Entrance Tank

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Problem Definition

Our area of focus is the Entrance Tank, where the influent water to the plant first enters. If this water's source is mostly clean and free of debris then the entrance tank is a simple concrete holding tank which feeds the water to the plant at a desired flow rate.

If the source has heavy contaminant flow, or has extremely turbid periods throughout the year, then a different design utilizing at least three hoppers is needed to deal with excess debris and turbidity. The entrance tank has a preliminary screening which will block out material such as sticks, leaves, rocks etc. In the hoppers, the larger particles will settle out forming sludge at the bottom of each hopper. See Figure 1 for an example of what an entrance tank looks like.

Our task is to design a new entrance tank with the capability to choose between two entering water sources in the event that one has much higher turbidity or debris flow than the other. This problem arises in plants which have multiple influent sources (for instance, coming from two different rivers. For now we will provide designs for plants with two influent sources. Once a source has been marked for discard, its flow will be directed into the drain channel and will exit the plant. Figure 2 shows the labeled diagram of the entrance tank.

Design Details

Our code will provide an alternative design to the current Entrance Tank code in the event of multiple influents.

Our overall job is to create an apparatus that will manage the two influent flows going into the plant. If one influent is more visibly turbid than the other influent, the former will get drained and the latter will go through the plant. If both seem to have relatively similar turbidity levels, we will have the two flows merge while going through the plant. To accomodate this, alterations to the first hopper must be made to allow for managing two influents. The other

Figure 1: Atima ETank

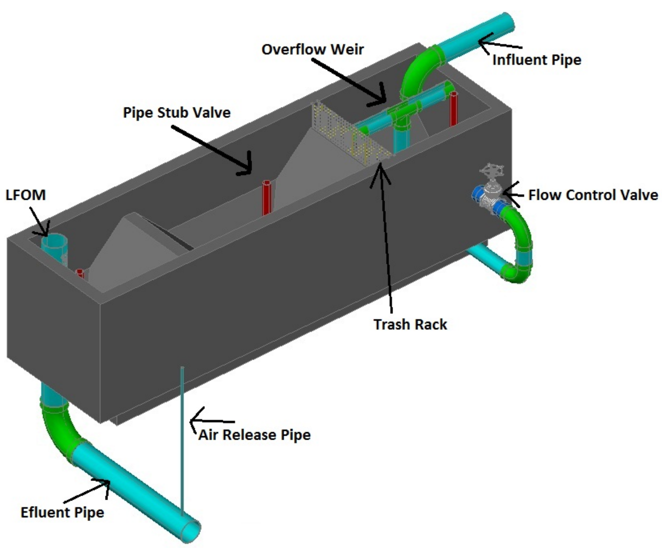

Figure 2: Entrance Tank

options considered involve piping that will directly funnel either of the inlet pipes to the drain channel before occupying the first hopper if they are choosen to be discarded. If the plant did not have spacial or economic constraints on its production, then creating two in parallel complete entrance tanks would be a viable option. Since this is not the case, we must accomplish what an entrance tank does to one influent while working with two. The control of the new design will be manual, including control of the removable wall as well as flow control valves. Plant operators will periodically monitor both influent sources. In the event of a large turbidity differential the operator will divert one of the sources to the drain channel.

The Mathcad files *EntranceTankAC, EntranceTank, and ExpertInputs* have been changed to allow for the option of two inlets.. The variable EN.TwoInlets will determine which design will be output. This will output a different design in this case to AutoCAD.

Documented Progress

Option 3 was chosen by our group as well as the subteam leader and advisor. It creates a reliable way to remove one source as well as use both sources and adjust the flow rate of both of them. A cost analysis was created in order to determine whether or not the design would be cheaper with two flow control valves or one larger flow control valve. The analysis discovered that there were a few flow rates for which one flow control valve was cheaper, but not the majority. For the sake of ease of control and simplicity, two flow control valves are included at all flow rates.

Design Options Considered

Option 1– Connect Inlet Pipe to Drain Channel

For this option, the only addition to the design will be a pipe connecting the inlet pipe (whose influent is being disgarded) to the drain channel (See Figure3). This will be done by collecting all the water from the influent in a larger diameter pipe right below, and funneling that out the front of the first hopper and underneath to the drain channel. (Note: Option 2 is similar to this method; the difference is it funnels the water straight down through the hopper stopper drain). In between the inlet piping and this new piping which collects the water there should be a gap where the water is in free fall, allowing for both the collecting pipe to be adjusted and for the plant operator to see how turbid this water is and collect samples.

In order that the drain can collect water from either source, the collector pipe must be adjustable so that it can sit under both inlet pipes and collect water. This is done through two elbow couplings, one of which can be

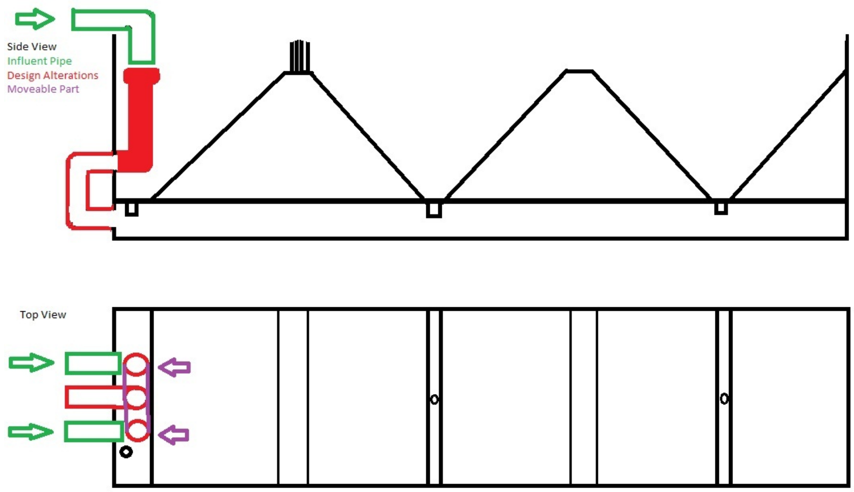

Figure 3: Option 1

swung under either influent. In this figure, the elbow is not collecting from either influent, but can be turned either way as Figure 3 demonstrates to collect either influent.

This design was discarded. The design would not allow for adjusting one or the other inlet flow rate, instead it would merely divert one of the flows into the drain channel. Also, the rotating aspect of the design which allows the flow control valve to be rotated underneath either of the inlet pipes was not figured out and most likely this would not work. The design assumed that the couplings adjoining the rotating drain pipe would be adjustable and still dependable which is not the case.

Option *2*– Rotatable Pipe Stub to Inlet Source Design

For this option, we will not need any pipes outside of the hopper or to make an additional hole in the side of the hopper like we did in option 1. We will replace first pipe stub (hopper stopper) with a pipe to divert the flow coming from the influent directly into the drain channel below the hopper. The pipe will come directly out of the hopper drain hole and up through the center of the hopper. Using two elbows, the pipe can rotate between either flow, like in *4* above.

To describe the adjustability in further detail, imagine the normal pipe stubs. These are removable to either allow drainage or not. The pipes are also hollow and water can flow through them. Option 2 utilizes this fact to use the pipe stubs as both a method of draining the sludge as well as

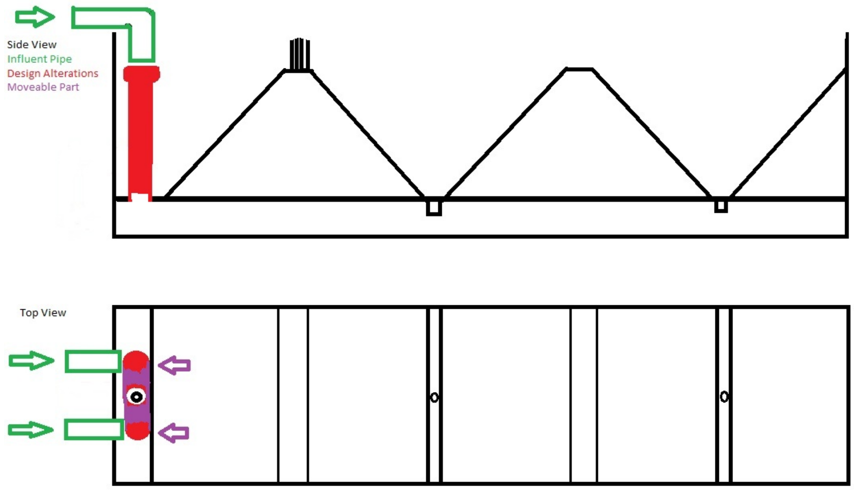

Figure 4: Option 2

draining the influent. Both processes cannot be done at once, but that's not necessary. This pipe stub now has piping extended off the top so that while the main pipe is perpendicular and in the drain, the extension can be rotated to collect water from either influent source. It will collect the influent water just as a cup collects water from a faucet. To accomodate the flow, the pipe stub will have a larger diameter which will also make this more sturdy rather than the flimsy 1" piping originally used.

This design was discarded. Unsure of how the rotating part would function.

Option *3* –Separate Hopper Design

This design divides the first entrance tank half hopper into two. Since the first hopper is usually half the size of the full hoppers, the two newly designed hoppers will be effectively a quarter the size of full hoppers. The flow from each influent pipe is permitted (if desired) to flow through the trash racks at the end of each "quarter hopper". The division is created by a removable wall.

The quarter hoppers run parallel just as water would normally flow, and once they both flow through the trash rack their flow is combined in the first full hopper. In cases of Influent 1 having high contaminant flow, water from Influent 1 would not proceed to the full hopper and the operator would only see Influent 2 coming through that quarter hopper's trash rack. In this case, the pipe stub valve will have been removed from the drain in Influent 1's quarter hopper to allow for the turbid water to flow into the drain channel.

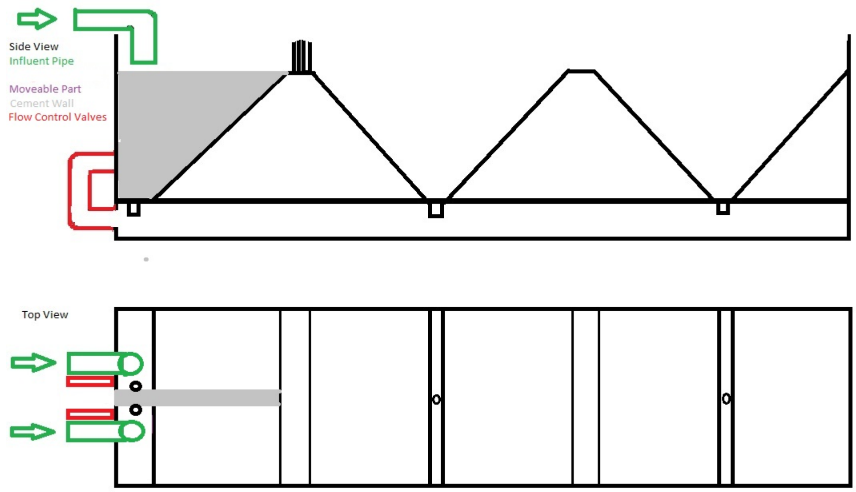

Figure 5: Option 3

In the event that the entie plant's flow rate needs to be reduced, a flow control valve (originally in the first hopper) is included in each quarter hopper. The reason this is needed even though we have the pipe stubs to halt flow is that sometimes we need to reduce the flow rate, and these valves can be calibrated to allow a certain flow rate of water from each source to flow through the plant. See Figure 5 for a model of design option 3.

Design Changes

Overflow Weir

The original design had the overflow weir in the first half hopper. Since the new design has two drain pipes, two flow control valves, and a removable wall in that hopper the overflow weir was moved to the second hopper. AguaClara Engineer Drew Hart approved of this change. Originally our team was uncertain of whether this move would interfere with its effectiveness and if the flow control valve remaining in the first hopper would cause issues.

Flow Control Valve

When two influent sources are involved, there is a range of possibilities of how to control the flow through the plant. To have ultimate control over the flow of both sources, two flow control valves are needed such that the turbidity of the flow is minimized while still maintaining enough water to meet the population needs. For instance, in Atima, one souce is extremely clean but has a low flow

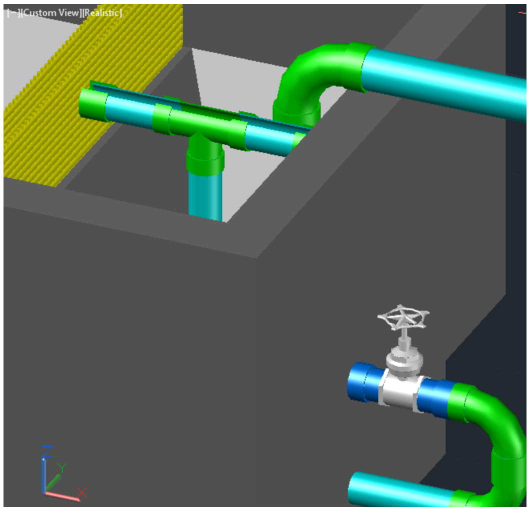

Figure 6: Original Overflow Weir

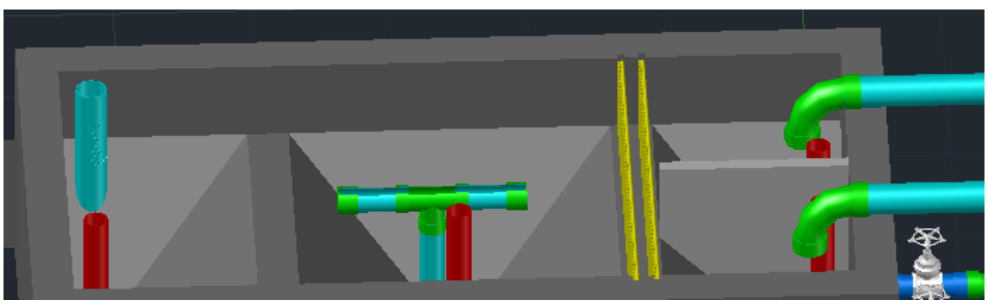

Figure 7: New Overflow Weir

Diameters (inches)	1	1.5	2	3	4	6	8	10	
Diameters (meters)	0.025	0.038	0.051	0.076	0.102	0.152	0.203	0.254	
Materials:									
		Lempiras (Nicgaraguan Currency)							**KEY:**
Flow Control Valve	500	500	800	3300	3500	12000	Na	Na	2 Valves at Specific Flow Rate
Elbow Coupling	12	15	15	135	100	800	Na	Na	1 Valve at Specific Flow rate
									Inputs
Regular Piping	0	0	0	0	0	0	0	0	Calculations
T-Coupling*	12	15	15	135	100	800	1000	Na	*Estimate same as elbow
COST at Diameter:	548	560	860	3840	3900	15200	Na	Na	3 elbow, 1 Tee, 1 valve
COST at Diameter:	1048	1060	1660	7140	7400	27200	Na	Na	2*(1 valve, 2 elbow)

Figure 8: Pricing of Valve Options for Given Diameters

while the other is turbid with high flow. The plant operators need a way to take all of the clean source, and supplement that with a portion of the turbid source to meet the plant flow rate needs.

An alternate design was suggested using a single flow control valve joining pipes from both quarter hoppers. This could have effectively regulated the flow from both sources while reducing the need for two pricy flow control valves. The reason this was not implemented was because the single flow control valve would have had to handle twice the flow rate, and at that volume the single valve would be more expensive in most cases than two individual valves. Additionally, having this single valve limits the ability of the operator to adjust both inlet flows individually. Figure 8 and Figure 9 show the pricing of each design at certain diameters, and how these diameters correspond to flow rates and which design is cheapest.

To change the flow control valve in Mathcad, a second command branch labeled *"Flow Control Drain Grit Two Inlets"* was created in *EntranceTankAC*. The easiest way to create this second valve is to take the origin of the first, add the proper distance, and duplicate the construction commands for the second valve at this new origin. The proper distance shown in the figure is

*2*S.Fitting + 2*ConRadius(ND.EtFlowControl)*

*+2*T.EtRemovableWallSupports + T.EtRemovableWall.*

At the bottom of the flow control script, an if clause was added to the *Stack* command such that if EN.TwoInlets == 0 the original code would be implemented and if not (if two valves are needed) than the additions are added to the stack command. Figure 10 shows the top view of the new first hopper.

In addition to creating the second flow control valve, the radius of the flow control valve must be changed. To implement this, in the *EntranceTank* file an if clause was created such that if there are two inlets the nominal diameter of the flow control piping is changed to take half of the plant's flow rate verus the original full flow rate. This will allow for the code to output smaller valves since each are required to regulate half the flow.

	Price Comparisons by Nominal Diameter							
L/s	L/s	m	m	in	in	2 valves	1 valve	
FLOW RATE	**Half Flow**	**Half Size**	**Full Size**	**Half Size**	**Full Size**	**Price Half**	**Price Full**	**Winner***
4	2	0.038	0.051	1.5	2	1060	860	1 Valve
6	3	0.051	0.076	2	3	1660	3840	2 valves
8	4	0.051	0.076	2	3	1660	3840	2 valves
10	5	0.076	0.076	3	3	7140	3840	1 Valve
12	6	0.076	0.102	3	4	7140	3900	1 Valve
14	7	0.076	0.102	3	4	7140	3900	1 Valve
16	8	0.076	0.102	3	4	7140	3900	1 Valve
18	9	0.076	0.152	3	6	7140	15200	2 Valves
20	10	0.076	0.152	3	6	7140	15200	2 Valves
22	11	0.102	0.152	4	6	7400	15200	2 Valves
24	12	0.102	0.152	4	6	7400	15200	2 Valves
26	13	0.102	0.152	4	6	7400	15200	2 Valves
28	14	0.102	0.152	4	6	7400	15200	2 Valves
30	15	0.102	0.152	4	6	7400	15200	2 Valves
32	16	0.102	0.152	4	6	7400	15200	2 Valves
34	17	0.152	0.152	6	6	27200	15200	1 Valve
36	18	0.152	0.152	6	6	27200	15200	1 Valve

Figure 9: Price Comparison of Flow Control Valve

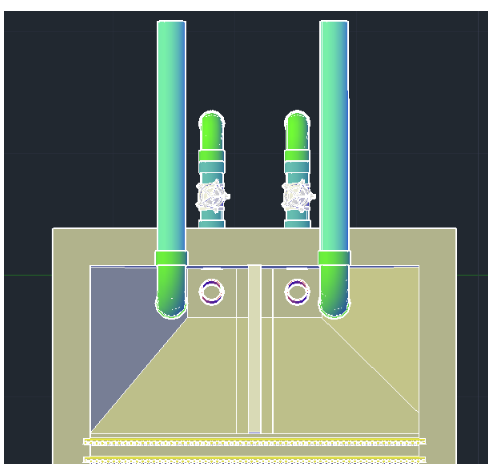

Figure 10: Top View of First Hopper

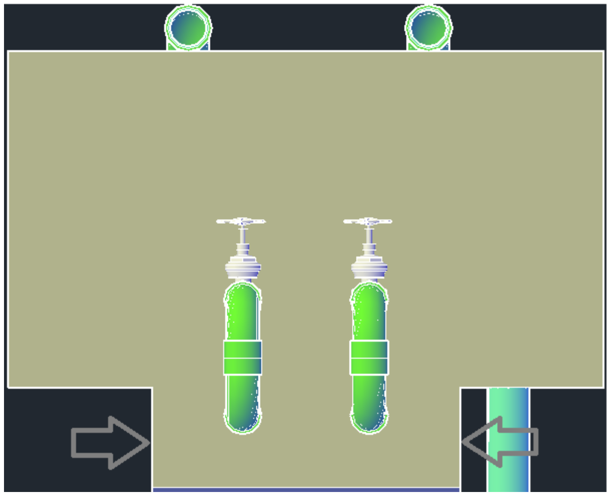

Figure 11: Drain Channel

Drain Hopper Stopper

A similar alteration to the drains, fittings, and hopper stoppers as required for the flow control valves is implemented. For the first hopper, the first drain is in the same location as with one influent source. The second drain aparatus is located the variable distance from the first drain to make room for the removable wall. Note for the drain and flow control valve, the drain channel has been adjusted so that they connect to the drain.

Width of First Hopper and Drain Channel

In *EntranceTank* the width of the total hopper as well as drain channel are both altered by an IF clause.

The total hopper width is calculated by a max statment to make sure it fits the width of the Lfom, Drain Channel, and now also the design with two hoppers if EN.TwoInlets == 1.

The width of the drain channel now has an if clause to accomodate

*4*S.Fitting + 4*ConRadius(ND.EtDrain) +*
*2*T.EtRemovableWallSupport + T.EtRemovableWall*

Since the flow control and drains are both within this distance, this is the perfect minimum width for the drain channel because it assures all the necessary pipes will meet up with the drain. Figure 11 shows the back layout of the entrance tank, and how the flow control valves wrap around and join the channel.

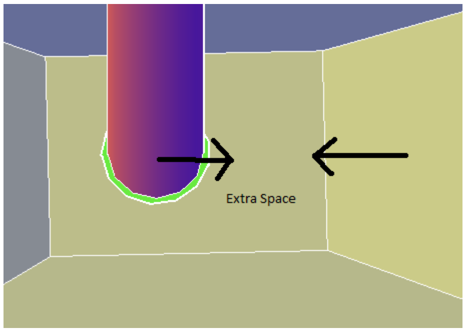

Figure 12: Drain

Hopper Back Wall

The first hopper with the new drain and removable wall requires the back sloped wall to be pushed back. This in turn widens the full entrance tank. In the second and third hoppers, the sloped back wall is still pushed out for this design, leaving a flat plane of empty space next to the second and third drains. This space needs to be eliminated so that the sediment lands on a sloped wall and flows down towards the drain rather than resting on this flat surface. See 12 for accompanying image. This “extra space” has been minimized in this picture. The distance between the coupling and the sloped wall should be a miniumum of S.Fitting in the code so that all of the settled debris and sediment can be effectively drained.

The design has been altered to accommodate this by creating a new wedge, beginning at the second hopper and extending past the first hoppers wedge (Wedge functions are used to create sloped walls). The full layout view is seen in Figure 13.

Removable Wall

To separate the two flows in the first hopper, a removable wall is built in the middle of the hopper as shown in Figure 14. It has two concrete side supports to keep it in place since the wall will need to be removable for cleaning and construction purposes. For now, the thickness of the wall and its supports are arbitary values set in ExpertInputs. The code to construct this was implemented in *EntranceTankAC* and under Entrance Tank Concrete branch. The functions are titled DividingWall. Note that this wall is in a new layer since it is a different material than the concrete which comprises of most of the tanks structure.

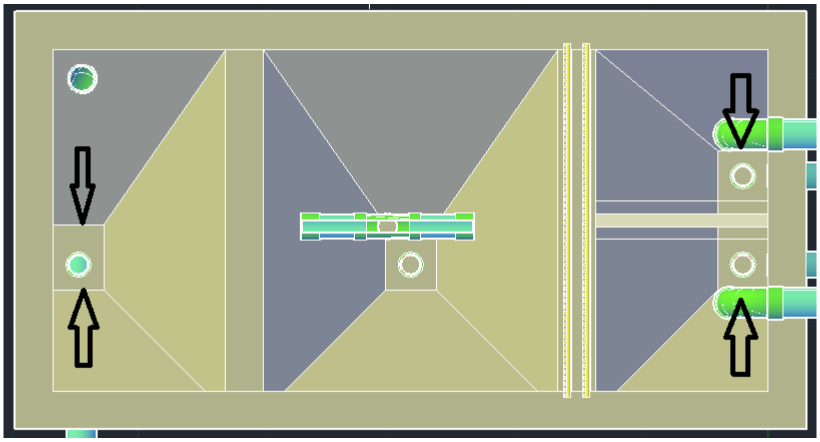

Figure 13: Hopper Full View

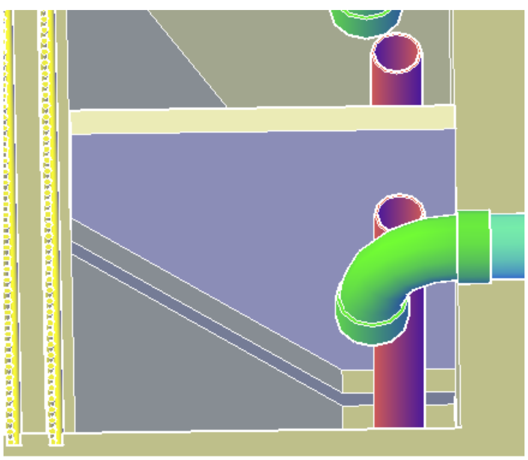

Figure 14: Removable Wall

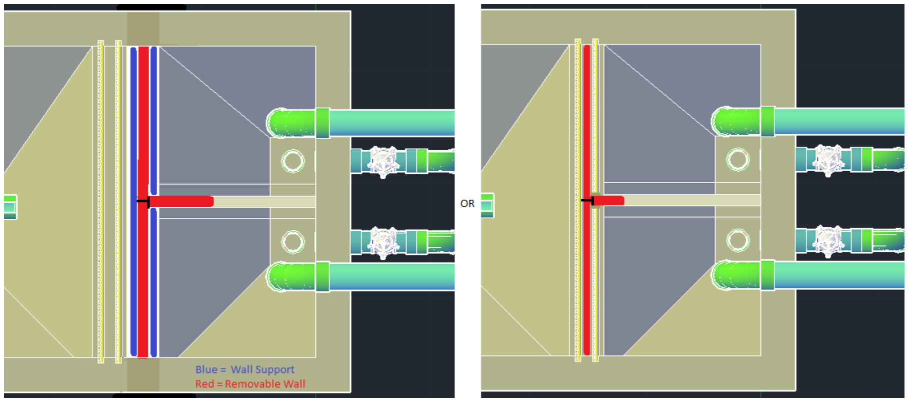

Figure 15: Removable Wall

Future Work

Second RemovableWall

Now that the first removable wall has been implemented, the second wall perpendicular to plant flow must be created. The idea behind this is that the water level will be much higher than the ledge between the hoppers, so although the first wall will separate the flows in the first hopper, if one flow is high and the other low, the high flow will move to the second hopper and then back into the other side first hopper. This would disrupt the flow and cause problems.

Two alternate designs are suggested for moving forward, shown in Figure 15. The first design requires adding in extra space on the first hopper ledge for two supports and a second removable wall that can be put on either side. This means the removable wall is as long as half the width of the entrance tank so that it can block off completely one side of the quarter hopper or the other. The image shows the wall on both sides, while in practice it will only be on one side or the other.

The second design involves cutting into the first trash rack to extend the first removable wall then incorporate a second removable wall and supports into the trash rack design to take away the need to extend the hopper length. This would be a space and money saving design if it ends up being possible. Both designs should be considered moving forward.

Material of Removable Walls

Currently, the two walls implemented have been called “removable wall”. Their material needs to be chosen. This should be decided by what is available in Honduras keeping in mind the material needs to be cheap, strong, and light enough to be removable on occasion. The wall supports will be concrete and just attached to the entrance tank body while the removable wall will rest within the supports to hold against the hydrostaic pressure exerted on the wall. Additionally, the removable walls must be able to form a water tight junction between them.

Thickness of Support and Removable Walls

Currently, the thickness of the supports and walls are 5cm. This thickness is approximatly what the design requries but no indepth calculations have been made or questions asked of the team in Honduras as to whether or not this is reasonable. Moving forward, these paremeters which are set in ExpertInputs will be adjusted from design to design from the structural engineer in Honduras's input.

Back Wall

One thing that has been altered but not finalized is the placement of the back wall. The goal was to create this wall as two sections, one for the first hopper and the other for the remaining hoppers. Since the first hopper has additional parts which need to fit on the flat section of the bottom of the entrance tank, its sloping back wall needs to start further away from the front slope. The back wall needs to start S.Fitting away from the second drain. For the remaining hoppers, this distance of S.Fitting remains but there is no second drain so the wall's slope starts that distance from the primary drain. We've played around with trying to adjust this but no design has been finalized.