Progress Report: Transition Flow Rates

Paroma Chakravarty pc479

May 17, 2016

1 Introduction

Design Team is responsible for translating the results and conclusions reached by the research teams into Mathcad code that draws AguaClara's treatment systems. The team works on design challenges each semester that range from editing an existing component of the treatment system to higher level design work that deals with the fluid mechanics of the treatment system, such as deciding the flow rates at which different design approaches are needed.

2 Transition Flow Rates

Significant changes in component geometry or overall plant layout occur as the treatment plant design scales from small village level flow rates to city level flow rates. There is currently an understanding that certain ranges of flow rates have certain design elements associated with them, but the exact zones of transition are unknown. One design challenge this semester is to make progress towards determining what these transition flow rates are and how the team will determine what design elements are associated with them. This task will use the existing code to determine what the AguaClara design can and cannot do at various flow rates. Changes to the design engine that use the new transition flows will be the primary deliverable along with a document that outlines the flow rate transition zones and the constraints that govern them. While the document will likely be a word file, the results from this design challenge should help the team determine how future plant designs will be coded.

2.a Challenge Details

2.a.1 Methods

The first step in this design challenge was to determine what constrained the design at lower flow rates by drawing a plant with two smaller sedimentation tanks at 2.5 L/s for a flow rate of 5 L/s. Another plant was also drawn at 5 L/s with the one sedimentation tank and the two designs were compared. Feedback from engineers in the field and Monroe was used to determine which plant design made more practical and economic sense. The next step concerned determining the constraint at the other end of the flow rates. The past maximum flow rate for a single treatment train was 70 L/s. That flow rate was based on a maximum LFOM diameter of twelve inches. This was due to the elbow at the end of the LFOM/rapid mix pipes that led to the flocculator. If the diameter of the pipe had been allowed to be larger, the elbow would have been too large and therefore too expensive to build. With the new entrance tank design, this elbow has been eliminated and larger LFOM sizes are allowed. With this new design capability, the LFOM code was manipulated to determine the maximum train flow rate. The equation

$$2 * \sqrt{\frac{(A_{LfomPipeMin}(Q_{Train}, HL_{Lfom}, \Pi_{LfomSafety})}{\pi}}$$

determines the nominal diameter for the LFOM for various Q_{Train} values. Several flow rates were tested and the corresponding nominal diameters were noted. The final maximum flow rate was determined based on the largest pipe size currently available in the AguaClara pipe database. Once the transition flow rates had been determined, variables within the design code, such as $Q_{PlantMaxLF}$ which governed the upper limit of "low- flow" AguaClara treatment system, were changed to reflect the new transition flow rate. While working with the low flow, high flow, and standard design codes, some coding and design inconsistencies were found and documented in the Future Work section of this report. Finally, a chart that contains the new transition flow rates has been created and included in this report as Table 1.

2.a.2 Discussion: Results and Analysis

The main goal of this design challenge was to determine which constraints determine transition flow rates. This involved drawing the plant at low and high flow rates (determined by the current transition zones) to see what the code could do. It also involved consulting with the engineers on the ground and with Monroe to determine what construction constraints exist with AguaClara's treatment systems. There were many issues with drawing a multi-sedimentation tank low flow plant. With multiple smaller sedimentation tanks, sedimentation inlet and outlet channels also had to be added to the low flow plant. The code that drew the channels did not draw the channels correctly when added to the low flow code. Figure 1 compares the channels in a standard plant with the channels drawn in the low flow plant to demonstrate the errors that were occurring in the low flow design. Additionally, there is a layer in the low flow code that is interfering with the drawing code. When the low flow plant is drawn from Mathcad, it has an over-sized blue pipe or giant circle surrounding the plant. When a low flow plant is drawn from the design server, it does not have this inconsistency. In an effort to see if the multiple sedimentation tank code is working, it was uploaded to the beta server and drawn from there. Currently, it is only drawn at the 5 L/s flow rate to demonstrate the idea of multiple sedimentation tanks at low flow rates. The beta server link was then sent to Monroe and AguaClara engineers in Honduras. While the file still had some issues of fitting the sedimentation inlet and outlet channels with the filters, there was useful discussion and feedback for the design. The engineers on the ground wanted to ensure that the sedimentation inlet manifolds were no shorter than 2.4m, which is based on the idea that the inlet/ outlet channel total width should not be more than twenty-five percent of the total sedimentation tank length (they are about 80cm long). The engineers also mentioned that at smaller flow rates like 5 L/s, it might not be cost effective to have multiple sedimentation tanks. They also mentioned that the prefab plant, which is being researched currently, might eliminate the current transition zone of one sedimentation tank completely. Monroe countered this with the idea that below 5 L/s, there would be multiple prefab plants working together. At 5 L/s, there could be only one sedimentation tank, but the plant would be designed with regular inlet/ outlet channels in case the plant needs to be scaled up to have another sedimentation tank. Monroe also mentioned that at 7.5 L/s, the plant could have two smaller sedimentation tanks with shorter manifolds that were still above the 2.4m minimum. 10 L/s would then have two regular sized sedimentation tanks. Monroe emphasized that the goal of these changes would be to eliminate the special design case of one sedimentation tank in a plant. This way, one tank could be taken off line for maintenance without disrupting the treatment train.

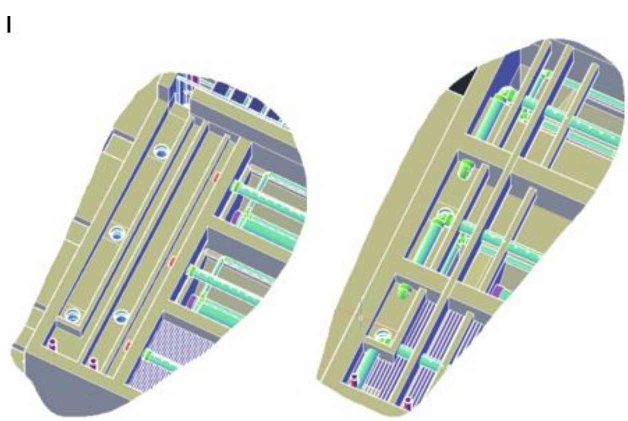

Figure 1: Channels drawn in the standard code versus channels drawn in the low flow plant.

In addition to working with the 5 L/s plant, the low flow upper transition point was set to 16 L/s because below this flow rate, EStaRs need to be used. At 16 L/s, two 8 L/s filters are needed. Filters are built in pairs for backwashing purposes, so two of the smaller filters are needed. The transition from OStaRs to EStaRs happens here because the filter boxes required for two OStaRs under 8 L/s filters get too small in width for masons to fit into. Currently, a width of .5 m is the minimum allowable dimension for a mason to be able to work in a filter box. As can be seen in Figure **??**, the filter box for a 8 L/s filter is extremely close to .5 m, so anything smaller than this is too small to construct. This transition is reflected in the code with the variable $Q_{PlantMaxLF}$ set to 16 L/s.

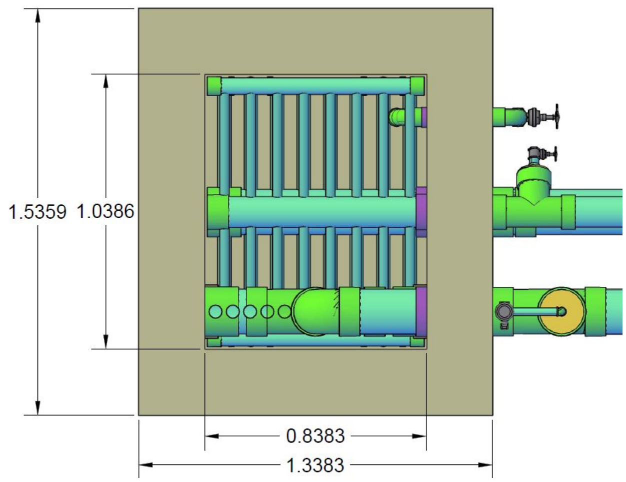

Figure 2: The filter box for an 8 L/s filter. Two of these filters are needed for a 16 L/s plant flow rate.

At the other end of the flow rate spectrum, Expert Inputs in the final designs folder was edited to have a new variable called $Q_{TrainMax}$. It is currently set at 150.1 L/s based on the fact that the largest pipe diameter available in the AguaClara pipe database and required for this flow rate is 24 inches. This flow rate and pipe size were found from the equation

$$2 * \sqrt{\frac{(A_{LfomPipeMin}(Q_{Train}, HL_{Lfom}, \Pi_{LfomSafety})}{\pi}}$$

mentioned earlier in this report. After creating this variable, the code that determine the number of trains needed was also changed. Figure 3 shows the new design code for determining the number of treatment trains needed in a plant. These changes mean that for now, the high flow transition to multiple treatment trains happens above 150 L/s. This is a flexible constraint that could be increased if larger pipe sizes are added to the pipe database.

$$Q_{TrainMax} := 150.1\,\frac{L}{s}$$

$$EN_{DoubleTrain} := \begin{cases} 1 & \text{if } Q_{Plant} \geq Q_{TrainMax} \\ 0 & \text{otherwise} \end{cases}$$

$$N_{Train} := \begin{cases} 1 & \text{if } Q_{Plant} < Q_{TrainMax} \\ \text{Ceil}\left(\dfrac{Q_{Plant}}{Q_{TrainMax}}, 2\right) & \text{otherwise} \end{cases}$$

$$Q_{Train} := \frac{Q_{Plant}}{N_{Train}}$$

Figure 3: The way of determining the number of treatment trains needed above the new maximum train flow rate.

After setting 150 L/s as the transition flow rate to high flow code, a standard plant was drawn at this flow rate to determine what design errors exist at such high flows. The main issue concerned the sedimentation channels. Figure 4 shows how wide the inlet channel are. This results in an extremely large and therefore impossible to build floc hopper. Additionally, the channels could get too deep and interfere with the floc hopper that way as well. The design theory behind drawing the sedimentation channels needs to be updated to prevent this from happening.

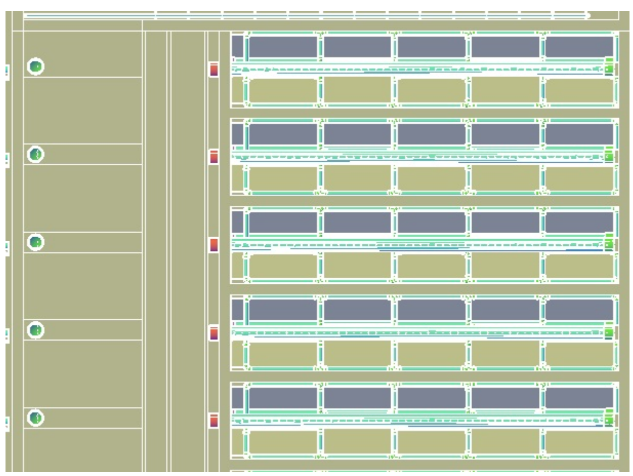

Figure 4: Channels drawn in a 150 L/s are extremely wide and are causing the floc hopper to be extremely wide.

Table 1 shows the final transition flow rates determined this semester. The constraint that governs the upper limit for each zone is explained in the table.

Table 1: Transition Flow Rates and Constraints

Description	Upper Constraint	Min Q (L/s)	Max Q (L/s)
Pre-fab plants	Number of pre-fab plants needed, beyond 4.9 L/s, use EStaRS design with sed tanks	1	4.9
2 EStaRS 1 sed tank with room for more sed tanks (include sed inlet and outlet channels when building)	A bigger sed tank (inlet manifold length of 3.5m) could be used at 7.5 L/s	5	less than 7.5
2 EStaRS or more, 2 sed tanks	The masonry needed for the filter boxes for OStaRS gets too difficult (too small for a normal sized person to maneuver) below 16 L/s.	7.5	16
2 or more OStaRS	Due to a 24in LFOM (biggest pipe size in database)	greater than 16	150
Multiple treatment trains (multiple chemical dosing, entrance tanks, flocculators)		150	1000

3 Future Work

Future teams should focus on creating and debugging low flow code so that it can draw different sized sedimentation tanks based on the low flow rate zones. Teams should debug the high flow code to be able to draw plants with multiple treatment trains. Finally, a team should debug the standard design code to be able to draw plants at the higher end close to 150 L/s and not have the sedimentation inlet/ outlet channels interfere with the floc hoppers as seen in Figure 4 .

4 Task Map

4.a Task Map Details

- Determine what design tool is currently drawing: due Thursday February 18th , Both the stock flow rates as well as the Mathcad code will be run to see what the code is currently drawing. A document that has a table of the flow rates and the associated parts of the plant will be created. This is to determine where the transition flow rates will be.
- Determine transition zones: using the current drawings, make a document listing where the transition flow rates are for the plants
- Determine stock flow rates: mid-April, once the transition zones are known, example flow rates should be included on the design server

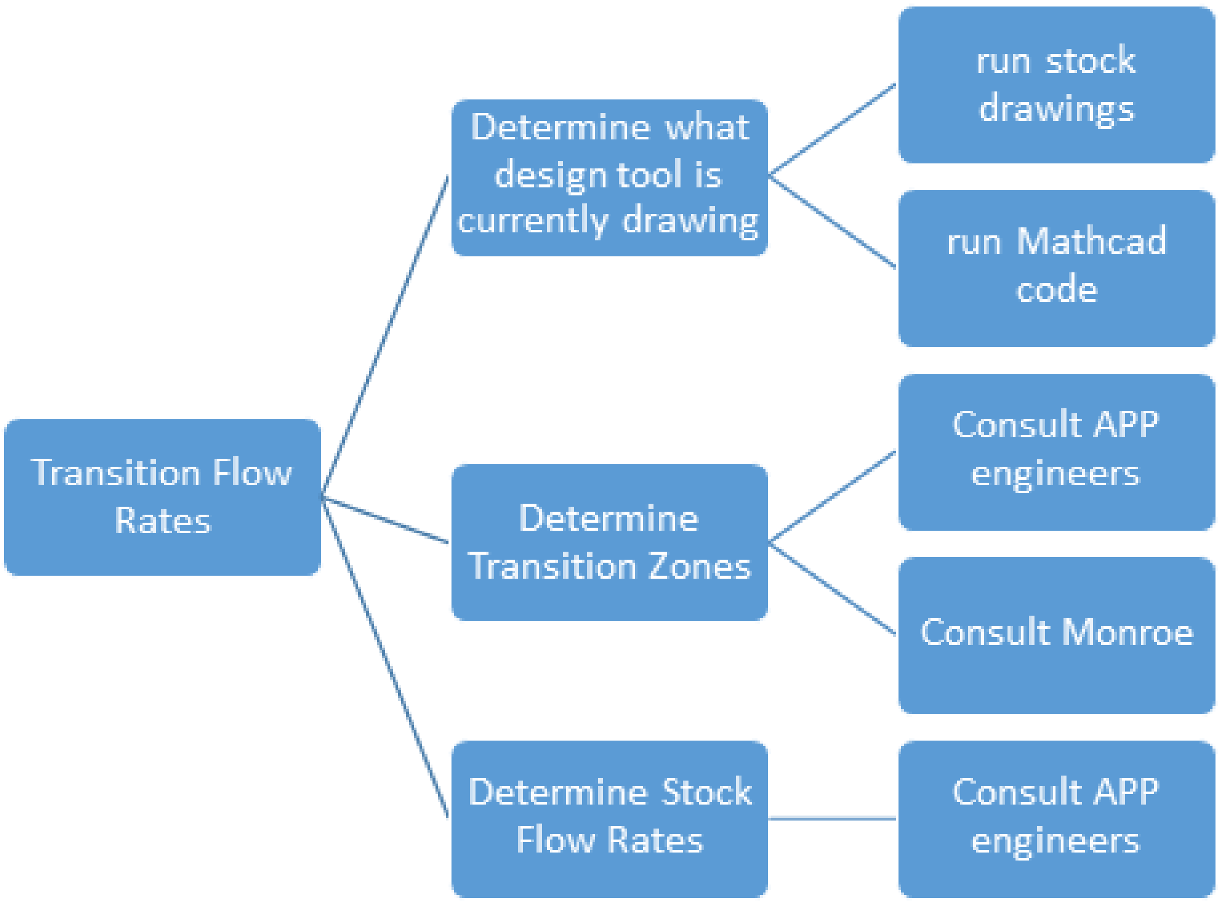

Figure 5: Task Map