Alternative Backwash without Slotted Pipes
Fall 2014

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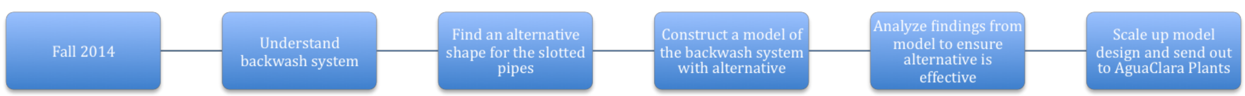
October 12, 2014

Task List

Task Map



Task Details

1. **Understanding the Current Backwash System -** *Jorge, Ainhoa, and Alberto*

To be completed by: *September 24*

In order to further our endeavors with our main goal of finding an alternative to the slotted pipes in the backwash system, we must all have a mutual and strong understanding of how the backwash system actually works, either through a lab demonstration or a meet up with our research advisor or perhaps a meet up with Professor Monroe. Also, by understanding the backwash system we strive to determine the after effects of removing the slotted pipes from the system as a whole, the paths which the sand and water take within the backwash system can be further understood and thus lead to ideas on alternative ideas to the slotted pipes.

2. **Build a model of a Backwash System without Slotted Pipes** -*Led by Alberto, with help from Jorge and Ainhoa*

To be completed by: *October 31**

Once research has been complete regarding a new design for the slotted pipes, we hope to build a small-scale model of the system to visually see how the water flows in the system. All research regarding materials to be used for the model, along with model specifications, will be collected and organized by Alberto and each of the team members, with the help of the Shop in the basement of Hollister Hall, will construct a small-scale model. In order to have the specifications, Jorge will work with dimensional analysis in reference to the large-scale backwash system to ensure that the small-scale model will be indicative of the behavior of the actual system. Based on the findings of the small-scale model, we will be able to determine how to scale it up if the findings provide feedback regarding our design to be an alternative to the current design. The team will need to evaluate failure modes and determine whether a solution exists that eliminates the need for slots.

2.1 Determine how to close the outlets during backwash.

To be completed by**:** *October 16**

After gaining knowledge and determining the shape of our first alternative pipe, we noted the fact that our inverted "U" design will have a large opening along one of its sides. To better visualize this shape, think of cutting off the bottom half of a circular pipe. We need to develop a system to close the outlets during the backwash, so that the sand doesn't leave the filter.

2.2 Determine how to design pipes and holes in the sand box so that they can be changed.

To be completed by**:** *October 18**

Constructing the model so that the pipes for inlet and outlet can be changed is a difficult challenge. To experiment as much as possible we want to be able to remove the pipes to use different shapes and sizes so that we can improve the model.

2.3 Determining the effects of changing the shape of the pipe - *Alberto*

To be completed by**:** *October 25**

Perhaps the problem may be that the current shape of the pipe is more prone to clogs than others. For example, instead of using the full, cylindrical shape with slots for the pipes, we could try to incorporate a pipe that has the same cylindrical shape but with no slots and that has a relative "U" shape instead of the usual "O" shape. We hope to find a way to keep the sand from flowing with the water into the pipes, thus clog the pipes. Though the "U" shaped pipe was a suggestion made by Professor Monroe, we hope to look at different shapes for pipes that may also prevent sand from building up. We will test these different shapes by building models of the pipes and implementing them into our model to be built in the future.

2.4 **Experimentation based on Fluids Mechanics and Geotechnics-** Ainhoa

To be completed by: *November 1**

Since the construction of the scale up model is going to take more or less 2 months, a spreadsheet with different values of velocities, diameters and sand densities will be written so that as rapid as the model is finished, we can begin to experiment with it.

2.5 **Construction of Model** -*Alberto, Ainhoa, Jorge*

To be completed by: *October 31**

With the help of Paul in the shop of Hollister Hall, we hope to construct the model fully in order to begin experimentation.

3. **Scale up model and implement design**-*Alberto, Ainhoa, Jorge*
<u>To be completed by</u>: *November 26**

Once a successful alternative for the slotted pipes has been found, we hope to scale up our small-scale model and create a design to be implemented in the water treatment plants in Honduras and India. We will determine which materials need to be changed, along with how to have these designs constructed easily with current resources in each country.

* Dates are tentative and are subject change.

Team Roles

Jorge Guevara: *Team Coordinator*

- Keep track of the progress the sub team has made with their tasks.
- Arrange meetings to be held outside of designated time weekly.
- Maintain communication with team members and our research advisor.
- Edit any reports that will be submitted.

Ainhoa Arribas Llona: *Head of Research*

- Ensure the validity of resources used for research.
- Organize research found by other team members and create a Word Document containing the research, the name of the team member who found it, the date when the team member found, and a detailed summary of findings that can be used from the found research.

Alberto Arnedo: *Head of Design*

- Lead the construction of any models required for the sub team by finalizing the materials needed for the model, the sketch of the model, and a tentative construction schedule.

In addition to the responsibilities assigned with each role, each member of the ABSP sub-team must follow the subsequent set of responsibilities:

- Maintain communication through the use of email and the phone app “WhatsApp”
- Submit research summaries and information to the Head of Research
- Update each other with findings that will have an impact on the project

Literature Review

The basis for the research being done by the Alternative Backwash with Slotted Pipes sub team is found in the principles of basic fluid mechanics and also in fluidization. As the raw water is brought into its final stages of filtration, it brings along with it some dirt and residue that had not been filtered out previously, and thus clogs the slotted pipes. It is essential for the alternative to slotted pipes to be at least as effective, or better, at helping ensure that the bed is being fluidized with the smallest approach velocity. And equation often used to calculate the fluidization velocity can be seen below:

$$V_{MinFluidization} = \frac{{\varepsilon_{FiSand}}^3 g D_{60}^2}{36 k \nu \left(1 - \varepsilon_{FiSand}\right)} \left(\frac{\rho_{Sand}}{\rho_{Water}} - 1 \right),$$

where ε_{FiSand} is the porosity of the aquifer material, g is the gravitational constant, D_{60} is the sand diameter, k is the Kozeny constant which typically has a value of 5 for most filtration conditions, v is the kinematic velocity, ρ_{sand} is the density of the sand, and ρ_{water} is the density of the water. When using the above equation it is vital to note that it is meant to be used with laminar flows. By using the above equation, the backwash velocity can be found and can, in return, provide information on the bed expansion that the bed goes through during fluidization. This expansion is an important factor to take note of when working with the backwash system.

Introduction

The Alternative Backwash with Slotted Pipes sub team has begun its first semester with the AguaClara project team in response to multiple problems arising from the use of slotted pipes in the backwash system. With the tools currently available at the AguaClara filtration sites in India and Honduras, problems have arisen regarding the fabrication of the tiny slots on the pipes. In addition to manufacturing issues, the slotted pipes have been prone to clogging up with a mixture containing sand that was not seived properly and some dirt brought in from the raw water. Some of the filtration plants have attempted to clean up the slotted piped by installing purge valves in order to remove the clogs, however this is not an ideal situation given the size of these pipes, which range in size depending on the filter type. The slotted pipes have diameters of 1" and 1.5" for the OStaRS (Open Stacked Rapid Sand) filtersand 1/2" and 1" for EStaRS (Enclosed Stacked Rapid Sand) filters. By finding a successful alternative to the slotted pipes, both the processes of construction and maintenance of the AguaClara filtration plants will be made more efficient by allowing for an easier fabrication process and reducing the amount of time and effort spent cleaning up the clogged slotted pipes. To get a better understanding of the attempts that have been made to clean the slotted pipes, refer to the recording of a purge valve in use on one of the OStaRS filters in San Nicolás, Honduras, in this video.

Methods

Once the first AutoCAD model was constructed, members of the subteam went to consult with Paul in the shop in order to get an idea of how the construction of the model would proceed. After the consultation, it was decided that the model will be made mostly from the use of acrylic sheets. Also, Paul expressed some concern with regards to trying to make the model able to be adapt to multiple shapes and sizes for the inlet and outlet pipes. The sub team took this concern into consideration and began to think of a method to deal with this issue. The sub team came up with the idea to make the holes where the inlet and outlet pipes enter as large as the largest pipe which the team would experiment with, which would most likely have a diameter of two inches. Since most of the fabrication ideas and materials were beginning to be finalized, the sub team, along with their research advisor, met with Professor Monroe to both consult with Monroe on the progress of the model and to get the AguaClara Account Number for ordering parts.

During the consultation with Monroe, many aspects of the design and project as a whole were discussed. From this talk, the team decided to alter the prior design for themodel and create a new one with some slight modifications, as seen in the figure below. The main changes to take note of are that the pipe closest to the base of the backwash model should be closer to the base in order to recognize the fact that the backwash inlet is different. Also, the pipe to be used there will have a diameter of one and a half inches, while the other two pipes will have diameters of one inch. In addition, a pump and a bucket to submerge the pump into were added into the model. The reason for the pump lies in the fact that water must move throughout the system and by using a pump, that gives the sub team more control with regards to the velocity of the water in the pumps. The bucket was added as a place for the backwash water to go to. The water used throughout the model will be recycled as a means to avoid the waste of clean water. A great feature of the bucket is that the sub team can know if the effluent pipe in the model has failed or not dependent on whether there is sand accumulation at the bottom of the bucket.

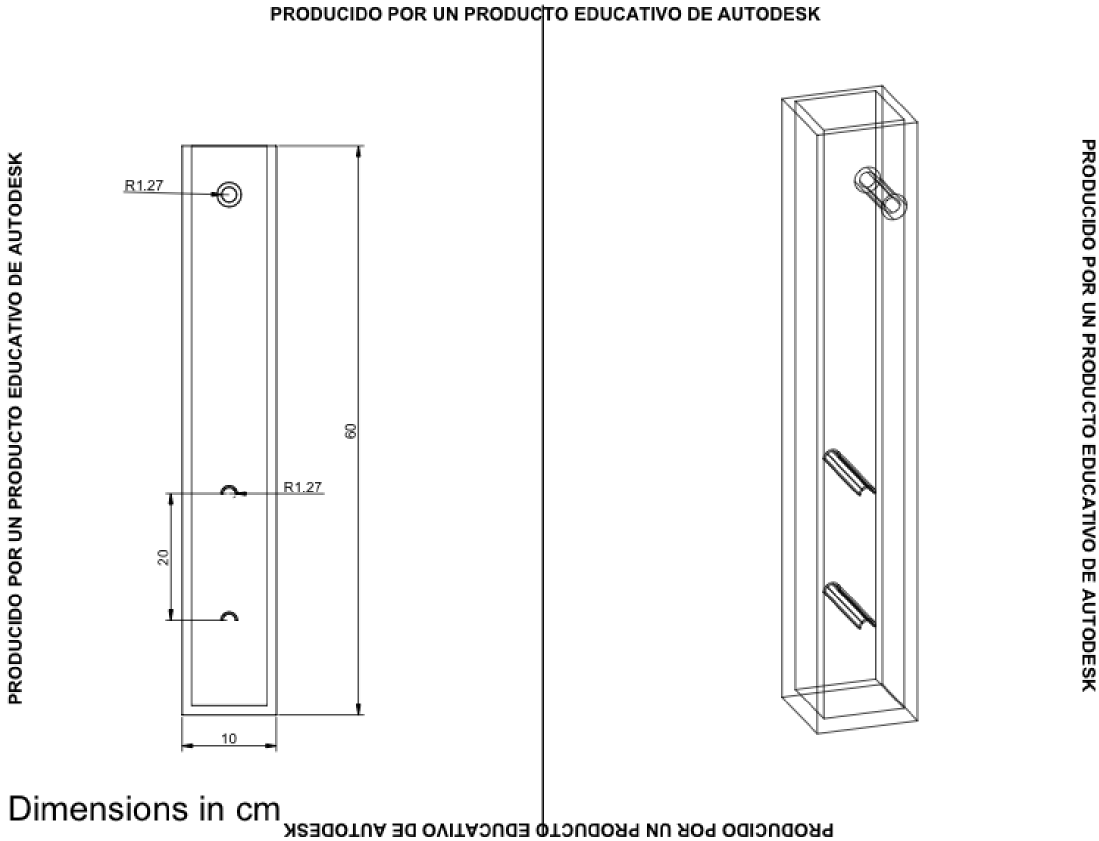


Figure 1: Previous AutoCAD Drawing of Backwash Model with Alternative Pipe with Dimensions in cm

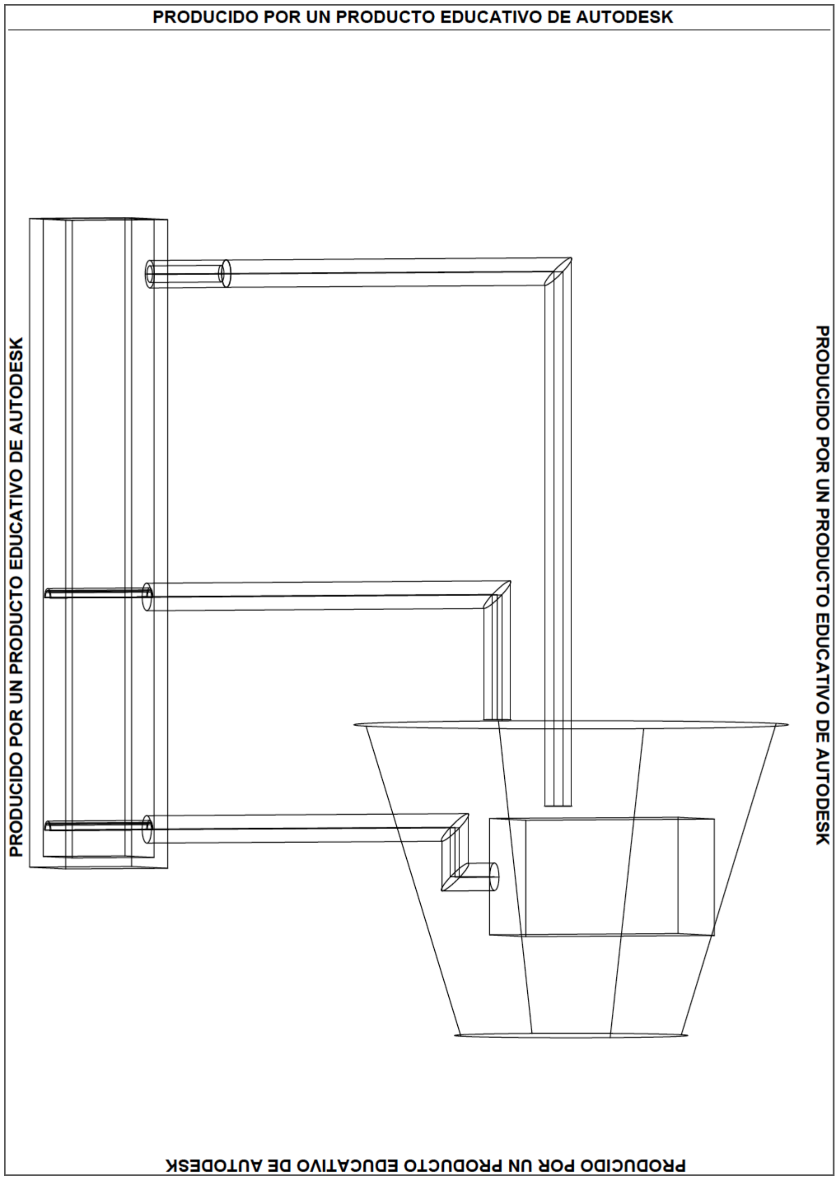


Figure 2: AutoCAD Drawing of New Backwash Model with Alternative Pipe with Dimensions in cm

In addition to the consultations held over the past two weeks, the sub team worked hard together to find a way to calculate the head loss. Since both Ainhoa and Alberto have both taken a fluid mechanics course prior to being a part of AguaClara, they both took lead in the calculation for the head losses.

Analysis

In order to ensure that the sub team as a whole has a general understanding of the importance of backwash, Professor Monroe had suggested the team calculate the head loss for the system with different tubes, ranging in diameter, and evaluating whether the numbers made sense. Though attempts were made to calculate these head losses, logical answers were not being calculated and so those numbers and calculations will be included in the next research report.

Specifications that were calculated are the velocity of filtration, which should not be any larger than *5 mm/s* to avoid fluidization, and the velocity of backwash, which was found to be *11 mm/s*. Since the velocity of backwash was found, the velocity of the water to be pumped through the pipes was found to be *110 mL/s*, which happens to be the same velocity used by the Turbulent Floc sub team. In addition to the multiple velocities found, the height of the model was another specification calculated to be *60 cm*. This height was found due to the fact that when the backwash velocity reaches 12 mm/s, the sand bed expands in volume by approximately thirty percent, thus meaning that the height of the model should account for the increase. Thus the height was found by multiplying the sand bed height, forty five centimeters, by 1.5.

Conclusions

From these past two weeks, the sub team learned that in order to experiment with multiple types of tubes in the model, the pipes with the smallest diameters (*diameters around one inch*) will be tested first and then as the experiments continue, the diameters of the pipes will increase as well. Also, the sub team, with the help of many consultations, have decided to close the inlet and outlet holes with silicon so that the pipes can be easily interchanged, regardless of the size of pipe.

Another important matter is that the model has gone through significant changes in order to better model the backwash system to thus better the experiments. The changes are now reflected in the newest AutoCAD drawings.

Future Work

The sub team hopes to begin the construction of the model as the next two weeks progress, as well as simultaneously researching and designing the siphon tube that will be used for the backwash. Additionally, the sub team will be brainstorming various shapes and designs for pipes to be experimented with in the future.

References

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