



GLHEPro Version 5.0 New Features

Last updated March 31, 2016

GLHEPro Version 5.0 has been released and has many new features, incorporating many years of research. This research has resulted in nearly 100 peer-reviewed papers and book chapters and has also led to many new features in GLHEPro. GLHEPro Version 5.0 has significantly expanded simulation and sizing options:

	Simulation (GLHESim)	Hourly Simulation (GLHESimHourly)	Sizing (GLHE-Size)	Hybrid Sizing (Hybrid GLHE-Size)
Vertical/Inclined				
Single U-tube	x	x	x	x
Double U-tube	x	x	x	x
Concentric	x	x	x	x
Standing Column Well	*	x		
Horizontal				
Straight	x		x	x
Slinky™	x		x	
* Average Monthly Loads can be used in the Hourly Simulation				

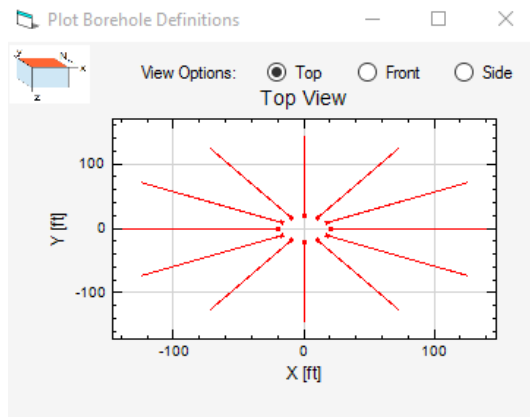
Significant new features include:

- User-specified borehole configurations for up to 30 boreholes – these can be vertical or inclined and irregularly placed. (Page 2.)
- Horizontal ground heat exchangers. (Page 3)
- Hourly simulations of GSHP systems. (Page 3.)
- Worldwide database of time- and depth-varying ground temperatures. (Page 4.)
- Hourly simulations of standing column wells.
- More detailed borehole model can account for short circuiting resistance and groundwater-filled boreholes.
- Improved flexibility in the hybrid system sizing feature.

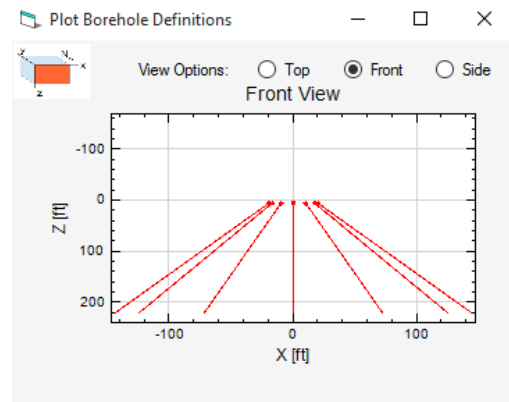
Free-Placement Finite Line Source Model: Inclined Boreholes and More!

For ground heat exchangers with up to 30 boreholes, users can specify their own configurations. Possibilities include:

- Irregular borehole layouts
- Inclined boreholes
- Boreholes with different depths
- Horizontally-drilled boreholes



12 boreholes arranged in a circle inclined outwards at 30° , top view.



12 boreholes arranged in a circle inclined outwards at 30° , front view.



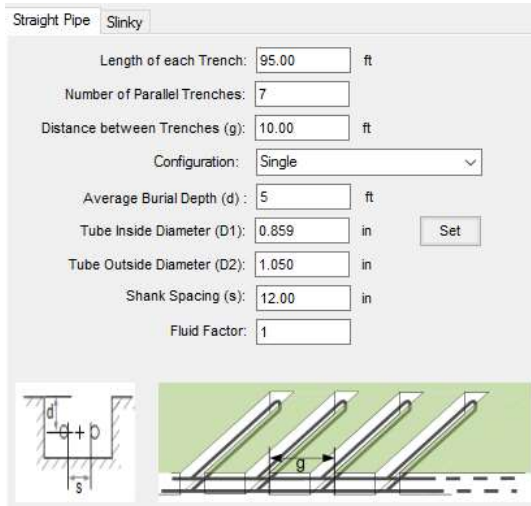
Two boreholes with significantly different depths.



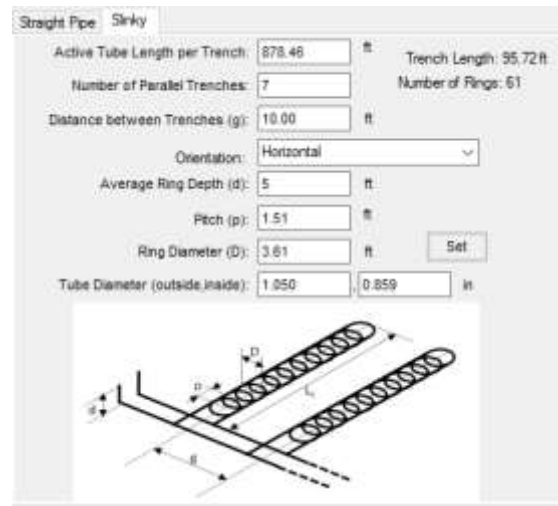
A horizontally-drilled borehole.

Horizontal Ground Heat Exchangers

Two-tube and four-tube horizontal ground heat exchangers and slinky heat exchangers can be simulated and designed.



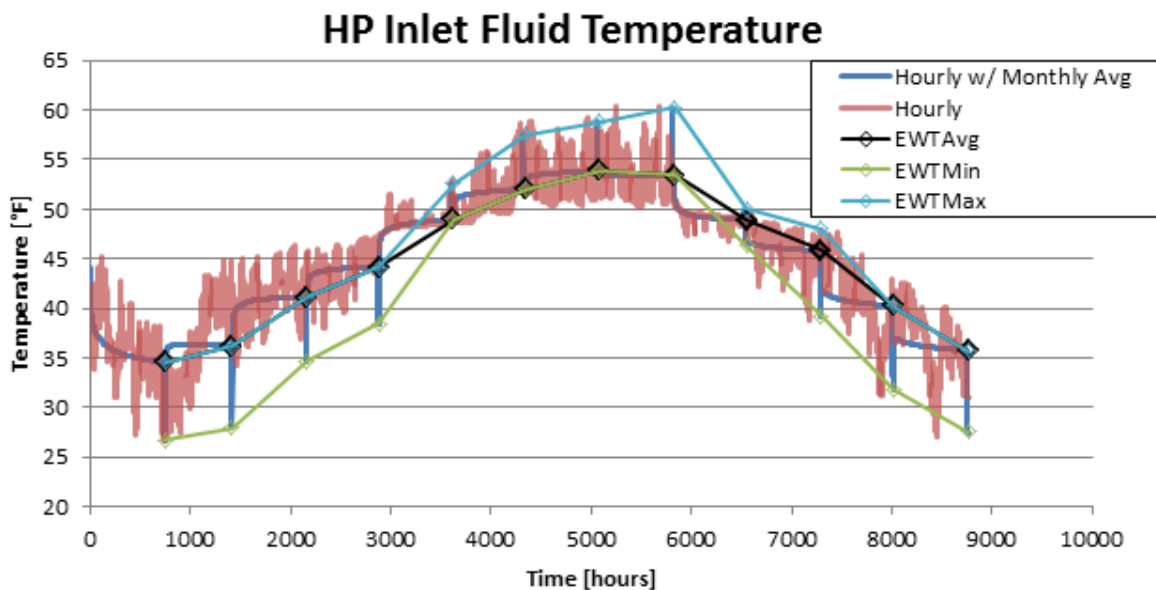
Two-tube horizontal ground heat exchanger.



Slinky heat exchanger

Hourly Simulations

All systems of vertical and inclined boreholes can use an hourly simulation in GLHEPro. The length of the simulation is limited only by the number of hourly loads you can supply. The figure below shows a comparison of the temperature responses for a monthly simulation to the hourly simulation options.



Ground Temperature Database

A new undisturbed ground temperature database has temperature profiles for 4,112 global locations!

By Location List | By Latitude/Longitude | Constant User Specified

Use the list boxes to load the records for your country into the table below.

Site Parameters

Region: NORTH AND CENTRAL AMERICA

Country: United States

Ground Cover: Short grass Tall grass

Search Table

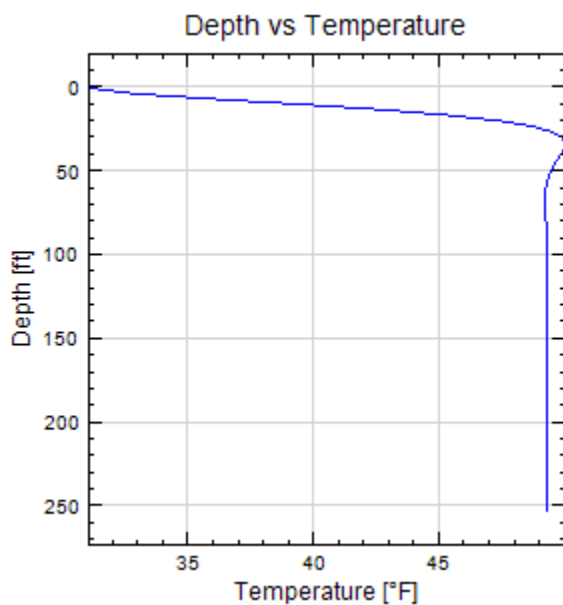
View Temperature Profile

Cancel OK

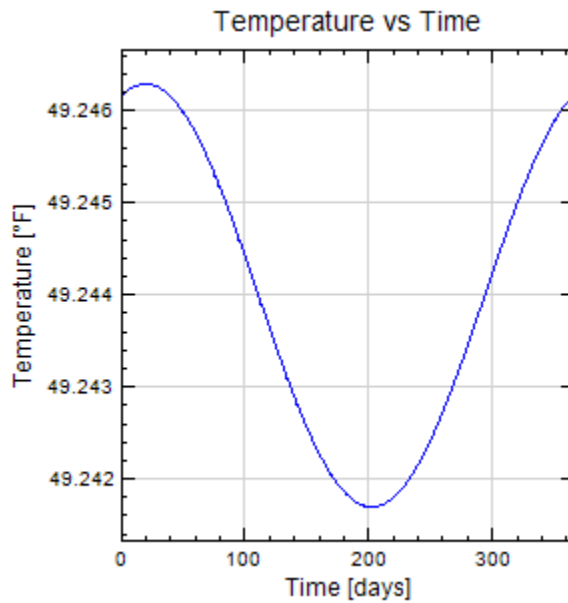
Select the best record for your location:

Station	Average Temperature [F]	Latitude	Longitude
Sioux Falls-Foss Field	49.244	43.58	-96.75
Watertown Muni AP	45.842	44.93	-97.15
Yankton-Chan Gurney Muni AP	50.396	42.92	-97.38
Bristol-TriCities Rgnl AP	57.704	36.47	-82.4
Chattanooga-Lovell Field AP	62.456	35.03	-85.2
Crossville Mem AP	58.802	35.95	-85.08

Select ground temperature by location, longitude/latitude, or specify a constant



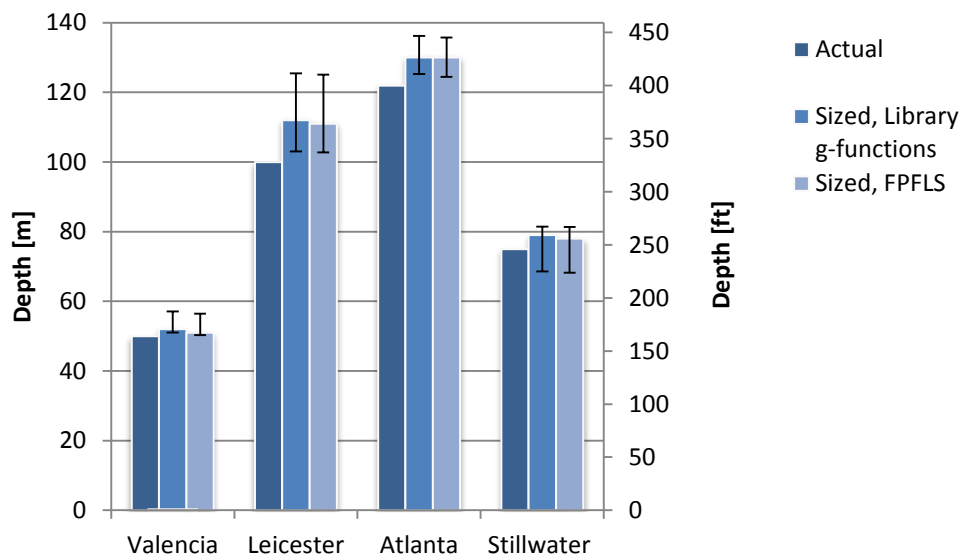
Depth vs. Temperature on March 14th



Annual Temperature Profile at a depth of 30 ft.

Validation

Yes, but does it work? We believe GLHEPro Version 4.0 is the only ground heat exchanger design software for which peer-reviewed validations¹ of the sizing algorithm against monitored systems have been published. GLHEPro Version 5.0 has been validated against four monitored systems located in three different countries. The systems have between 3 and 56 boreholes. The approach taken was to use GLHEPro to size existing systems, using the measured loads on the ground heat exchanger as inputs and the measured minimum and maximum heat pump entering fluid temperatures as the design limits. Compared to the actual ground heat exchangers, GLHEPro oversized between 2 and 11%, with an average value of 6%. This is illustrated in the figure below, where both the library g-functions and the new Free Placement Finite Line Source g-functions were used. The error bars represent the effects of the uncertainties in the inputs on the predicted size. Since GLHEPro does not account for the horizontal connecting piping, a small amount of oversizing is expected. The journal paper¹ that reported on the GLHEPro Version 4.0 validation also showed that the ASHRAE handbook method could significantly oversize the ground heat exchangers for these same cases.



¹ Cullin, J. R., Spitler, J. D., Montagud, C., Ruiz-Calvo, F., Rees, S. J., Naicker, S. S., Konečný, P. and Southard, L. E. 2015. Validation of vertical ground heat exchanger design methodologies, *Science and Technology for the Built Environment*, 21:2, 137-149

Versions Available

There are several versions of GLHEPro Version 5.0 available for purchase. The table shows the features that come with each version.

	GLHEPRO 5.0-30	GLHEPRO 5.0-120	GLHEPRO 5.0-400+
FPFLS Boreholes	x	x	x
includes a line-source model that allows free placement of 30 vertical or inclined boreholes			
Horizontal GHE	x	x	x
includes line-source models of the Straight pipe and Slinky Models			
Vertical Boreholes		x	x
includes 307 different configurations with 1 to 120 boreholes. Configurations include lines, L-shaped fields, U-shaped fields, open rectangular fields and rectangular fields.			
Extended Vertical Boreholes			x
includes large rectangular borefields, 100 boreholes and larger.			