Loopfields and Piping Design Workshop

Week 3 – Review and Exercises with GLD2014

Welcome!

Instructor: Dan Bernstein

Welcome! Week 3: Piping Design & Optimization; Exercises

The objective of this workshop is to provide the geothermal designer with an in-depth look at designing practical and purgeable piping system designs using the industry leading Ground Loop Design GLD2014 Software Suite.

You are encouraged to interact with your instructor. We are seeking to provide the geothermal professional with the tools and familiarity that he/she needs to optimize a wide range of GSHP systems.

By extending the user's mastery of the GLD program, it is possible to eliminate the design and field guesswork that has often been used to connect loopfields to the load systems. Designers will quickly discover that the drudgery of hand calculations can be eliminated and replaced by a much more accurate and practical tool that designs piping systems which can be effectively purged and can be built with pipe sizes and types that are appropriate to your operations.

Workshop Outline – Homework Review

- **Homework From Last Week**
- Using the CFD Module to Design Piping Systems
- Brief Review of GLD
- Exercises
  - Exercise 1 – Vertical Heat Exchanger
  - Exercise 2 – LifeCycle Costing
  - Exercise 3 – Design a Single GHX Module Using the CFD Module
  - Exercise 4 – Vertical Design
  - Exercise 5 – Horizontal Design
  - Exercise 6 – CFD Module
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Exercise 1 - Homework Review

Exercise 1

Objective: To design a vertical heat exchanger with 300 ft deep boreholes and no space/area constraints.

Homework Review

Optimize Loads → 1) Import Loads

↓

2) Select Heat Pump (s)

↓

3) Design Heat Exchanger ↔ Piping Optimization

↓

4) Finance/CO2 Analysis

Homework Review

- **STEP 1**: Loads:
  - CaseStudy1.xls
- **STEP 2**: Pump:
  - Water to Air Pump (approximately 5-8 ton)
- **STEP 3**: Vertical Heat Exchanger
  - Entering Fluid Temperatures- 87-92F/40F
  - Flow Rate: 3 gpm/ton
  - Fluid: Water
  - Ground Temperature: 58F
  - TC test results: 1.10 Btu/(h*ft*^{0}F) , 0.60 ft^2/day
  - Time- 10-20 years
  - Pipe: single u-bend, you select
  - Grout: 0.88 Btu/(h*ft*^{0}F)
  - Borehole diameter- 5.25 in
- **GOAL**: depth of <u>300 feet</u>, no space constraints

Homework Review

Question 1

Run a 10 year monthly simulation. Are the calculated peak inlet cooling and heating temperatures from the monthly simulation the same as those selected as your original Design Day inlet temperatures? If not, why do you think they are different? If they are different how could you modify your design so that the monthly temperatures are closer to those that you originally used for the design day calculation? Do you need to do this?

Question 2

Looking at your monthly results, what is the difference between a heat pump EER/COP and the Seasonal Heat Pump EER/COP? Which one is appropriate to use when doing lifecycle costing? Why? Let's see an impact on the lifecycle calculations when we compare the two.

Question 3

Reduce or increase your borehole spacing by 5 ft, run the monthly simulation again and determine the impact of this one change on Seasonal Heat Pump EER/COP results.

Homework Review

- Utilities
  - $0.11/kWh for summer and winter rates
- Emissions Rates
  - TBD
- Emissions Costs
  - TBD
- Initiation Delay
  - 3 years

Homework Review

Question 1

What is the effective initiation delay?

Question 2

How many tons of CO_2 did your system emit over 10 years of operations?

Exercise 2 - Homework Review

Exercise 2

Objective: Transfer your heat exchanger design into the lifecycle costing module and then determine the annual energy costs to run your system. Your secondary goal is to determine how many tons of CO^2 your design is expected to emit over 10 years of operation.

Exercise 3 - Homework Review

Exercise 3

Objective: Design a single GHX Module using the CFD Module. Use the automatic wizard to build a piping system, auto design the headering, determine the purge pump size and finally determine the Reynolds numbers under normal operating conditions.

Homework Review

- Reverse Return System
- Circuit #, Circuit Separation, One-Way Circuit Length and Circuit Pipe Size
  - TBD
- Header Pipe Size
  - TBD
- Supply Return Runout Length
  - 200 ft
- Supply Return Runout Size
  - Same as Header Pipe Size

Homework Review

Question 1

What capacity purge pump do you need to purge the system at 2 ft/sec?

Question 2

What is your overall GHX module pressure drop under Peak Load flow conditions?

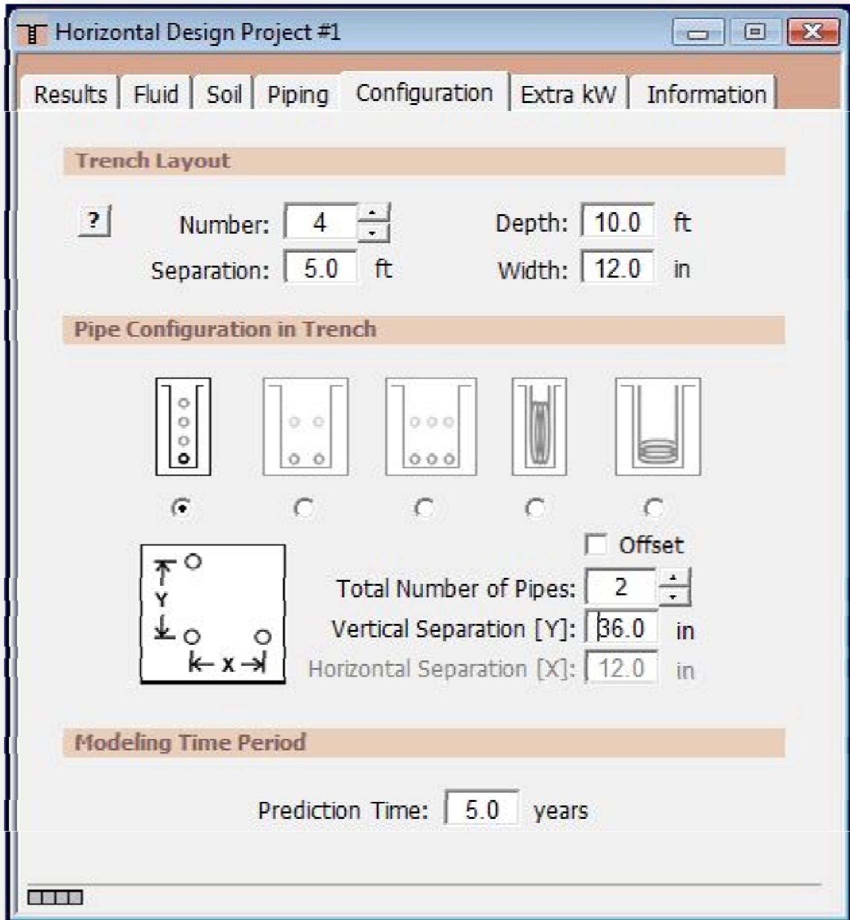
Question 3

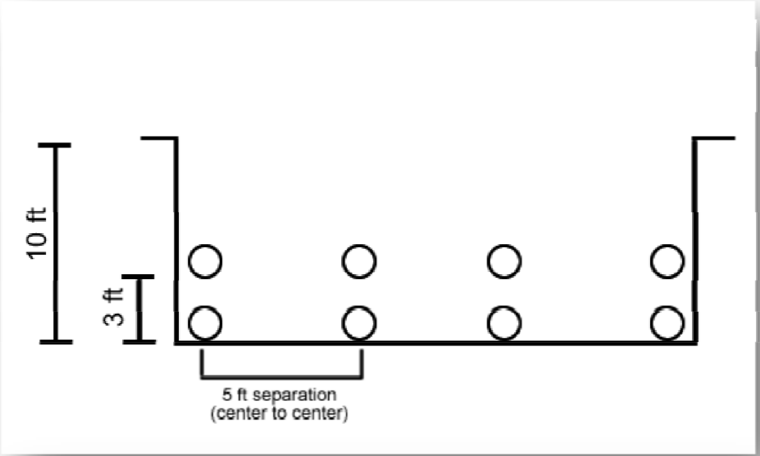
What are the Reynolds numbers in the GHX Circuits under Peak Load flow conditions?

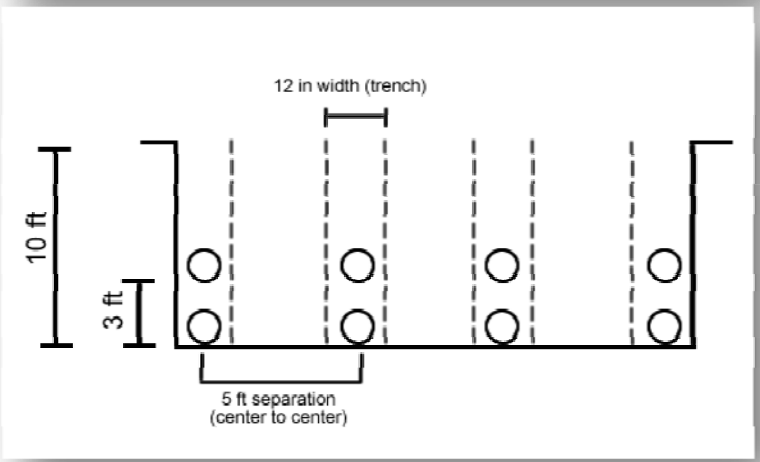
Question 4

Change the fluid types in the Fluid Tab and see what happens to the Reynolds number results. Summarize.

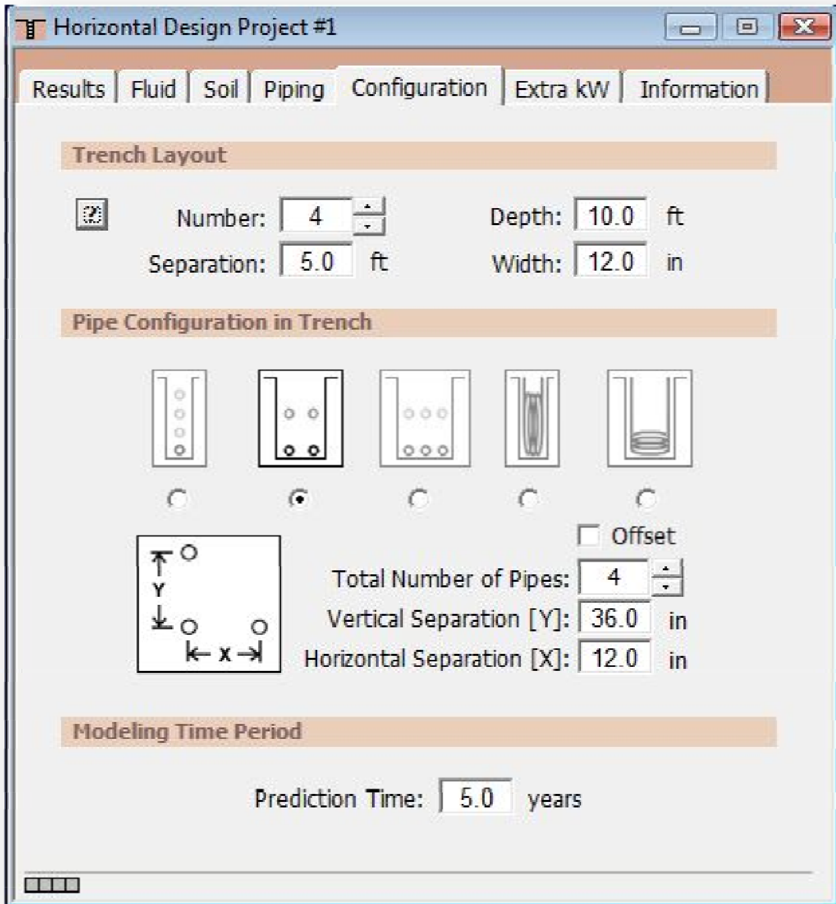
Homework Review

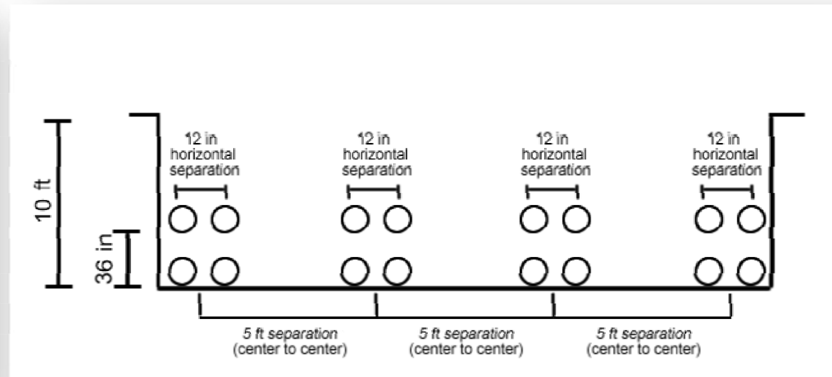


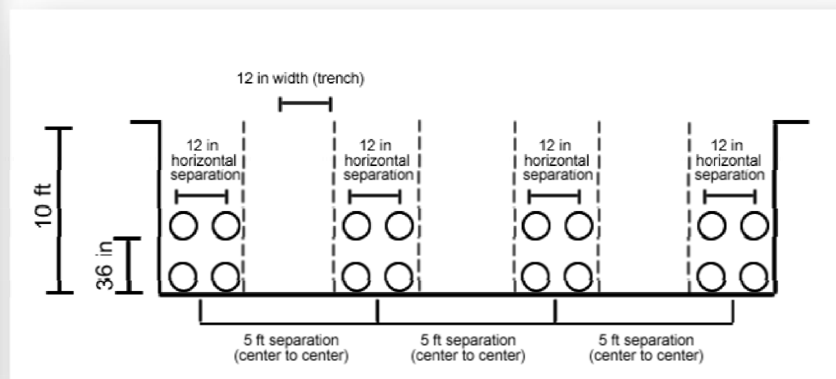




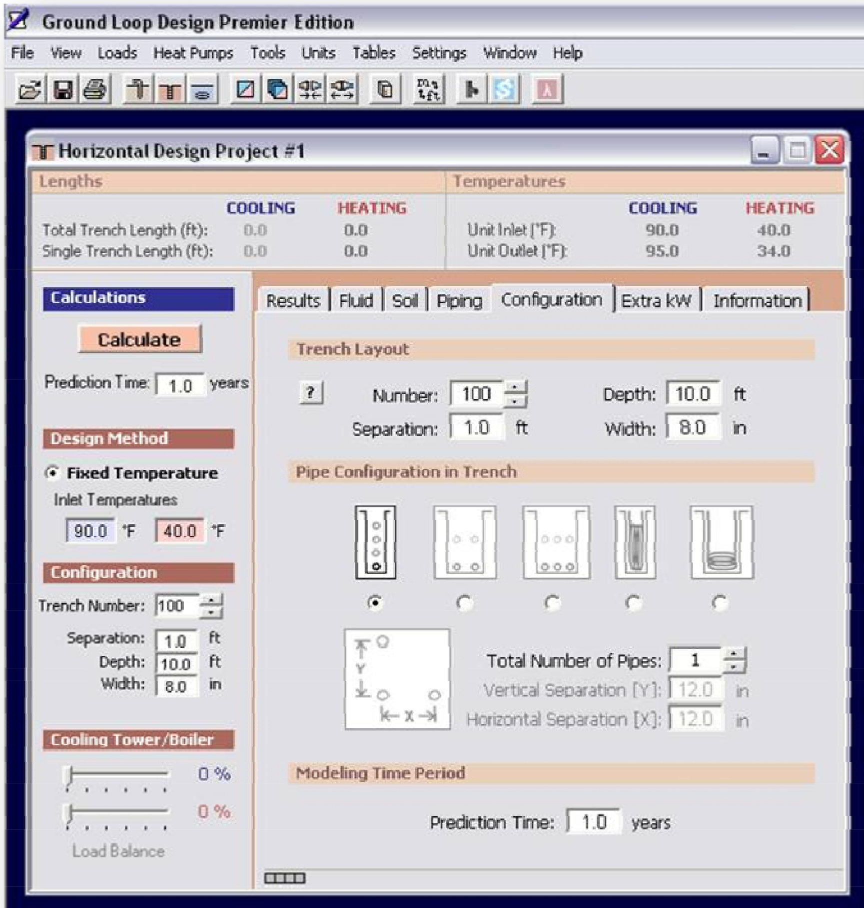
Homework Review







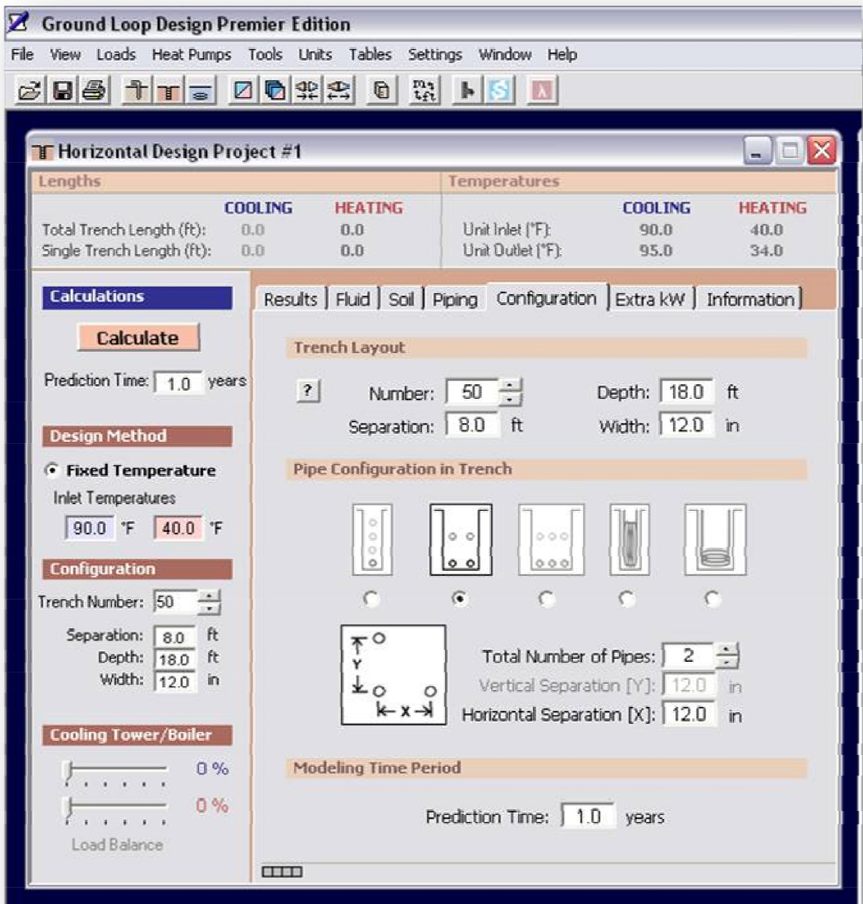
Homework Review



Horizontal loopfield:

Close spacing
10 ft deep pit

Homework Review



Horizontal bore system:

16 -20 ft below surface
8 ft separation

Can you see the error?

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The CFD Module

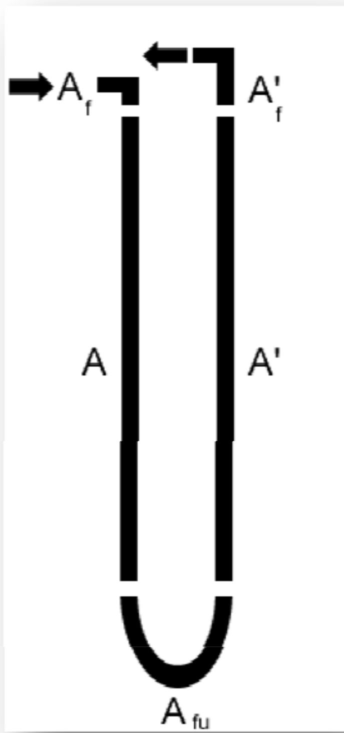
What results do I get out of the Module?

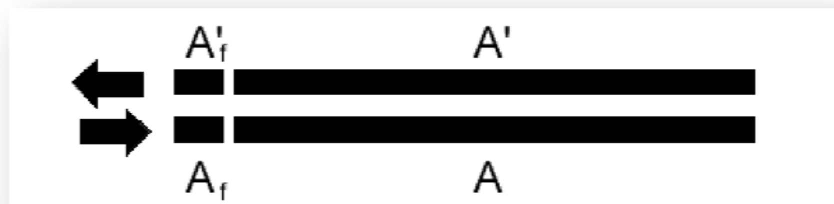
Outputs include flow rates, fluid velocities, Reynold's numbers, pressure drop, fluid volume and the like for every single point in a dynamic geothermal piping system.

The CFD Module - Nomenclature

Basics:

Two Key Components: the **GHX Circuit** and the **Pipe Pair**



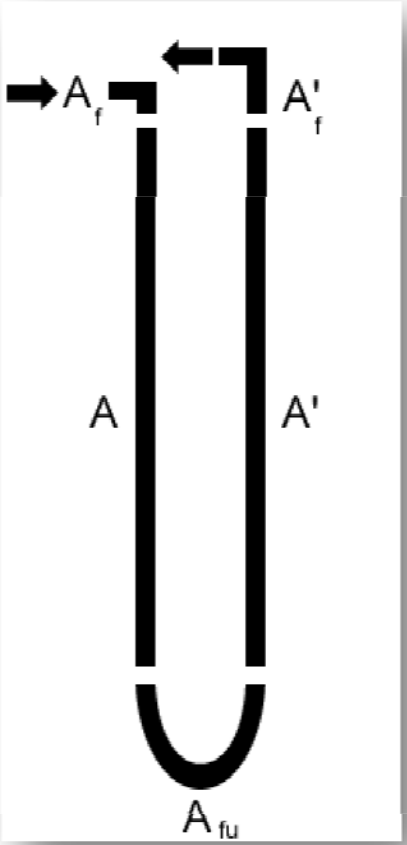


The CFD Module - Nomenclature

The GHX Circuit

An individual GHX Circuit consists of the following five subcomponents:

A_f - Fitting for attachment to parent header pipe (optional)
A - Supply side pipe
A_{fu} - End fitting that connects Pipe A and Pipe A' (optional)
A' - Return side pipe (usually length A = length A')
A'_f - Fitting for attachment to child header pipe (optional)



Definable features for each subcomponent:

- Fitting type (socket tee branch, butt tee branch, etc.)
- Fitting pipe size
- Fitting equivalent length
- Fitting name
- Fitting volume
- Pipe size, type, inner & outer diameter
- Pipe length, Extra pipe length
- Pipe name, volume

Using the CFD Module

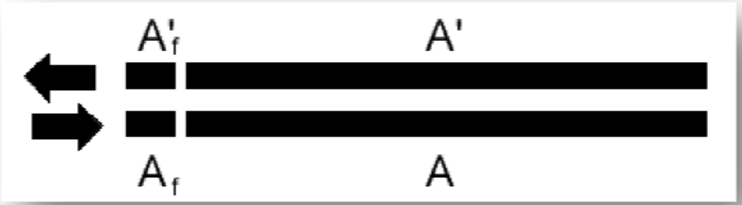
The Pipe Pair

An individual Pipe Pair consists of the following five subcomponents:

A_f - Supply side fitting (generally before the supply side pipe)
A - Supply side pipe
A' - Return side pipe
A'_f - Return side fitting (generally after the return side pipe)

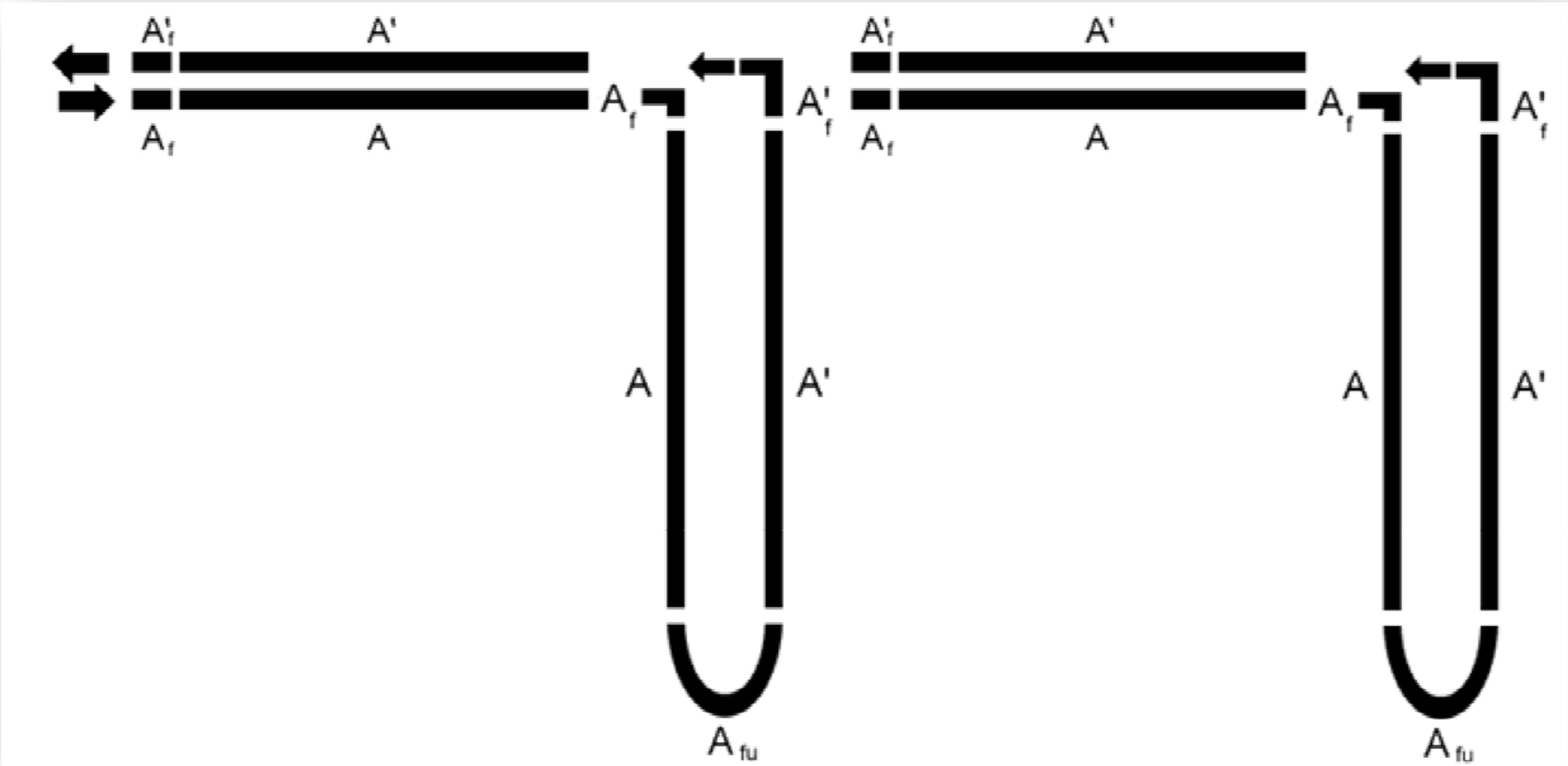
Definable features for each subcomponent:

- Fitting type (socket tee branch, butt tee branch, etc.)
- Fitting pipe size
- Fitting equivalent length
- Fitting name
- Fitting volume
- Pipe size, type, inner & outer diameter
- Pipe length, Extra pipe length
- Pipe name, volume



Using the CFD Module

"Snapping" The Components Together to Form a System



Using the CFD Module

- Manual Design Methods
- Automatic Design Methods
- Headering Design
- Adding Circulation Pumps
- System Performance Review

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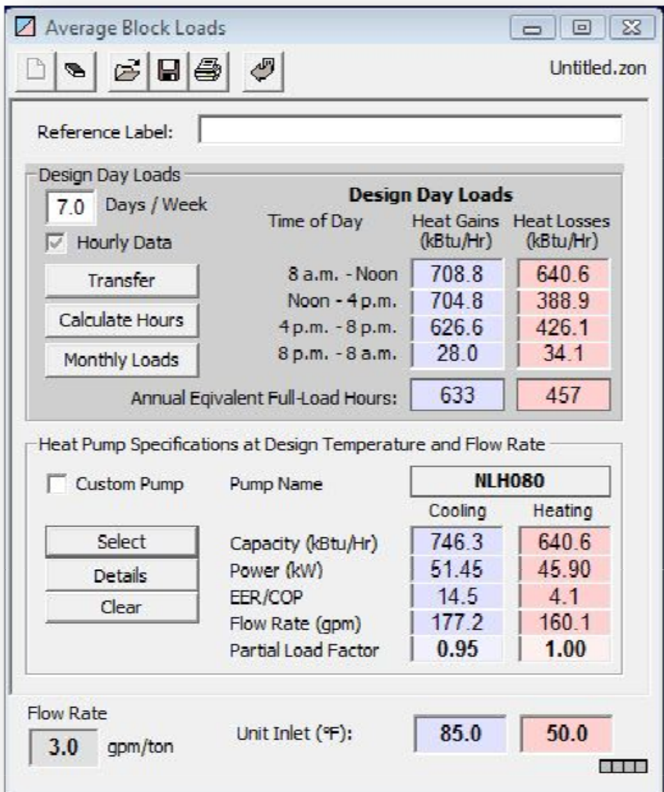
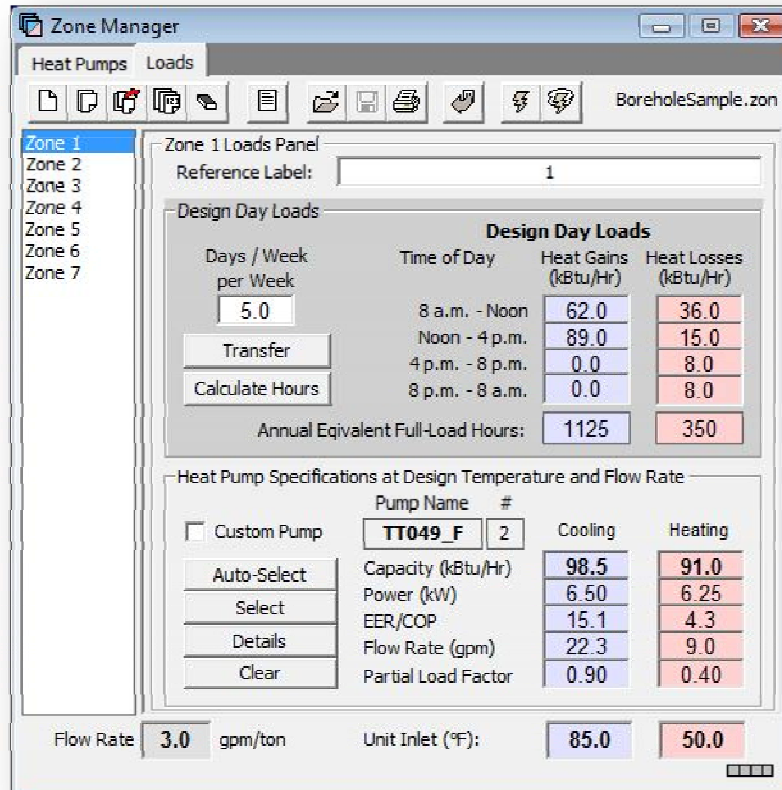
Review: Average Block vs. Zone Manager

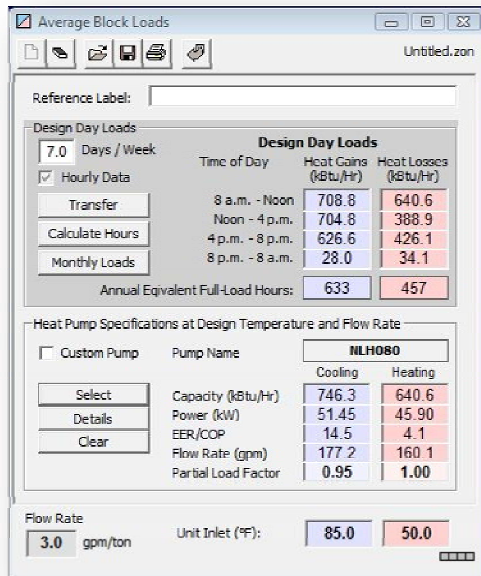
The Average Block and Zone Manager Loads modules provide identical heat exchanger lengths assuming the inputs are identical.

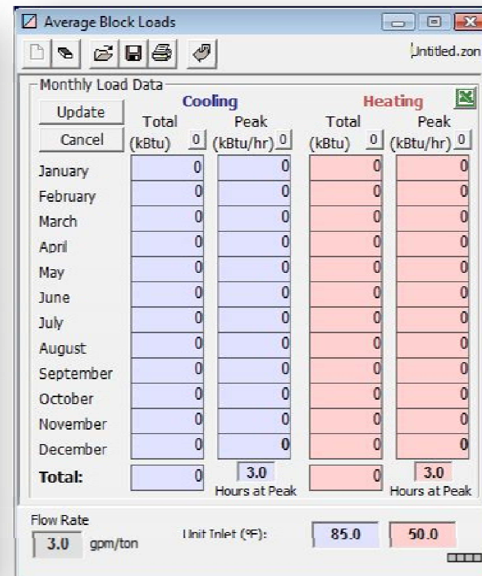




Review: Average Block vs. Zone Manager

- Rapid method of entering enter system info into one block load and quickly designing a system
- Uses a particular “style” of pump (or COP) and matches it in an average way to the entire load
- Can be used to perform monthly or hourly simulations

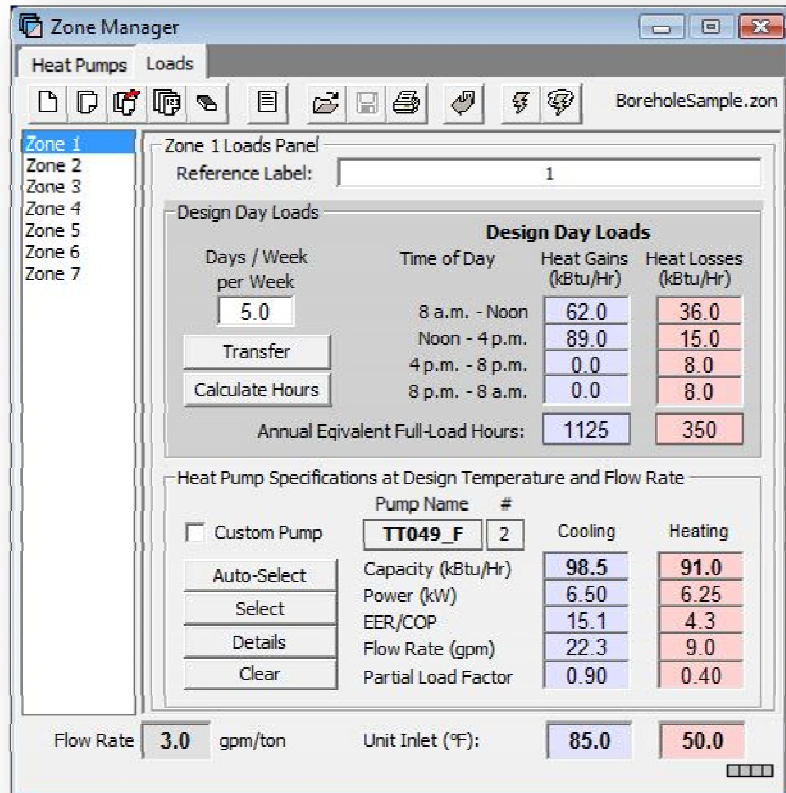




Average Block Loads Module

Review: Average Block vs. Zone Manager

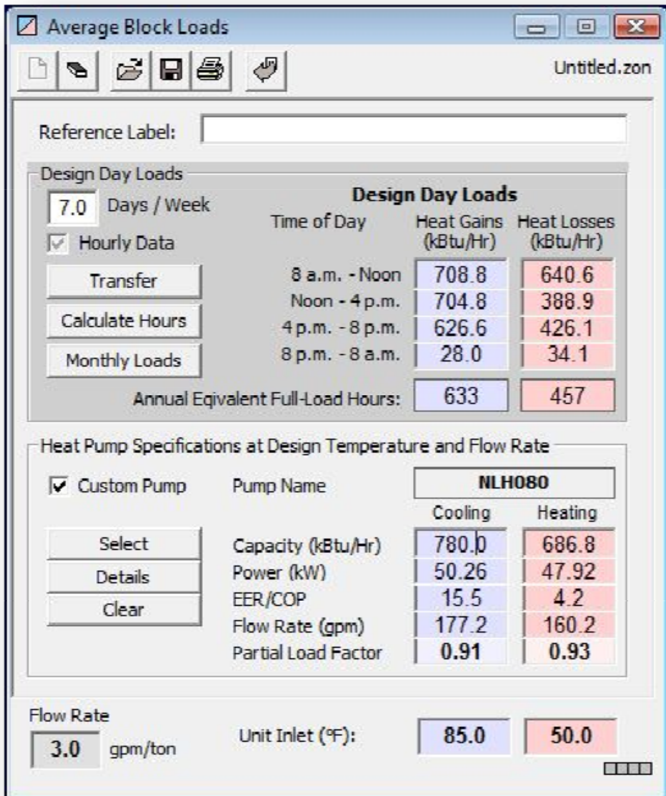
- Loads are input in separate zones
- Each zone precisely matched to pumps
- Can mix and match heat pumps
- Can not do monthly/hourly sims



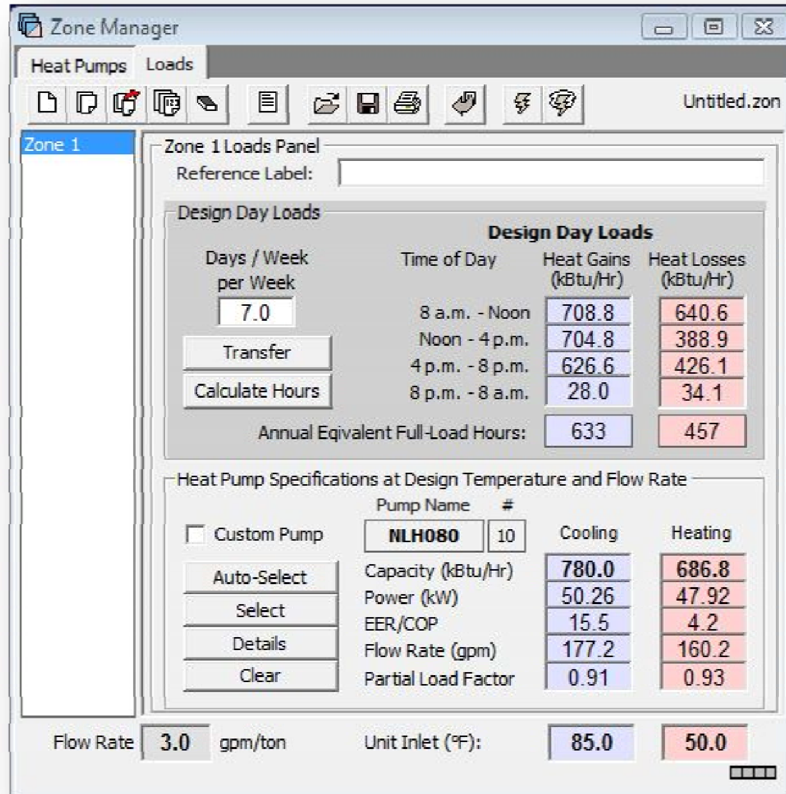
Zone Manager Loads Module

Review: Average Block vs. Zone Manager

Inputs are identical



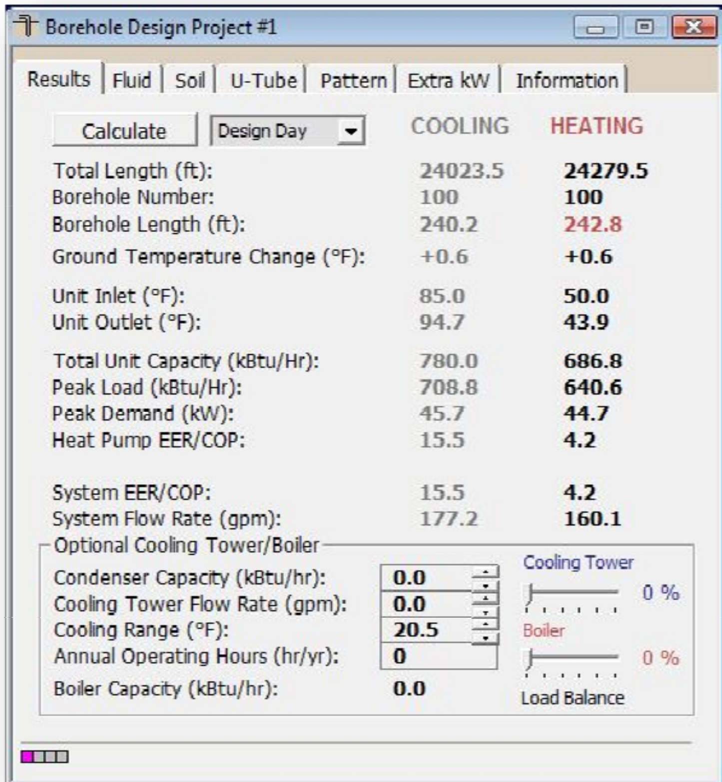
Average Block Loads Module



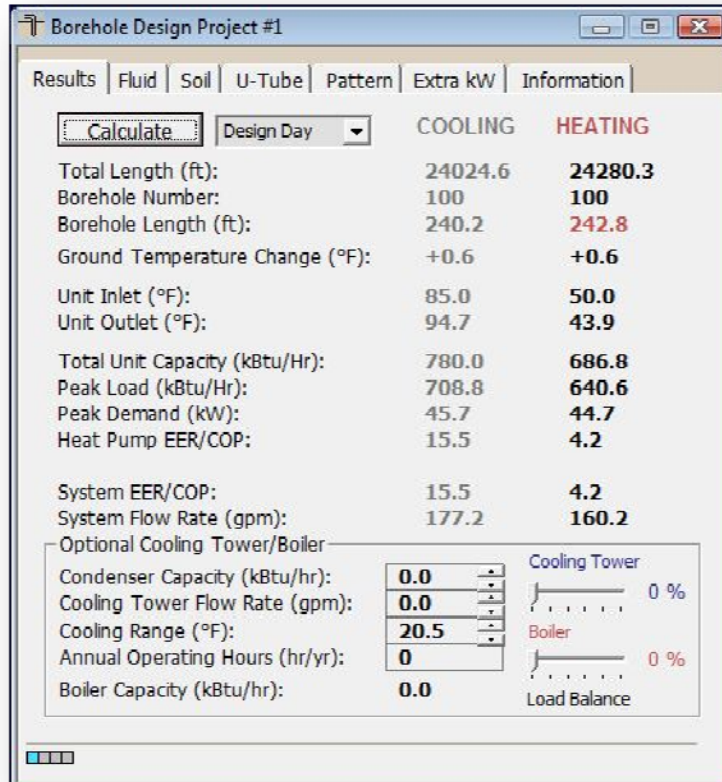
Zone Manager Loads Module

Review: Average Block vs. Zone Manager

Therefore results are identical



Linked to Average Block Loads Module



Linked to Zone Manager Loads Module

Review: Bringing Loads Data into GLD

Design Day Loads

- Manual Entry
- Copy/Paste from Excel

Monthly Simulation Loads

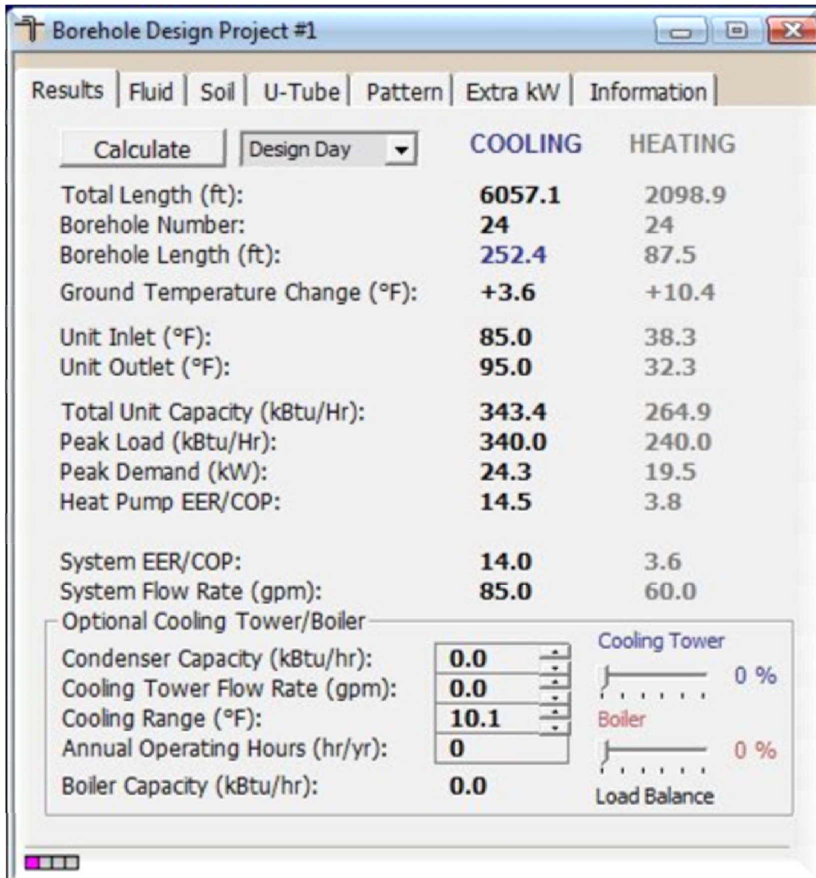
- Manual Entry
- Copy/Paste from Excel
- Import CSV and Proprietary Files

Hourly Simulation Loads

- Import CSV and Proprietary Files (IES “APS” files and Trace “GT” files

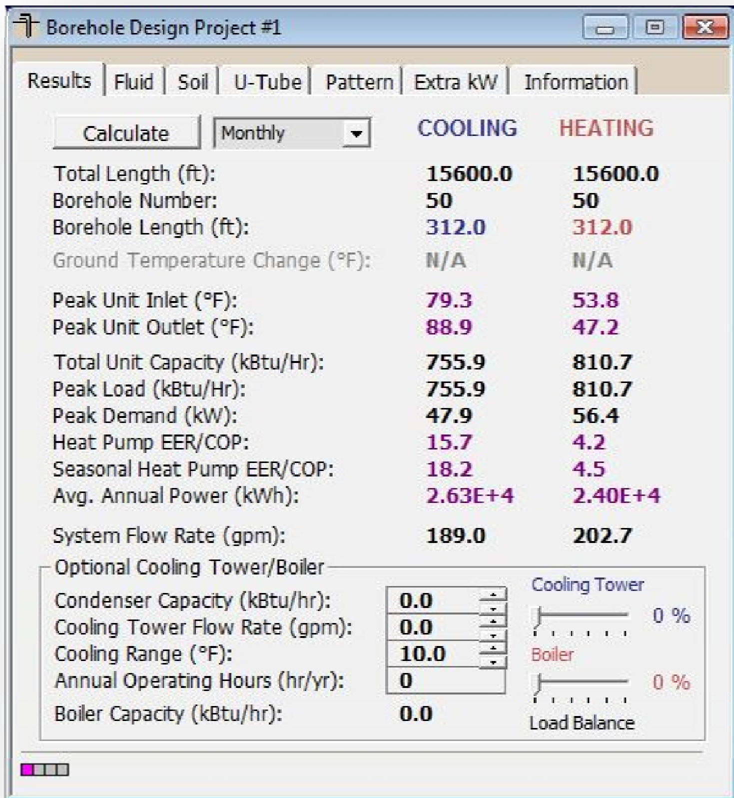
Review: Design Day Method

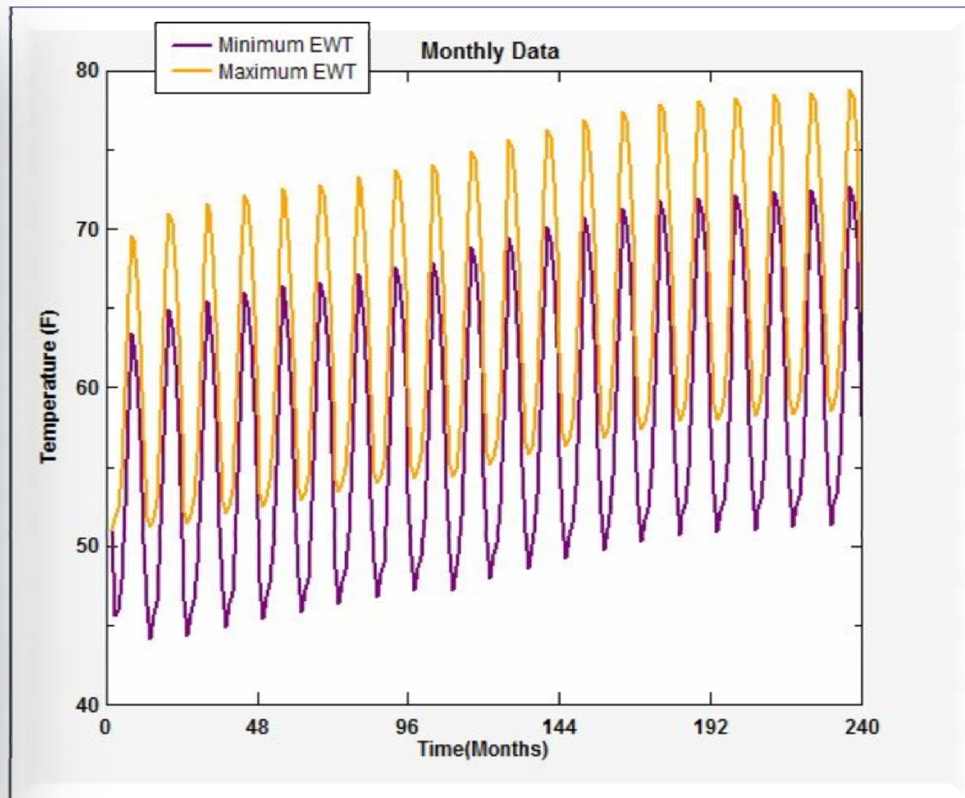
Design Day Method Outputs:



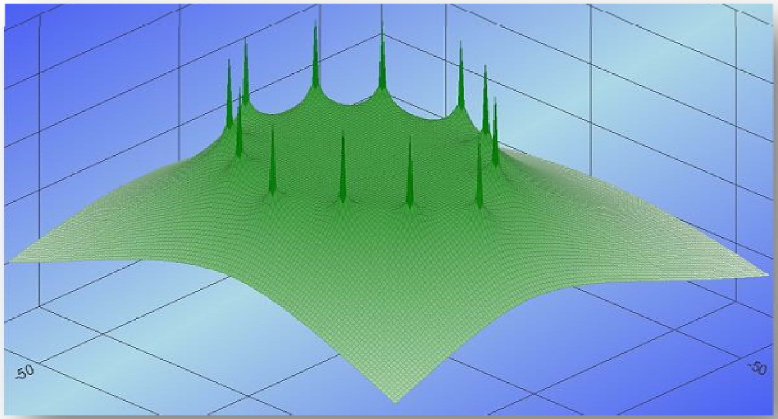
Review: Monthly Method

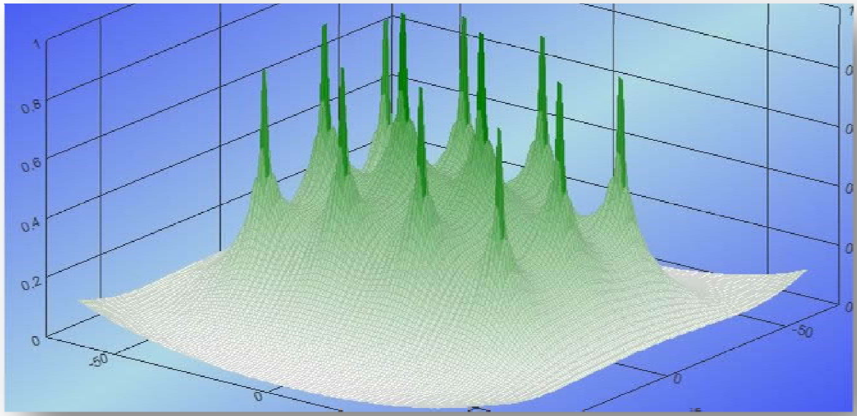
Monthly Method Outputs:





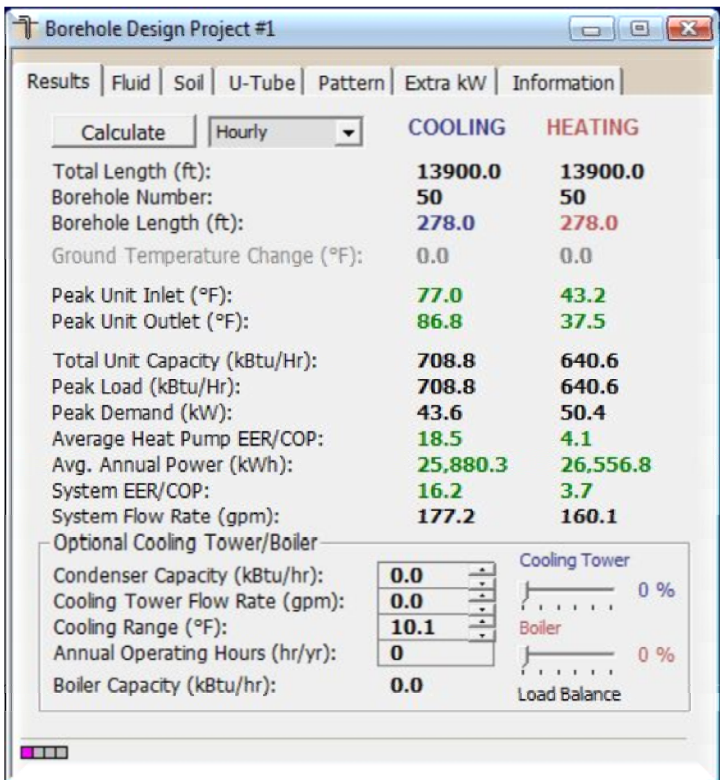
Review: G Function

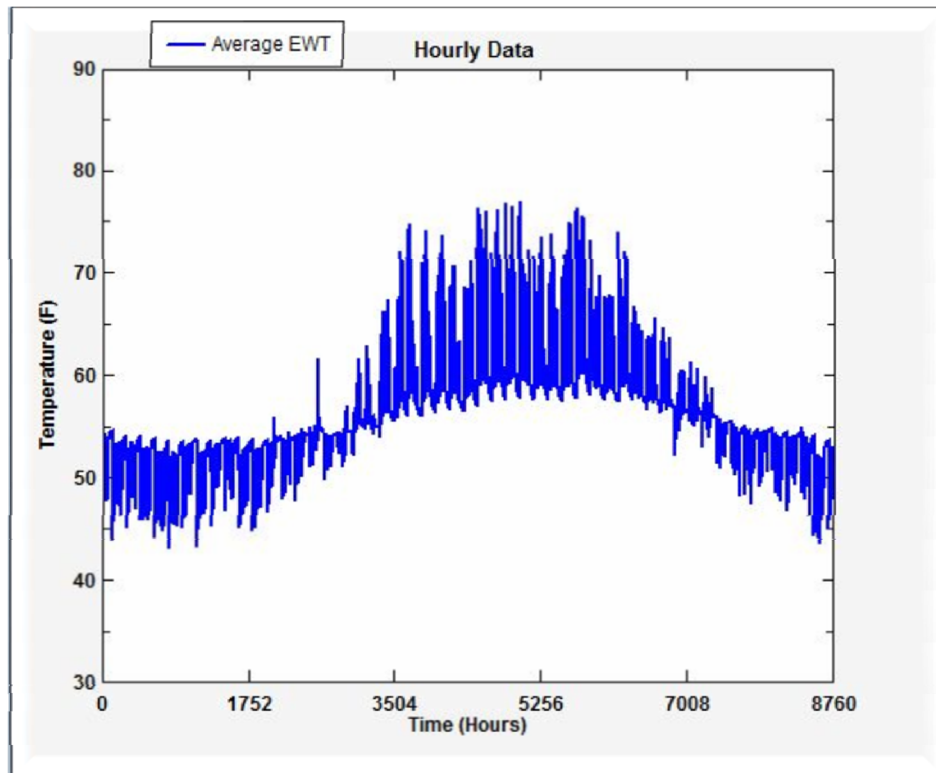




Review: Hourly Method

Hourly Method Outputs:





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Workshop Outline - Exercises

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Exercise 4: Vertical Design

- Step 1: Loads
  - Import Fraser.gt1 file (from Trane Trace)
- Step 2: Pump:
  - ClimateMaster GSW (water-to-water) GSW 120
- Step 3: Vertical Heat Exchanger
  - Entering Fluid Temperatures- You CHOOSE
  - Flow Rate: 3 gpm/ton
  - Fluid: You CHOOSE
  - Ground Temperature: 57F
  - TC test results: 1.3 Btu/(h*ft*^{0}F) , 0.94 ft^2/day
  - Time: 10 years
  - Pipe: You CHOOSE
  - Grout: 0.69 Btu/(h*ft*^{0}F)
  - Borehole diameter- 6 in
- GOAL- depth of 250 ft and maximize your COP

Exercise 5: Horizontal Design

- Step 1: Loads
  - Import Fraser.gt1 file (from Trane Trace)
- Step 2: Pump:
  - ClimateMaster GSW (water-to-water) GSW 120
- Step 3: Horizontal Heat Exchanger
  - Entering Fluid Temperatures- You CHOOSE
  - Flow Rate: 3 gpm/ton
  - Fluid: You CHOOSE
  - Ground Temperature: 57F
  - TC test results: 1.3 Btu/(h*ft*^{0}F) , 0.94 ft^2/day
  - Swing Data: Minneapolis, MN
  - Time: 5 years
  - Pipe: You CHOOSE
- GOAL- aim for same COP as exercise 4, compare lengths.

Exercise 6: CFD Module

1) Use the wizard to build a GHX Module
   - Reverse Return
   - 10 Circuits
   - 15 ft Circuit Separation
   - 325 ft one way Circuit Length
   - 1 in SDR 11 Circuit Pipe Size
   - 2 in SDR 11 Header Pipe Size
   - 200 ft Supply-Return Runout Length
   - 2 in SDR 11 Supply-Return Runout Pipe Size

Exercise 7: CFD Module

Using the GHX Module that you built in the previous exercise:

1) Display the pipe size, pipe length and pipe type for the entire system

2) Switch to purge mode and then select the results you wish to see in purge mode

3) Auto Adjust the Purging Flow Rate so that 2 ft/s is achieved in the GHX circuits

4) Manually adjust the purging flow rate so that 2 ft/s is achieved in the entire system (including the headering pairs)

5) Auto Size the Headers so that 2 ft/s is achieved in the headering pairs while minimizing flow rate

Exercise 8: CFD Module

Using the GHX Module that you optimized in the previous exercise:

1) Determine the flow rate and head loss requirements for the purge pump (write this number down for later use!)
2) Switch to PEAK LOAD mode
3) Select the results you wish to see for operational simulations
4) Enter a Peak Load Flow Rate
5) Select propylene glycol with freeze protection to 20F
6) Determine the Reynolds numbers
7) Determine the Head Loss for the GHX Module under operational conditions (write this number down for later use!)

Exercise 9: CFD Module

1) Use the wizard to build a GHX Module
   - Reverse Return
   - 10 Circuits
   - 15 ft Circuit Separation
   - 325 ft one way Circuit Length
   - 1 in SDR 11 Circuit Pipe Size
   - 3 in SDR 11 Header Pipe Size
   - 200 ft Supply-Return Runout Length
   - 3 in SDR 11 Supply-Return Runout Pipe Size

Exercise 10: CFD Module

Using the GHX Module that you built in the previous exercise:

1) Display the pipe size, pipe length and pipe type for the entire system

2) Switch to purge mode and then select the results you wish to see in purge mode

3) Auto Adjust the Purging Flow Rate so that 2 ft/s is achieved in the GHX circuits

4) Manually adjust the purging flow rate so that 2 ft/s is achieved in the entire system (including the headering pairs)

5) Auto Size the Headers so that 2 ft/s is achieved in the headering pairs while minimizing flow rates

Exercise 11: CFD Module

Using the GHX Module that you optimized in the previous exercise:

1) Determine the flow rate and head loss requirements for the purge pump (compare this result from the system you designed before with 2 in headers)
2) Switch to PEAK LOAD mode
3) Select the results you wish to see for operational simulations
4) Enter a Peak Load Flow Rate
5) Select propylene glycol with freeze protection to 20F
6) Determine the Reynolds numbers
7) Determine the Head Loss for the GHX Module under operational conditions (compare this result from the system you designed before with 2 in headers)

Thank You!

Q & A

Thank you for using GLD Software and for learning how to use it correctly!

- For more information about GLD Software, visit our website at:

www.groundloopdesign.com

- Additional training is available for advanced GSHP systems. Visit the Geothermal Training Institute website at:

Geothermal Training Institute
www.geotrainers.com