
The CONDENSATE DRAIN moves water out of the school's HVAC system. When cooling equipment is working, moisture in the air accumulates from the temperature change, the same way that water collects on the outside of a cold glass. These pipes drain this condensation away from the equipment and out of the building!
duct feeds air to the Energy Recovery Unit on the roof, which helps hang on to heat from the exhausted air, saving energy.
The purple and green GREYWATER PIPES divert rainwater from the roof to the big gray greywater storage tank below.
FIRE PROTECTION PIPES carry and regulate water that will extinguish a fire in case of emergency. These pipes may look small, but they're helping to keep you safe!
SUPPLY AIR DUCTS pull fresh air from outside into the school's HVAC system. Once it's filtered and tempered by the DOAS unit, this air will be delivered to the classrooms. By the time it reaches you, the air will be fresh and comfortable!
DEDICATED OUTDOOR AIR SUPPLY (DOAS) units supply fresh air to the school. They filter, purify, and change the temperature of outside air before pushing it into the classrooms.
The GREYWATER STORAGE TANK holds rainwater that's collected from the roof. This water is pumped back up to the school's toilets for flushing. Using greywater helps to conserve natural resources!

# SYSTEMS

# HVAC Systems - What is Important to You?

## Results from ESBC Meeting 12/13/2022

**Higher Priority**

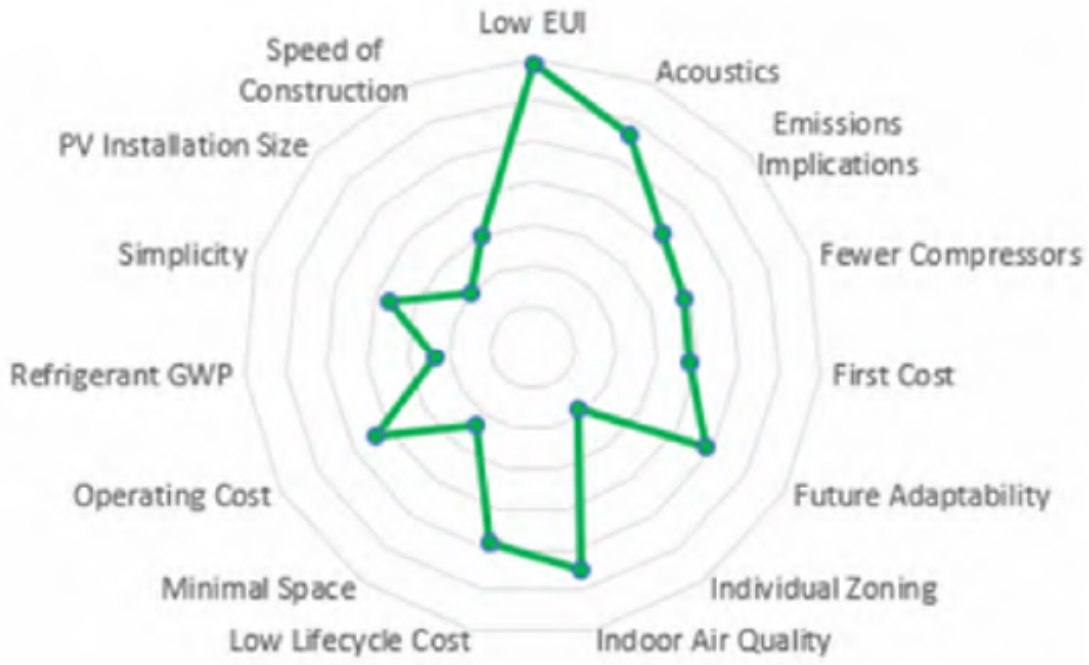
1. Low EUI
2. Acoustics
3. Indoor Air Quality
4. Lowest Life Cycle
5. Future Adaptability

**Medium Priority**

1. Operating Cost
2. Emissions Implications
3. First Cost
4. Fewer Compressors
5. Simplicity

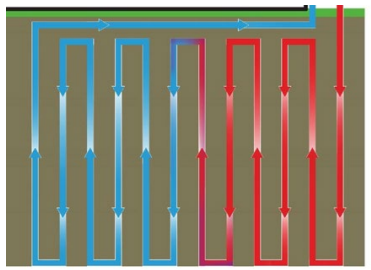
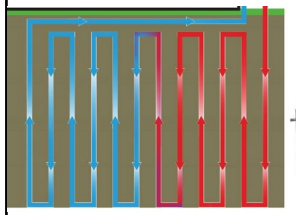
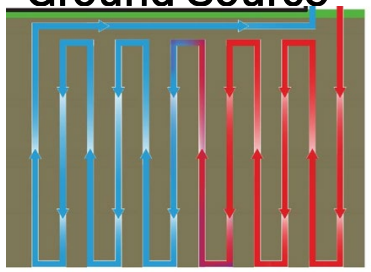
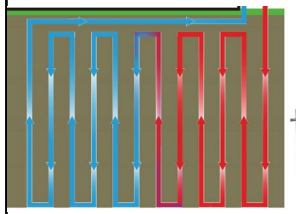
**Lower Priority**

1. Speed of Construction
2. Refrigerant Global Warming Potential
3. Minimal Space
4. PV Installation Site
5. Individual Zoning



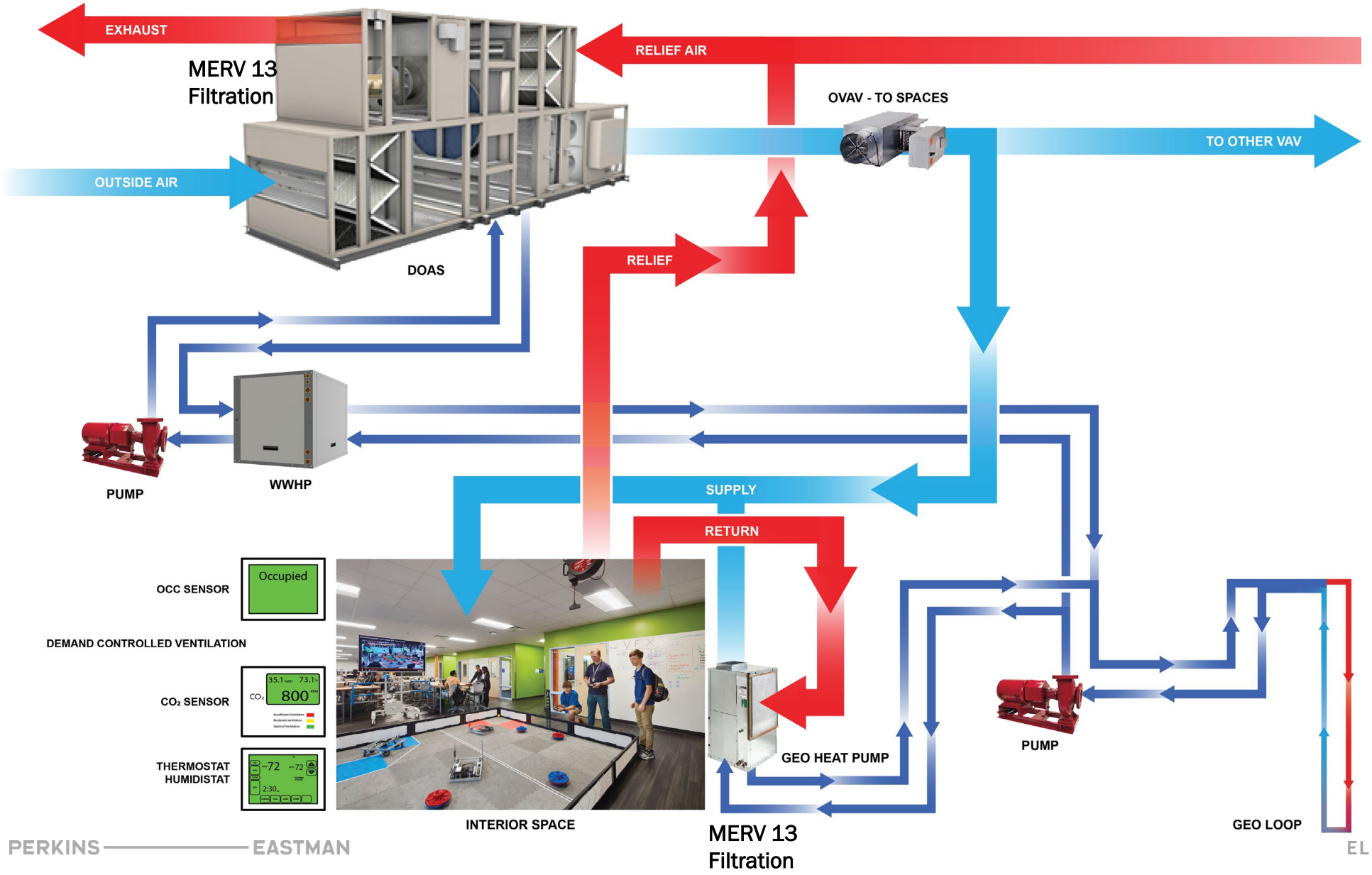

Each circle represents 0.5 point – the closer to the outer ring, the more important

# Recap - HVAC System Options

| | Option 1a – Electric GSHP | Option 1a - Electric VRF | Option 1c – Electric GSHP / ASHP | Option 2 Natural Gas Boilers, Chiller, VAV |
|---|---|---|---|---|
| Heating Source | Ground Source  | Air Source  | Ground & Air Source   |    |
| Cooling Source | Ground Source  | Air Source  | Ground & Air Source   |  |
| Distribution | Heat Pump Unit  | Ceiling Cassette  | Heat Pump Unit  |  |


# Distributed Ground Source Heat Pumps

# Distributed Ground Source Heat Pumps




How is this different than the Library System?

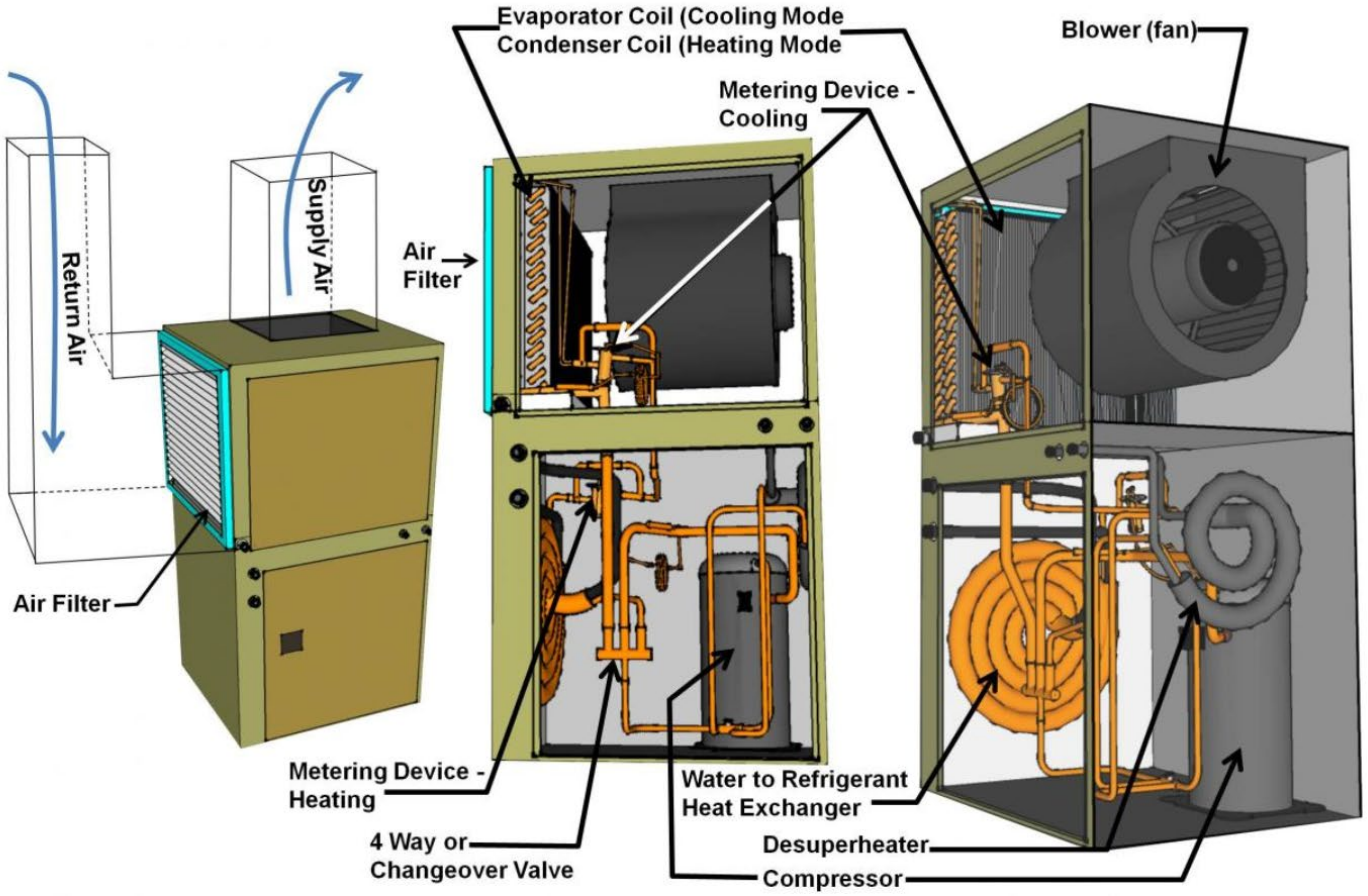
Tour of Buckley ES

# Distributed Ground Source Heat Pumps

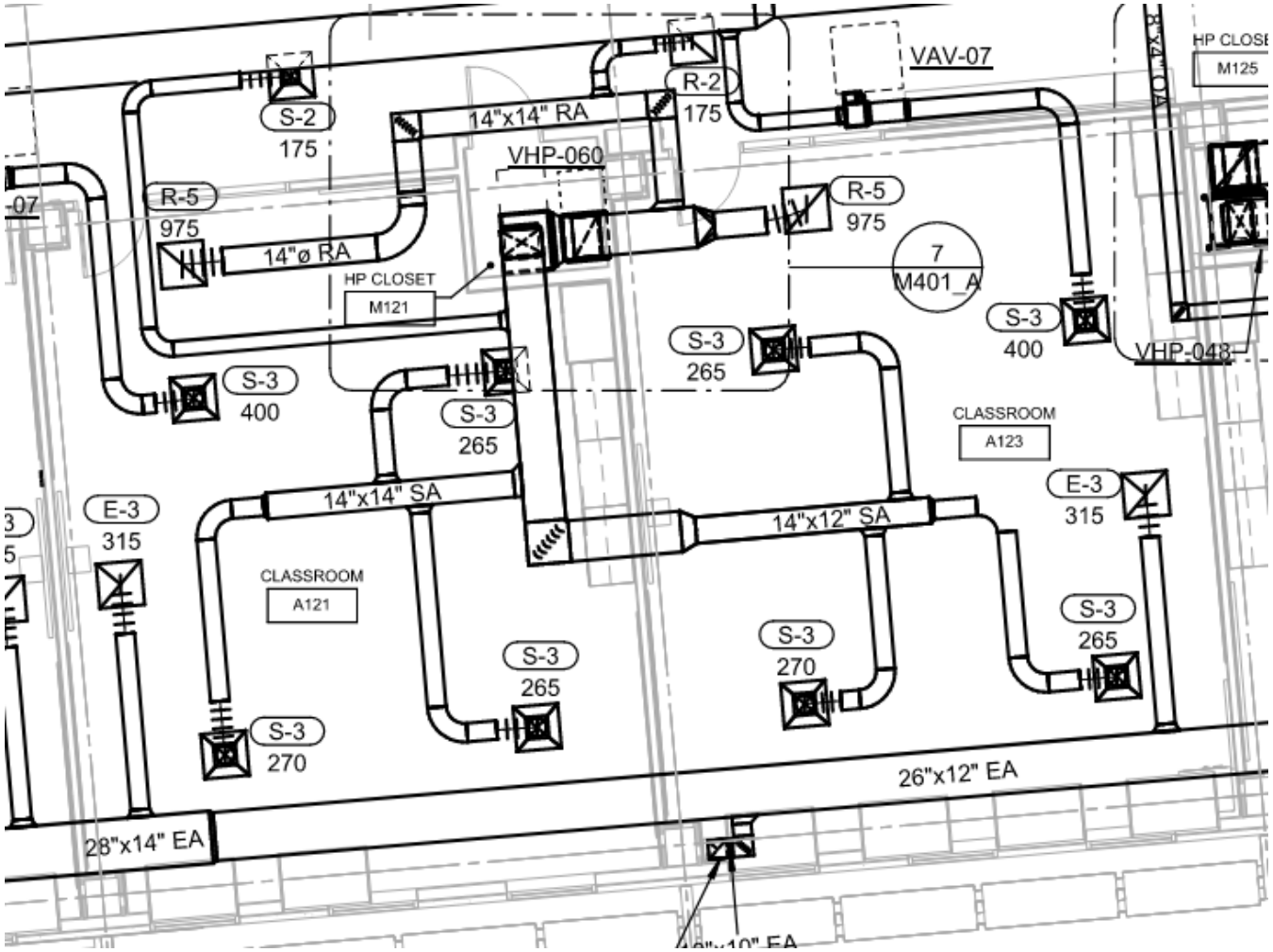
**Vertical Heat Pumps**
Ducted, Concealed
¾ - 6 ton capacities
MERV 13 Filter Options

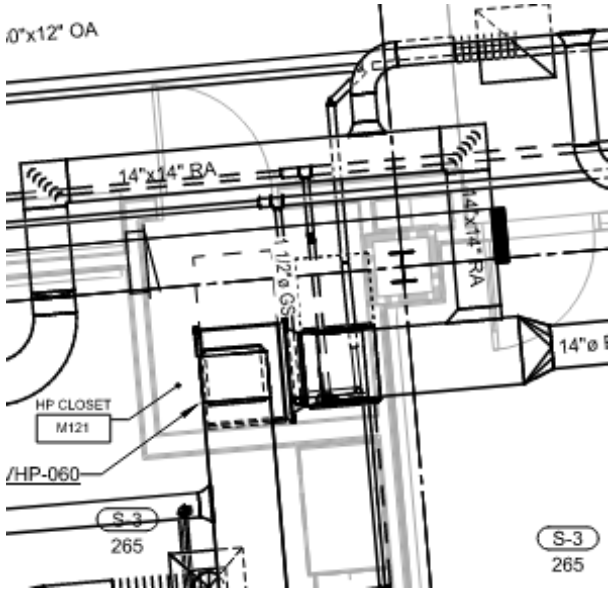
**Horizontal Heat Pumps**
Ducted, Concealed
¾ - 6 ton capacities
MERV 13 Filter Options

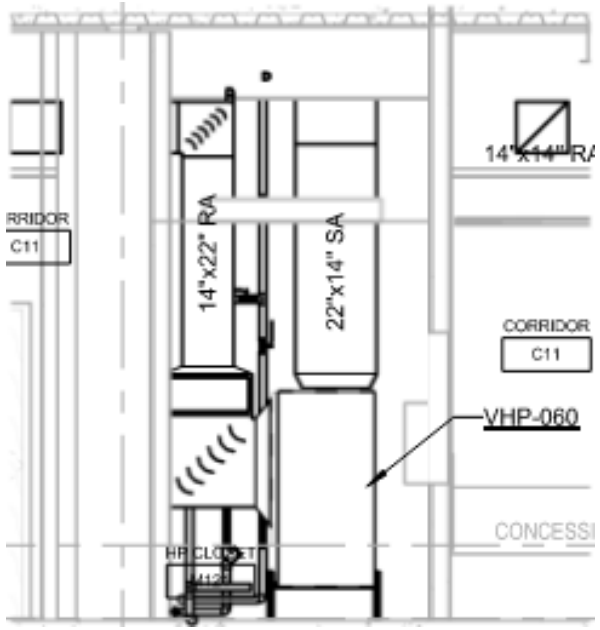
**Large Vertical Heat Pumps**
Ducted, Concealed
6 - 25 ton capacities
MERV 13 Filter Options

# Distributed Ground Source Heat Pumps

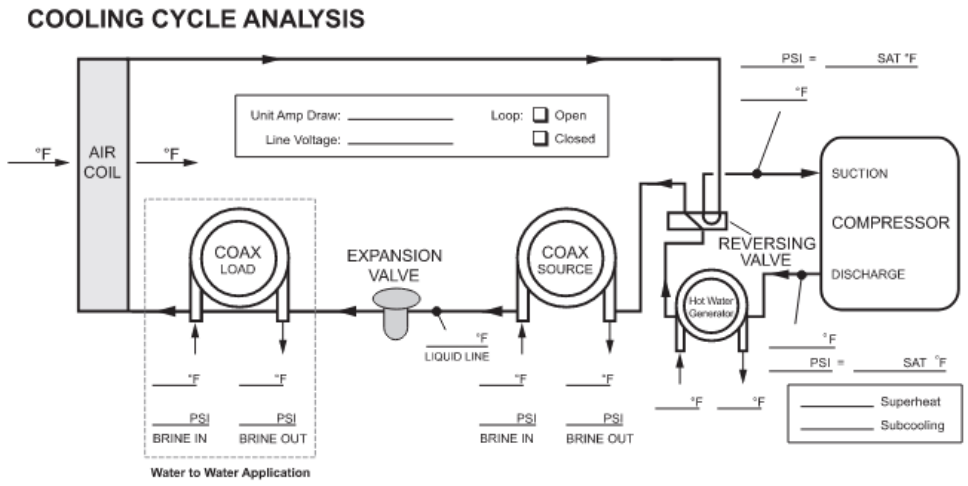


# Maintenance Considerations – Ground Source Heat Pumps

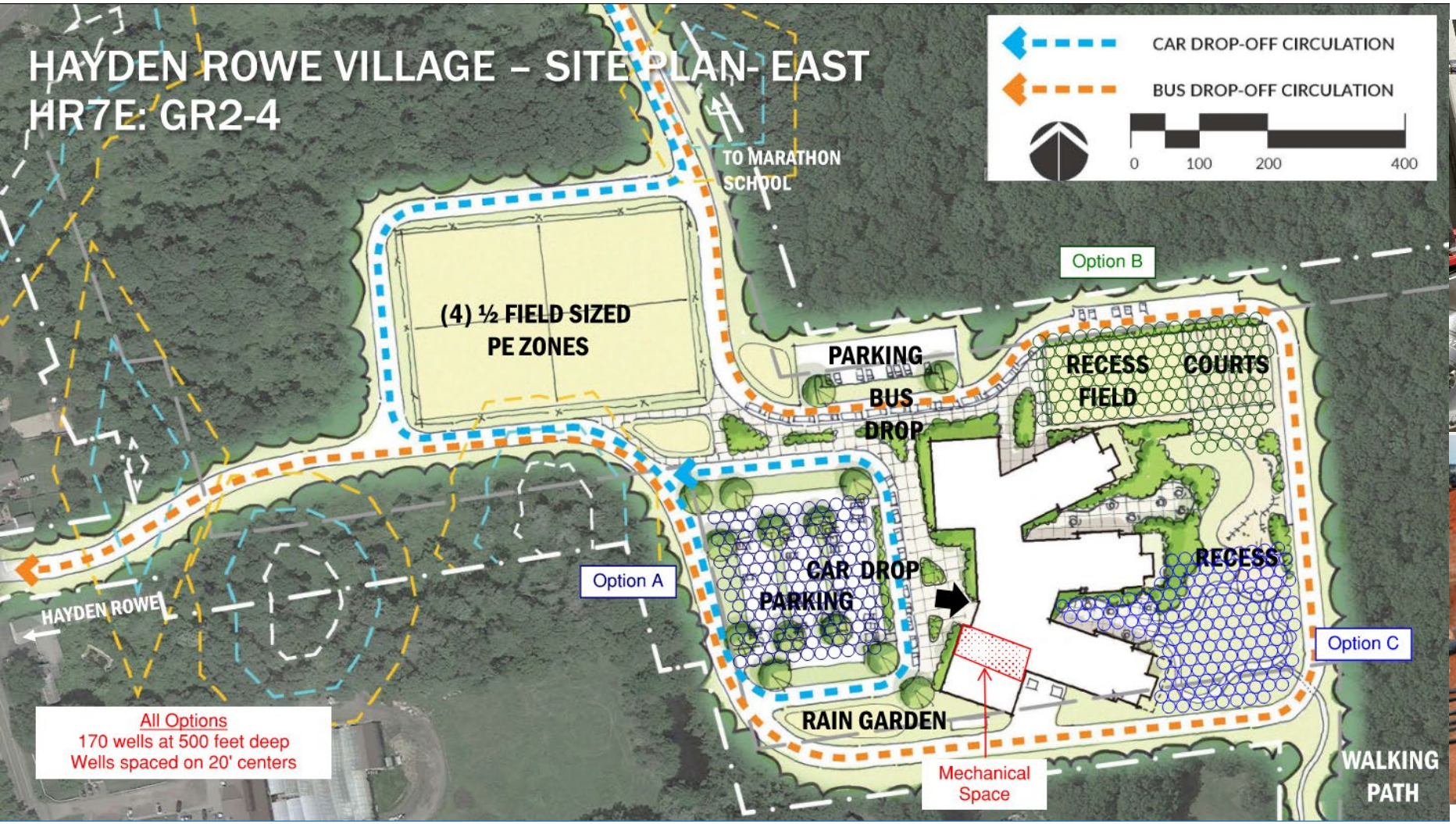
1. **Standard Filter Size – 24”x24” – Replace on district standard schedule**
2. **Drain Pan and Evaporator Coil – Clean on district standard schedule**
3. **Fan/EC Motor – Direct drive, sealed ball bearings, no belts, no lubrication**
4. **Condenser Coil – 2-way, 2-position water flow control valve. Keep closed loop pressurized, treated and air free. Anti-freeze optional.**
5. **Warranty – One year + 2nd-5th year compressor parts (can customize)**
6. **Refrigeration circuit with compressor, evaporator, condenser, expansion valve and reversing valve.**
7. **Typical trouble shooting diagrams for cooling cycle**




**Heat of Extraction/Rejection = GPM x 500 (485 for water/antifreeze) x ΔT**

**Note: DO NOT** hook up pressure gauges unless there appears to be a performance problem.

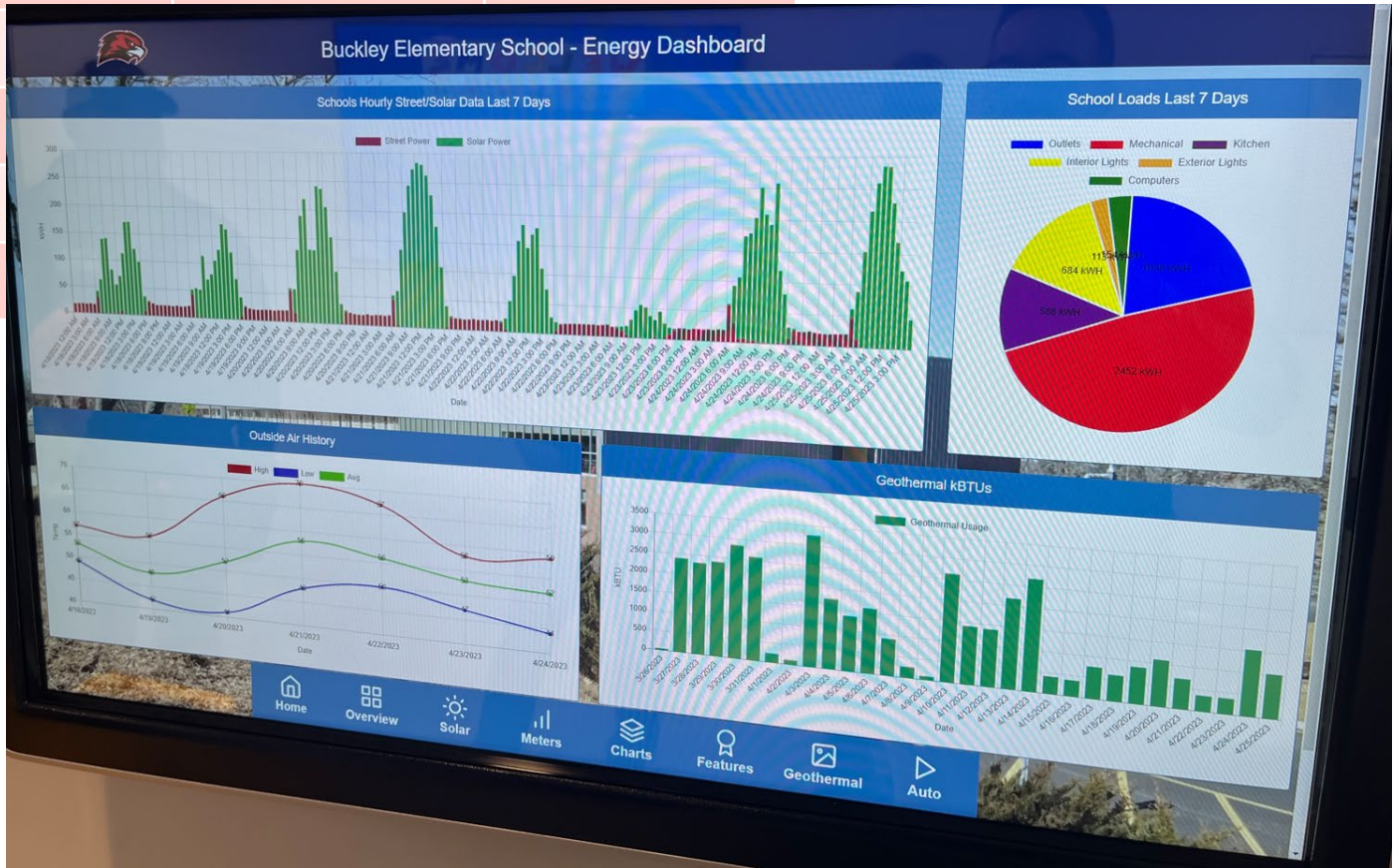
# Geothermal Wellfield Options



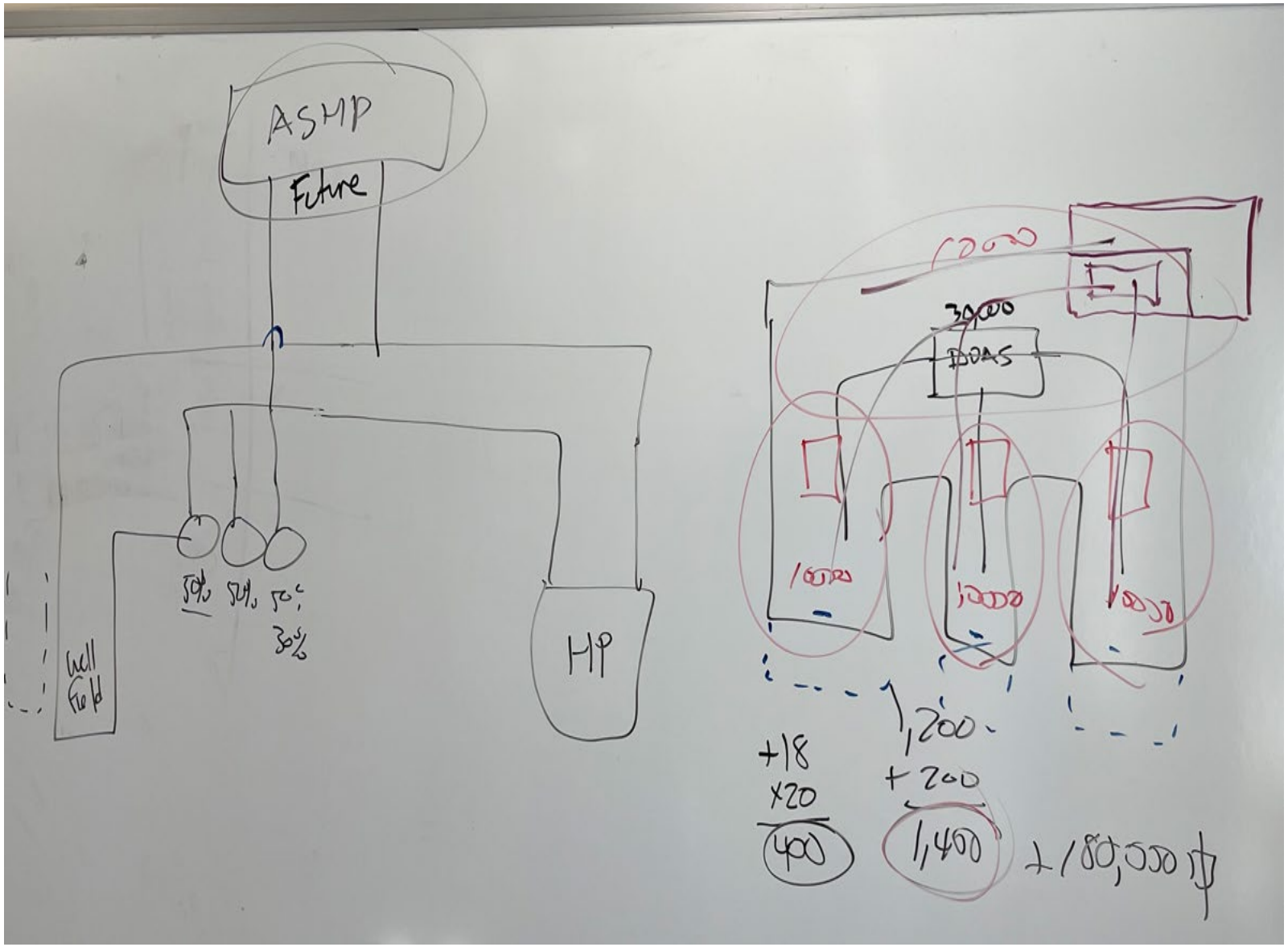

# Schedule / Occupancies & Impact on Energy

| Hours of Operation | M-F | Sat. | Sun. | Holiday Breaks | Summer |
|---|---|---|---|---|---|
| Classrooms | | | | | |
| Kitchen | | | | | |
| Administration | | | | | |
| Guidance | | | | | |
| Cafeteria | | | | | |
| Gymnasium | | | | | |
| Media Center | | | | | |

- Model occupancy impact on EUI
- Discuss summer occupancy strategies and building usage



# System Schematics from 4/26/2023 Meeting




Additional Areas of Study

- Planning for expansion with connections to geothermal loop.
- Planning for added air source instead of expanding wellfield.
- Amount of Air Source Heat Pump Offset to Limit Well Field
- Single Unit DOAS system vs. Individual DOAS systems distributed among wings
  - -occupant diversity considerations
  - -duct sizing/routing
  - -redundancy

# Additional Considerations

- 100% Geothermal is carried in the estimate.

- Geothermal Test Well needed to establish conductivity and confirm number of wells.
  -A 10% variation in a 170 well wellfield could be $850,000 or more in first costs.

- Planning for future expansions
  -Size DOAS for 1,800 occupants
  -Cap ducts/pipes at ends of wings for extension into future additions
  -Wellfield not sized for expansion, could be upsized later or ASHP included

- Reduced PV need from the more efficient geothermal against the capacity of the building alone to offset its EUI

- Options to address with extreme temps –> reduce load factors
  -Turning down fresh air or turning off the DOAS to limit load in extreme cold weather.
  -Monitor wellfield loop temperatures
  -Anti-freeze

# System Analysis – All Options

*Analysis based on 172,000 sq ft facility*

| | Option 1a<br>Electric GSHP | Option 1b<br>Electric VRF | Option 1c<br>Electric GSHP / ASHP<br>75% Geo | Option 2<br>Natural Gas Boilers,<br>Chiller, VAV |
|---|---|---|---|---|
| Energy Use Intensity (EUI) | 25 | 45 | 31 | 55 |
| First Cost<br>(Net Zero Ready) | $17.7 mil | $12.9 mil | $15.3 mil | $12.4 mil |
| Mass Save Incentives | -$2.1 mil | -$0.5 mil | -$1.4 mil | $0 |
| IRA Incentives | -$7.1 mil | $0 mil | -$4.6 mil | $0 |
| First Cost<br>w/ Mass Save Rebates | $15.6 mil | $12.4 mil | $13.9 mil | $12.4 mil |
| Life Cycle Cost (30 year)<br>With MassSave<br>Incentives | $39.9 mil | $51.7 mil | $42.8 | $45.0 mil |
| Decision Factors | Zero Emissions<br>Lowest Energy<br>Lowest PV for NetZero<br>Maximum IRA Benefits | Zero Emissions<br>Higher EUI<br>Higher PV for NZE | Zero Emissions<br>Moderate<br>Moderate PV for NZE<br>Reduced IRA Benefits | Fossil Fuels<br>Lowest 1st Cost<br>Contrary to Town's<br>NetZero Goals |

# HVAC System Selection Cost Details

*Analysis based on 172,000 sq ft facility*

| | Option 1<br>Electric GSHP<br>(EUI 25) | Option 1c<br>Electric GSHP / ASHP 75% Geo<br>(EUI 31) | Option 1 vs. Option 2 |
|---|---|---|---|
| System First Cost | $17.7 mil | $15.3 mil | +$2.4 mil |
| Annual Operating Cost<br>(Energy & Maintenance) | $320,000 | $378,000 | -$58,000 |
| Replacement Cost @ Year 20 | $5.5 mil | $6.2 mil | -$0.7 mil |
| Mass Save Incentives | -$2.1 mil | -$1.3 mil | +$0.8 mil |
| Life Cycle Cost (30 year)<br>With MassSave Incentives | $39.9 mil | $42.8 mil | -$2.9 mil |
| Other Considerations | | | |
| PV First Cost | $2.8 mil | $3.5 mil | -$0.7 mil |
| IRA Incentives | $7.1 mil | $4.6 mil | +$2.5 mil |