GLD Skill Booster #3:
Header Design with the CFD Module

The GLD Skill Boosters are a series of documents that guide you through the process of performing a specific task in GLD. With this series you can hone your functional skills in only a few minutes. This Skill Booster was built using GLD2012.

Piping design is an underappreciated aspect of the geothermal system design process. After a designer has determined the ground heat exchanger parameters (depth, borehole number, etc) for a particular project, the next important step is determining the optimal way to interconnect the system, often referred to as “tying in”. To “tie in” a system properly requires a detailed understanding of the fluid dynamics of a particular piping design. Since fluid dynamics equations are computationally challenging (and dreaded by many a designer), software tools such as the GLD Computational Fluid Dynamics (CFD) module offer tremendous time savings and yield an optimized configuration.

With the CFD module, the piping design process is broken into two distinct steps:

- Headering design
- System optimization

In this Skill Booster module we will look at the first step and learn how to auto-design a headering system in GLD.

As a geothermal designer, you will benefit from knowing how to design headers in GLD because the skill will:

- Enable you to understand the relationship between purging velocities and headering design
- Enable you to teach others about the importance of proper headering design
- Enable you to save a lot of design time
- Enable you to enhance your professional skills

Headering Design Background Info

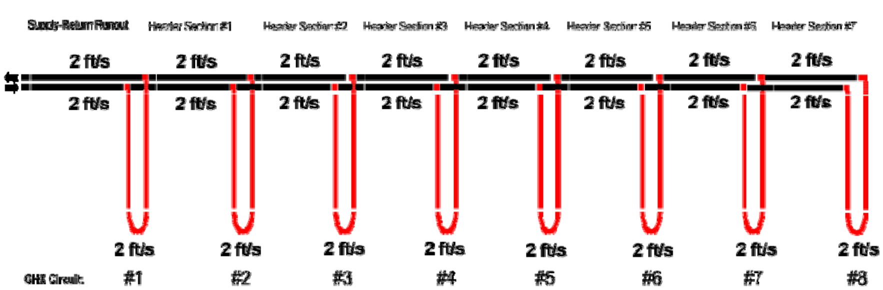
- When a geothermal heat exchanger piping system is constructed and fused together, there is lots of “stuff” that can get trapped in the piping system. Air gets trapped. Drilling materials or backfill may fall into a pipe and get trapped. People even have been known to drop cell phones, wedding rings and the like into u bend pipes! The list goes on and on.

- Anything that is in the pipes (besides the circulation fluid) will cause significant problems for system operation. As a result, it is essential that the loopfield system can be, and is, purged with <u>water</u> (and not a freeze protected circulation fluid).

- A geothermal heat exchanger is typically purged one supply-return run-out pair at a time. In other words, if there is a 100 borehole system with 10 supply-return run-out pairs (each with 10 boreholes), each supply-return run-out pair is purged separately. Typically, the entire borefield system is <u>*not*</u> purged at the same time.

- The key fluid dynamics variable for properly purging a system (fluid dynamics has a lot of variables including flow rates, fluid velocities, head losses, fluid volume, Reynolds numbers, etc.) is the **fluid velocity**. A fast flowing fluid is able to purge air bubbles and other “junk” that is in the piping system. The appropriate target purging fluid velocity varies depending on what needs to be purged. A ***minimum*** purge velocity is **2 ft/s,** although in many cases, higher velocities are warranted, especially when there is lots of debris in the pipes. Users can select the minimum purge velocity in the CFD module.

- The minimum purge velocity must be achieved in every single component in the piping system. If one component does not see a high enough velocity, air bubbles and debris may get “stuck” in that area and the purging process will be unsuccessful. An example of a successful 2 ft/s purge looks like this:

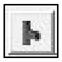


- The designer/installer team must have access to an appropriately sized purge pump that can effectively purge a system. The purge pump will have to achieve the minimum velocity throughout the entire piping system while providing a flow rate that is "reasonable." An example of "reasonable" could be a purge pump that needs to provide 50 gpm with 50 ft. of head. An example of "unreasonable" could be a purge pump that needs to provide 350 gpm with 400 ft of head.
- Headering design is critical for ensuring target purge velocities are achieved throughout the entire piping system. If a "reducing" headering system is not designed and installed properly, purging can be difficult or impossible. The CFD module in GLD designs "reducing" headering systems automatically.

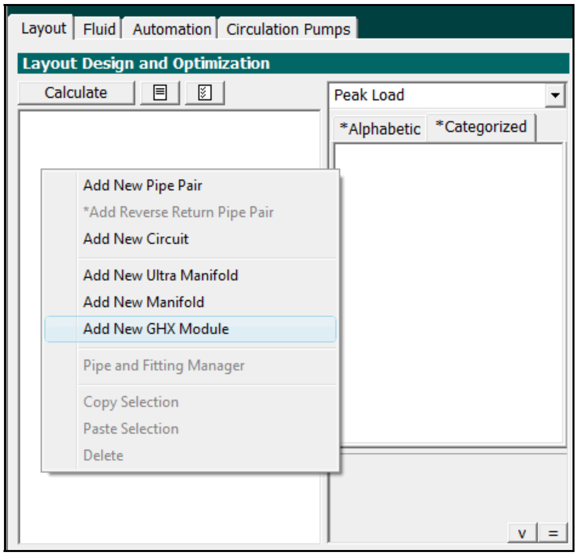
How to Optimize Headering Design in GLD

Here is how you can auto-optimize the headering system (i.e. design a reducing headering system) for a single supply-return run-out pair:

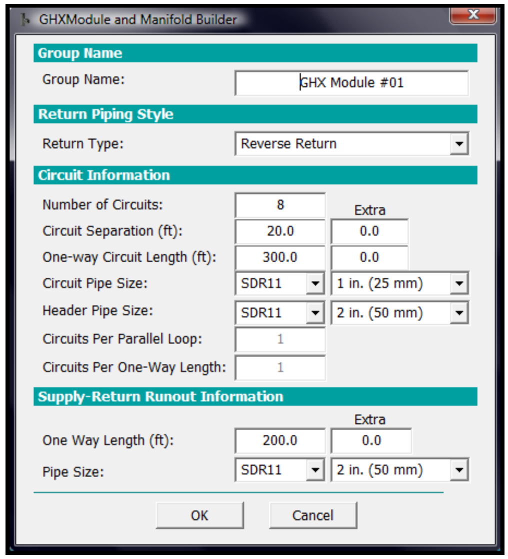
1) Open the Computational Fluid Dynamics (CFD) module by clicking on this icon (which can be found at the top of the GLD program):



2) On the Layout tab, right click the mouse in the open white space area and choose to add a new "GHX Module":



3) Adding the new GHX module will open the GHX Module Builder:



4) Select a **Reverse Return** piping style

5) For **Number of Circuits**; enter “8”. This represents 8 boreholes on a single supply-return run-out pair.

6) For **Circuit Separation;** enter “20”. This represents 20 feet between boreholes.

7) For **One-way Circuit length;** enter “300”. This represents a borehole of 300 ft depth.

8) For **Circuit Pipe Size;** select 1 inch SDR11.

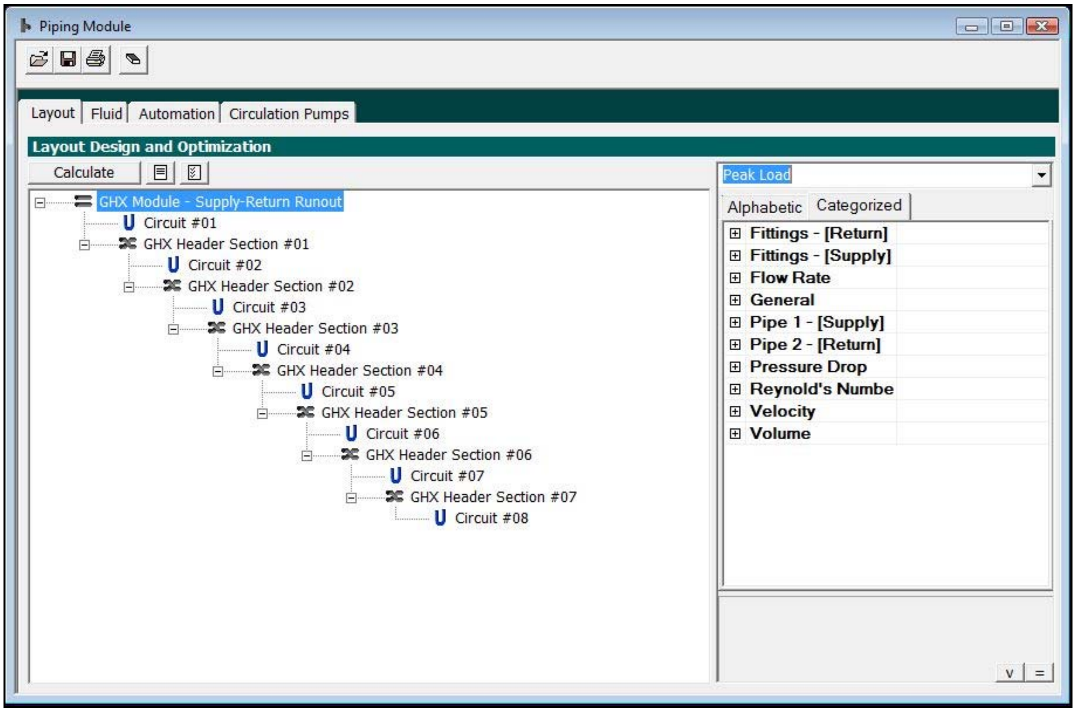
9) For **Header Pipe Size;** select 2 inch SDR11. This is the diameter of the pipe in the header that connects the boreholes together. It does not include the supply-return run-out pipes.

10) Leave both **Circuits Per Parallel Loop** and **Circuits per One Way Length** at “1”. These variables relate to double u-bends and we will not be focusing on them in this Skill Builder.

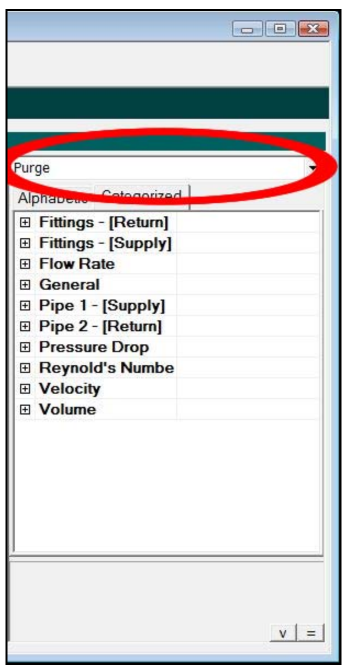
11) For **One Way Length;** in the Supply-Return Run-out, enter “200”. This is the length of the supply run-out from the manifold/building/pump to the first borehole.

12) For **Pipe Size;** select 2 inch SDR11.

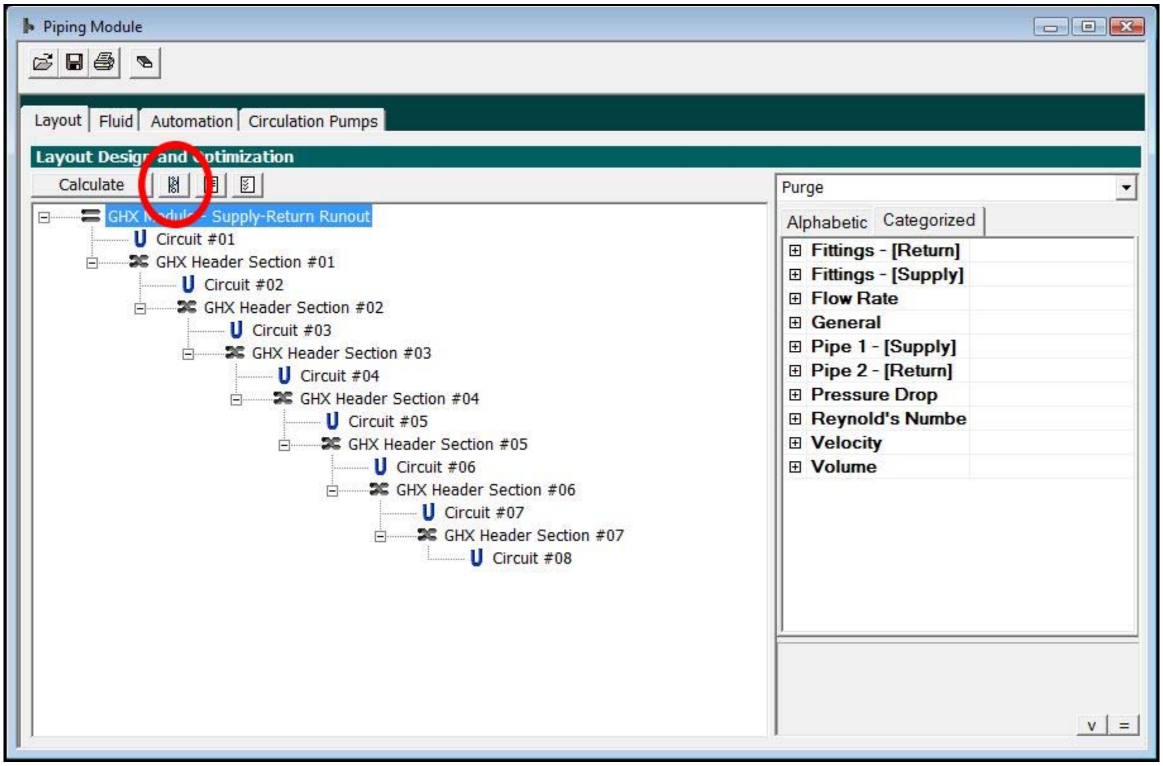
13) Hit the 'OK' button and the CFD module will build the "bones" of the piping system:



14) To optimize the system for purging, we need to first select the **purging mode**. Ensure that purging mode is selected:

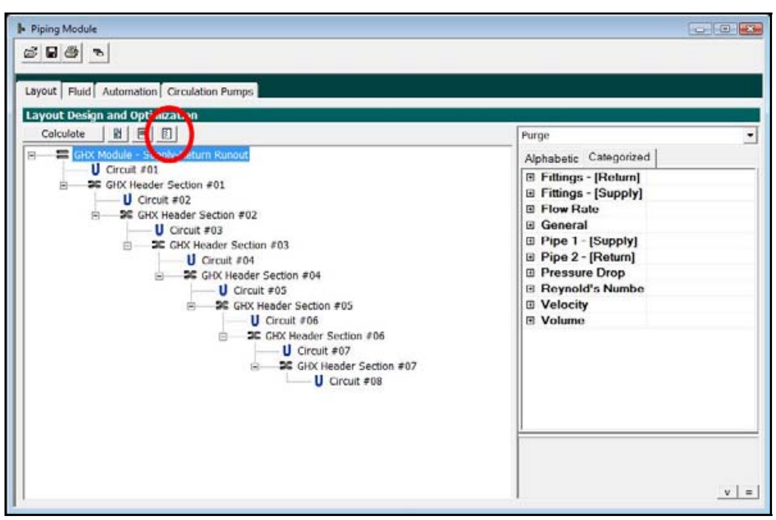


15) After purging mode is selected, a purge button control appears:

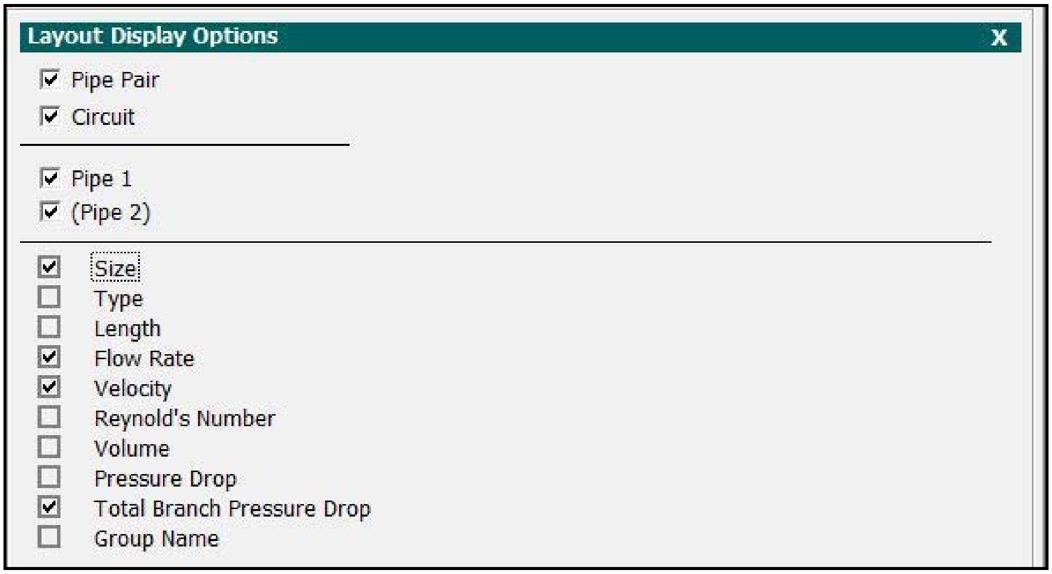


16) Click on the Purge Button and activate both features: "auto-adjust purging flow rate" and "auto-size headers." The program is now ready to auto-design the headering system. In doing so, it will determine where and how to reduce the headering pipe sizes to provide the target purge velocity (in this example 2 ft/s) while minimizing the required flow rate and head loss for the purge pump.

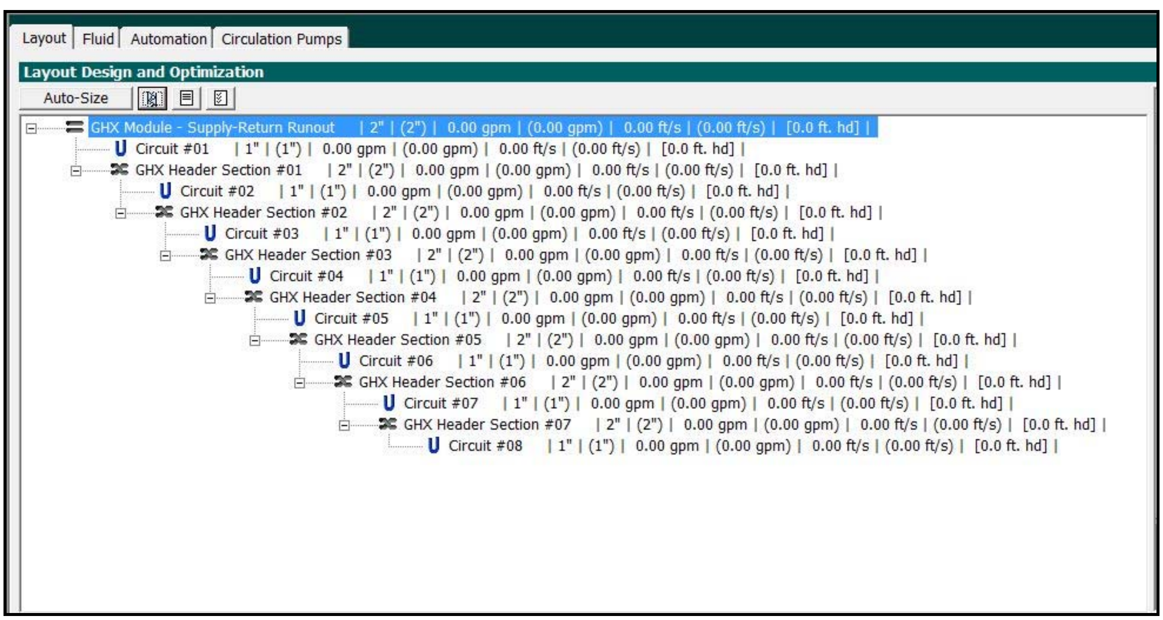
17) Click the "display" button so that we can see the fluid dynamics results that are useful for headering design and purging optimization:



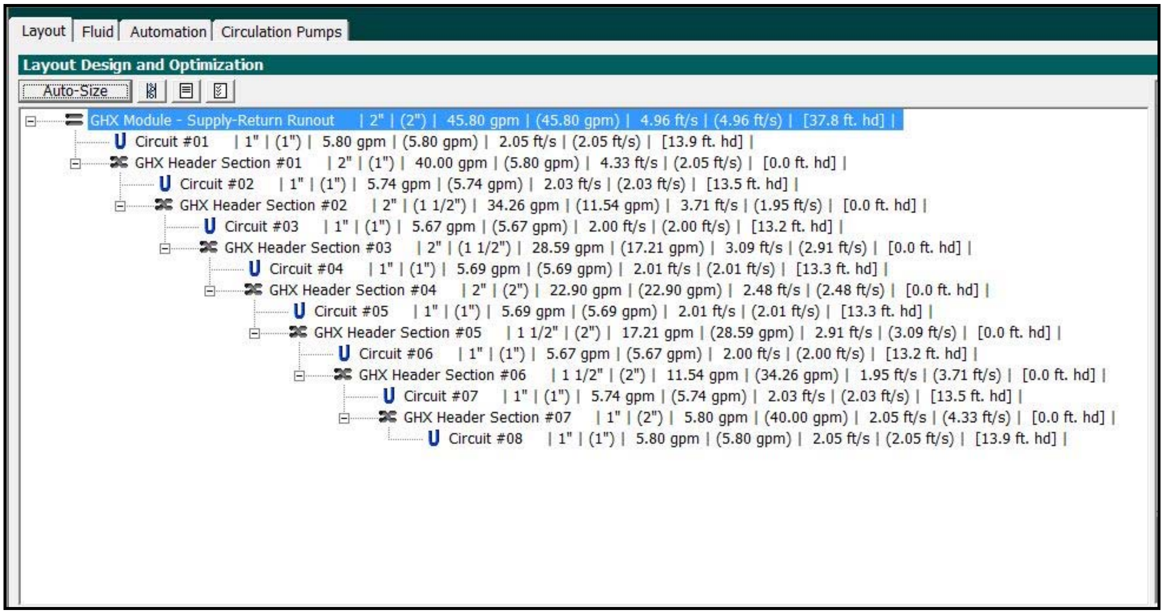
18) Choose "Multiselect" to view all of the available results. For purging and headering design, select the following :



19) Press the "X" button in the upper right corner to return to the main design screen (note that the module can be expanded as necessary to see everything:



20) Now, hit the 'Auto-Size' button. The program will modify the headering pipe sizes as necessary to ensure a 2 ft/s velocity throughout the entire piping system while minimizing the purge pump flow rate and pressure drop. Here are the results:



Look carefully and notice that the entire system has a velocity that is greater than or equal to 2 ft/s. Also notice that the header sections are no longer 2 inch pipe for both the supply and return. The program has changed the headering pipe sizes and created a “reducing” headering system.

21) The CFD module can save designers a huge amount of time by automating laborious calculations. If you are interested in learning more about what the CFD module can do (it can do a lot), contact us for more information about training materials and on-line classes.

In summary, a piping system must be designed for efficient purging. If it is not, the system will likely have performance issues. The key to designing a system for efficient purging is dependent on:

a) designing one supply-return run-out pair at a time for purging rather than designing an entire system for one huge “purge” and

b) designing a “reducing” headering system to ensure target purge velocities are met throughout the entire system. The CFD module in GLD is a very powerful tool for achieving these design goals quickly.