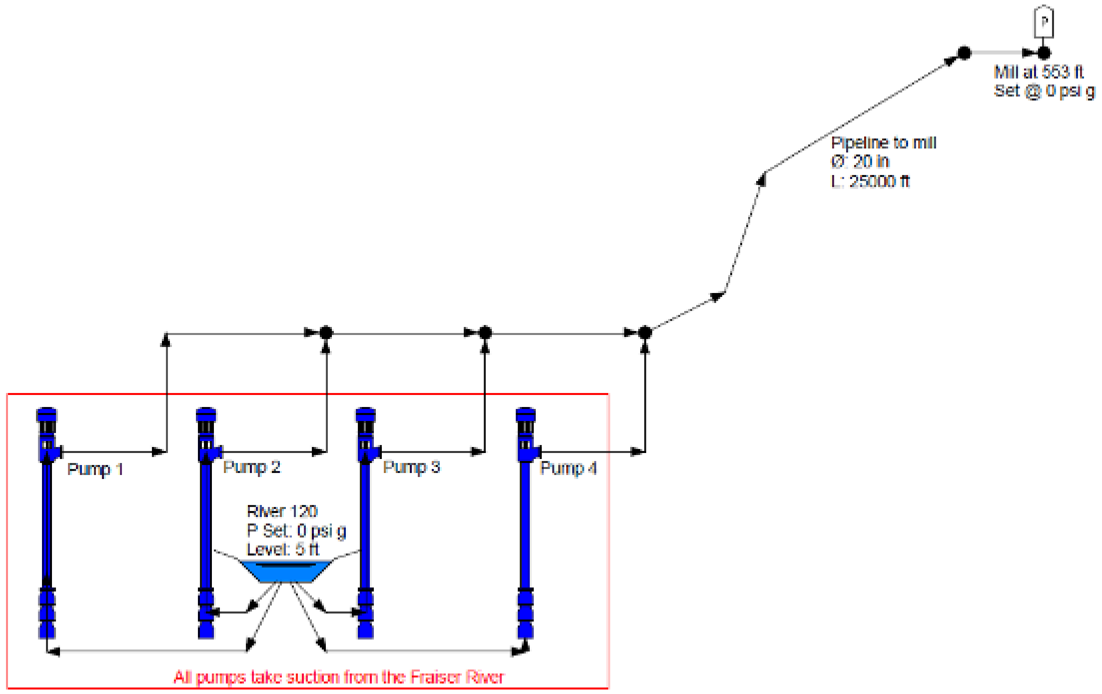
Case Study – Finding System Bottlenecks

System Bottlenecks

This case study is based on an actual analysis of a reclaim water pump system in a nickel mining operation. The reclaim water system consisted of four 10-stage vertical turbine pumps operating in parallel, and a 25,000-foot long 20-in diameter pipeline passing 12,700 gpm of river water. The mine wanted to increase the flow rate from the river to 15,000 gpm. They decided to model the reclaim water system using PIPE-FLO in order to determine the Total Head required for the additional flow rate.



Piping System

Reviewing the piping system shown above you will see four pumps draw suction from the river at an elevation of 120 ft above sea level and discharge through a common header which is a 25,000 foot long, 20 in. diameter pipe to the mine located at an elevation of 553 ft. above sea level.

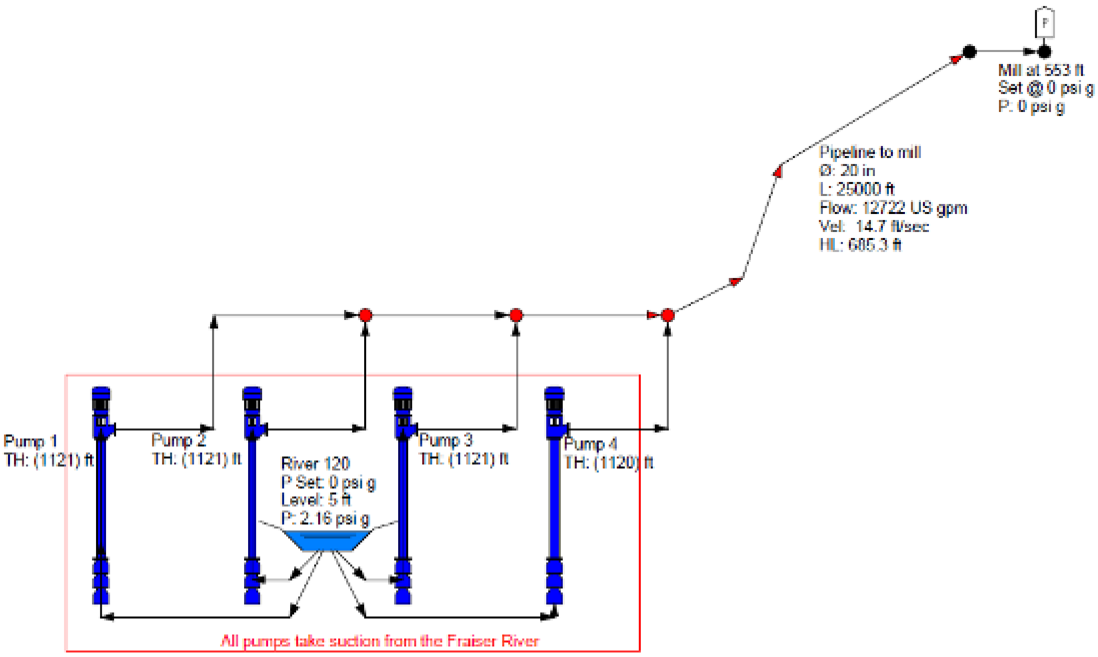
In this example we will calculate the Total Head needed to pass 15,000 gpm through the system, or a flow rate through each pump of 3,750 gpm. While doing this analysis we will:

• Review the calculated results for the design case of 12,700 gpm to see how our current system operates.

• Perform a pump sizing by specifying the new flow rate of 3,750 gpm per pump and calculating the Total Head needed to achieve the new design flow of 15,000 gpm.

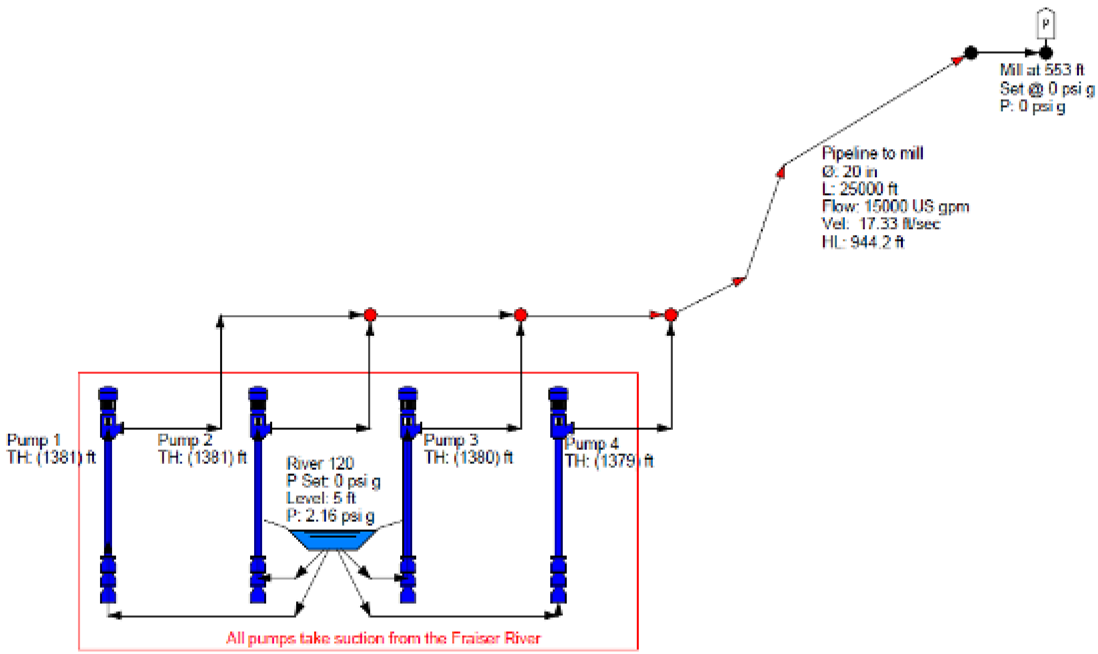
• With the Total Head for the new flow rate, we can determine the number of additional stages required for the four vertical turbine pumps.

Resizing the Pumps



View the results on the calculated system above. The calculated flow rate through the pipeline called "Pipeline to mill" is 12,722 gpm, which closely agrees with the 12,700 gpm observed in the plant.Notice the "Pipeline to mill" has red arrowheads, indicating the fluid velocity is outside the design guides on the high side.You can also see that the velocity is 14.7 ft/sec.This is a very high velocity for a pipeline.

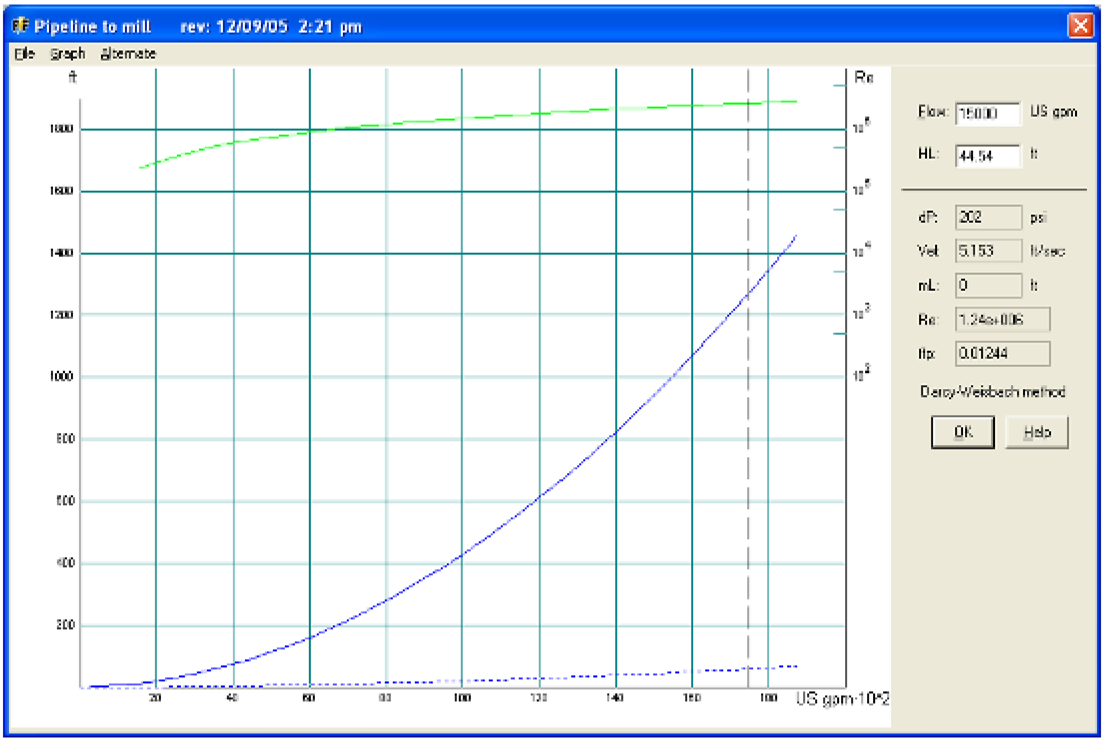
On the system above, you can see the dynamic losses for the pipeline are 685 ft! We may want to consider a system modification to lower the fluid velocity in the pipeline, which will reduce the pumping head required. But before we make any changes, let's see what the Total Head requirement is for the pumps at 15,000 gpm. To determine the Total Head requirement at the higher flow rates we must change the flow rates in each of the pumps to 3750 US gpm.Then we will calculate the system again.



In reviewing the results, an additional 260 feet of Total Head will be required from the pumps to achieve the additional 2300 gpm of flow. Two stages might be added to the pumps, however this would exceed the maximum number of stages available for the existing pumps. As a result, we will either have to replace the four existing pumps with pumps that can meet the additional head requirements, or we can look at what can be done in the system to reduce the high fluid velocity going in the mill pipeline.

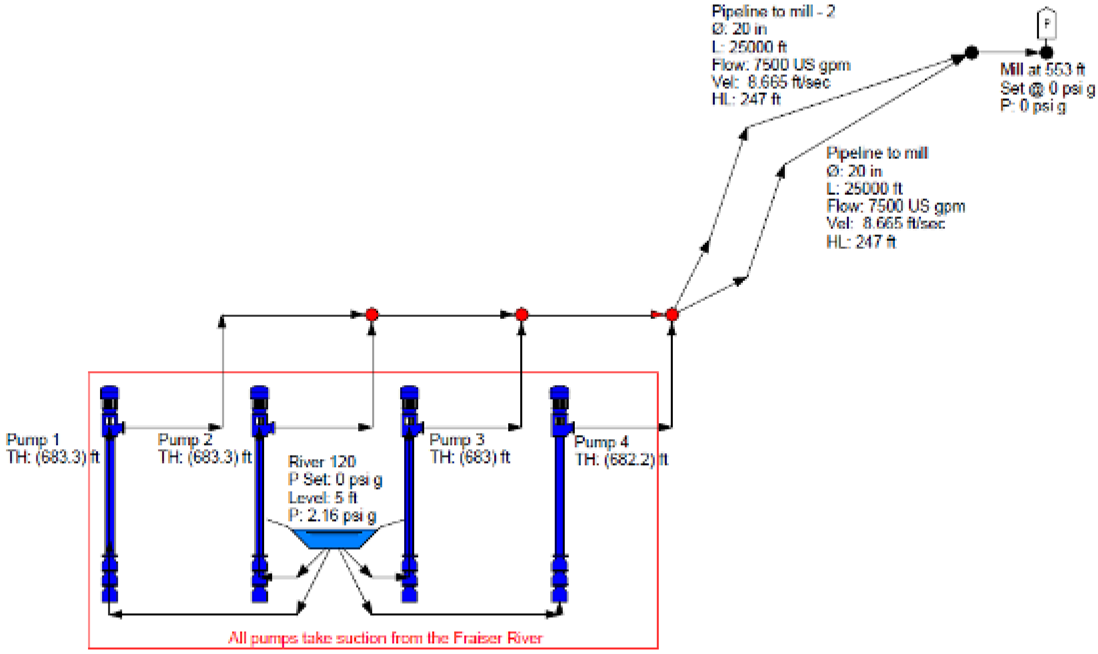
Considering an Alternative

It is obvious that the high velocity in the pipeline is causing extreme pipe friction losses. Let's see what will happen if the "Pipeline to mill" was 36 inches in diameter instead of the current 20 inches.Notice from the image above that when the flow is 15,000 gpm the head loss in the pipe is 944 ft.To do an alternative analysis on "Pipeline to mill" we will graph the pipeline.Then we will add an alternate pipe size. The solid blue line is the head loss in the 20 in. pipe and the dotted blue line is the 36 in. pipe.Notice the head loss in the 36 inch pipeline is only 44.54 ft vs. the 944 ft of head loss for the 20 in. diameter pipe.



Making the System Changes

Since the 25,000 ft of 20 in diameter pipe was already in the ground, it was decided to run a second 20 in diameter pipe next to the existing pipeline. That way the pressure loss in the 25,000 ft line is reduced and there will be greater future capacity. To do this we will just copy "Pipeline to mill" and paste it next to the original pipeline.With the calculated results we can see the Total Head needed for the pumps.



Notice the pumps' new Total Head requirements are 683 ft of head, instead of the 1,380 ft found with only one 20 inch pipeline to the mill.

In reviewing the pump curves for the existing pumps, it is determined that 5 stages can be removed from the existing 10-stage vertical turbine pump. How does this affect the pumping cost?

With the system operating at 15,000 gpm for 4,000 hours per year and $.08 / kWh, the pumping cost for the four pumps is as follows:

• Pumping into the single 20 in pipeline the pumping cost is $1,189,350 per year.

• Pumping into the two 20 in pipelines in parallel the pumping cost was reduced to $545,520 per year.