Marcala Plant Design

Marcala Flocculation Details

Flocculation Tank

The baffle configurations and dimensions had to be calculated to fit the existing infrastructure in Marcala. Instead of the plastic polycarbonate baffles used in the Ojojona plant, ferrous cement baffles will be used in the Marcala plant. Using polycarbonate baffles provide an advantage in the flexibility of design because the spacing's can be adjusted. Since the ferrous cement baffles will be used instead, they will be mortared to the tank. This leaves no room for adjustment in the baffles once they are constructed.

Grooves will be made on the flocculation tank walls to support the ferrous cement baffles. These grooves will need to be constructed accurately to hold the baffles correctly. Also, in order to drain the flocculation tank, drains between each two consecutive baffles are now necessary. Previously, using polycarbonate baffles, water crept through the sides of the baffles when the operator wished to drain the flocculation tank. The use of ferrous cement baffles that are mortared to the wall restricts the water from being able to drain between the baffles. As a result, a hole will need to be placed on the bottom of the baffles to allow for drainage. This hole must be sized optimally to ensure minimal short circuiting of the flow and to ensure proper draining time for the plant.

Baffle Spacing for the Marcala Plant

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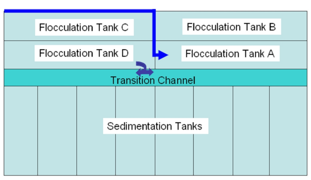

General Layout of the Marcala Plant

#This figure depicts a general top view of the layout of the Marcala plant. Only the baffle spacing for flocculation tanks C and D were calculated due to anticipated changes to the current flocculator design program. The spacing in tanks A and B are areas with more variation in potential baffle spacing's and since the baffles are not removable, the calculations will be delayed for these two sections. Due to the many constraints in the flocculation tank including the sloping floor and the cement beams under which it was preferred not to build, the spacing of the baffles was a unique challenge.

The spacing between the baffles in flocculation tanks C and D was calculated using Monroe Weber-Shirk's flocculator design program. Important care must ensure that the baffles are the correct spacing to keep the flocs from breaking apart. The results of the MathCAD program were slightly modified through the two tanks to accommodate the unique tanks. Additionally, the thickness of the ferrous cement baffles themselves had to be considered in the design. Each ferrous cement baffle will be approximately 3.8 cm in thickness.

The flocculator design program calculates the optimal open space between the baffles to be 54.6cm wide. However, due to the design constraint of not being able to put the baffles under an 8cm wide ceiling beam that runs horizontally approximately over the middle of tanks C and D, this spacing was not used for all of the baffles. The flow path between baffles in the beginning of tank C is 92 cm across and the open space between baffles is 51.75 cm wide, just over 3cm closer together than what was recommended. The velocity of the water is determined by the open space between the baffles multiplied by the flow rate, so this smaller distance causes the water to move faster than is recommended through this section of the flocculator. Greater velocities can cause flocs to break up, but since there will be a lot more flocculation occurring after this section with the closer baffles, any flocs that break up should clump together again as they move further along the flocculator. The spacing in this first section of 55.25cm when measured from the center of one baffle to the center of the next baffle (on center), and thus taking the baffle thickness into account, keeps any of the baffles from being under the ceiling beam. All the baffles further down the flocculator must be spaced with at least 54.6cm of open space between them so that the velocity does not increase thus breaking up more flocs. The baffles on the other side of the ceiling beam in tank C have the program recommended open spacing of 54.6 cm. The open space measurements were used for the calculation of the velocity because only the area where the water can go matters.

The baffles in tank D all have an open spacing between the baffles of 66.2 cm wide, with an on center spacing of 70cm. Since the open space is greater than that recommended by the flocculator design program, only distances which include the baffle thickness matter for the placement of baffles in tank D. A spacing of 70cm on center keeps all the baffles out from under the ceiling beam that was discussed previously. The turn from tank C to tank D is treated as a spacing between baffles, thus since the last baffle in tank C has the water flowing under it, the first baffle in tank D has an overflow path. The entrance into tank C from tank B has a water depth of 45 cm in the existing structure. This pathway will have to be changed so that the water depth is 77.2 cm above the divider. #The table lists the spacing between each baffle in tanks C and D in distances measured from the center of each baffle because that is the measurement needed when placing the baffles in the actual tank.

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Horizontal Distance between baffles in tanks C and D

Between baffle #s	Distance on center (cm)
Wall between B & C-->1	73.35
1-->2	55.25
2-->3	55.25

3-->4	55.25
4-->5	58.4
5-->6	58.4
6-->7	58.4
U turn	
Wall @ beginning of tank D -->8	60
8-->9	70
9-->10	70
10-->11	70
11-->12	70
12-->13	70

The opening to the transition channel running from the flocculator to the sedimentation channels will be placed on the side of tank D at the very end of the flocculation system. This opening will be 90 cm wide (38 cm + 52 cm) and will cut into the area with the ceiling beam by approximately 38 cm. The rest of the opening will be taken from the wall in tank D. The figures show both the #side and #top views of the transitional chamber.

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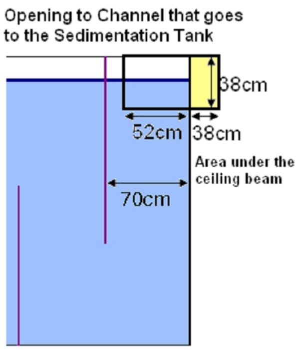

Side view of the outlet to the transition channel that runs to the sedimentation tank

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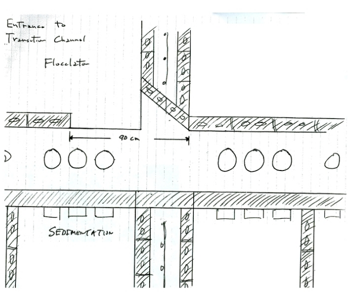

Top view of the outlet to the channel that runs to the sedimentation tank drawn by Fred Stottlemyer

The #top of the "up" baffles will have at least a 5cm free board and come almost all the way up to the top of the tank. Some room should be left between the top of the "up" baffles and the top of the tank if possible to keep any instances of overflow from flooding out of the tank.

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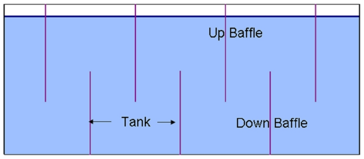

Simplified version of 'Up' and 'Down' baffles in flocculator and what the Draining Program considers a 'tank'

The change in the spacing of tank D's baffles to a distance greater than the value recommended by the MathCAD Flocculator Program created a problem of short circuiting. Utilizing the 1.5b rule for the height of the flow path does not allow the "up" and "down" baffles to overlap. The 1.5b rule is suggested by Schultz and Okun for the height desirable above the baffles to provide sufficient area for the flocs to remain intact. Using the factor if 1.5 for the calculation of the height of the flow path for tank D's baffles allows the water to go straight through the tank instead of under and over the baffles. #This figure illustrates the error that results if a baffle spacing of 66.2cm and a factor of 1.5 is used in tank D.

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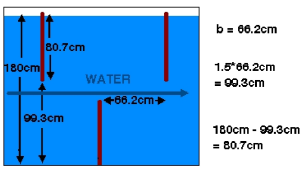

Depiction of short circuiting through the flocculator due to 1.5b rule

An was added to the end of the flocculator draining programming to calculate factor (f) by which the baffle spacing (b) should be multiplied by to calculate the distance between the bottom of the tank and the bottom of the "up" baffles, which is the same distance between the surface of the water and the top of the "down" baffles. This equation calculates a new f based on the height of the water (water), b, and an "overlap" variable. The "overlap" variable is the amount by which the user wishes the "up" and "down" baffles to vertically overlap so that the bottom of the "up" baffles are below the top of the "down" baffles by this distance. This makes the water go over and under the baffles. The amount of overlap is arbitrary and can be set by the user. This value is set at 2cm for the calculation of a new f for tank D.

The f factor for the baffles in tank D was calculated with

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The f for tank D is 1.37, which provides a 2 cm overlap between the "up" and "down" baffles. The height of the flow path is thus 1.37*66.2 cm = 91 cm. Since a factor of 1.5 is not known to be strictly necessary in order to not break up flocs as they go around the baffles, a factor 1.37 is considered acceptable at this point. The final baffle spacings for tanks #C and #D are shown in the following figures.

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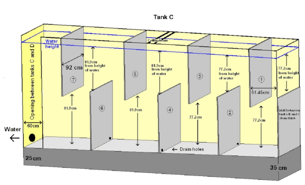

Flocculation tank C with dimensions related to the baffles

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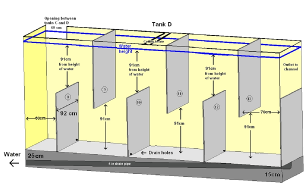

Flocculation tank D with dimensions related to the baffles

Draining the Flocculation Tank

The water treatment plant being built in Marcala, Honduras will have a different flocculation system from others AguaClara has designed. The baffles in the flocculation tanks will be made of 1.5 inch thick ferro cement slabs and these baffles will not be removable. As mentioned, an additional challenge with this design is devising a scheme for draining the flocculation tanks that would not cause short circuiting in the system or take an exorbitant amount of time to drain. A program called Final Floc Draining Time with Forces Calculated was created to model this process.

A simple method of emptying a flocculator tank without removing the baffles is to construct a small hole into the bottom of each down baffle. The size of the hole depends on the desired draining time. The larger the hole, the faster the tank will drain. However, putting a hole in the bottom of each down baffle would allow the flocs to short circuit and cause a new flow path. The holes are modeled as orifices and must have a minimal area, chosen to be less than 1% of the flow path area to minimize the likelihood that they would compromise the flocculation system. The orifices are also staggered to further reduce the risk of short circuiting; the holes will alternate between the left and the right side of the baffles. Another factor in selecting orifice size is the amount of time it would take for the tanks to drain. A compromise must be made between draining time and the increased short circuiting.

A MathCad program was written to model the use of different orifice sizes to #drain a series of connected tanks. The space between each down baffle is treated as an individual tank and the height of the water in each assumed to be equal. At time zero, with the heights of the water even throughout the set of tanks, the only head is the distance between the water height and the outlet valve. As the first tank begins to drain it creates head between it and the next tank causing the second tank to begin to drain which in turn creates head for each consecutive tank. The program calculates the flow rate through each orifice based on the current head then calculates the new height of the water in each tank according to the #equation for orifice flow.

$$Q_{orifice} = K_{orifice} A_{orifice} \sqrt{2gh}$$

Since all tanks are not only draining but are also receiving water from the adjacent tank (with the exception of the beginning tank) the flow rate used to calculate the water height is the difference between the rate of flow into the tank and the flow rate out of the tank. The water heights during each iteration are calculated using the following #equation.

$$h_{new} = h_{previous} + \frac{(Q_{outflow} - Q_{inflow}) * \Delta t}{base * width}$$

The program continues to cycle through a while loop until it meets the stopping criteria of which water height in the last tank is sufficiently small. This value is chosen as one thousandth the initial height in the flocculation tank.

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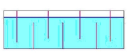 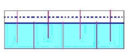 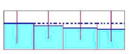

Draining of a Flocculator

Inputs for tank draining program:
*h~initial~: 1.8m
*n~tanks~: 4
*base: 66.2cm
*width: 92cm
*percent_allowable_area: 1
*height of space: 1.4*base

The "base" variable refers to the distance between consecutive baffles and the "height_of_space" variable is the distance between the bottom of the up baffles and the floor of the tank in the deepest area of the tank. A "tank" in this program refers to the space between two down baffles. The number of tanks is the number of down baffles plus one for the end wall. The "percent allowable area" is the area of the orifice compared to the area on top of the up baffles (height_of_space*width).

An initial vector of orifice diameters is used for the program to loop through. The program outputs several plots describing the relationship of water heights in different tanks. There is also an accompanying animation of the process. Only the orifice sizes that short circuit less than 1% the flow are considered. As illustrated in Table 2 all #orifice diameters considered meet this specification. The forces on each baffle as a result of tank draining are also calculated. This information is useful knowledge for construction as strength requirements for the baffles.

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Results of Flocculator Draining Program for Tank D

Orifice Diameter (in)	Drainage Time (min)	Percent Area
0.5	383.82	0.014
1	95.955	0.055
1.5	42.647	0.125
1.75	31.332	0.17

2	23.989	0.222
2.5	15.353	0.347

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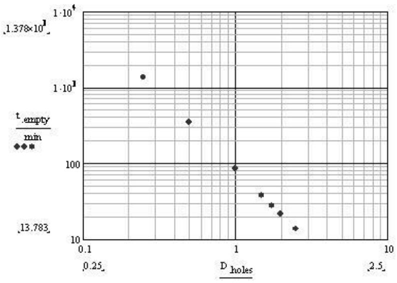

Tank draining time as a function of the diameter of the orifice

#This graph plots the draining time in minutes that corresponds to each of the possible orifice diameters in inches. As depicted, the time it takes to drain a tank decreases as the size of the hole increases. The hole should be chosen so that the tank drains in an acceptable amount of time. A drainage time of around 30 minutes is adequate for the Marcala plant. Due to the still evolving design for the baffle spacing in the flocculator tank, only tanks C and D were modeled. These tanks are far enough down the flocculation process that as long as the baffles are spaced either the distance the current flocculator model recommends or further apart, there should not be an issue with flocs breaking up. Since these flocculator tanks have different baffle spacing and different floor heights each tank was analyzed separately.

Tank C's draining time was modeled using the 54.6cm spacing and 4 "tanks" (areas between down baffles). These values allow tank C to drain in a little less than 17.5 minutes with a 2 inch hole. Tank D takes longer to drain. Though the program calculates the drainage time with a 2in orifice as almost 24min, the actual drainage time will be a little longer since all of the water in the channel up to the sedimentation tanks will be draining as well. These drainage times are acceptable, so a hole with a 2in diameter should be made in the corner of each down baffle, alternating the side of the baffle that the hole is on. Note this is only 0.22% of the total flow path area between the bottom of the up baffles and the floor in tank D. This area percentage should keep most of the water from short circuiting by going through this orifice. Since the height of the water changes throughout both tanks due to the sloped floor, the greatest water depth in each tank was used for calculations since this gives a more conservative estimate of drainage time.

#This graph shows how the water level in each "tank" responds to draining. The plot of indicates that the "tank" closest to the drain loses water at the fastest rate while the last tank plotted, has a shallower curve indicating a slower draining rate. Note: The 'i' variable indicates the entire time over which the tank is draining.

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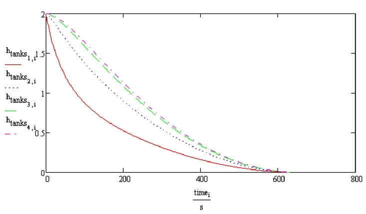

Tank draining times

Calculating Forces on Each Baffle

The force on the baffle is due to the pressure exerted by the water in each tank. The pressure in each 'tank' is depicted #here.

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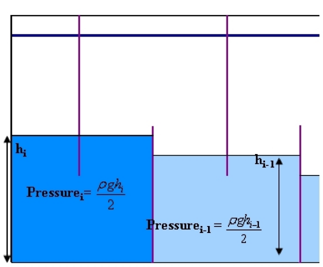

Calculation of the average pressure on a baffle

This force, calculated as pressure x area is constantly changing as the water heights decrease when draining the flocculator. #Equation 3 calculates the heights of the water in the flocculator. These values are stored in a table using MathCAD. Using the #equations below, the force on each baffle can be calculated as a function of the difference in water heights.

$$Pressure = \frac{\rho g h}{2} \quad Force_i = \left(\frac{1}{2}\rho g W_{baffle}\right) \cdot \left[h_i^2 - h_{i+1}^2\right]$$

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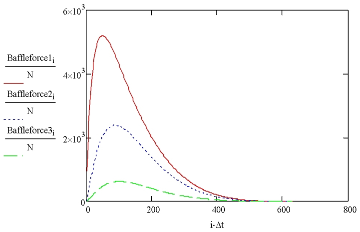

Force on Flocculation wall in Newtons for duration of draining of flocculation tank

#This graph illustrates the force on the outside of each baffle in Newtons as a function of time in seconds. The force rapidly reaches a peak then slowly goes down to zero. The further the baffle is from the drain, the less the pressure gradient between two consecutive baffles. When the operator 'unplugs' the flocculator, the strongest force exists on the baffle closest to the wall of the flocculator since the difference in head is greatest in the tank that is emptying to waste.

Force analysis provides valuable information on the structural parameters of the baffles. Using the above figure, it can be seen that the maximum force exerted on the baffles when draining is 1,169 lbf (5,200 N). Hence the baffles must be designed to withstand this force.

Sloping floor and Drains

Diagrams of the floors in the flocculator were compiled through drawings sent by Fred Stottlemyer and a phone conversation with him. The sloping floors are meant to make draining the flocculators easier and to thoroughly clean out any floc build up on the bottom on the flocculation tanks.

Tanks #A, #B, #C and #D will have a floor with a downward slope of roughly 10 cm over the length of each section. Tank A will begin at 58 cm above the current floor, tank B will begin at 48 cm above the current floor, and tank C will begin 35 cm above the current floor. Tank D starts at the height that tank C ends at and slopes down to 15cm above the original floor. The diagrams are shown at the end of the drainage section.

Included in the tank drawings are the drain placements in the flocculator system. There are three main drains in the series of tanks. One is on the side of tank B just before tank C. Another one is at the end of tank C and the last drain is in the floor of tank D at the end of the tank. This last drain connects to a 4 inch pipe running under the floor of tank D with a 90 degree elbow. The water then leaves the system through the wall at the beginning of tank D. The pipe has a downward slope with the beginning being at a height of 15 cm and the end at 5 cm above the original floor level where it then drains out of the side of the tank. These drains have already been placed in the Marcala plant in anticipation of a sloped floor.

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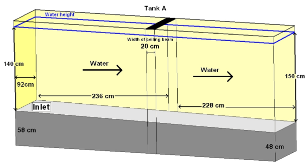

Flocculation tank A with tank dimensions

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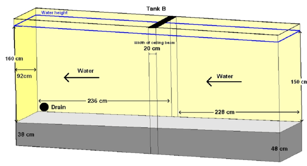

Flocculation tank B with tank dimensions

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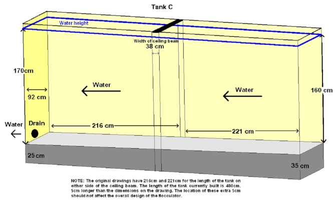

Flocculation tank C with tank dimensions

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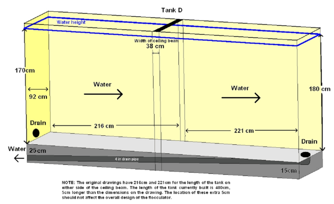


Flocculation tank D with tank dimensions

Marcala Transition from Flocculation to Sedimentation

The depth of the channel connecting the flocculation tanks to the sedimentation tanks was needed. The channel must be designed so as to make sure that the transition between the two tanks does not break up the flocs formed in the flocculation tank. Another constraint to include in design is to ensure proper depth as the plant operator will need to cap the sedimentation inlet pipes when draining a sedimentation tank.
The design process began with the consideration of the equation of velocity gradient as a function head loss, velocity and residence time.

$$Gamma = \sqrt{\frac{g \cdot h_l}{\nu \cdot \theta}}$$

The head loss equation accounting for minor and major losses dictate the flow in the channel

$$headloss = \left(\sum K + f \cdot \frac{L}{4R_h}\right)\frac{V^2}{2g}$$

Rewriting the above two equations, the following equation is derived

$$G = V\sqrt{\frac{1}{2\nu\theta}(\Sigma K_{minor} + f\frac{L}{2R_h})}$$

The residence time is a function of length and velocity in the reactor

$$\theta = \frac{L}{V}$$

Assuming that minor losses dominate the following equation is obtained from the combination of the above two equations:

$$V = G^{2/3} \times \left[\frac{2\nu L}{\Sigma K_{minor}}\right]^{1/3}$$

This equation must be used to solve for the required area of the channel, and then obtain the height of the channel given the flow rate.

$$A \cong \frac{Q_{channel}}{\bar{G}^{2/3}\left[\frac{2\nu L}{\sum K_{\text{minor}}}\right]^{1/3}}$$

$$H_{channel} \cong \frac{Q_{channel}}{\bar{G}^{2/3}\left[\frac{2\nu L}{\sum K_{\text{minor}}}\right]^{1/3} \cdot W_{channel}}$$

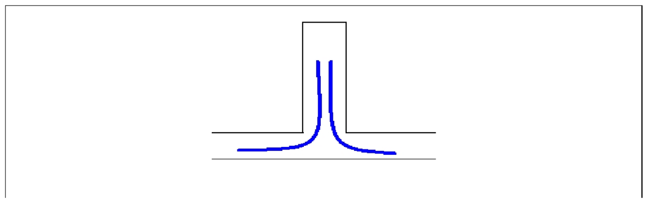
A reasonable distance over which the energy from the minor losses is dissipated, L, when the flow goes around the 90 degree bend and into the channel must be determined to solve this equation. We assumed that this dissipation occurs over a length that is double the width of the channel giving us equation below.

$$H_{channel} \cong \frac{Q_{channel}}{\bar{G}^{2/3}\left[\frac{2\nu W_{channel}}{\sum K_{\text{minor}}}\right]^{1/3} \cdot W_{channel}}$$

Additionally, the head loss coefficient for a 90 degree bend is approximately 0.5 (assuming it is like a pipe installed flush with the wall of a tank). The existing infrastructure restricted the width of the channel to 45 cm. A velocity of 0.093 m/s in the channel was calculated by setting the channel velocity gradient to be 15 /s, equal to the desired at the end ofthe flocculation process.
The flow in the channel should be ½ the total flow of the plant because the flow is split into two directions. The final height of the channel was calculated to be 37.6 cm given that the length needed to dissipate the energy from head loss was double the channel width.

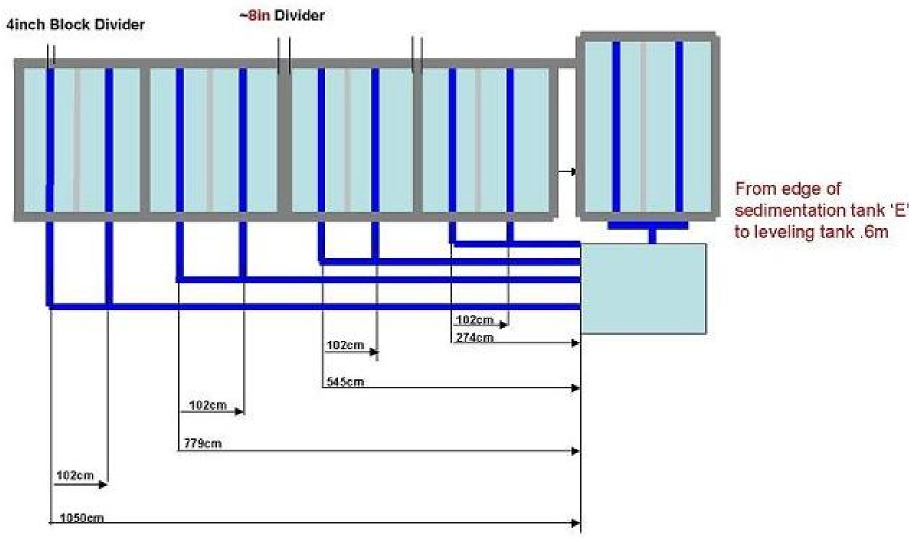
Design parameters for the transition channel:

- Expected Gbar: 15/s
- Flow rate in each ½ of the channel: 250 gpm
- Dissipation Length: 90.0 cm
- Depth: 37.6 cm
- Width: 45.0 cm
- Total Length: 10 m



Marcala Sedimentation Details

Sedimentation Tank



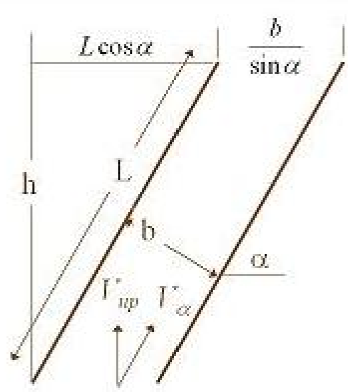
Marcala Sedimentation Tank Dimensions

Due to previous constraints, each sedimentation tank's area was given to be 105 cm wide by 240 cm long, expect for the last sedimentation tank which will be 265cm. Since the flow will be split into eight different sedimentation tanks, the flow rate that each manifold must accommodate is 189 L/min. The width of the plate settlers is determined by the width of each tank. Other assumptions are listed below. They are all based on recommendations from previous AguaClara plants. A MathCAD program was also utilized to calculate the needed parameter.

Assumptions

- Lamella Length: 36 in
- Lamella spacing: 5 cm
- Angle of Plate Settlers alpha: 60º
- Depth: 2 m

The sloping of the plate settlers will create an 'inactive' length in the sedimentation tank. This length is equal to , depicted below. This value was calculated to be 45.7 cm and must be subtracted from the tank length since sedimentation will not take place in this area. Since the length of the tank is 240 cm long, the active area of sedimentation will be 194 cm. The diagram below presents this concept.



Mathematical Parameters in Sedimentation Tank

This will allow for plate settlers to be installed. The upwards velocity in the tank allows for the critical velocity in each tank to be calculated. The critical velocity, Vc, denotes the maximum amount of time required to just capture a particle. Sources such a Schultz and Okuni recommend critical velocities between 20-60 m/day. The critical velocity for our designed sedimentation tanks during normal operation was calculated to be 17.08 m/day using the equations below.

Through experience with the plant in Ojojona, it has been suggested to keep the critical velocity below 15 m/day. If the critical velocity is too high, it is believed that flocs tend to rise instead of settle. When two sedimentation tanks are offline (two drain at the same time, discussed below), the critical velocity in the other six will increase if the flow through plant remains constant. Alternatively, the flow rate into the plant could be reduced temporarily while the sedimentation tanks are draining.

Vup

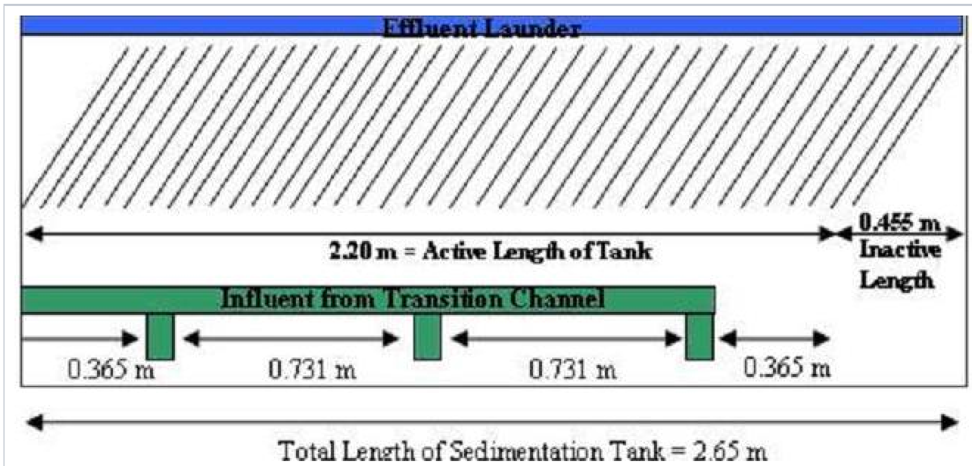
$$V_{up} = V_c \times \left(1 + \frac{L_{lamella}}{b_{lamella}} \cdot \cos(\alpha) \cdot \sin(\alpha)\right)$$

Alternative Vup

$$V_{up} = \frac{Q_{tank}}{L \cdot w}$$

Design parameters for the sedimentation tank are below.

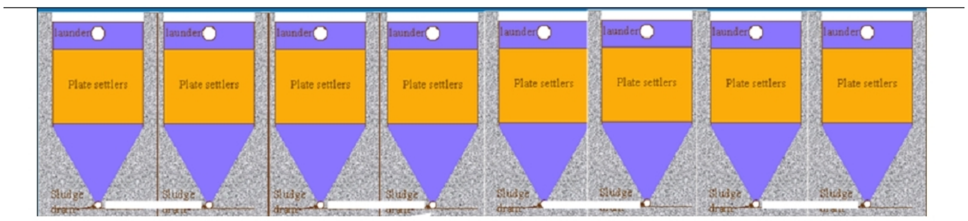
- Depth: 2 m
- Vc: 13.06 m/day
- Vup: 116.51 m/day
- Vc: 22.77 m/day, with two tanks offline
- Vup: 203.1 m/day,
  with two tanks offline+
- Qtank : 189.27 L/min
  +* Qtank: 83.3gpm with two sedimentation tanks offline+
- ¿: 60 degrees
- Width: 102cm
- Llamella: length of lamella 36in
- L: Total Length, 2.65 m
- Lacutal: Active Length, 2.20 m
- blamella: Lamella Spacing, 5 cm
- Number of Plate Settlers: 38
- Wall Height: 2.3 m



Marcala Sedimentation Tank Parameters

Sludge Removal for the Marcala Plant

A sludge removal system must also be designed. The current experimental system in Ojojona has confirmed the success of using a manifold at the bottom on the sedimentation tank to remove sludge build up. This manifold will have several small orifices to equally pull sludge out of the bottom of the sedimentation tank. Furthermore, by sloping the sides of the sedimentation tank below the plate settlers to a central valley, more sludge is likely to be removed. Figure 4 depicts end view of 10 sedimentation tanks showing the proposed sludge removal system. Note that each two successive sedimentation tanks are tied in series. This will cause two sedimentation tanks to drain at the same time.



Proposed Sludge Removal System

The water depth in the sedimentation tank will remain at 2 m measured from the water surface to the bottom of the drain pipe. The drain pipe will have an orifice in the top of the pipe spaced every 10 cm, this distance was chosen as a conservative measure to collect sludge evenly. Accumulated sludge is pulled out from the entire bottom of the tank while clean water is carried out of the tank by the effluent launder. The drain pipe will have , or 26 orifices to drain the sludge.

The diameter of the sludge manifold is found by an iterative process using the following equation.

$$D_{manifold} = \left(\frac{8Q_{manifold}^2}{gh_l\pi^2} \frac{1 + \left(f\frac{L_{manifold}}{D_{manifold}} + \sum K \right) \left(\frac{1}{3} + \frac{1}{2n} + \frac{1}{6n^2} \right)}{1 - Q_{ratio}^2} \right)^{\frac{1}{4}}$$

Where

- The projected flow through the manifold when draining is estimated at double the average drain flow rate divided by the number of sedimentation tanks. The extra factor of two is because two tanks will drain at one time. This design specification was employed so that although there are eight sedimentation tanks, there are effectively only four draining tanks. This way the walls dividing the four tanks into two did not need to be built strong enough to withstand the force of water pushing outwards. Figure 25 is a photo from Fred Stottlemyer of the current sludge drains and how they are connected to one another. Note that the photo depicts two adjacent sedimentation tanks which will drain together.

Equation 17

Proposed Sludge Removal System. The three influent pipes can also be seen entering the sedimentation tank. Note that these influent pipes enter the tank horizontally because the channel is located outside of the sedimentation tank.

The three influent pipes can also be seen entering the sedimentation tank. Note that these influent pipes enter the tank horizontally because the channel is located outside of the sedimentation tank.

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$$f = \frac{0.25}{\left[\log\left(\frac{\epsilon}{3.7D} + \frac{5.74}{Re^{0.9}}\right)\right]^2}$$

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- : 5.3m, double the length of the sedimentation tank (2.65m)

- : 52, the number of orifices in drain pipe. Note there are 26 orifices in one drain pipe, but since two sedimentation tanks will drain at the same time, we must account for the total number of orifices
- : 2m, the depth of the sedimentation tank
- : 0.8, the ratio of flow from the first port to the flow through the last port
- : the parameter we are iterating about, found to be 1in.
- Epsilon is the Roughness factor of PVC
- nu is the kinematic viscosity of water, 10-6 m2/s

In order to find the sizes of the orifices, we use the orifice equation.

Equation 19
Where

- The flow is calculated as
- : 0.63
- h is the available head for the sludge ports, calculated as the total elevation drop minus the head loss in the manifold and minus the velocity head at the end of the manifold.
  The headloss through the manifold changes as it goes by each port, but for simplification we assume flow into each port is identical.

Equation 20

Where is the sum of the minor and major head loss through a pipe with f defined in +Equation 18 and Equation 19. In this case we use K=0.+

Equation 21

The velocity head at the end of the manifold is calculated as shown.

Equation 22

Design parameters for the sedimentation sludge manifold are as follows.

- Space between Orifices: 10 cm
- n , Number of Orifices on each manifold: 26
- Time to Empty Tank: 45 min
- Qratio - Ratio of flow between first and last orifice: 0.80
- Qdrain - Maximum drain flow rate: 126.9gpm
- - Head loss through the manifold: 8.89 cm
- - The velocity head: 15.73 cm
- - Head loss allowable through the orifices: 2m- - =175.38 cm
- Dmanifold - Diameter of Pipe: 3.0 in
- Orifice Diameter: 0.287 in

Note: The exact positions of how the sides of the bottom of the sedimentation tank slopes (to help accumulate sludge in the drain pipe) and the interaction with the inlet pipes from the transition channel have not yet been specified.

Effluent Launder

The effluent launder will carry water out of the sedimentation tank to be chlorinated and stored in a tank for distribution. A similar program used to calculate the sludge drain was used. The launders leaving the sedimentation tanks are designed in a similar manner as the sedimentation sludge drain manifold. There will be orifices on both sides of the launder spaced between every other plate settler. The launder flow rate is the flow rate in each sedimentation tank, the plant flow rate divided by eight. By using salvaged pipe for the launder, the pipe launder diameter was specified to be 6in diameter. UsingEquation 11 Equation 12
and by setting the depth under the water elevation for the effluent launder to be 10cm, the allowable head loss is calculated. The depth of the launder is specified at 10cm through an iterative process in order to confirm the use of 6in pipe diameter is accurate using Equation 16 calculates the orifice diameter using the allowable headloss and flow rate through each orifice.

Design parameters for the sedimentation tank effluent launders are as follows.

- Qratio: 0.95
- Launder Length: 2.65 m
- Launder/ Exit Pipe Diameter: 6 in
- Head loss in the launder (not including head loss to the plant level tank): 10cm
- Total number of orifices: =38, with two on each side of the launder, spaced above every other plate settler
- Spacing between orifices: = 11.55 cm (two rows of orifices with this spacing!)
- Head loss through the manifold: 0.036 cm
- Velocity head: 0.238cm
- Head loss through the orifices: 10cm- - =9.726cm
- Orifice size: 1.232 cm

Marcala Plant Regulator Tank

The plant regulator tank (PRT) will connect all effluent tubes from the sedimentation tanks into one tank that will incorporate chlorination and discharge the chlorinated water to the distribution tank. This tank will regulate the water level in the sedimentation tanks. Currently, there are 5 pairs of sedimentation tanks, each with an effluent pipe collecting the clean water. Each effluent pipe will connect to form 5 pipes that lead into the PRT. The water from each pipe will enter the PRT through the bottom of the tank which will enable easy capping of the pipes in order to shut off one pair of sedimentation tanks for cleaning. Water will exit the tank through a pipe sticking up through the base of the tank. The height of this pipe can be adjusted in the future if a change in the water levels or flowrate of the plant if necessary. The rim of the pipe will function as a weir to control the level of the water.