Challenges Summer 2010

Team Challenges for Summer 2010

Design Team Summer 2010 Challenges

*Items in **purple** are complete.*

Designs for Honduras

- Coordinate with the team in Honduras to create detailed designs for Marcala, Jalaca, and Atima. Add these sites to the project sites page including design flow, population served.

Training

- Train new students to code using modular programming techniques that build on functions that have already been developed. Require students to learn what each of the sections of code do.
- Introduce the variable naming guide and create a function naming guide.
- Create a quiz to evaluate how well the training worked.

Code Organization

- Create a flow chart of the entire coding structure of the design tool with explanations of the various components. This will serve as a guide for new team members as they learn about the structure of the code.
- Evaluate our code structure and look for ways to make coding more efficient. Identify high level drawing procedures that are frequently used and create high level functions with easy to use inputs to execute these procedures. The goal is to create easy to use modular code. Our overall code organization could be rearranged to make designing and drawing components more modular. We could put all of the core functions for creating AutoCAD scripts at the top of the MasterProgram. Then the high level drawing code for each unit process would be included in the same file where the dimensions are calculated. Thus the code to draw the flocculator would be at the bottom of the flocculator 3 file.
- Review the methods used to draw plant components. Evaluate the possibility of creating higher level functions for drawing objects. These functions should handle creating the layers, freezing other layers, if necessary subtracting from an array of layer (for pipes). The functions should be intuitive to use and generic. They should be created using lower level MtA functions. We need to draw more plant piping and thus creating easy to use piping algorithms would be VERY useful. Drawing a pipe might require...
    - layer name where the object is to be drawn
    - array of layers that the pipe should subtract from (to go through concrete walls)
    - point defining start of pipe (3 element array of xyz)
    - point defining end of pipe3 element array of xyz)
    - pipe geometry (inner diameter and wall thickness) or (Nominal diameter and pipe specification)
- Review the method used to create different design cases. Evaluate different approaches for handling cases given our constraints in MathCAD. Will the integration of the design and drawing code into the same file make it easier to handle design cases? If in the future we want to create

designs with options for not using plate settlers or adding filter units then we will need to have clear procedures for implementing cases.

Wiki Documentation

- Update the wiki documentation (convert to Word documents and follow the updated Wiki Organization Guide)
- Create and document a better method of exporting CAD drawings for use in MSWord and the wiki. One possibility is export as a wmf (windows metafile). This creates a vector based drawing that can be imported into MSWord. It can be converted to a editable drawing object.
- Archive old files from the design part of the wiki (there is now an archive space in our wiki)
- Create a new wiki page with a series of tables of designs showing the variety of designs that can be created by the ADT. Parameters to vary are Q.Plant (5 L/s, 10 L/s, 25 L/s, 50 L/s, 100 L/s), N. SedTanks of 2 for the 5 L/s otherwise increase to 3 or more for large plants, N.SedBayEst (1 for small flows, increase as the flow increases and try different numbers of bays for larger flows to vary the plant layout). For each design, list the input parameters from the online ADT in a table and then provide links to the AutoCAD, xls, and PDF documents.

Variable Naming Guide

- Add a function naming guide to the variable naming guide. Review the naming guide with the team and then implement the naming guide
- Confirm that all variables in the VNG follow the naming convention and edit and update and noncompliant variables
- Extend the naming convention if there are additional types of variables that don't fit in the existing categories
- Check for consistency with variable names in the specifications document
- Confirm that all variables that are returned to the client in the spreadsheet are defined for all design cases. If there are variables that can't always be defined, then the LabVIEW code will need to be modified to not report variables that aren't defined. It is important that we eliminate errors in the spreadsheet that we return to the client so they don't assume there is a problem with the design.

Online AguaClara Design Tool

- Add language specific email responses that include the requirement that the design be reviewed by a professional engineer and that Cornell is not liable for any damages due to the design. These could be simple text files with a naming convention that includes the identifying number of the language (English is 0, Spanish is 1)
- Update the language file that goes with the ADT so that all labels are translated correctly. Determine if we need to add any new languages. Update the language file where it is posted on the wiki.
- Review input parameters. Consider adding the slab thickness as a separate input parameter.
- Assuming that filtration will be added soon, create a strategy for how the filtration design will be accomplished.
- Should there be an option for designing individual unit processes rather than always designing the entire plant?
- Considering adding an option for specifying the length of a flocculator channel. Handle this parameter in the same way that the depth of the flocculator is handled.

Creating layouts and adding dimensions (Tai)

1) Create layouts showing views in paper space as required by the engineer and possible as required for the design specifications document. Create the layouts of standard views based on the suggestions by Gonzalo.

a) Finish debugging the new functions related to creating layouts.
b) Find a way to create and edit multiple view ports in one layout. Alternately (and Monroe recommends this approach) only create one viewport per layout. Keep the layouts simpler and less cluttered.

2) Add dimensions and elevations to the layouts

3) Add a scale to the layouts

4) Add the AguaClara logo and disclaimer to each layout page

5) We do not have a simple method for adding text descriptions in the user specified language. We need to determine if it is going to be necessary to add text to the layouts. If it is necessary to add text to the layouts then we need to devise a method to do this. We would need a database of text blurbs and unique codes that identify each of the blurbs. The database would have a column of text blurbs for each language. The LabVIEW Design Server would need to send customized commands for each text entry based on the user selected language.

Documentation (Lindsey)

- Fix flocculator section in the design document. We want to change the field code so that it automatically displays text corresponding to either vertical or horizontal flocculators (whichever is appropriate to the design generated by the design tool). Then, if a vertical flocculator is chosen, we want it to display information about either plastic or rigid baffles (again, whichever is appropriate)
- Update all variables to follow the VNG conventions.
- Determine what drawings are needed to supplement the written information.
- *Integrate the materials list into the design document.*
- Carefully review the document and double check all reported values against the CAD drawings to make sure that all variables are described correctly.
- Make sure that all dimensions are accurately specified to avoid confusion between inside and outside dimensions and center to center or space between.
- Request documentation review from field engineers
- Translate the document into Spanish.

Design Review (Error Testing – contact Julie Pierce for guidance)

- Check all elevations as drawn to see if they are correct. There appear to be problems with the rapid mix pipe elevation and the stock tank elevation equations need to be revised based on the actual head loss through the float valve orifice plus a factor of safety (perhaps 20%).
- Create a MathCAD document that executes at the end of the design process (at the bottom of the list of references in the master program)
- Devise a series of independent calculations (with equations that don't rely on ANY other MathCAD files) to check the design
- One goal is to create an error message explaining what went wrong if the design tool produces a design that is incorrect or if there are variables that are out of range. This error message would be returned to LabVIEW and included in the email to the client.
- Design checks would include
    - Energy dissipation rate in the flocculator
    - Collision potential based on total flocculator head loss, flocculator residence time, collision potential efficiency based on H/S.
    - Head loss through the launder orifices
    - Head loss in the waste channels
    - Energy dissipation rate in the inlet manifold ports
- The design checks could also be used to calculate parameters that are reported to the client in the specifications document.

Plant Design for Operator Access

Draw the walkways and any necessary stairs at appropriate elevations so it is easy for the operator to access plant controls. Make sure the operator can easily access the CDC and the chemical stock tanks as well as the tank drain valves. The walkways should be quite high (perhaps 50 cm below the tank walls) on the upper side of the plant near the chemical stock tanks. The walkway covering the drain canal could be at the same high elevation or it could be lower and hence closer to the drain valves. The operator must be able to control the valves and observe the sludge/water exiting into the drain canal from the walkway. Perhaps this walkway needs to be built using a metal grate so the operator can see the drain.

The stock tanks need to be accessible for filling with water and chemicals and for stirring.

There needs to be a place to fill a bucket with clean water from the exit channel. This should be a 1.5 inch pipe through the wall with a valve. The walkway must be low enough so that the bucket fits under this valve.

Chemical Storage Tanks

- Evaluate the feasibility of creating a plastic pipe database. Rotoplast is a likely source of plastic tanks in Latin America.
- Determine how the chemical addition and mixing will be done especially as the tank sizes increase. What is the upper limit for mixing using a paddle?
- Draw tank outlets, which should be located 10 cm above the base of the tank to allow for sedimentation.
- Add dimension calculations for the chlorine stock tanks to the "ChemStorageTanks" MathCAD file. The existing algorithm to calculate Alum stock tank dimensions can be useful to figure out how to do this.
- Edit "Chlorinestock" in the "AutoCAD Scripts" folder so that it draws the stock tanks (refer to the "Alumstock" file that contains design algorithm for the alum stock tanks).
- Note that the chlorine tanks could be located lower than the alum tanks since the chlorine is applied in the exit channel. If we set the chlorine tanks lower, then it won't be possible to prechlorinate. It may be better to set the chlorine tanks at the same elevation as the alum tanks so that the CDC can be used to control both alum and chlorine (and base).
- Draw pipes connecting the storage tanks to the float valve in the constant head tank.
- Include a T in a horizontal section of the line with a drain valve that can be used as a sediment trap to reduce the amount of sediment that gets to the float valve orifice

Entrance Tank/Rapid Mixer

Entrance Tank Coordination with CDC

- Determine if the CDC should also control the chlorine and base chemical feeds.
- Determine how the stock tanks for the various feeds should be positioned to make access and plumbing easy.
- Determine if the CDC is going to continue to be positioned directly on top of the entrance tank or if there is a method to move the dosing half of the CDC lever off to the side to reduce the risk of spills into the entrance tank and to make the CDC more accessible.
- If the CDC continues to fit directly on top of the Entrance Tank, then make sure that the entrance tank is wide enough for the CDC to fit. Devise means for the CDC to fit on larger entrance tanks for larger flows.
- Coordinate with the CDC team to add the Kerick valves (mini and larger sizes) to a database so that the correct valve can be selected based on the valve orifice size. Note that the flow ratings

providing by Kerick are for high pressure and are irrelevant for us. We need to use the orifice equation based on the difference in elevation between the stock tank outlet and the float valve. The orifice sizes are given for each valve and are not to be confused with the thread size!

- Draw the CDC in the correct position.

Entrance Tank improvements

Consider sloping the bottom of the entrance tank at 60 degrees like a cone to the drain. Or add a drain system that is similar to the drain system in the bottom of a sed tank. This drain would be opened daily to flush out accumulated solids

Use a minimum of 3” drain valve (the 2” drain valve at Marcala clogs). However, clogging might not be as big of a problem if this is purged at least every day. Perhaps the drain valve should be large enough to handle the entire plant flow so that the purge velocities are high and the large sediment can be scoured out of the tank. A valve to handle the entire plant flow will be large and expensive. How can we create a reasonable design algorithm for this valve?

Consider adding

- inlet manifold - (to eliminate short circuiting). The inlet manifold would be directly connected to the LFOM that is in the Raw Water Control Box. In this case the bottom of the Entrance Tank would be a valley identical to a sedimentation tank bay.

- plate settlers - It would be good to test this in a facility. It wouldn’t take many plate settlers in an entrance tank and we could determine if they make any difference in water quality. Their effectiveness would depend on the raw water composition.

- launder – how would this connect to the rapid mix pipe and alum dosing line.

The alum feed line must be installed securely because it can’t be easily checked during operation.

Eliminate the macro/micro mix orifices and replace with a single orifice that generates 1 W/kg of energy dissipation. This will eliminate or significantly reduce clogging problems. Design the rapid mix orifice /alum feed line so that it can easily be accessed and removed for inspection.

Raw Water Control Box

All of our plants should be designed so that the transmission line is allowed to run continuously even when the plant is shut off. This way when there is dirty water coming to the plant the plant can be turned off and the transmission line will eventually clear itself of the very dirty water. This will be accomplished with a raw water control box. The overflow will be across a sharp crested weir. This will make it impossible to send more flow to a plant than it can handle.

The raw water control box will be a small shallow tank inside the entrance tank. The raw water control box should contain the screen that is used to catch large debris to protect the control orifices from clogging. It must be easily accessible to the operator because the screen will need to be cleaned.

Water will exit the RWCB through a pipe that goes through the bottom of the RWCB. This pipe will serve as an inlet manifold into the entrance tank.

Low Flow Rapid Mix Design

- Create a micromix orifice interface on the coupling.

- Create a method to adjust the total head loss through the plant by adding more small orifices to the orifice plate. This is necessary to get the desired relationship between head loss and flow for the entire plant. It is done once at plant startup.
- Determine how to calculate the number of micromix orifices. This number is constrained by the goal of being able to easily add more orifices to adjust the total plant head loss at plant startup

High Flow Rapid Mix Design

For plant flows that require rapid mix pipes larger than 8 inches in diameter it probably makes more sense to build the entrance tank sharing a wall with the flocculator. The rapid mix would then be a constructed square duct. The micro mix orifice would be the inlet at the bottom of the floc tank wall.

- Create the algorithm to select which plant layout is used
- Create the design logic to draw the two different plant layouts
- Determine how to choose the entrance tank dimensions and location. Should the entrance tank be a channel that is similar to a flocculator channel? Or should the entrance tank have geometry that is closer to square? Do an analysis of construction materials. Note that the entrance tank is higher than the flocculator and thus if it shares a wall with the flocculator, that wall will need to be higher. Should the entrance tank be along the side of the flocculator or along the end of the flocculator channels? Consider the plumbing connections to the stock tanks and operator access.

Drain Systems for Entrance Tank and Stock Tanks

- Add a drain for the entrance tank that can be opened by pulling a pipe nipple (that protrudes through the water surface) out of a coupling embedded in the entrance tank slab.

- Connect drains from the stock tanks and the entrance tank to the drain line that runs along the side of the plant to the drain channel.

- Add a 2 inch nominal diameter drain port under the perpendicular weir that will connect the inlet and outlet channels to the control box. The drain port will consist of 2 elbows connected by a short pipe nipple that is buried in the concrete beneath the perpendicular section of the weir. The top of the elbows will be flush with the channel floor and will provide a means to drain the part of each of the channel that currently can't be emptied into the control box. A pipe nipple that extends through the water surface will be used in the control box to plug these drain ports. This addition may require the control box to be made slightly larger or may require that the existing ports in the control box be relocated.

Drain Channel (Dchannel)

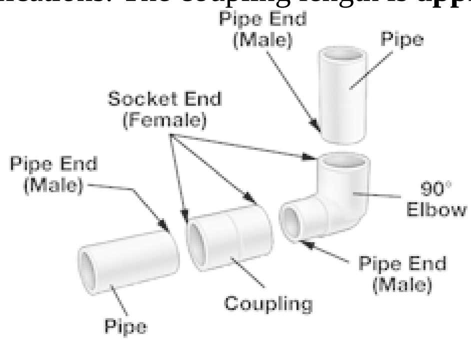
- Draw the drain channel along the inlet channel side of the sedimentation tank and flocculation tank.
- The channel should be sloped with the high end at the floc tank and the low end at the sed tank.
- Devise method of building channel when the flocculator tank slab is higher than the sedimentation tank slab.
- **Draw elbow attached to the inlet tee that empties waste water directly into drain channel. Elbow should be angled at 45 degrees so that waste water shoots down the channel in the direction of the flow.**

Plant Pipe Plumbing

Identify high level drawing procedures that are frequently used and create high level functions with easy to use inputs to execute these procedures. One possible high level plumbing procedure could take a series of points in 3D and draw a pipe and elbows to connect those points. To get from the line connecting one pair of points to the line connecting the next pair of points would require a 90 degree bend – an elbow.

PVC Pipe Couplings

- Couplings are currently drawn to a user-specified length, but in reality come only in lengths dictated by the pipe geometry and pipe specifications. The coupling length is **approximately** twice the socket depth plus the pipe wall thickness.



  Research at McMaster to find coupling lengths, add to the pipe database, and update so function calls pre-specified lengths. Compare the coupling function with the functions that are used to create tees, elbows, and caps and make sure that they use a consistent approach with similar inputs.
- Update all couplings to coupling subtract function so we do not have to keep both files/functions.

PVC Pipe Male Adaptors (female socket to male National Pipe Thread)

- Add PVC Pipe Male Adaptors to the pipe database.

- Make sure that all drawings of male adaptors (to connect to threaded components) are done using a high level function call that references the pipe database for dimensions.

Flocculation Tank (Rami)

- Adapt the code used to create the plate settler modules to create baffle modules for the case where the baffles are plastic.
- Review the construction photos from Agalteca to see how the baffle modules are constructed. Note the use of a large cap to provide an easy way for one module to connect to the next module.
- Make sure that the hydrostatic force of the water (caused by the head loss across a channel full of baffles) is transferred to the wall by the PVC connector pipes at the downstream end of the channel. Thus direction matters in how these baffle modules are placed in each channel.

Sedimentation Tank (Andrew, Molly, Brian)

- Add a constraint for the minimum flow per sed tank bay. Override the user inputs for both the number of bays and the number of tanks if the user specified values cause flows that are too small. The sed tank design fails for very small flows because the tanks get so short that there is no space between the channels.
- **Add documentation to the sedimentation tank design MathCAD code**
- **Create a description of the algorithm steps at the top of the MathCAD file and then label each significant step in the code**
- Insert MathType equations to show how the algorithm is solving for the various geometries.

- We will add a constraint to the code for the minimum flow rate per sed tank bay to prevent the design from failing when the flows are too small. If the rates are too small, the tanks are drawn too small. The constraint will override the user inputs for both the number of bays and the number of tanks if the user specified value causes the error.

- We will annotate the sedtank with pieces MathCAD file and outline the steps the code takes. Then we will write an overall description of the algorithm at the top of the document.
- We will update the sed design program wiki page by inserting MathType equations that describe how the algorithm is solved for various geometries.

Completion Date: July 9 th , 2010

Inlet Manifold

- **The inlet manifold moves outside the plant for high flow rates. Identify the source of this error and fix it.**
- Use a flexible coupling based on the new design that will make it possible to remove the Inlet Manifold given the tight space constraints in the sedimentation tank and the goal of having the manifold extend the entire length of the sedimentation tank.

- Determine the cause of the influent manifold drawing error for large flow rates and fix it.
- Use a flexible coupling based on the new design to have the manifold extend the entire length of the sedimentation tank

Completion Date: July 24 th , 2010

Launders

- **Add specifications for flexible pipe couplings to the pipe database. Standard dimensions are available at McMaster .**
- Launder connection at exit channel end needs to be updated to a flexible coupling: a short piece of tubing will extend out of the coupling that is embedded in the wall which will connect to the flexible rubber coupling connecting to the launder.

- Maximize length of launder to extend tight against the inlet channel wall.
- Code and place small concrete ledges on the inlet channel wall of the sedimentation tank to support the end of each of the launders. Take into account the outside diameter of the pipe cap on the end of the launder.

- Add specifications for flexible pipe coupings to the pipe database. Standard dimensions are available at McMaster

- Update the launder connections at the exit channel to use a flexible coupling.
    - NOTE: a short piece of tubing will extend out of the coupling that is embedded in the wall which will connect to the flexible rubber coupling connecting to the launder
- Maximize the length of the launder to extend tight against the inlet channel wall.
- Code and place small concrete ledges on the inlet channel wall of the sedimentation tank to support the end of each of the launders. Take into account the outside diameter of the pipe cap on the end of the launder.

Completion Date: August 1 st , 2010

Plate Settler Modules

Make the distance from the bottom of the first lamella (on the left) to the center of the bottom connector pipe be the same as the distance from the top of the last lamella (on the right) to the center of the top pipe. I'd suggest that the pipes should be further from the top and bottom of the lamella (see below for why).

The modules don't have any way of supporting each other yet. The pipe that fits through all of the plates in a module must extend through the last (and first) plates and then be capped with a PVC pipe cap such that the cap rests on or supports the next module. (This is another reason why the pipes must be further from the top and bottom of the plates because they must lean against the next module. This must be done with the length of connector pipe set exactly right so that the spacing between modules is the same as the spacing between plates.

Plate Settler Support Frame

- **Add holder supports in between bays to provide stability for the mainframe.**
- **Draw ledges on sed tank walls to support the mainframe**
- Add stubs along vertical pipes to provide stability to the plate settler modules.

Floating Floc Skimmer (Potential addition)

This item should be evaluated through discussions with the team in Honduras.

A drain pipe that makes it possible to skim flocs from the surface of the sedimentation tank. We have these installed at Marcala and Tamara. We need to assess whether they are necessary and useful or whether the new submerged chemical feed system at Agalteca makes these skimmers obsolete.

Floc Hopper (Potential addition)

This item should be evaluated through discussions with the team in Honduras.

This option may become necessary if we succeed in creating a floc blanket. The floc hopper would be used to control the depth of the floc blanket.

Control Boxes (formerly called weir tanks)

- Draw the control boxes as an extension of the inlet and exit channels. See the pictures from the Aga lteca construction to see how they are built.

- Remove tanks from the code and draw as extensions of the inlet and exit channel instead.

Completion Date: July 15 th , 2010

Filtration

We are in the process of evaluating filtration (either foam or stacked rapid sand filters) for addition to the AguaClara plants. Although we are still early in the research stage it would be useful to begin creating the design algorithms and the drawing tools for the eventual addition of filtration. This team needs to work very close with the filtration research teams. Given the concerns about long term durability of foam Monroe suggests focusing this early design effort on the stacked filtration approach.

- Create algorithms for determining critical elevations
  - bottom of the filter
  - backwash gutter elevation relative to water source coming from exit channel of sedimentation tank
  - Distribution tank inlet elevation
- Add backwash velocity equation to fluids functions
- Add clean filter head loss equation to fluids functions
- Experiment with new plumbing functions for drawing the required manifolds, valves.
- Determine what new user inputs will need to be added to the ADT. For now include these inputs at the top of the MathCAD filtration file.
- Determine what new expert input will be needed. For now include these inputs at the top of the MathCAD filtration file.
- Create preliminary automated drawings.

Materials List (Lindsey)

- Check and update the existing materials list equations to ensure that they are still accurate.
- Incorporate the horizontal flocculator into the code. Make sure the return the correct material amounts only for the relevant case.
- **Ensure that the ferrous cement calculations are accounting for the case of plastic baffles.** (Co mmitted: 07/06/2010)
- **The materials list returns a raw number of valves. Change the code to account for valves of different diameters when returning the materials list.** (Discussed: 07/07/2010)
  - The Design Values document (returned from ADT) specifies the number and nominal diameter of valves in the Sedimentation Tank and the Flocculation Tank, as well as the head loss through each valve in the Sed Tank.

edit this file

Inlet Manifold Research Challenges Summer 2010

Summary of Spring 2010 Results

Data collection methods were inadequate. When the ratio of the manifold area to the total area of vena contracta, $\frac{A_M}{A_{VC}}$, was reduced from 1.0 to 0.5, collected data was erratic with many outliers (Figure 1).

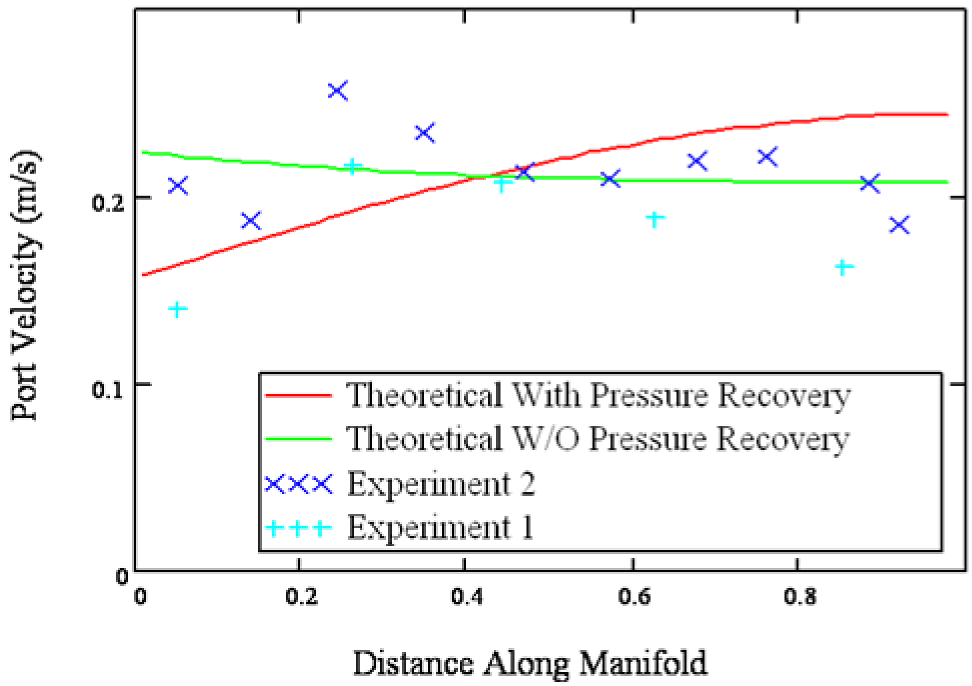


Figure 1 . Inlet manifold results with a flow rate of 3.8 L/s (1 gal/min) for values of $\frac{A_M}{A_{VC}}$ of 1.0 by drilling 1 row of 2.5 cm holes every 5 cm in Experiment 1 and 0.5 by drilling 2 rows of 2.5 cm holes every 5 cm on a 3.05 m (10') long 15.2 cm (6") PVC pipe.

Even with the ratio at a value of 1.0, the trend showed decreasing port velocity as distance along the manifold increased as opposed to an increasing trend as predicted by pressure recovery (Figure 2).

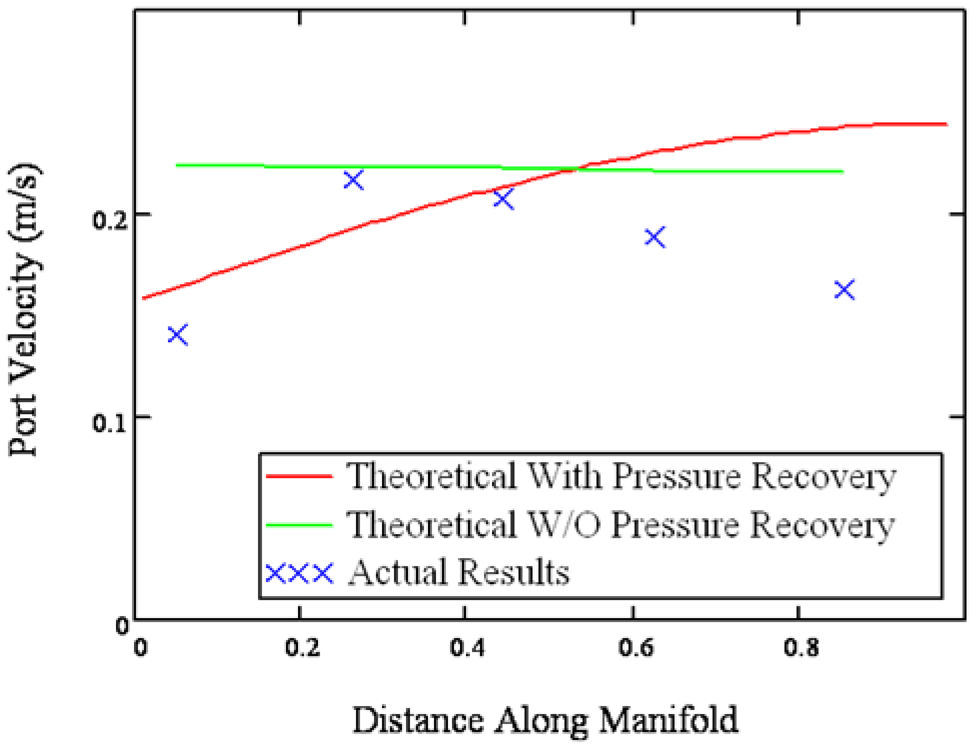


Figure 2 . Inlet manifold results with a flow rate of 3.8 L/s (1 gal/min) for values of $\frac{A_M}{A_{VC}}$ of 1.0 by drilling 2.5 cm holes every 5 cm a 3.05 m (10') long 15.2 cm (6") PVC pipe.

Challenges

Summarize and collect important articles that would help our understanding of manifold research and how to collect and process data from ADV

Understand what an ADV is, the flow regime we are measuring, and errors associated with the measurement

A good resource for both understanding how an ADV works and troubleshooting appears in Chamson et al. (2008), however, there may be other literature and resources to talk to before we even begin experimentation. For the most part, measurements for inlet manifold will occur in a turbulent flow. Previous research has shown that ADV signal outputs can be effected by Doppler noise, signal aliasing, turbulent shear, and turbulent velocity fluctuations (Chamson et al., 2008). Chamson et al. (2008) also notes that simple "raw" ADV velocity data should never be used without adequate post-processing. I am not sure that the software package that we currently use handles post-processing effectively or not.

Calculate anticipated port velocities before running the experiment

Calculations could be performed both to anticipate performance expected with pressure recovery and without. Better understanding and confidence of how accurate an ADV measurement could be (i.e. the anticipated standard deviation or average correlation of signal-to-noise) could also enable us in understanding whether the reading we record is reasonable or if there is something wrong with the data we are collecting.

Some signal processing advice

- When taking data samples, remove all data samples with average correlation below 60% of the signal-to-noise ratio (SNR) below 5 to 15 dB.
- The data can be further processed using phase-space thresholding techniques such as WinADV 2.025.

Solid boundary effects?

Proximity wall effect has been shown to be characterized by a significant drop in average signal correlations especially in small flumes. Perhaps we are experiencing some of these effects?

Solid objects or dye can improve recording?

It has been shown that there are recurrent problems with ADV signals including low correlations and low signal to noise ratios because of lack of particles in solution. We could mix in dirt and vegetable dye or even milk to perhaps increase the confidence we have in our readings. Adding flocs is perhaps another way we could increase the confidence in our readings.

Understand how to effectively operate the ADV and collect reasonable data

It is not clear how consistent the operation of ADV was in collecting data. In the future, perhaps we should work with a graduate student who is familiar with ADV operation, consult the operational manual in full, and note important parameters of ADV operation such as the distance of the ADV from a manifold port which is currently recommended to be between 16 and 17 cm by the former Inlet Manifold team. A sample experiment should be run and we should calculate expected velocities come out of the manifold beforehand. Perhaps we should also calculate typical flow distribution that would be expected from the ADV.

How does the flow leave the ADV?

The group noted that the flow does not leave the ADV perpindicularly. Perhaps a dye test is necessary with each experiment with subsequent imaging technology to assure us that flow is leaving perpendicularly or we have enough confidence to correct for the direction of flow.

Improve our understanding of how data varies with respect to location and time

A central challenge is to increase our ability to take replicable experimental data, and understand how velocities of flow in a pipe vary with respect to both distance and time. A sample of how data collected is shown in Figure 3 . Improvement in data collection would reflect the actual location of the port with respect to where the ADV is sampling and labeling the distance negative or positive with respect to distance from the center of the port. Another improvement would be to take three measurements at each of the port locations and understand how these measurements vary with time. When the location of flow is located that gives the maximum flow rate, perhaps several measurements could be taken over the course of 5, 10, or even 15 minutes so that we have some statistical understanding of how flow varies over the data set.

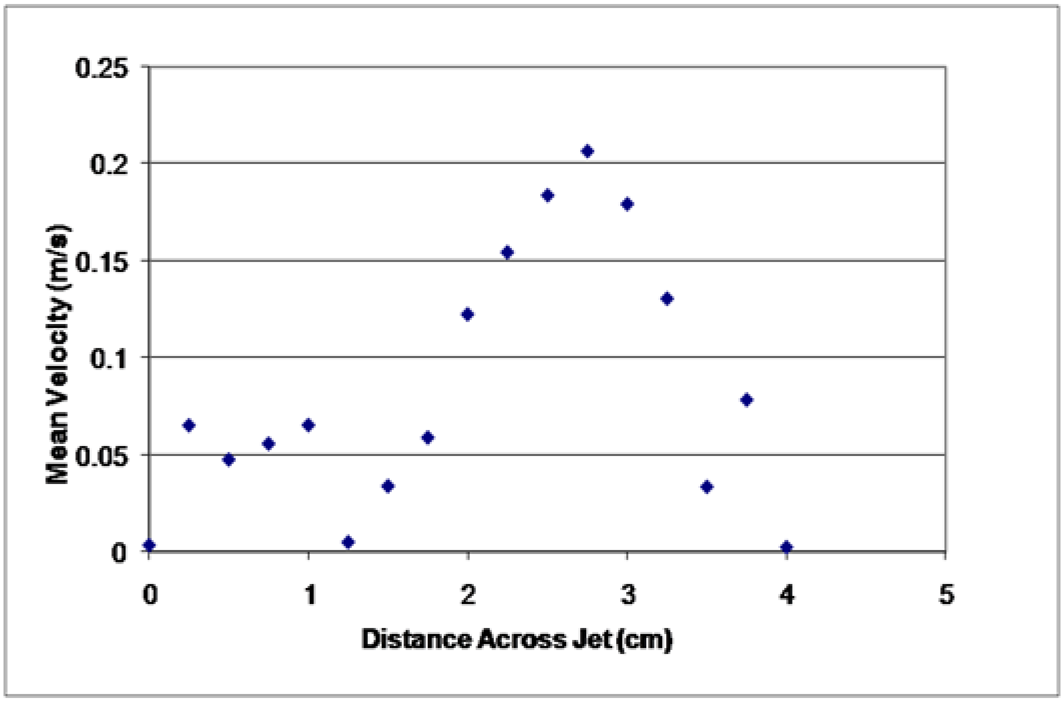


Figure 3 . Sample of mean velocity from a port with respect to distance across jet. The center of the port with respect to distance is assumed to be at 2.5 cm but is unlabeled.

Improve data processing capabilities

Perhaps we could write a program that could anticipate the flow conditions expected and then subsequently with data such as average correlation or signal-to-noise ratios we could eliminate bad data and improve our understanding how well the collected data is working.

Design a way to mount the ADV and easily, accurately shift measuring distances with ADV

I think utilizing a break system with 80/20 with an attached tape measurer or ruler would be most effective.

Final recommendation: Until, we can get reproducible data from one experiment and have appropriate data analysis capabilities, there is no sense in running any other experiments. The teams' priority next semester is ***reproducibility*** .

References

International Meeting on Measurements and Hydraulics of Sewers , 2008, F. Larrarte and H. Chanson (Eds), Hydraulic Model Report No. CH70/08, Div. of Civil Engineering, The University of Queensland, Brisbane, Australia

Challenges ANC Summer 2010

Summary of Work

The goal of this project is to provide a mechanism to increase the acid neutralizing capacity. It was hypothesized that a lime feeder could be designed such that the lime would dissolve producing hydroxide ions that would increase the alkalinity of the source water sufficiently so that aluminum hydroxide precipitation in low alkalinity source waters would be effective.

The mechanisms which lead to the failure of the lime feeder to produce saturated effluent over long periods of time are still poorly understood. We hypothesize that small lime particles may be more effective in dissolving and producing hydroxide ions because they have a higher volume to surface area ratio. A fluidized bed of lime has been observed to flocculate and produce relatively low pH effluent. This suggests that perhaps the flocculated particles dissolve poorly. An alternate hypothesis is that the particles become coated with calcium carbonate. The carbonate could be from the source water or from lime that contains calcium carbonate.

We would like to continue to evaluate the feasibility of using lime because it is relatively inexpensive and is produced in Honduras for use in making tortillas as well as other uses. It is possible that there are no good options for creating a lime feeder. Thus one of the priorities of this research is to assess the feasibility of using lime as a reliable and economical source of ANC. The tasks for this research team may need to be significantly revised based on the results of the tests to determine the carbonate concentration in the lime.

Challenges

Test the carbonate content of local and Honduran lime

There are two tests that are proposed here: we will measure the carbonate concentration of both the Honduran lime and local US agricultural lime. We will use a TC (Total Carbon) test utilizing the Total Carbon Analyzer in lab environmental engineering teaching lab. Po-Hsun has already agreed to instruct teams on the use of this instrument.

Calculate the mole fraction of the calcium that is associated with carbonate. Compare this fraction with the duration of the high pH during lime feeder tests relative to the theoretical predictions. This will make it possible to determine whether the failure to maintain a pH greater than 12 is due to a coating of calcium carbonate on calcium hydroxide particles that prevents dissolution or if it is simple that the fraction of calcium hydroxide in the lime is lower than we expected.

The other test will be to measure the alkalinity of lime utilizing the Gran Plot technique using the pH meter software. It is our hope that these tests will further elucidate if there is a major difference between the two sources of lime. If both lime sources have a significant amount of carbonates, then it may be necessary to try a different base.

The alkalinity test will make it possible to measure the total calcium concentration of the lime because the alkalinity is the same whether the source is calcium carbonate or calcium hydroxide. By combining the results of the carbonate and alkalinity tests it will be possible to determine the concentrations of calcium, carbonate, and hydroxide in the lime.

Set-up the pH probes to give more reliable readings

Instead of trying to read the pH of flowing effluent water, try placing the pH probes in a small beaker through which the effluent flows. Set up hydraulic conditions that cause intermittent flow into the beaker using either a solenoid valve or a intermittent self-priming siphon. The goal is to electrically isolate the measured sample from the rest of the apparatus and from the building plumbing system. This will eliminate voltage fluctuations and may result in more accurate pH readings.

Run an experiment with distilled water and the Honduran lime

The experiment would be run starting with 100 grams of lime with distilled water. Every six hours an aliquot equal to the amount of lime that would deliver six hours of a source water above pH = 12 will be added. The results will be run until the capacity of the lime has run out and this will be compared to tests from Spring 2010. If the results look promising, research with lime may continue. However, if the pH does not remain stable at above 12, then we may decide to switch to a different source of base.

Model of acid neutralizing capacity, pH, and alum dose

A MathCAD model will be developed and well documented that will calculate the capacity of both sodium carbonate and calcium hydroxide in providing alkalinity to an AguaClara plant. The model will take the raw water pH, alkalinity, and alum dose as inputs and calculate the required dose of lime or other base.

Plan for a full-scale evaluation at one of the AguaClara plants in Honduras to test the feasibility of using sodium carbonate

Begin by getting current prices for various bases that are available from the chemical supply houses in Honduras. Based upon those results , design a test that could easily be implemented in Honduras to see if the addition of base improves plant performance. Provide clear guidance for how a plant operator would set the dose of base. Work with the CDC team to devise a method for dosing the base.

Other Possible Ideas for Later Exploration

Develop a smaller-scale apparatus that is easier to control

The team could work with smaller, simpler experimental set-ups so that experiments can be run more easily and the important mechanisms can be isolated. Working with the large feeders, while important, can be cumbersome. Investigating the behavior of lime in suspension may be more fruitful in smaller-scale tests.

One potential set-up for a smaller scale experiment would be to put several shorter vertical columns in series, connected by flexible tubing, and end with one final diagonal tube settler column. This is an experiment that could easily fit on the bench top and would be easier to control and run. Figure 1 shows a possible set up for this experiment:

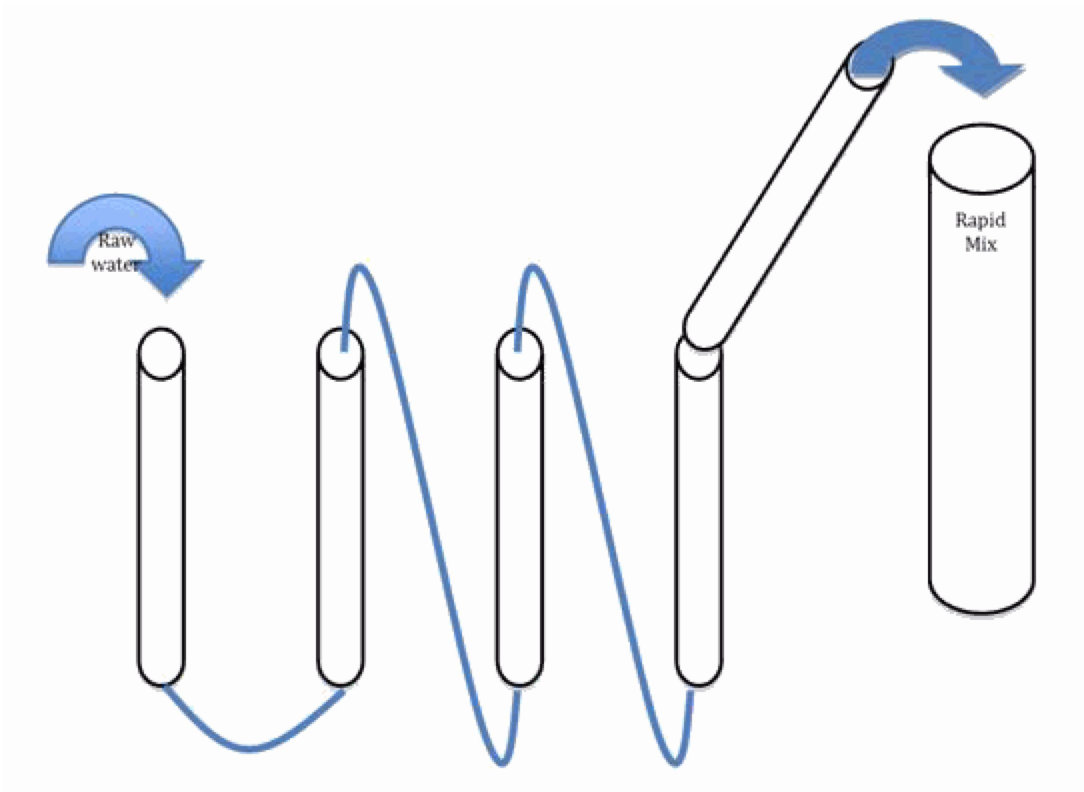


Figure 1. Potential experimental set up in which the vertical column is broken up into multiple, shorter columns followed by one final diagonal tube settler.

Determine if the method of preparing the lime suspension matters

Does blending the lime suspension improve its solubility?

Does creating a slurry before adding it to the lime feeder help?

It is possible to simply dump powdered lime into the lime feeder?

Explore entirely alternative methods of feeding lime or otherwise adding alkalinity to the plant flow

Challenges Tube Floc Summer 2010

Overall Challenges for the Tube Floc Team

The goals of this team are to provide an experimental basis for the required collision potential and the optimal energy dissipation rate in flocculators. These results will guide the design of flocculators and will help us understand the tradeoff between performance and flocculator residence time.

The challenges as described below don't provide sufficient detail to guide the research program. Thus the first challenge is to develop a matrix of experiments that will be conducted. The baseline conditions of the experiments need to be clearly described and then the parameters that are varied, the range, and the increment, need to specified for each experiment. Some experiments need to be replicated to assess the reproducibility. For each experiment the measured parameter is residual turbidity as a function of sedimentation time. These measured values can be transformed into a floc sedimentation velocity distribution and a curve of residual turbidity as a function of capture velocity.

Future Challenges

Organize experiments and the team

There should be a significant amount of work divided between the team members. Each team member ideally will be able to run experiments in process controller and analyze data by Week 3 in the summer. The apparatus should be run as much as possible and schedules should be coordinated in advance to avoid delays in collecting data.

Run the first experiment on the matrix of experiments and make data processor as robust as possible

The data processor needs to be updated and made more robust for the purposes of better data analysis.

Validate FReTA using a known suspension of particles

The reviewers of Water Research noted that FReTA has not been validated by a known particle suspension to ensure that the settling velocities obtained from data processor are reasonable. There are several proposals to test this known suspension. A particle size analyzer in CEE may have a valid test suspension. Other possible departments to look for samples include Material Science and Chemistry.

We have also purchased a known particle size but it has been proven to be a difficult test to conduct because the particles tend to flocculate and some do not seem to settle out of solution. However, the previous test was run with a line that had clay and some aluminum hydroxide in the line. It is proposed that we attempt to dye a new set of these particles with Methylene Blue. Ideally, once the dye adsorbs to the surface of the beads, it should absorb more light than the translucent beads. However, the dye in solution should have little effect on the turbidimeter readings.

Other Challenges to be explored...

- Investigate tapered flocculation designs. Hydraulic flocculators in AguaClara plants are currently designed such that the energy dissipation rates incrementally decrease over the length of the flocculator. Begin with an experimental setup that has two energy dissipation rates and determine if there is any benefit. The energy dissipation rate in the second section of the flocculator can be independently controlled by using a peristaltic pump to remove a fraction of the flow. Thus the same size tubing can be used for both sections of the flocculator.
- Investigate the influence of microscale mixing. For these tests use a well designed flocculator that produces very low residual turbidity. It is unclear what influence rapid mix parameters have on plant performance. Compare performance of systems with no rapid mix to systems that have a high energy dissipation rate (of at least 1 W/kg). Measure the effects of changing the energy dissipation rate (perhaps 0.1 W/kg to 10 W/kg) and the residence time (1 s with a single orifice mixer to 100 s with a long small diameter coil) in the rapid mix unit.
- Measure the potential impact of poor macroscale mixing by adding approximately 10% of the turbidity AFTER the rapid mix process.

• A laboratory scale hydraulic flocculator that operates under turbulent conditions that are relatively homogeneous and easy to characterize could go a long way into understanding turbulent flocculation. Comparison of residual turbidity and floc sedimentation velocity from turbulent and laminar flow flocculators could be used to validate flocculation models. Design a turbulent tube flow flocculator by using a larger diameter tube. Determine the required flow rates and assess the capabilities of the temperature controlled water source and the peristaltic pumps to deliver the required flows. Design an upgrade to the experimental apparatus to deliver the higher flow rate if needed. A turbulent tube flocculator that uses minor losses to generate energy dissipation could be created by inserting a string of spheres into a tube. This simple geometry could be a reasonable model of the full-scale baffled flocculators.

Later Challenges

Test the effects of pH and organic matter on flocculation

Measure the effects of organic matter and pH on the sedimentation velocity distribution and residual turbidity. Varying the pH of the influent may help elucidate changes in floc strength as a function of pH. It is possible that floc strength (as measured by floc size) is well correlated with optimal alum dose and pH. Raw water that contains a high concentration of organic matter relative to the concentration of clay may produce flocs with lower sedimentation velocities. An understanding of this effect on floc sedimentation is critical in designing plate settlers. The effect of pH on floc strenght and residual turbidity may help develop a more fundamental understanding of how to optimize the flocculation process.

Challenge for
Stacked Filtration Summer 2010

Summary

We have a preliminary idea of how we want to set up our stacked filtration system. The first task is to build a robust, laboratory stacked filtration system to test the feasibility of backwashing a filter containing multiple inlet and outlet manifolds and to test the particle capture efficiency.

Constraints:

- We are going to utilize the 4” ID column that was previously utilized for demonstration of rapid sand filtration in the environmental teaching lab
- The filtration system will need to be redesigned and then modified.
- Valves to switch between backwash and filtration will have to be operated manually
- We are going to utilize the tap water supply to deliver a flow rate of 2000 mL/min for rapid sand filtration. A clay stock suspension and an alum solution will be combined with the tap water to provide a test suspension.
- A backwash flow rate of approximately 4800 mL/min will be supplied and we suspect that this can be accomplished as a direct line from the tap
- A diagram of the system is shown in Figure 1.

Future Challenges

Determine the hydraulics and flow characteristics of the slotted pipe

A slotted pipe will be put in the 4" ID column to act as a manifold for the water such that the raw water is evenly distributed into and out of the filter. The percent "open" area of the slotted pipe seems to be a bit low. Calculations should be done to determine the head loss through the slots at the experimental design flow rate.

Test and troubleshoot the experimental apparatus

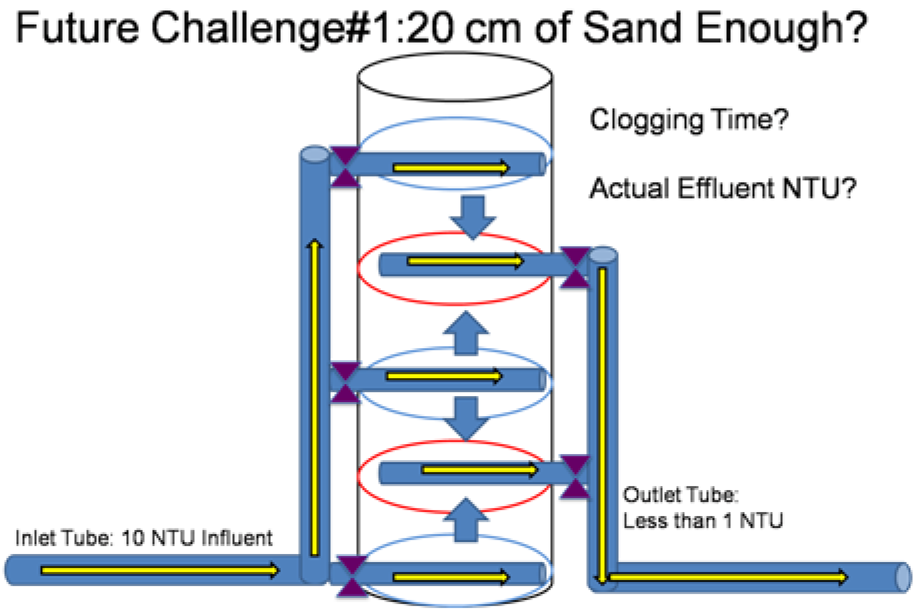
After you have built the experimental apparatus, the next step is to verify how it works. Check that all connections are water tight, and that backwash is sufficient to fluidize the sand bed. Backwash will be controlled by manual valves. The backwash sequence steps are…

1. Close all effluent manifold valves
2. Open the valve that takes backwash water from the top of the filter to waste
3. Close the inlet manifold valves starting at the top of the filter and progressing to the 2nd inlet manifold (counting from the bottom). This will force all of the water to enter the filter through the inlet manifold at the bottom of the filter.

Test the performance and efficiency of 20 cm sand

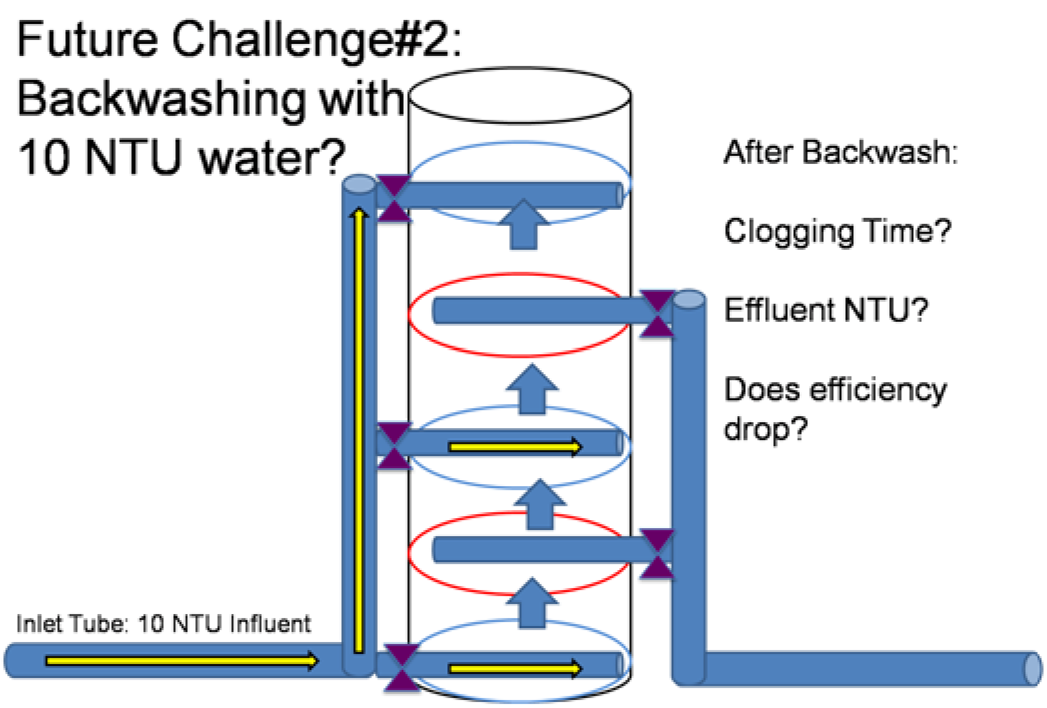
Ensure that process control is set up and that both the influent and effluent turbidity is appropriately sampled. Build a continuously stirred stock tank containing a concentrated suspension of clay. Design this to last at least 26 hours. The stock tank can probably be a few liters in volume. Use small diameter tubing to connect the stock tank to the peristaltic pump and to the point where it blends with the tap water. The peristaltic pump should also be running at high rpm so that the velocities in the tubing are high to prevent sedimentation. Dose with alum at a concentration of approximately 3 mg/L (30 mg/L per 100 NTU).

A second goal is to measure head loss within the filter as a function of time.



Backwashing with 5-10 NTU water

We need to find out the implications of backwashing the sand filter with water that is normally used as the influent. Does the filtration efficiency eventually decrease over time? Using this model, we can also simulate backwash with 5-10 NTU water dosed with 30 mg/L per 100 NTU alum and then rerun the first experiment to see how backwashing with the unfiltered water effect the filtration efficiency as backwash cycles are repeated .

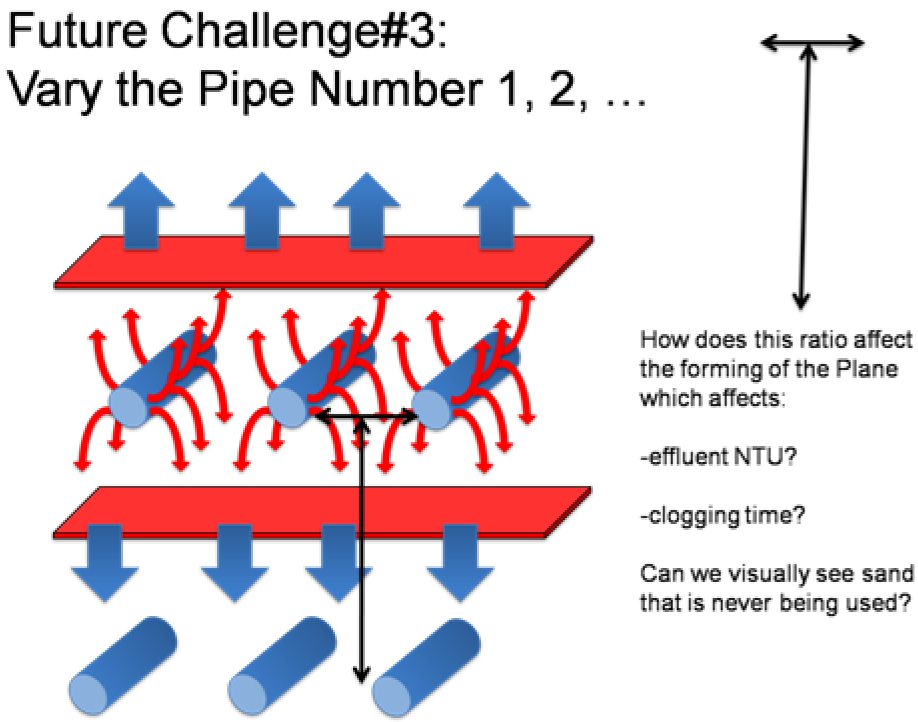


Later Challenges

Decrease the spacing of the sand layer or increase the spacing of the sand layer depending on results

Increase Natural Organic Matter content (NOM) and/or increase/decrease pH

Vary the pipe number utilizing a larger diameter reactor if possible (detailed in Figure 3)



Advice to the Future Filtration Team Member:

1. If you are not proficient in process controller, MathCAD, and wiki, find help early and learn.
2. I ntroduce yourself to Paul Charles and Tim Brock at the shop early. Who are they? Go find out.
3. Even when you are split into various different sub teams, meet every week to share progress and get feed back. We found that members from different subteams can provide insight and synergy and fair, fresh, and impartial evaluations. We also ended up switching team members between sub teams so it is good for team members to periodically meet each other.
   Set up a rountine where you meet with Monroe and Matt periodically as you make progress. They can catch mistakes that you miss and save you a lot of time and headache. This is a good way to avoid group think.
4. This search engine is great for articles related to hydraulics and filtration: http://www.jstor.org/action/doBasicSearch?Query=water+wire+filtration&wc=on&dc=All+Disciplines
5. If possible, take Monroe's Sustainable Water Supply Class and Professor Bisogni's Physical Chemical Process class. If not possible, get the notes.
6. Be flexible and proactive! It is hard doing all this initial research, but stay on top of it and document through out the process, otherwise it will be hard at the end .
7. Stay in constant communication with Monroe and Matt- they are filled with great ideas and will keep you focused.

Summary

A lot of progress was made during this semester and we are closer to building a prototype that could be tested and possibly utilized in the future in AguaClara plants.

Immediate Challenges

Learn Process Controller and Data Processor

A process controller method and data processor has been developed for this team. All new members must be trained with respect to filtration theory, process controller, and how to use data processor for experimental results.

Re-run experiment with foam column on its side

We suspect that the first one did not run correctly since the alum wasn't all used . Test to ensure that there was no aluminum hydroxide precipitation in the connections and that the dissolved concentration is appropriate. This experiment is vital and will give us an insight as to whether or not our plant design with foam socks is possible and will achieve turbidities of less than one . If there is failure again, we should continue to troubleshoot and try to ascertain the failure associated with this experiment before proceeding to build a laboratory scale model for AguaClara plants.

If tests prove to be successful for the foam column on its side, then built a prototype model

Current designs indicate that effluent water from the sedimentation tank will flow into a reservoir tank with stacked foam filter columns. Water from the sedimentation column will flow through the foam and through a slotted PVC pipe ideally delivering a clarified effluent below 1 NTU.

One important piece of this research will be to understand how to join sides of foam together and make the foam water-tight.

Another important piece of this research will involve coming up with an effective and reliable method of cleaning the foam in an AguaClara plant.

Challenges Plate Settler Spacing Summer 2010

The team's future challenges include: finishing the planned velocity gradient experiments using the clay stock and current reservoir system; reviewing settling velocity experiment calculations, setting up and running the experiment; and rerunning the velocity gradient experiments using natural organic matter instead of clay. Following this, the team should organize and prepare documents for publication of the results.

Verify floc blanket performance (replicability)

The central goals of these experiments are to finally determine spacing of plate settlers in an AguaClara plant that are robust enough to handle a variety of raw water conditions including low turbidity and high natural organic matter content (NOM). The first task subsequently is to verify that different flocs blankets formed under the same raw water and flocculation conditions do not vary significantly in performance at steady-state. To this end, several experiments will be run under conditions of forming a floc blanket with 100 NTU water and alum dosage of 45 mg/L. Real-time performance in a turbidimeter from both the clarified effluent and tube settler will be verified for two or three separate floc blankets and also subsequently compared to performance when tube settler effluent is accumulated in a reservoir and released to a turbidimeter.

Vary Velocity Gradient with clay as turbidity source

This experiment seeks to differentiate the effects of velocity gradients from capture velocity on plate settler performance. The capture velocity is set to 0.12 mm/s (the value used in AguaClara plants). A range of diameters (5/8", 1/2", 3/8", and 1/4") were chosen to reflect relevant AguaClara spacing. Every tube diameter will be tested at mean upflow velocities of 1 mm/s, 2 mm/s, and 5 mm/s with different lengths of tubing for each to achieve appropriate capture velocities. Failure is not expected to occur at a 1 mm/s upflow velocity, so the team plans to use this set of tubes as a control experiment to show success. For higher upflow velocities, failure is expected to occur. (See the excel file: "Materials List Velocity Gradient Experiments, PSS 5-12-10" for expected failures that is, Pi-V ratio of less than 1)

Tasks

1. Review the calculation methodology in the MathCAD (titled "spring 2010 new mathcad file, 510" in the PSS_Spring2010 folder under AguaClara team folders.
2. Make sure the materials list (titled "Materials List Velocity Gradient Experiments, PSS 5-12-10") for the velocity gradient experiments match up with the MathCAD calculations

3. Prepare tubes, fittings, and manifolds for the experiment
4. Verify/make necessary alterations to the Process Controller Method (titled "Constant Vc 5-4-10 Vup 1mm-s.pcm") under the folder "PSS_Spring2010\Constant Vc Experiments"
5. Run experiments, ensuring 3 residence times of the tube settler, manifold, reservoir, turbidimeter system
6. Analyze and summarize results

The conclusion of this experiment should provide enough data for a research paper. This paper will document the equations of floc roll-up and capture velocity and will show graphs of residual turbidity as a function of the velocity gradient at constant capture velocity.

Vary Velocity Gradient with natural organic matter (NOM)

This experiment is aimed at testing the effects of natural organic matter on plate settler failure. The team will use a natural organic matter (humic acid) in place of a clay stock and rerun the original velocity gradient experiments. NOM tends to produce flocs that are less dense than clay flocs. This leads the team to believe that failure will happen at lower velocity gradients and thus at larger tube diameters. The team hopes that this experiment will provide some justification for larger plate settler spacings.

Tasks

1. If possible, model the effects of NOM on floc formation
2. Create a MathCAD file similar to the velocity gradient experiments with clay stock but for NOM
3. Review the required materials and setup, ensuring that the procedure is adequate.
4. Run the experiment, analyze and summarize results, compare to the clay sedimentation velocity

Settling Velocity Measurements

The team plans to perform this experiment in order to determine the settling velocity distribution of particles in the floc blanket. This information will allow the team to predict the magnitude of failure based on the capture velocity and predicted failure particle size. Furthermore, this test will determine whether different floc blankets produced by the system have similar characteristics. This experiment is performed using a single tube whose dimensions are detailed in the MathCAD file spring 2010 new mathcad file, 510" in the PSS_Spring2010 folder under AguaClara team folders. The capture velocity will be ramped by adjusting the flow rate through the tube settler. Details on the required flow rates are in the MathCAD file.

Tasks

1. Review calculation methodology in the MathCAD file (titled "spring 2010 new mathcad file, 510" in the PSS_Spring2010 folder under AguaClara team folders) to ensure correctness and verify needed materials
2. Order required tubing and make any necessary alterations to the experimental setup
3. Program the necessary Process Controller Method
4. Run experiments, analyze and summarize results

Documentation

The team wants to ultimately be able to provide length and average velocity recommendations for all spacings tested that correspond to effluent turbidities below 1 NTU. The documentation should include supporting evidence from at least the Velocity Gradient Experiments with cay. The subsequent two experiments detailed above will provide supplementary information.

Tasks

1. Review all MathCAD modeling and results from experiments
2. Appropriately format and organize the information
3. Write and submit an article for Journal of Water Supply: Research and Technology-AQUA

Challenges CDC Summer 2010

Objectives

Improve on current dose controller design.

- Convert as practically as possible to locally available materials
- Eliminate components that have small pieces that can easily be lost (i.e. no more compression fittings)
- Convert to materials that are suitable for both alum and chlorine dosing
- What can't be obtained locally to be made of high quality, reliable components that will reduce down time / lead time resulting from component failure
- Add sedimentation trap and calibration column between stock tank and constant head tank to improve testing, calibration and performance testing of dose controller
- Modify administering tube so that a positive visual indication of flow can be seen

Validation testing of orifice

- Test precision of orifice. Will drilling technique play a roll in dosing reliability? Will $K_{orifice}$ change with different materials, or for that matter, different drilling techniques? Understand and accommodate surface tension issue. Is the triple scale the solution? Is there are simpler solution available? Perform literature survey of alum and chlorine to see if these fluids would have a different effect.
- Clogging experiments. Check with Antonio and Sarah to determine if sediment is still a problem at Agalteca or if the sediment trap has solved the problem. Determine if they are stirring the alum stock tank every few hours based on the myth that they are keeping the alum in suspension. If they are, that could be the source of the sediment. We have not yet discovered the cause of the clogs in Honduras - precipitation or sediment. Run a series of gravity fed experiments to determine if alum precipitation is a potential problem. If we cannot prove alum precipitation then we can assume the problem is sediment. Sediment will be much easier for us to deal with as a simple strainer or sedimentation trap can be used to solve these problems.
- Analyze any possible error caused by moving the slider to higher or lower concentrations. This movement shifts the moment around the pivot point and effects dosing

Future Objectives

- Automate selection of orifice and design of scale. From a given plant flow rate, we should be able to produce the two (or three) orifice sizes and the two (or three) scales.
- Incorporate rotameters in design between stock tank and constant head tank to allow quick and accurate visual indication of dosages. Determine the effect on the location of the stock tanks. Note that this will require the stock tanks to be elevated to accommodate head loss in the rotometers.
- Generate a parts list of all components. Work with engineers in Honduras to determine which components need to be compromised to allow local material access.
- Work with the design team to create a float valve database of the Kerick valves that we will use for larger plants. Also, find different fittings for valve so that we are using a barbed connection instead of compression Create the design algorithm that will choose the correct float valve
- Create a poster and presentation to display P3 competition and award

- A second acrylic model plant needs to be constructed. Also modifications need to be made to the first one: a larger manifold in the bottom of the sed. tank.

Research Areas

Material selection

Survey peer-reviewed journals of the materials listed below to determine their suitability for use with alum and chlorine. Please note that although Wikipedia is a great source for initial information gathering, it is generally not considered peer-reviewed.

- Components:
    - PVC and CPVC
    - Acetal
    - Polpropylene
    - Polyamide (Legris)
    - PVDF (Kynar)
- Piping / Tubing
    - PVC / CPVC rigid pipe
    - PVC flex tubing
    - PEX rigid tubing

Materials suitable for our application will then be analyzed for cost and ease of availability. We will not be able to readily determine which materials are available in Honduras but we do have two people in Honduras who can suss out materials for us.

In addition to material selection, we will discuss different fitting styles and select the most appropriate:

- Barbed
- Compression
- Quick-Connect

Once material and component selection is made, we will create a standardized material list for installation of the chemical doser.

Validation Testing of Doser I – Precision

Determine the precision of the dosing orifice. Suggest starting with 5 each of 3 different sizes. If there is no variance demonstrated, no further testing is needed. If variance is documented, we need to continue testing and determine what amount of variance exists and what amount of variance is acceptable to us.

Validation Testing of Doser II – Accuracy

Using data from first validation test, describe the accuracy of the doser, e.g. compare measured vs calculated values. Our preliminary results show that there exists some inaccuracies at the low range that are attributable to surface tension. Ensure that no other inaccuracies exist.

Validation Testing of Doser III - Material Selection

Determine if material selection will play a roll on orifice performance. Validation test I will be performed using the polyamide Legris Caps. Repeat the experiment with acetal caps. This test need not be completed with the same rigor as Validation Test I. Collect enough data to determine if a relationship exists.

Validation Testing of Doser IV - Surface Tension

Validation test II will show inaccuracies in the low range that we attribute to surface tension. The current solution to this problem is to add yet another scale and orifice to the system. Evaluate whether or not this is the best solution. Research liquids used in plant (alum and chlorine) and determine if we may see a smaller degree of error when using these fluids.

Validation Testing of Doser V – Clogging

At this point, we will postpone clogging experiments. I have discussed this issue with the engineers in Honduras and it appears this problem has been reduced with the addition of a sedimentation tap. Addition al clogging results from precipitant forming along the walls of the tubes, which builds up until a small piece breaks of and leads to clogging. They will be playing with a preventative maintenance program that may improve or eliminate this problem.

Validation Testing of Doser VI - Moment Errors

The above experiments will be performed without using the float and lever arm. This will allow us to keep any possible errors isolated. The sixth validation test will be done using the lever arm and float to ensure that no other errors are incorporated into the chemical doser. Use aquarium to simulate water level changes in entrance tank. Compare readings with those from previous Validation Test I and from calculated values.