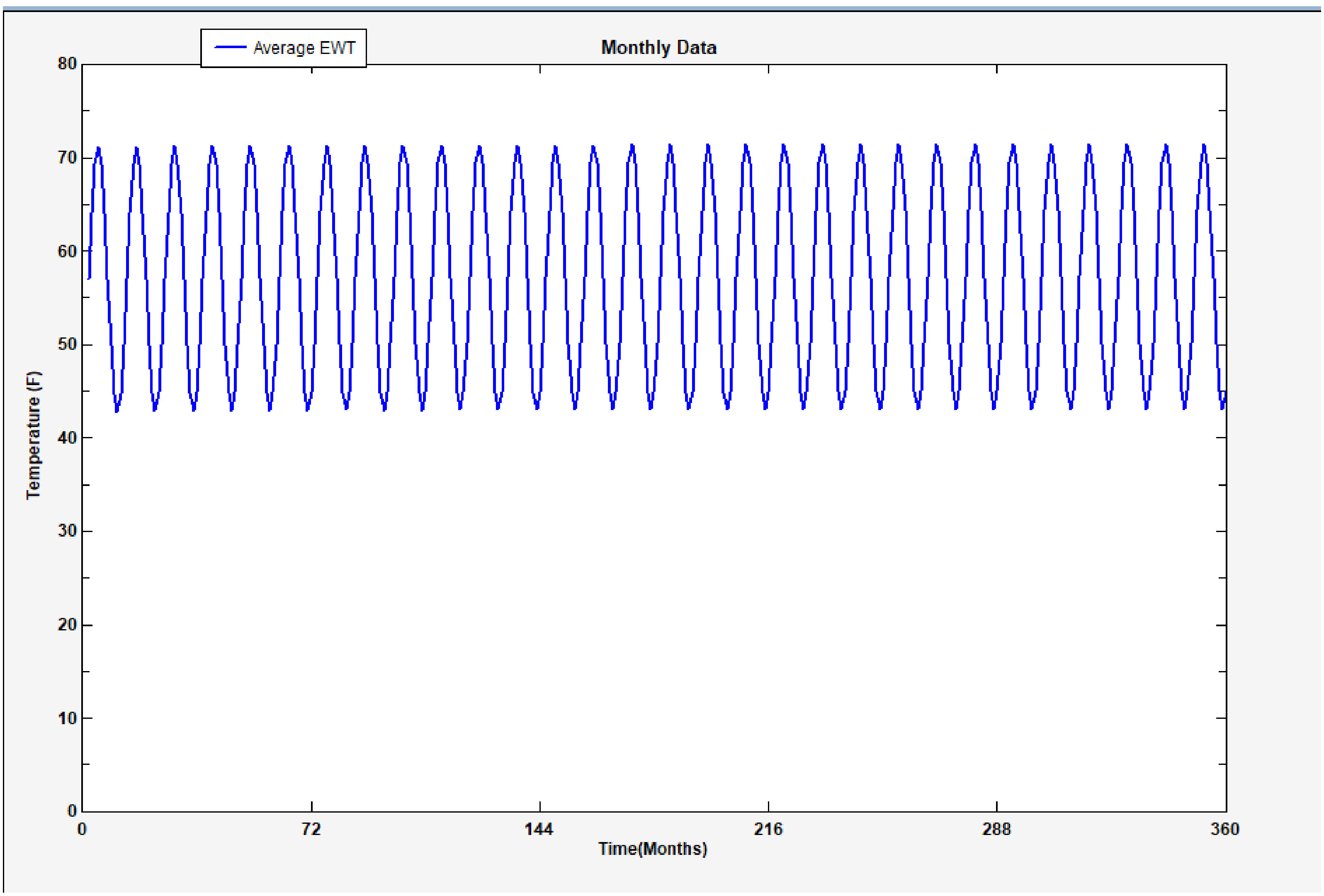
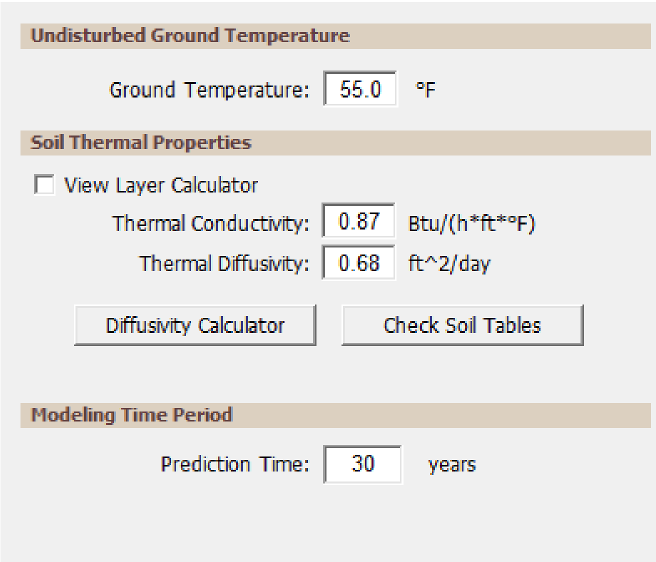


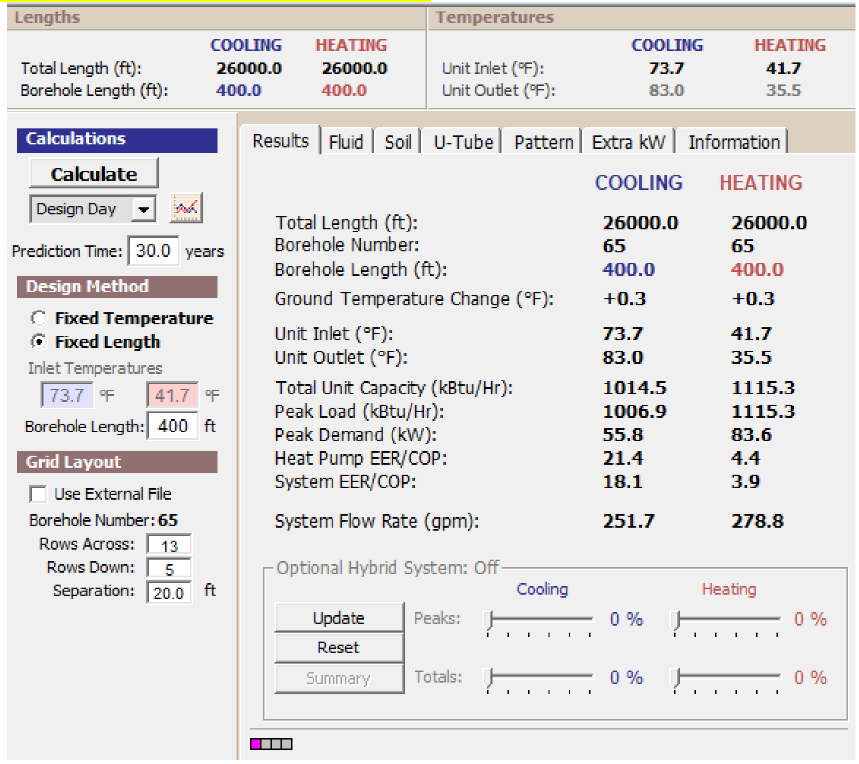


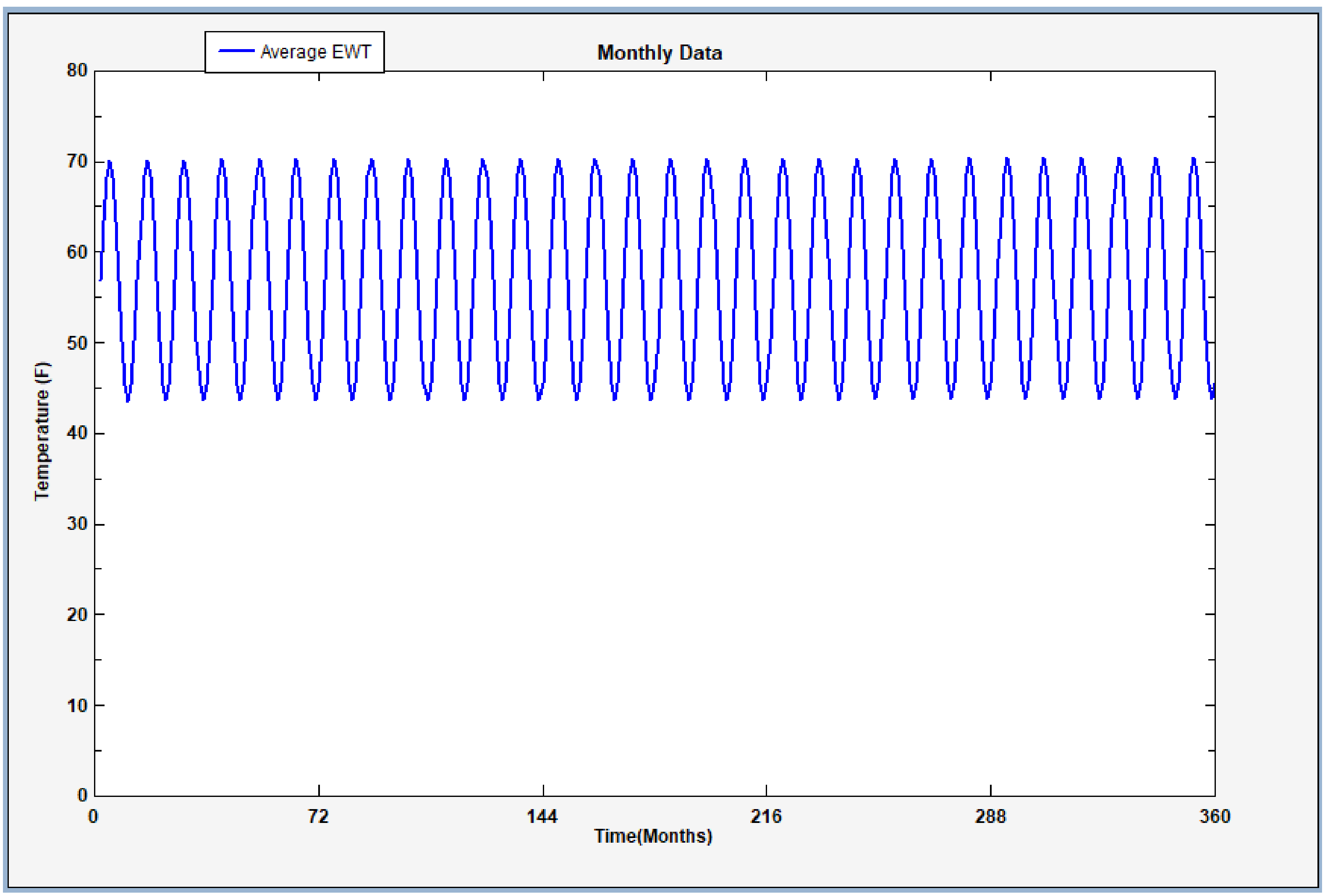


Russell
400' Depth, 65 bores, 20' spacing, 1.0 grout

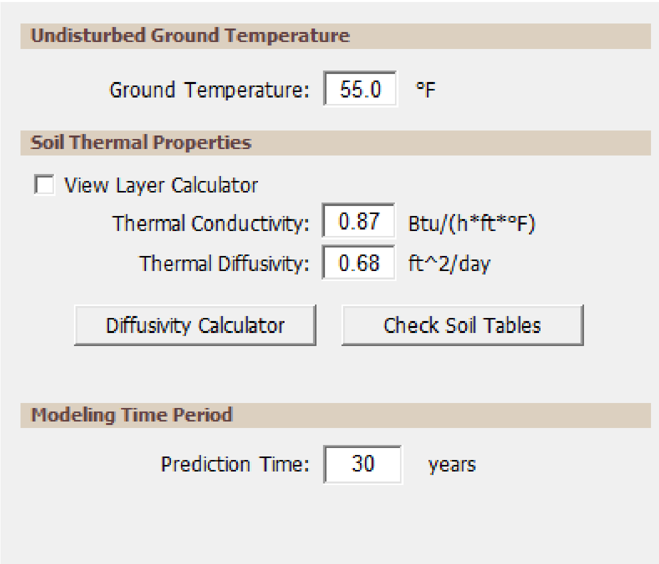
Likely need 67 bores to hit unit outlet of 36

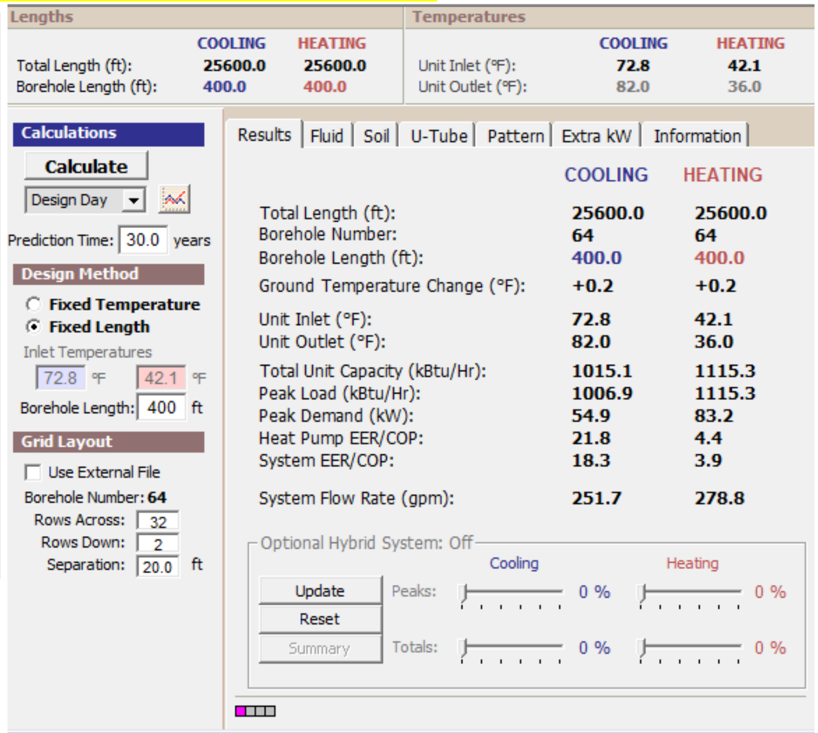


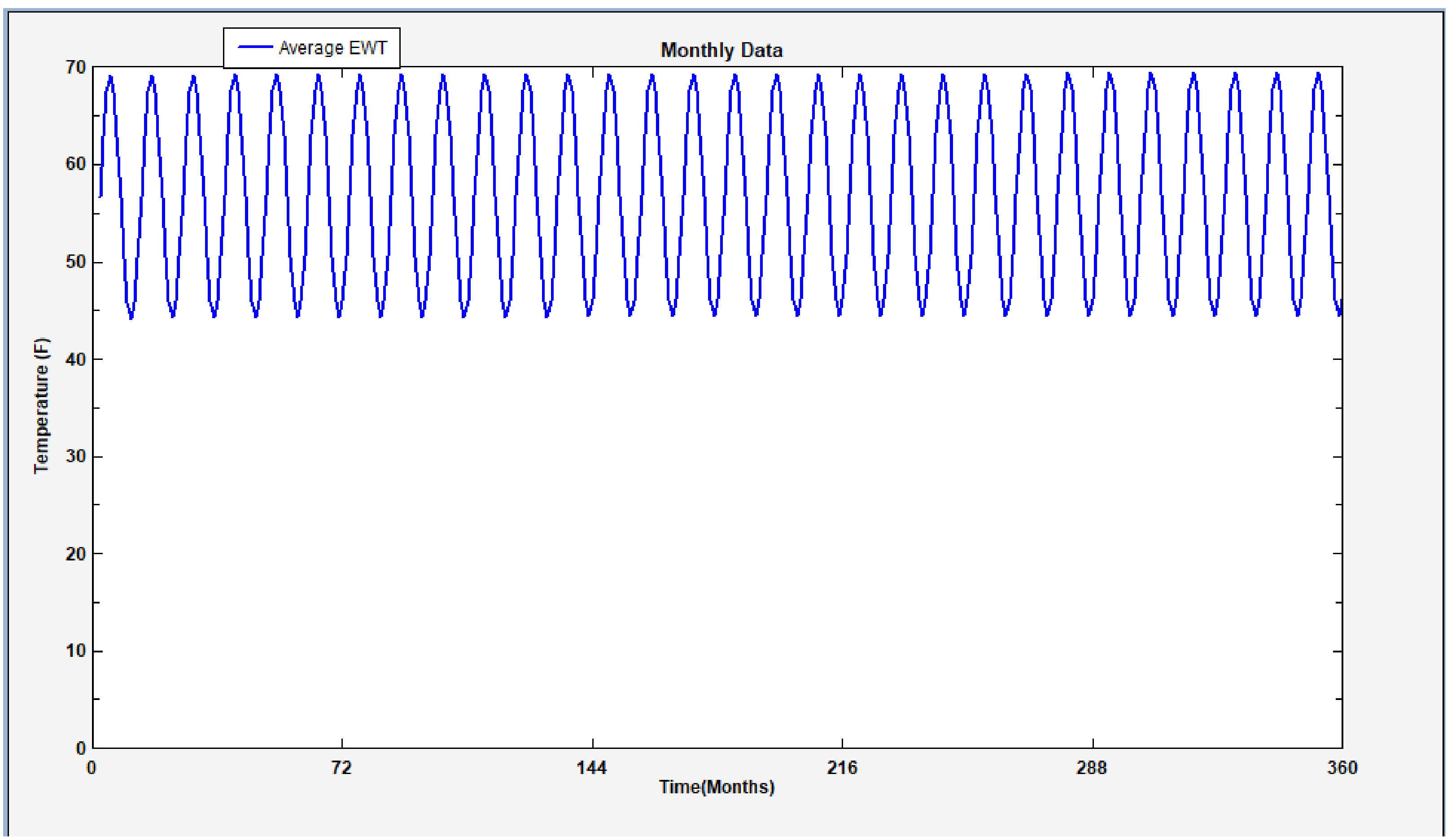




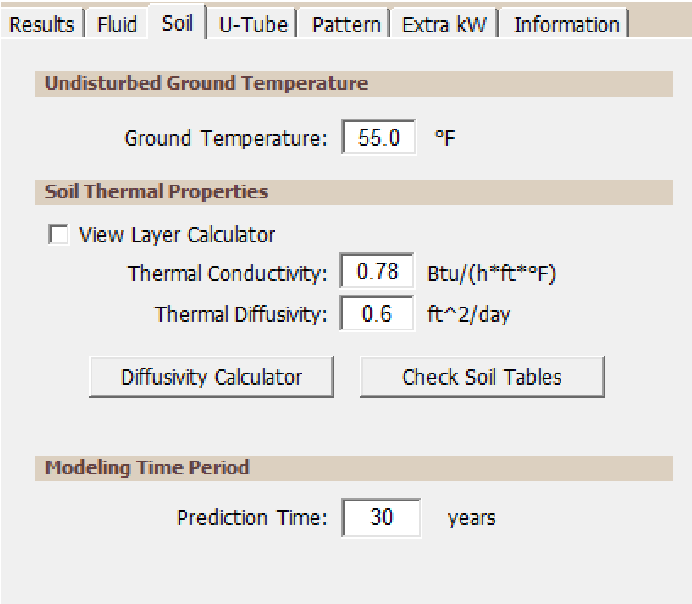
Russell
400' Depth, 64 bores, 20' spacing, 1.2 grout

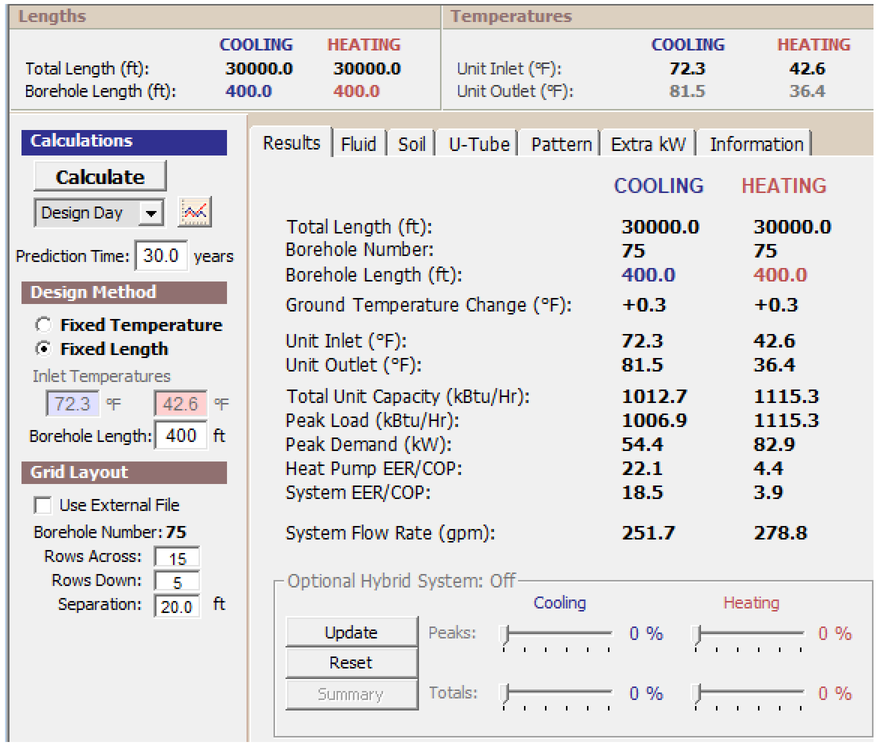




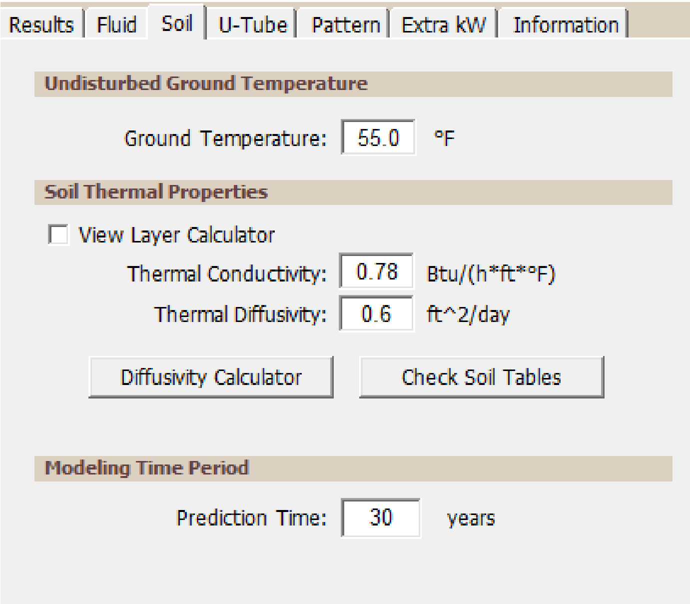


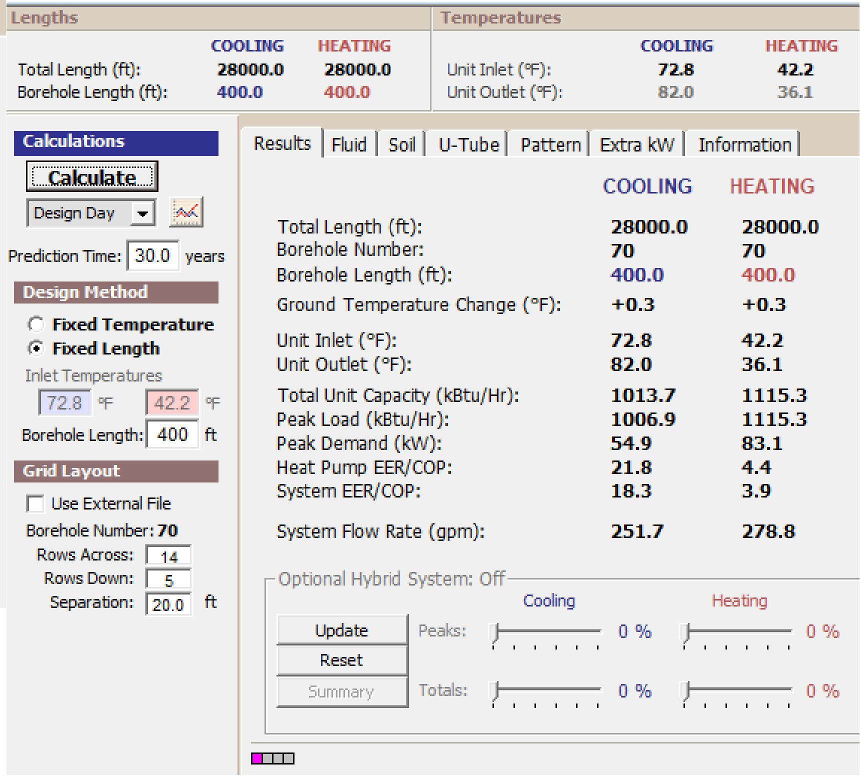
Shaver
400' Depth, 75 bores, 20' spacing, .85 grout





Shaver
400' Depth, 70 bores, 20' spacing, 1 grout





Shaver
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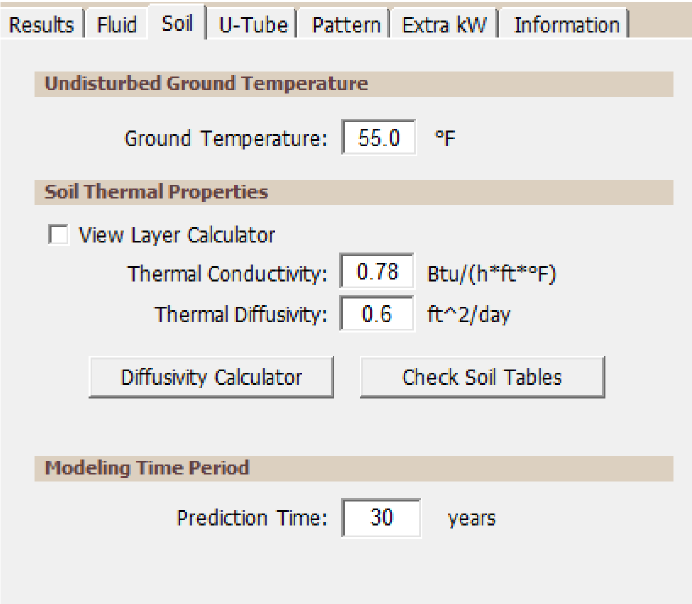

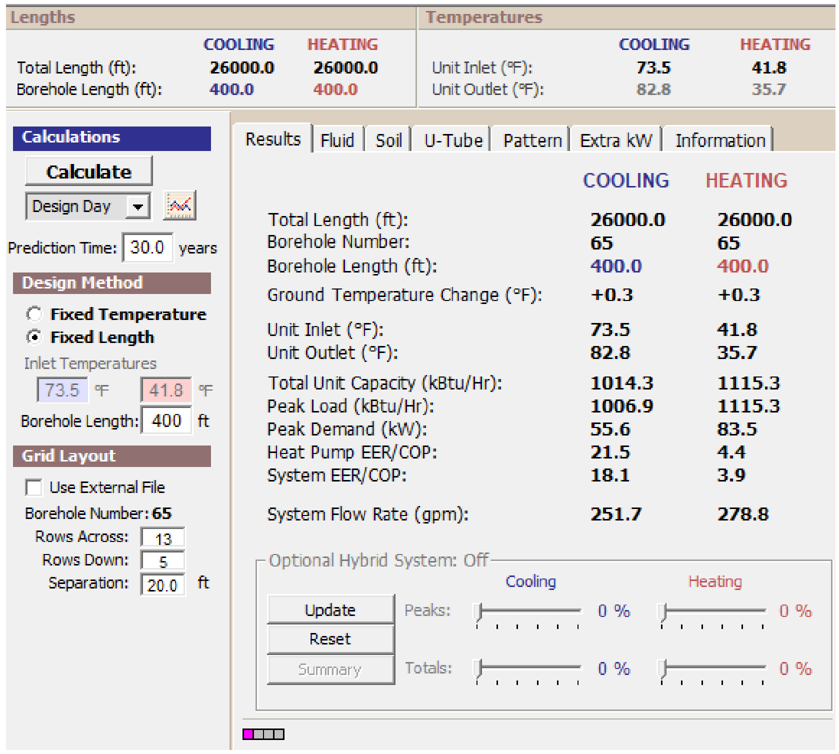

STATE OF OREGON
CLOSED LOOP GROUND SOURCE
HEAT PUMP BORING
(as required by OAR 690-240-0035)

MULT 143599

8/19/2025

(1) OWNER/PROJECT

Hole Number FTC

PROJECT NAME/NBR: G25-05-PARKROSE SD-SHAVER ELEM

First Name
Last Name
Company PARKROSE SCHOOL DISTRICT
Address 10636 NE PRESCOTT
City PORTLAND State OR Zip 97220

(2) TYPE OF WORK

[X] New [ ] Deepening [ ] Abandonment
[ ] Alteration (repair/recondition)

(3) CONSTRUCTION

[ ] Rotary Air [ ] Hand Auger [ ] Hollow stem auger
[X] Rotary Mud [ ] Cable [ ] Push Probe
[ ] Other

(4) TYPE OF HOLE:

( ) Cased Permanent
(•) Uncased Permanent

(5) BORE HOLE CONSTRUCTION

Special Standard [X] (Attach copy)

Depth of Completed Hole 412.00 ft.

Grout additives used **Power tec graphite as per special standard**

BORE HOLE Dia	From	To	Grout Material	From	To	Amt	sacks/lbs
5.5	0	412	Bentonite Grout	0	412	24	S

(6) CASING/LOOP

Casing	Loop	Dia	+	From	To
( )	(•)	1.25	[ ]	0	370

(7) LOCATION OF HOLE (legal description)

County MULTNOMAH Twp 1.00 N N/S Range 2.00 E E/W WM
Sec 23 SE 1/4 of the SW 1/4 Tax Lot 2000
Tax Map Number Lot
Lat ° ' " or 45.54878300 DMS or DD
Long ° ' " or -122.52846200 DMS or DD
(•) Street address of hole ( ) Nearest address

3701 NE 131ST, PORTLAND, OR 97230

(8) SUBSURFACE LOG

Material	From	To
top soil	0	1
clay brwn silty	1	13
gravels w/clay	13	18
gravels & cobbles very loose	18	76
sand & gravels tight	76	102
gravels & cobbles w/some boulders	102	260
sand cemented w/gray clay	260	294
gravels & cobbles	294	364
clay gray sticky	364	412

Date Started 7/31/2025 Completed 8/6/2025

Professional Certification (to be signed by an Oregon licensed water or monitoring well constructor, Oregon registered geologist or professional engineer).

I accept responsibility for the construction, deepening, alteration, or abandonment work performed during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License/Registration Number 1483 Date 8/19/2025

First Name JOHN Last Name STADELI
Affiliation

Comments/Remarks

ORIGINAL - WATER RESOURCES DEPARTMENT
THIS REPORT MUST BE SUBMITTED TO THE WATER RESOURCES DEPARTMENT WITHIN 30 DAYS OF COMPLETION OF WORK

Form Version:

CLOSED LOOP GROUND SOURCE - Map with location identified must be attached and shall include an approximate scale and north arrow

MULT 143599

8/19/2025

Map of Hole

STATE OF OREGON
WELL LOCATION MAP

This map is supplemental to the WATER SUPPLY WELL REPORT

Oregon Water Resources Department
725 Summer St NE, Salem OR 97301
(503)986-0900

LOCATION OF WELL

Latitude: 45.54878300 Datum: WGS84

Longitude: -122.52846200

Township/Range/Section/Quarter-Quarter Section:
WM1.00N2.00E23SESW

Address of Well:
3701 NE 131ST, PORTLAND, OR 97230

Hole Nbr: FTC

Printed: August 18, 2025

DISCLAIMER: This map is intended to represent the approximate location the well. It is not intended to be construed as survey accurate in any manner.

Provided by well constructor

STATE OF OREGON
CLOSED LOOP GROUND SOURCE
HEAT PUMP BORING
(as required by OAR 690-240-0035)

MULT 143514

8/7/2025

(1) OWNER/PROJECT

Hole Number: FTC

PROJECT NAME/NBR: G25-05-PARKROSE SD

First Name:
Last Name:
Company: PARKROSE SCHOOL DISTRICT
Address: 10636 NE PRESCOTT
City: PORTLAND State: OR Zip: 97220

(2) TYPE OF WORK

[X] New [ ] Deepening [ ] Abandonment
[ ] Alteration (repair/recondition)

(3) CONSTRUCTION

[ ] Rotary Air [ ] Hand Auger [ ] Hollow stem auger
[X] Rotary Mud [ ] Cable [ ] Push Probe
[ ] Other

(4) TYPE OF HOLE:

( ) Cased Permanent
(•) Uncased Permanent

(5) BORE HOLE CONSTRUCTION

Special Standard [X] (Attach copy)

Depth of Completed Hole 413.00 ft.

Grout additives used **Power tec graphite as per special standard**

BORE HOLE Dia	From	To	Material	Grout Material From	To	Amt	sacks/ lbs
5.5	0	413	Bentonite Grout	0	413	24	S

(6) CASING/LOOP

Casing	Loop	Dia	+	From	To
( )	(•)	1.25	[X]	0.5	405

(7) LOCATION OF HOLE (legal description)

County MULTNOMAH Twp 1.00 N N/S Range 2.00 E E/W WM
Sec 26 SE 1/4 of the NW 1/4 Tax Lot 8100
Tax Map Number Lot
Lat ° ' " or 45.54151100 DMS or DD
Long ° ' " or -122.52963500 DMS or DD
(•) Street address of hole ( ) Nearest address

2700 NE 127TH AVE, PORTLAND, OR 97230

(8) SUBSURFACE LOG

Material	From	To
top soil	0	1
clay brwn w/cobbles & gravel	1	4
gravels & cobbles tight	4	15
silty sand&gravels tight w/occ cobbles&boulders	15	192
cobbles & boulders intermittently tight & loose	192	285
same as above but rougher	285	308
sand & gravel w/boulders	308	383
clay gray sticky	383	413

Date Started 7/17/2025 Completed 7/23/2025

Professional Certification (to be signed by an Oregon licensed water or monitoring well constructor, Oregon registered geologist or professional engineer).

I accept responsibility for the construction, deepening, alteration, or abandonment work performed during the construction dates reported above. All work performed during this time is in compliance with Oregon geotechnical hole construction standards. This report is true to the best of my knowledge and belief.

License/Registration Number 1483 Date 8/7/2025

First Name JOHN Last Name STADELI
Affiliation

Comments/Remarks

A lot of lost circulations from 192' to 383'

CLOSED LOOP GROUND SOURCE - Map with location identified must be attached and shall include an approximate scale and north arrow

MULT 143514

8/7/2025

Map of Hole

STATE OF OREGON
WELL LOCATION MAP
This map is supplemental to the WATER SUPPLY WELL REPORT

Oregon Water Resources Department
725 Summer St NE, Salem OR 97301
(503)986-0900

OREGON WATER RESOURCES DEPARTMENT

LOCATION OF WELL

Latitude: 45.54151100 Datum: WGS84
Longitude: -122.52963500
Township/Range/Section/Quarter-Quarter Section:
WM1.00N2.00E26SENW
Address of Well:
2700 NE 127TH AVE, PORTLAND, OR 97230

Label: none

Printed: August 7, 2025

DISCLAIMER: This map is intended to represent the approximate location the well. It is not intended to be construed as survey accurate in any manner.

Provided by well constructor