Controlling the Units

In the Basic Treatment Units, we discussed the four basic stages of treatment in the activated sludge package plant; preliminary, secondary, tertiary and solids handling. We also introduced the idea that each stage uses physical, biological or chemical processes to remove pollutants and prepare the water for final discharge. The type of process will determine which type of control method is used.

Stage	Process	Control Method
Preliminary	Physical	Visual Observation
Secondary	Physical	Visual Observation
	Biological	Chemical Analysis
Tertiary	Physical	Visual Observation
	Chemical	Visual Observation
Solids Handling	Physical	Visual Observation

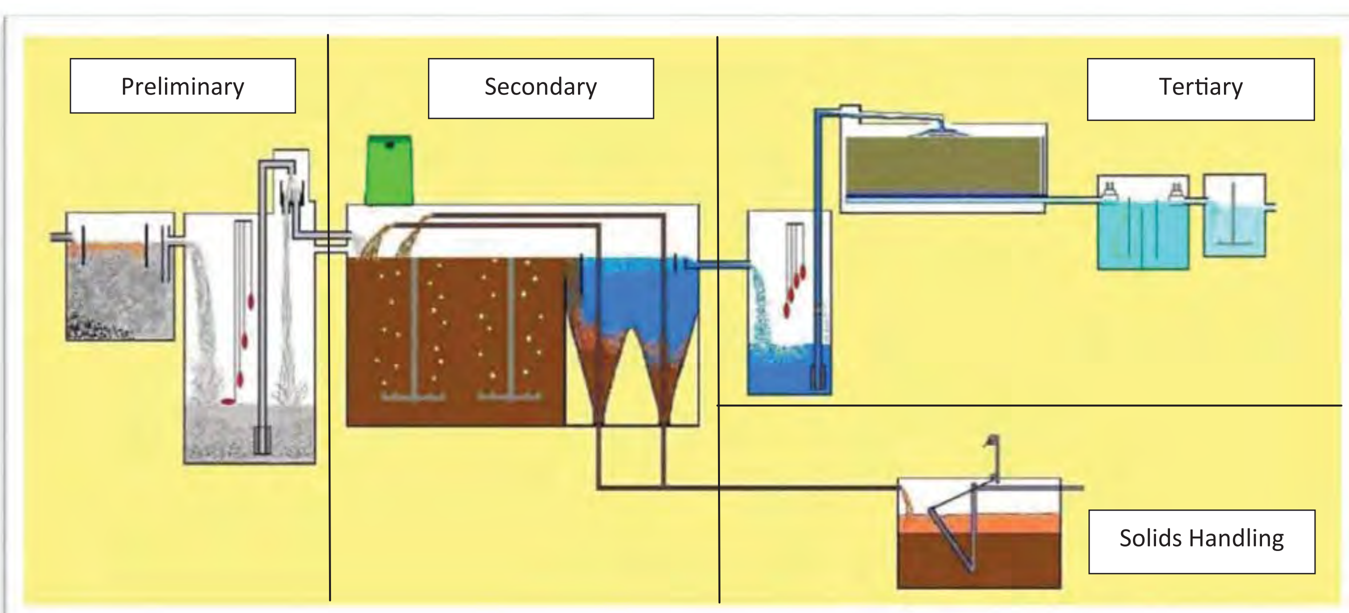
The units in the Preliminary Stage use physical processes, so visual monitoring or observations of the process will provide insight into whether these units are performing as designed.

The Secondary Stage also uses physical processes, so observations are valuable monitoring tools. However, the aeration tank is a biological process within the Secondary Stage. This biological process cannot be evaluated by observations alone, but requires additional chemical analysis to track performance.

The Tertiary Stage, relies mainly on physical processes and can be monitored visually. The disinfection unit in the Tertiary Stage may use a chemical process, however, it can be monitored by visual observations.

The Solids Handling Stage relies mainly on physical processes which can be controlled by visual observations.

Each stage is designed for the removal of a specific pollutant . As pollutants are removed an excess of bacteria are generated which also must be disposed of properly. Each stage must perform its task or a problem will be passed on to the next treatment stage. Failure of any stage to perform its designed function will lead to loss of control. This sets in motion the "domino effect" in which small stress events are multiplied through the treatment system.



Controlling the Units

An initial failure within a specific treatment unit is multiplied as it travels through the remaining treatment system. The causes for failed performance may be identified from within that specific unit or, like a row of fallen dominos, might need to be traced back to a treatment unit upstream of the "observed" failure.

As more dominos fall, the system becomes more labor intensive and more expensive to maintain. Upsets will occur, but each upset requires cleanup. If the process is not controlled you will find yourself in a reactive mode, constantly "fixing" instead of "preventing". A well-controlled treatment system produces the fewest upsets. A common myth is "I don't have enough time to operate the system." In reality a small investment in controlling the process is the most efficient use of your time. The truth is "You won't have enough time if you fail to control the process."

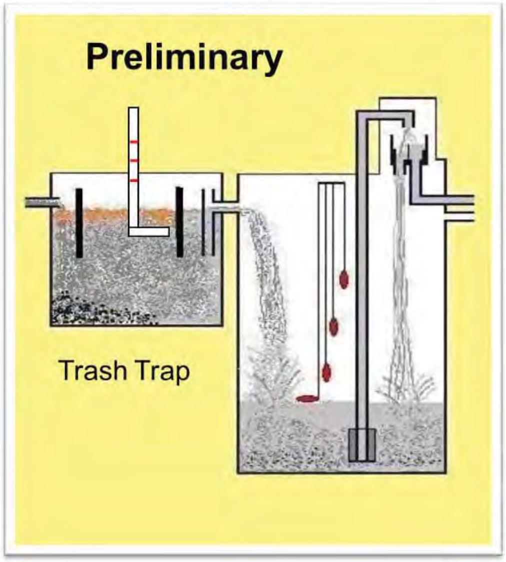
Loss of control can also lead to a loss of revenue. As effluent violations continue, so does the possibility of enforcement action with the probability of monetary fines. As if inefficiency and expense were not sufficient, there is also the degradation of the water quality in the local environment. So the most efficient and economical approach to wastewater treatment is to control each individual process.

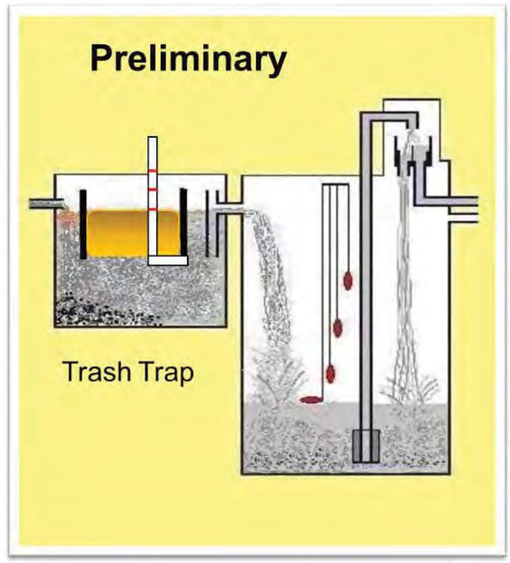
In order to control the package plant we need to first understand what is expected of each treatment process, so we collect data or information to measure if the expected performance is being achieved. When the data indicates a process is drifting outside its intended design, determine the cause of the drift and the correct response to reverse the trend. Then implement the correct response to bring the system back in line.

The data should indicate the system is trending back into control. The same tools and methods that are used to adjust the process are also the same tools and methods used to troubleshoot the cause of an upset. If the process is controlled there is no need to troubleshoot upsets. The goal is to respond before the upset occurs.

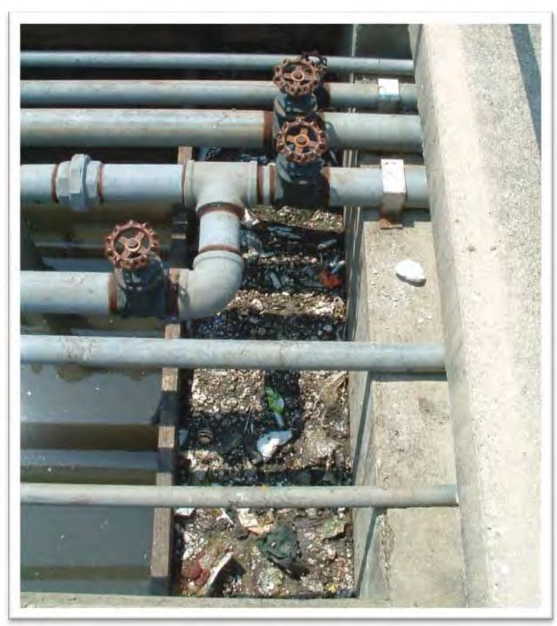
Preliminary – Trash Trap

The trash trap is a physical process which can be monitored by simple observations. The purpose of the trash trap is to remove scum and grit, but allow suspended and dissolved pollutants to pass through to the secondary stage. Measuring the scum level in the trash trap provides information to prevent pass through of scum.





If we could view the trash trap from the side it would be obvious as to when the trap would need to be pumped out. Unfortunately we can only view the trap from the surface and the scum depth is difficult to determine. A simple tool to gage the depth of the floatable material is an "L" shaped staff. First determine the depth of the baffle in the trash trap. Next lower the staff into the grease layer and slowly raise the staff until you can feel resistance from the bottom of the scum layer. The side of the staff is marked in increments. By noting where the markings on the staff line up with the top of the trash trap you can estimate the depth of the scum layer. When the scum blanket reaches the bottom of the baffle, pass through of scum increases. When the baffled zone is full of floating grease it can no longer perform its design function and these undesirable pollutants pass through to the next treatment stage.

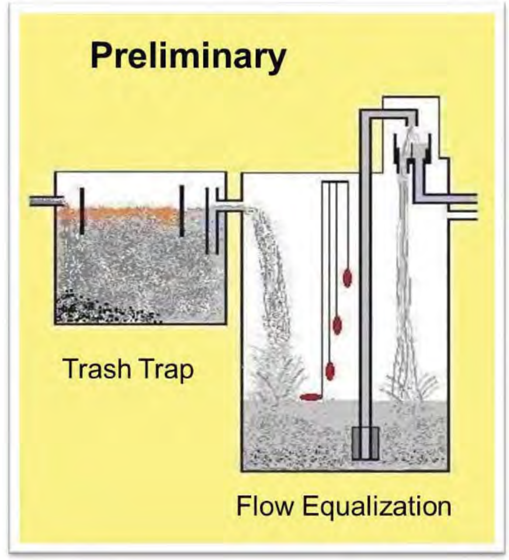


Another visual check is to examine for evidence of scum or grease passing through the trash trap. If you observe excessive amounts of grease downstream of the trash trap, then the trap is failing or the grease loading is too excessive and needs to be controlled at the source.

The evidence is most obvious in the secondary clarifier. As the trash trap's effectiveness decreases, more scum is observed in downstream units, typically in the clarifier.

The trash trap is designed to prevent scum and debris from passing through. Eventually it needs to be physically removed to maintain effectiveness. Contact a local septage hauler to have the scum and grease pumped out and disposed of properly.

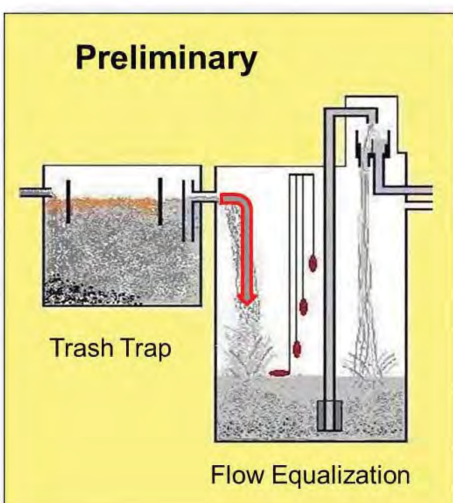
Preliminary – Flow Equalization (EQ)

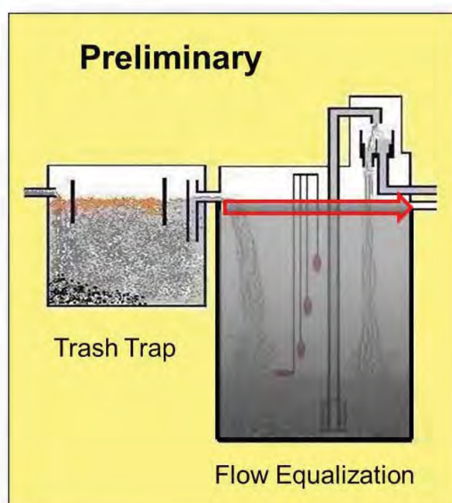


When influent flows exceed the pumping capacity of the flow equalization pumps wastewater accumulates in the flow EQ tank.

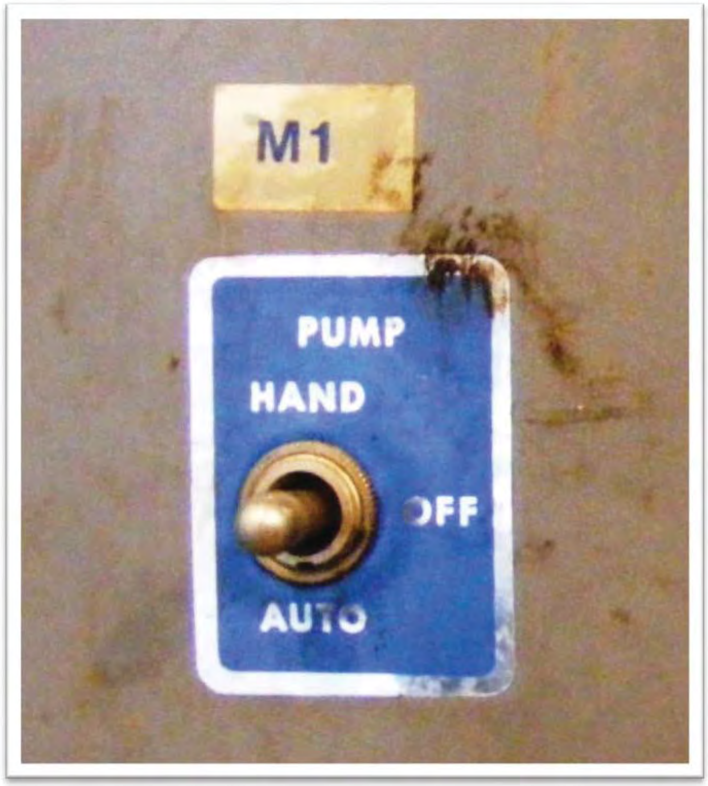
Mechanical pumps in the flow equalization tank operate off of a sensor that monitors water elevation in the tank. The sensor is typically a float switch. As water elevation increases, the floats will activate electrical controls to turn pumps on or off.

If influent flows exceed the pumping capacity of the flow equalization pumps, eventually the tank fills to an elevation where it will flow through a transfer line into the aeration tank to prevent an overflow of the preliminary stage. This also serves as a back-up if electrical power is lost to the treatment system or if the flow equalization pumps are out of service. When the EQ tank is full there is no flow equalization being provided to the downstream treatment stages.





Preliminary – Flow Equalization (EQ)



If the flow equalization tank is passing wastewater to the Secondary Stage through the transfer line, either there is more flow being received than the system was designed for or there is an issue with the Flow EQ pumps keeping up with the flow rate. It will be obvious if the pumps are not operational due to a power failure. However, if there is a problem with the actual pumps or the floats, a little detective work is needed. This begins by looking into the electrical control panel which services the flow EQ pumps.

Inside the control panel there typically is a control for each submersible pump in the EQ tank. The pump controls are designed with three operational modes. The "off" position of the pump control should prevent the pump from operating. However, to isolate if the problem exist with the pump, switch the controls to the "Hand" or "On" position. If the pump does not start the issue is associated with the pump or the electrical control wired directly to the pump.

If the EQ pumps operate properly when in the Hand or "on" position, then evaluate if there is a problem in the float switches causing improper operation. Switch the pump control to the "Auto" position. Manually activate the float switches by raising them and tipping the floats by hand to close the contacts and monitor if the pumps are activated.

If the pumps do not operate there could be an electrical connection problem in the float and the float switch might need to be replaced. Perform the same test on both pumps. The transfer line might be overflowing due to just one pump being operational.

Preliminary – Flow Equalization (EQ)

Air is diffused into the bottom of the EQ tank to provide for mixing and suspension of pollutants and prevents their deposition on the bottom of the EQ tank. There is typically a blower and motor unit specifically for the Flow EQ tank.

Similar to the Flow EQ pump controls, the blower and motor controls also have a Hand, Off, Auto control option. Typically a clock located inside the control panel is used to cycle the blower on and off when the blower controls are set to the Auto setting.

The same process for troubleshooting the EQ pumps can be used to troubleshoot the EQ blower. Switch the controls to Hand or "on" position to confirm a problem with the motor, blower or diffusers then switch the controls to Auto and adjust the clock to operate the blowers. Failure of the blower to operate in either the "Hand" or "Auto" setting will lead you to follow up with the necessary diagnostic to ensure proper aeration of the Flow EQ tank.

As the water elevation increases in the flow EQ tank, diffusing air on the bottom of the tank requires more pressure from the blower. Be sure to verify the aeration provided by the blower provides mixing at these high water elevations in the flow equalization tank.

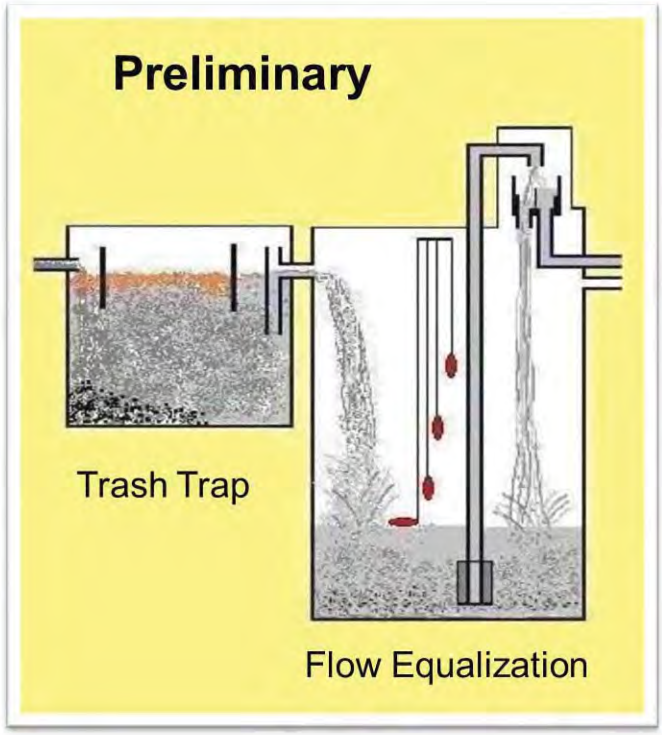
Preliminary Stage– Summary

Visual observation is the primary tool to monitor the process. A walk through the system will expose the operator to potential issues. Visual observations do not require any expensive specialized tools, but will identify the onset of an upset condition.

Unfortunately, many operators fail to notice the subtle changes which signify the beginning of an upset. Visual observations are limited by the thoroughness and awareness of the person making the observations.

Trash Trap

Monitor the scum accumulation in the trash trap and have it pumped out before it allows undesirable pollutants to pass through. This is achieved by measuring the depth of scum in the trash trap and by monitoring plastic/paper/grease accumulation in the clarifier scum baffle area.



Flow Equalization

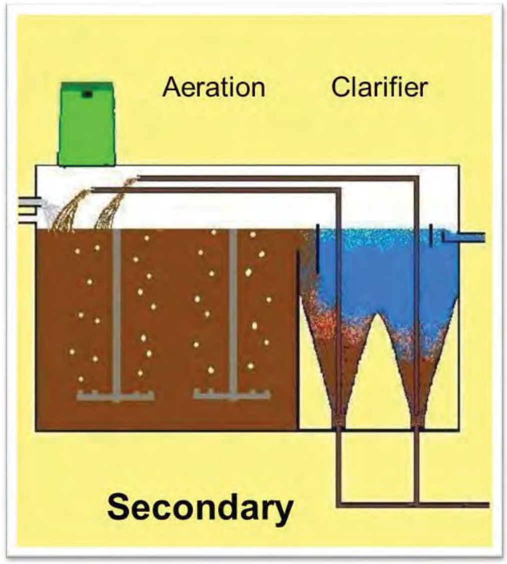
If the transfer line is continually flowing full there is a problem which needs to be investigated and eliminated. The transfer line is designed to prevent the wastewater from backing up into the trash trap by allowing wastewater to flow by gravity if there is an electrical outage or the EQ pumps become inoperable.

Verify all submersible pumps in the flow EQ tank function in the "ON" and "AUTO" position of the controls. It could be a mechanical problem with the pumps or an electrical problem with the control panel or floats.

Verify the motor and blower, which provide mixing to the Flow EQ tank, is operational. Confirm the blowers provide sufficient pressure to mix the Flow EQ tank when the water elevation in the EQ tank reaches the same elevation as the transfer line.

Problems that occur this early in the treatment process have a greater impact on effluent quality. When the first domino falls, all downstream treatment stages are impacted. These physical processes require visual analysis which is inexpensive and prevents the "domino effect", but typically is neglected due to complacency. The most valuable tool available to you in controlling the process is to notice what the system "looks" like when operating efficiently and be aware of the subtle changes that indicate a drifting from this idea operational condition.

Secondary Stage - Aeration



The secondary stage is a physical and biological process which will require visual observations for the physical processes and chemical analysis to monitor the biological process.

The two units in the Secondary Stage, aeration tank and clarifier, work together to first convert dissolved and suspended pollutants to bacteria in the aeration tank and then to separate the bacteria from the water in the clarifier.

Visual observations of the aeration tank can provide information on the operational condition. Several factors to note are the color of bacteria in the aeration tank, the amount and type of foam on the aeration tank surface and the aeration mixing pattern.

Aeration Color

Aeration tanks treating domestic waste typically have a brown color. Color can range from a light, milky brown shade to a heavier, dark brown appearance. One reason for this variation in shades of color can be caused by the concentration of bacteria in the aeration tank. As bacteria concentrations increase, a darker shade develops.

Abnormal colors can be a grey shade, usually due to insufficient bacteria concentrations or insufficient aeration being applied or a black color from anaerobic condition. Neither of these conditions is acceptable for an aeration tank environment.

Observe the color of the aeration tank, and then compare the current color with the color of the aeration tank when the system is operating properly. This is a simple method of monitoring performance. The health and condition of the bacteria in the aeration tank determine the quality of the water discharged from the treatment system.

Secondary Stage - Aeration

Aeration Foam

In addition to color, another visual clue is the appearance and amount of foam on the aeration tank. Foaming on the aeration tank surface is typically associated with one of two probable causes.

Having sufficient bacteria in the aeration tank to treat all of the influent pollutants is critical to prevent effluent violations. However, having an excessive amount of bacteria in the aeration tanks creates a "starved" growth condition in the aeration tank. Under this situation certain bacteria will generate faster than other types. Those bacteria, which will dominate in population under this starved condition, also generate a stable brown foam.

Typical remedies for eliminating the condition is to reduce the concentration of bacteria in the aeration tank. This requires the operator to reduce the amount of bacteria being used to treat the pollutants entering the aeration tank. The situation can also be adjusted by reducing the number of aeration tanks in service and/or reducing the run-time of the aeration tank blowers. This will be discussed in more detail later in this section on Controlling the Units.

Another foaming condition occurs when the concentration of bacteria necessary for treatment is insufficient. This type of biological environment develops white, crispy foam. This foam can be "knocked down" by spraying water. This typically occurs when the operator has removed too much bacteria from the aeration tank by over wasting or the biological environment is recovering from a toxic load or an extended time of having the aeration blower off.

Secondary Stage - Aeration

Mixing Intensity

Another observation is the rolling pattern created by the diffused aeration. There needs to be sufficient mixing within the aeration tank to mix the influent pollutants with the bacteria. An important observation of the aeration tank should include the operation and mixing intensity of the diffused air.

Ideally diffusers should be designed on the length of the aeration tank. Systems with diffusers along the width might require additional aeration to provide sufficient mixing within the aeration tank.

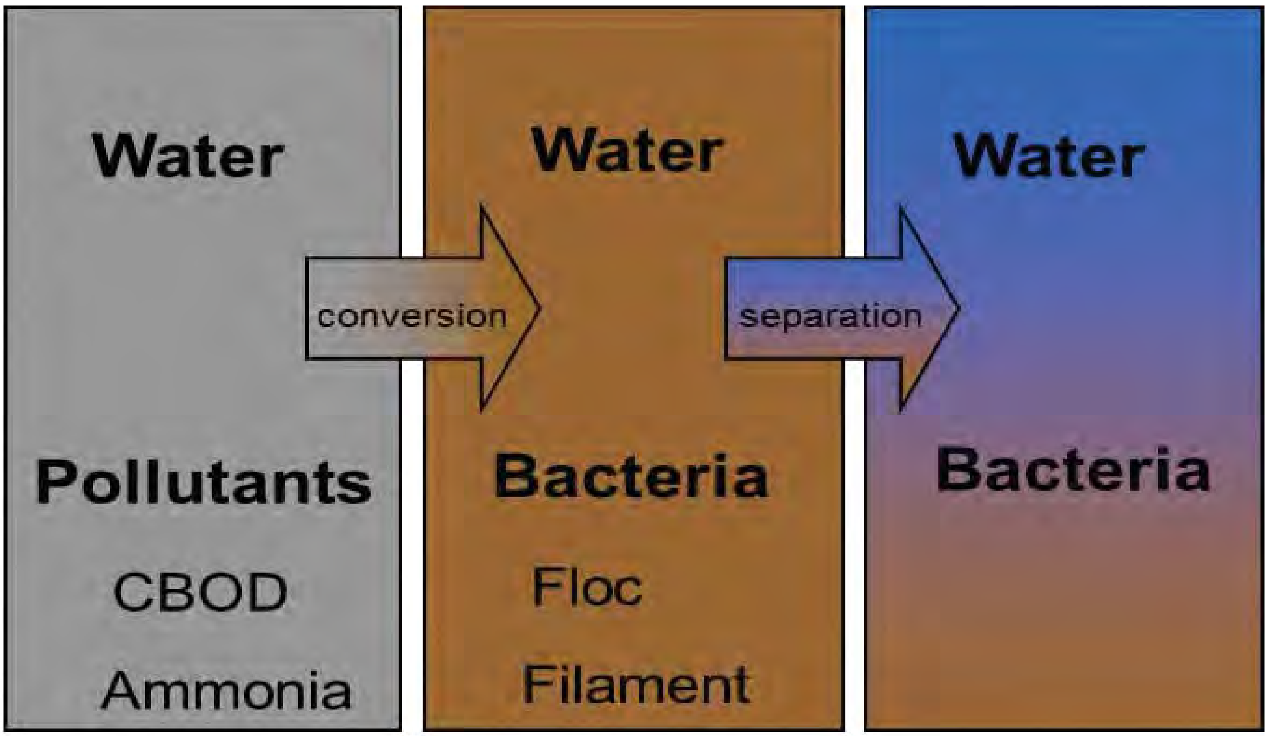
The aeration tank is typically designed with equipment similar to the flow EQ for providing air and mixing. Switching the blower motor controls to "Hand" should bring the aeration unit into service. Switching the blower motor controls to "Auto" should bring the aeration unit into service depending on the timer setting on the clock located in the control panel. Manually adjust the clock to confirm the aeration unit is functioning properly. Once the aeration system is providing mixing to the aeration tank, observe the aeration pattern for mixing intensity and coverage.

By opening the valves controlling the air flow to the drop pipe, the mixing intensity and mixing coverage can be improved. When sufficient aeration is applied for adequate mixing you should be able to observe a rolling action across the surface of the aeration tank.

Secondary Stage - Aeration

It is impossible to control the Secondary Stage by visual observations alone. There is a biological process associated with the conversion process in the aeration tank. This will require a different method for monitoring the process. The dissolved and suspended pollutants enter the aeration tank in the form of carbon, quantified as cBOD, and in the form of nitrogen as ammonia. These pollutants serve as a "food" source for aerobic bacteria in the aeration tank. These pollutants are consumed and then converted into more bacteria.

Preliminary Effluent Aeration Tank Effluent Clarifier Efflu-



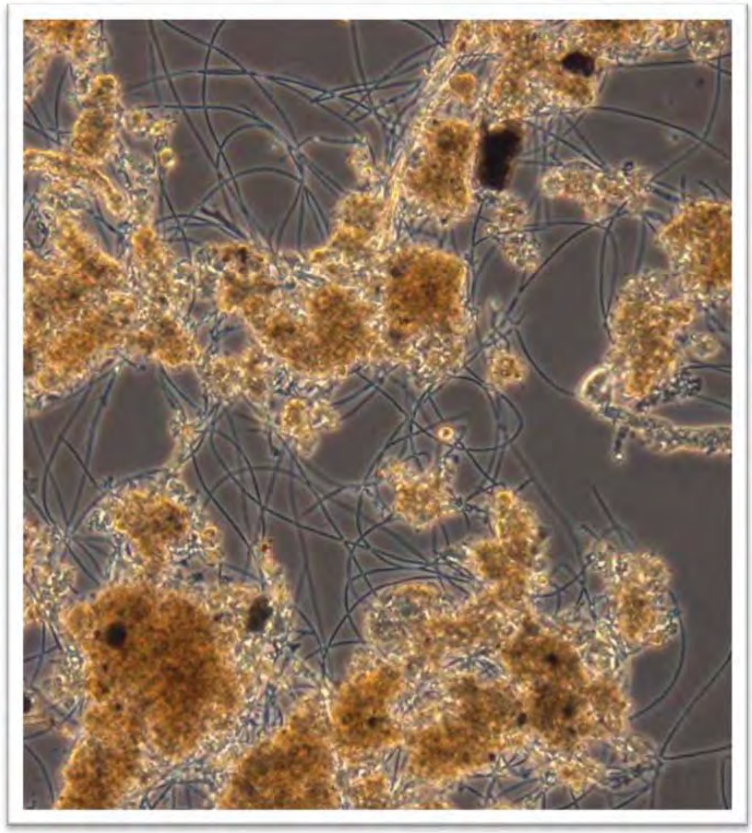
The Preliminary effluent has a high concentration of dissolved and suspended pollutants as cBOD and ammonia. These pollutants are converted to additional bacteria in the Secondary Stage aeration tank. The aeration tank effluent has a high concentration of flocculating and filamentous bacteria. As these bacteria separate from the water in the secondary Stage clarifier, the clarifier effluent has a low concentration of bacteria which prepares the water for final treatment in the Tertiary Stage.

The conversion process is monitored by measuring the ammonia concentrations after the Secondary Stage. Both pollutants, cBOD and ammonia are converted in the aeration tank, however the bacteria that convert the ammonia are more sensitive to the aeration tank environment. If the aeration tank environment is not adequate, ammonia will not be converted and will pass through the Secondary Stage. If ammonia concentrations from the Secondary Stage are less than 1 mg/L, then conditions are also adequate to convert the less difficult cBOD pollutants.

Because of the sensitivity of the nitrifying bacteria, we can chemically monitor the Secondary Stage ammonia concentrations to determine if conversion is complete. If ammonia values are low, conversion is complete. Chemical analysis for ammonia can be performed in the field within a few minutes.

Secondary Stage - Aeration

These bacteria develop into one of two basic structures, either flocculating or filamentous bacteria. The dark brown clusters are flocculating bacteria. These bacteria grow together like "clusters of grapes" and add density which promotes faster settling characteristics.



A second type of bacteria structure, the filament, grows "end to end" and develops a "stringy" structure. This type of bacteria structure tends to settle much slower than the flocculating bacteria, however it helps to filter out fine suspended solids from the water column.

As these bacteria enter the clarifier this combination of flocculating and filamentous bacteria have sufficient density to settle and filter the water allowing clean water to leave the Secondary Stage and flow into the Tertiary Stage for final treatment.

Failure to convert pollutants to bacteria allows pollutants to pass through the Secondary Stage into the final effluent. Failure to separate bacteria from the clean water causes solids to accumulate on the sand filter. Neither is desirable. Controlling the biological environment in the aeration tank is critical to first provide the necessary conditions to convert all the pollutants into bacteria and to "develop" a bacterial culture which will settle and filter in the clarifier.

Conversion of pollutants is the first goal. You can not settle bacteria in a clarifier if you have not grown them in the aeration tank. When Secondary Stage effluent ammonia values are less than 1 mg/l, conversion is complete. Chemical monitoring of the secondary stage effluent will notify the operator is the conversion process is effective.

Secondary Stage - Clarifier

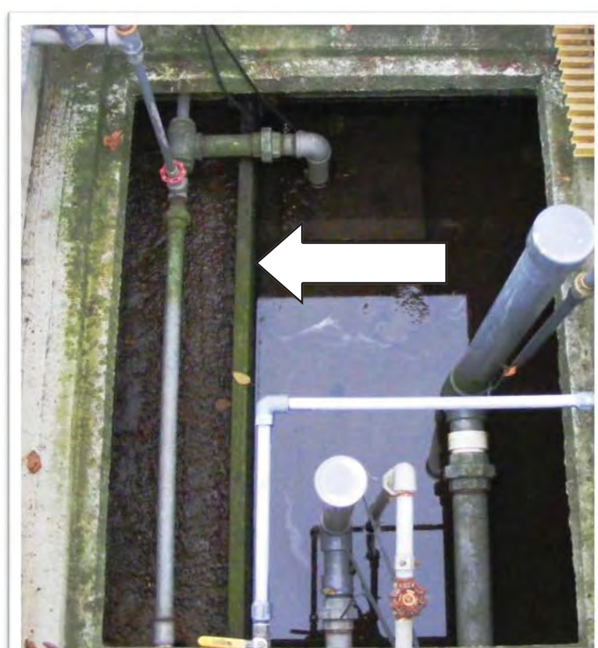
The clarifier is a physical process of gravity separation of bacteria from the clean water. These physical processes can be monitored by visual observation. Key monitoring points of the clarification process include the scum baffle, surface skimmer, weir baffle, weirs and the return pumping rate of settled bacteria (sludge) back to the aeration tank.

<u>Clarifier Scum Baffle</u>

To prevent floating materials not captured by the trash trap from entering the clarifier, a scum baffle is designed at the inlet to the clarifier.

Failure of the trash trap to capture these materials in the Preliminary stage allows them to accumulate in the clarifier scum baffle area.

The more significant the trash accumulation in the clarifier scum baffle area, the more likely the trash trap needs pumped out. While the septic hauler is on site pumping out the trash trap, request the scum baffle area be pumped out.



If the biological environment in the aeration tank is not properly maintained, strong, viscous type foam can be generated. This foam will naturally collect in the clarifier scum baffle area and harden over time. As this foam begins to break down anaerobically, dissolved pollutants are dispersed into the clarifier and will lead to upset conditions or violations of the permitted effluent limits.

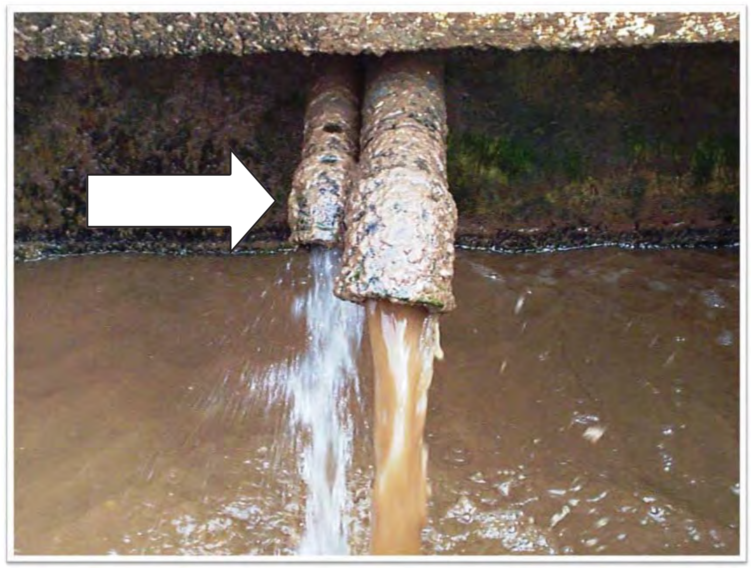
Pumping out the foam is similar to placing a "Band-Aid" on a deep cut. The foam will return unless there is a change to the aeration tank environment which is producing the foam. Change the condition which is generating the foam in the aeration tank, then removal of the scum is beneficial.

Secondary Stage - Clarifier

Skimmer– operational

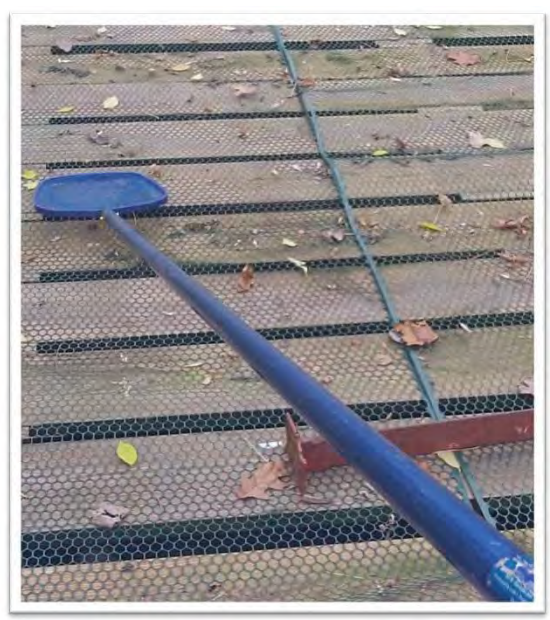
The clarifier is designed with a skimmer to prevent undesirable material (paper, plastic, grease, biological foam, floating bacteria) from exiting the Secondary Stage and accumulating on the sand filter in the Tertiary Stage immediately downstream.

The first observation is to verify if the skimmer is operational. A visual inspection should verify if the skimmer is operational. The skimmer discharge will be directed to the aeration tank and should appear as clear water.



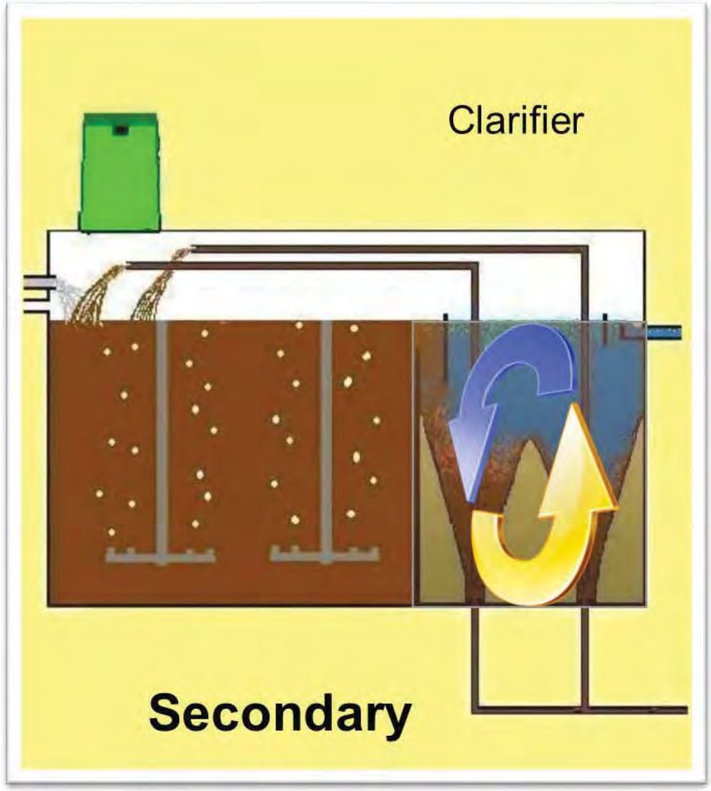
Clarifier Skimmer– paper, plastic, grease

The skimmer operates on the principles of an air lift pump. (This air lift pumping is discussed in the Basic Units chapter.) The airlift pump has several advantages for use in a package plant treatment system, however, it has a limitation in effective removal of low density material (plastic, grease) from the clarifier's surface.



These low density materials will not be removed from the clarifier surface and will need to be manually skimmed from the clarifier. Manual removal is the best option for permanent removal.

Skimmer– paper, plastic, grease



Material of low density requires manual removal by the operator, but even material of higher density (paper, rags), normally removed by the skimmer, are pumped back into the aeration tank only to find their way back into the clarifier. In essence the clarifier surface skimmer does not necessarily remove floating material but recycles these material through the Secondary Stage.

This recycling of material does not provide a significant treatment value, however, it does have a negative effect by increasing the hydraulic flow through the clarifier. This increase in turbulence in the clarifier makes it more difficult to separate bacteria from the clean water.

Operating the skimmer continuously is not necessarily the most effective mode of operation. Manually cleaning floating material is more effective, then the skimmer can be taken out of service so the hydraulic pressures through the clarifier are more conducive for separation of bacteria from the water in the clarifier.

Clarifier Skimmer– biological foam

The environmental condition of the aeration tank has a significant impact on the types and concentration of bacteria which are generated. As discussed previously, the aeration tank which experiences a "starved" growth environment will generate a type of bacteria which causes a brown foam on the aeration tank. If the aeration growth environment is not corrected, this biological foam will become so excessive the foam will migrate to the clarifier and can cover the entire surface area.

Biological foams generated from improper aeration tank environments can be returned, but depending on the severity of the foaming conditions the skimmer will eventually become overwhelmed. Again, first focus on stopping the generation of the foam in the aeration tank, and then, work on removal of the foam from the clarifier.

Since this biological foam is generated in an aeration tank which is operating at a "starved" growth condition, the solution is typically to adjust the ratio of food (pollutants coming into the aeration tank) to micro-organisms (the concentration of bacteria in the aeration tank). Since there is no control for increasing the influent pollutant concentration (food) the only option is to reduce "oxidative pressure" in the aeration tank. (reduce amount of bacteria in the aeration tank, reduce the number of aeration tanks in service, reduce aeration cycle times, combinations of all three options).

Skimmer– floating bacteria

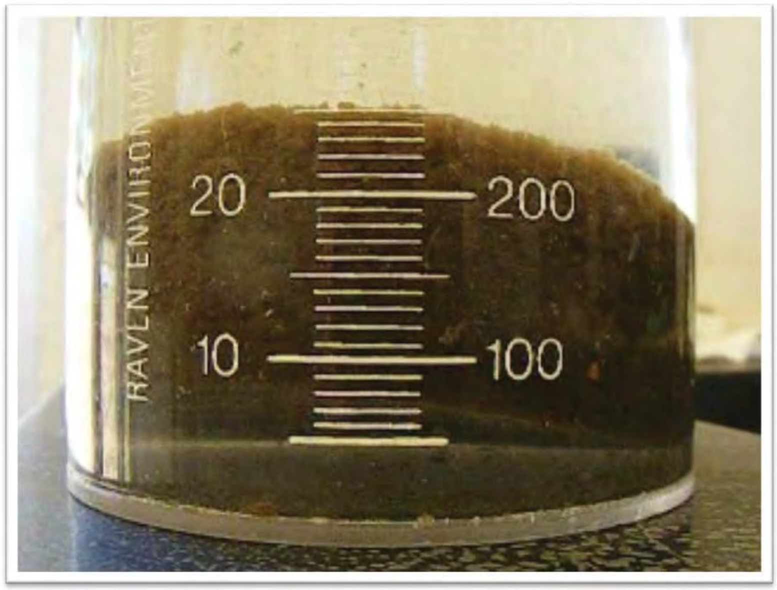
There is a situation where the skimmer is very effective and continuous operation of the skimmer is beneficial. This occurs when the clarifier experiences floating bacteria in the clarifier.

In the aeration tank environment, the pollutant ammonia nitrogen (NH_3) is oxidized or converted to nitrate nitrogen (NO_3). Under aerobic conditions in the aeration tank the nitrate nitrogen is stable. However, it is possible for nitrate nitrogen to be converted to a nitrogen gas bubble (N_2) under certain environmental conditions (no dissolved oxygen), which can exist in the settled bacteria in the clarifier.

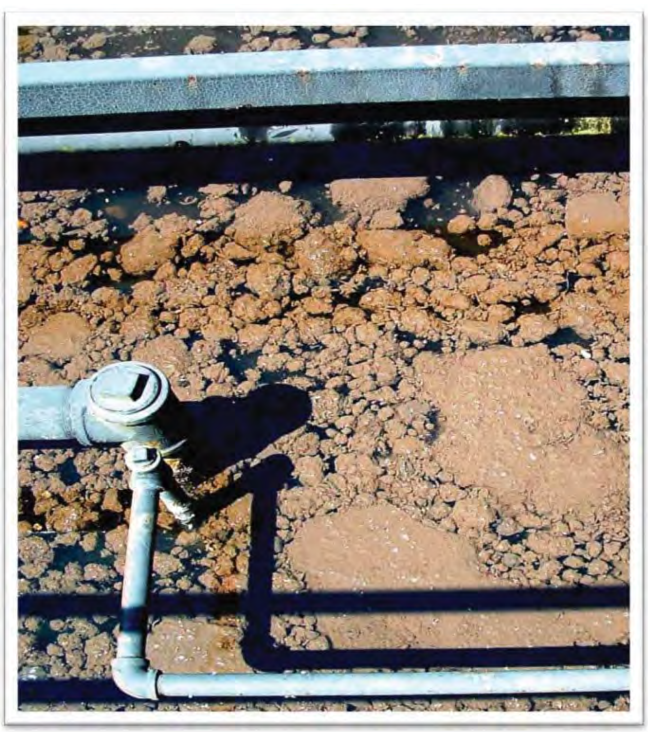
This environmental condition will occur if bacteria that have settled in the clarifier remain too long and are not returned back into the aeration tank.

When sufficient nitrogen gas bubbles are generated in the settled bacteria, the settled sludge becomes buoyant and is lifted to the clarifier surface. This is commonly referred to as "popping" of the settled sludge and technically termed denitrification.

Here is a photo of bacteria which has settled in a settleometer and now is beginning to "pop" due to nitrogen gas bubbles being generated within the compacted sludge.



The surface of the clarifier will contain "clumps" of sludge which are being suspended by the nitrogen gas bubbles attaching themselves to the once settled sludge. To confirm this as denitrified sludge, a gentle agitation of the floating sludge will typically detach the nitrogen gas bubbles and the floating solids will immediately settle out.



Since the floating sludge will settle out after the gas bubble is removed, the skimmer is capable of returning the sludge back to the aeration tank. Unlike low density material, like plastic and grease, floating sludge is temporarily buoyant because of the gas bubble. If you remove the bubble, you remove the buoyancy.

Observation of "clumps" of compacted bacteria floating on the surface indicate settled bacteria are remaining in the clarifier too long and denitrification is occurring. To confirm if floating bacteria is due to denitrification gently disturb the floating bacteria on the clarifier surface. If the floating bacteria is gently agitated the nitrogen gas bubble will release and the bacteria will settle into the clarifier.

Skimmer– floating bacteria

Two possible causes for denitrification are (1) settled bacteria are not able to reach the inlet to the return activated sludge pump (RAS) which pumps settled bacteria back to the aeration tank or (2) the clarifier sludge blanket is too high in the clarifier.

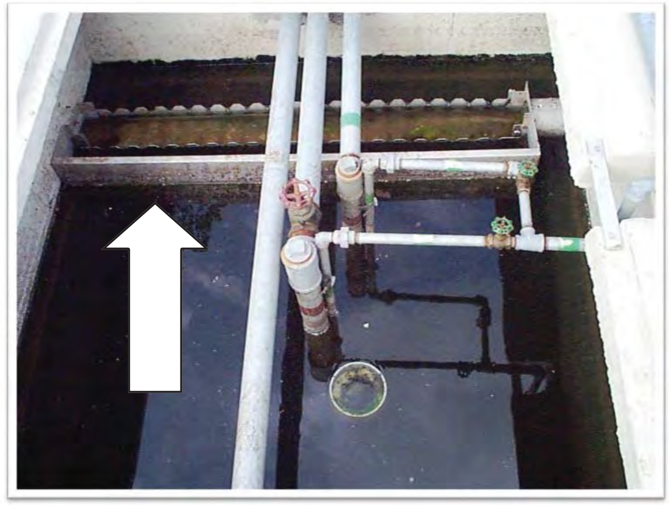
Bacteria entering the clarifier may settle out and be unable to reach the inlet of the RAS pump. This is due to bacterial solids settling on the sloped side walls. The typical clarifier used in package plant design is the "hopper" type clarifier. The hopper design has side walls that slope to the center of the tank to allow settled sludge to accumulate near the intake of the return sludge pump.

The solution requires the operator to scrape the side walls to prevent solids build up in the clarifier. A simple squeegee can be used to gently push solids on the side wall down to the inlet of the return pump.

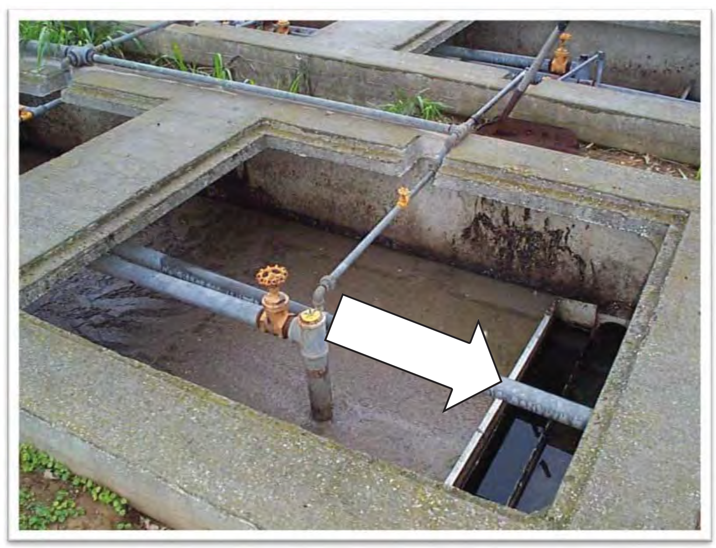
An early indicator of the onset of denitrification is that the clarifier surface may contain a dusting of what appears to be ashes on the surface. This is commonly referred to as "ashing" and can be a visual indicator . Again, a gentle agitation of the floating ashes will release the nitrogen gas bubble and the floating solids will settle out. Ashing by itself is not an operational issue, but is an indicator of the potential of more serious denitrification to follow if the situation is not addressed.

Weir Baffle

The last step to prevent floating material from exiting the clarification unit of the Secondary Stage is the weir baffle. This baffle is located near the clarifier's effluent weir and is intended to retain any surface scum that has made it past the trash trap and clarifier scum baffle or, denitrified sludge which has "popped" to the surface after entering the clarifier.



At this point in the treatment process it is best to physically remove any floating paper, plastic or grease. A swimming pool net is a useful tool for cleaning the clarifier's surface.



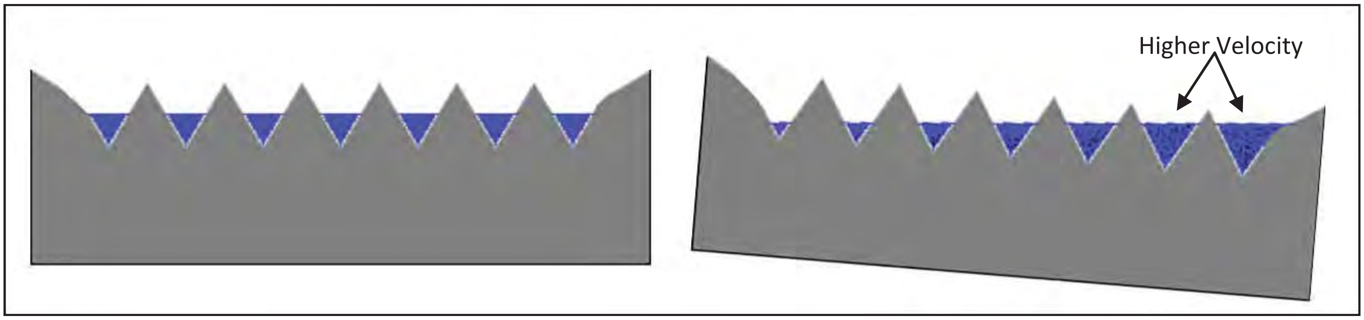
Excessive biological foam generated in the aeration tank will be retained by the weir baffle however, the floating bacteria will begin decaying and re-releasing dissolved pollutants into the water which will lead to effluent violations of the NPDES permit. Don't allow the clarifier to be smothered by biological foam.

Solids which overflow the clarifier weir at this point in the treatment process are captured on the sand filter. The skimmer is most effective in removing this floating bacteria if the operator guides this floating bacteria into the skimmer and physically removes the low density material.

Weir

The clarifier effluent weir is the exit point of the treated water from the secondary stage. As water enters the clarifier from the aeration tank, the solids settle and the clean water overflows the weirs and discharges into the next treatment stage.

The weir must be keep level so the water overflows the entire length of the weir. If the weir is not level, water will overflow a smaller section of the weir. This smaller overflow area increases the velocity of the water overflowing the weir. An increase in velocity overflowing the weir can cause suspended solids to be "pulled" up and out of the clarifier.



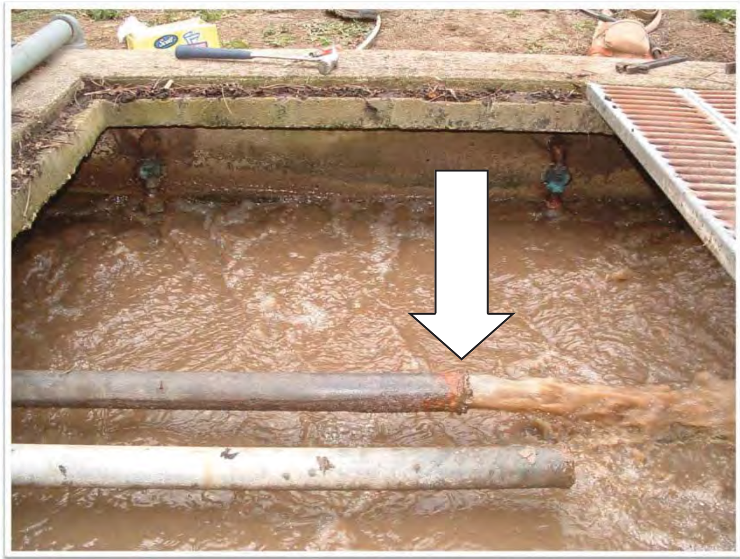
The weir on the left is level which causes the water to overflow each v-notch equally. The weir on the right is not level. As the water elevation rises in the clarifier more flow occurs at the v-notches which are lower. The flow through the lower v-notches has a higher velocity which "pulls" solids over the weir and leads to solids loss.

Weirs should be level when installed, however, algae growth on sections of the weir can cause sections of the weir to be obstructed, which leads to higher velocity in other areas. The solution is keep algae growth from blocking sections of the weir.

A " swimming pool" brush can be used to prevent the excessive build up of algae on the clarifier effluent weirs.

Return Sludge Pump

One last device within the clarifier is the return sludge pump. A simple visual observation is used to determine if the return sludge pump is operational. The return sludge pump is an air lift pump and requires a blower to provide air to operate. If the blower is not in operation the RAS pump will be off.



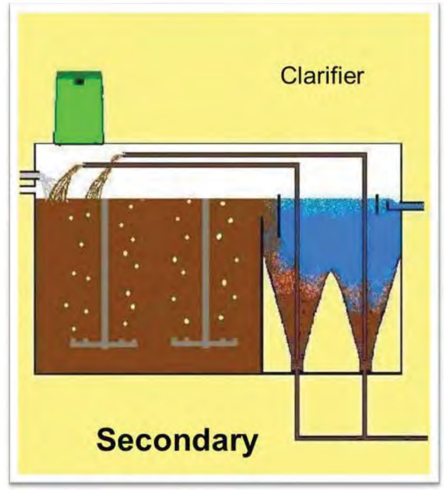
The settled bacteria being returned from the clarifier hopper will typically be a darker color since the settled sludge should be at a higher concentration.

After confirming the Return Activated Sludge (RAS) pump is operational the next visual observation is to determine if the pumping rate is correct. A clarifier core sampler is slowly used to visually monitor the settling effects of the bacteria in the clarifier. The core sampler is inserted into the clarifier from the surface to the deepest depth located near the inlet of the RAS pump. As the core sampler is withdrawn, a foot valve at the bottom seals off the tube and a representative profile of the settling environment of the clarifier is obtained.

In the photo on the right the bacteria have accumulated and formed a “sludge blanket” of approximately three feet in depth (red bracket). The area above the sludge blanket in this core sample is fairly clear and is referred to as “supernatant”. There is approximately four feet of supernatant in this core sample (blue bracket).

Return Sludge Pump

When the return sludge pumping rate is correct, a sludge blanket occupies approximately 20% to 30% of the clarifier depth. Like most dual hopper clarifiers, the first hopper will typically have a higher sludge blanket level than the second hopper. Use a clarifier core sampler and measure each hopper. Average the two sludge blanket levels and determine if they are less than 30% of the clarifier water depth.



Each hopper has its own RAS pump and it can be adjusted by increasing or decreasing the air flow into the RAS inlet pipe. Minor adjustments are possible, however, the air lift pump has a narrow operational range. If the air flow to the inlet pipe is restricted too much the pump will fail and the sludge blanket will increase in depth. Because of this narrow range, operators will error on operating the RAS pumping rate greater than desired, however, too fast of a return rate also has disadvantages.

The faster the RAS pumps the more the clarifier experiences greater hydraulic pressure. This increased flow through the clarifier works against the clarifier's main responsibility; separating bacteria from the clean water.

The RAS pump is capable of pumping faster than bacteria can settle to the bottom of the clarifier. Increasing the RAS pumping rate will NOT bring bacteria to the bottom of the clarifier faster, but can actually keep them from settling due to the increased hydraulic pressure within the clarifier.

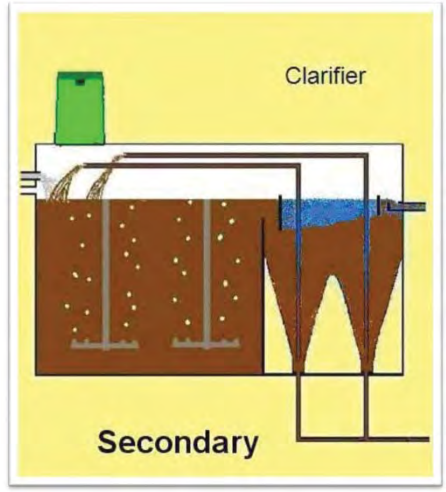
Sludge blankets less than one foot in depth are close to being nonexistent. A LOW sludge blanket is okay, but NO sludge blanket can eventually lead to solids loss.

The photos below show what happens to the sludge blanket if the RAS pumping rate is faster than the bacteria settling rate. The photo on the left represents the sludge blanket condition at a certain pumping rate. The photo on the right is the same clarifier which has increased the RAS pumping rate. The black line in each clarifier represents the influent scum baffle to the clarifier. Notice the increase in the sludge blanket in the photo on the right due to the increased RAS pumping rate.

Return Sludge Pump

The pumping rate of the return sludge can have a significant impact on performance.

If the return sludge pumping rate is too slow more solids are going into the clarifier than what is being pumped out of the clarifier. Eventually the solids will accumulate in the clarifier and the settled sludge blanket will increase in depth.



As the sludge blanket increases, the efficiency of the clarifier in retaining solids decreases, which leads to solids loss from the secondary stage. An adjustment to increase the pumping rate will bring the sludge blanket down to a more desirable depth.

A sludge blanket which occupies 80% of the clarifier capacity only has 20% of the clarifier available for solids separation.

Using the clarifier core sampler to identify if the RAS rate is too slow or too fast is simple and easy to perform. If the sludge blanket is within the desired 20% to 30% range, then no adjustments are necessary. However, if the blanket doesn't fall within this range the desired RAS pumping rate needs to be determined and then adjustments made to bring the pumping rate within an acceptable range.

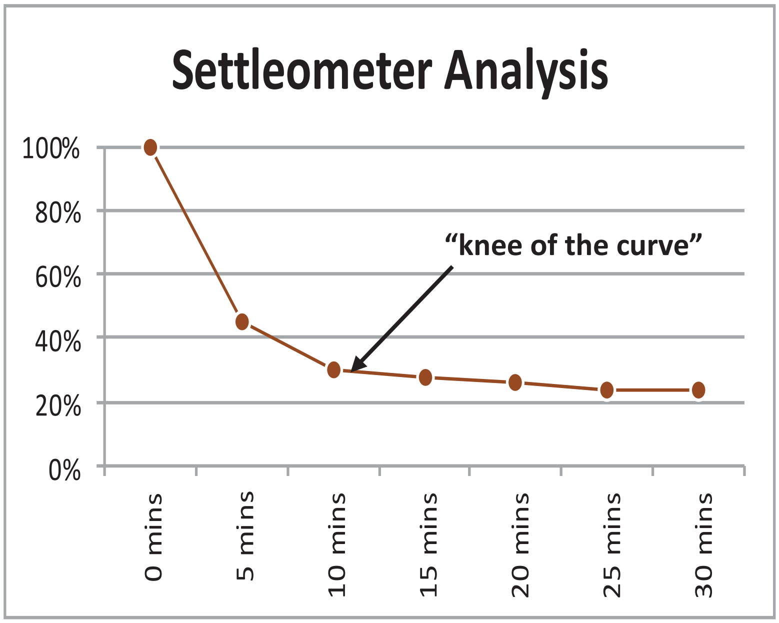
The first step is to determine the settling rate of the bacteria. After the bacteria settling rate is determined then the RAS pumping rate needs to be determined. If the pumping rate is faster than the settling rate, the RAS rate is decreased. If the pumping rate is slower than the settling rate, the RAS rate is increased.

Both of these measurements (settling and pumping rate) can be determined with in a few minutes with the use of a settleometer and a centrifuge. It is important to know you cannot use the RAS pump to "pull" bacteria to the bottom of the clarifier, but you can use the RAS pump to "expand" the settled sludge blanket! RAS pumping rates must be adjusted to match the sludge settling rate. RAS rates based on another condition can eventually lead to solids loss from the clarifier.

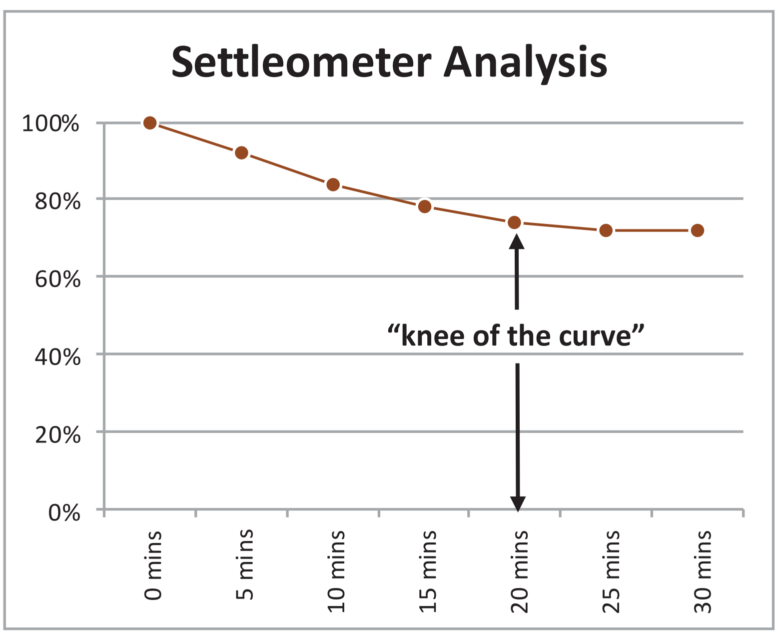
Return Sludge Pump

Determining the settling rate of bacteria

The settling rate is determined by the use of a settleometer. A settleometer is a clear cylinder marked with increments in percent by volume. A sample of the aeration tank effluent is collected and the settleometer is filled to the 100% mark. As the sludge settles in the settleometer the sludge elevations are recorded at 5 minute intervals.



The data recorded is then charted to visually identify the settling rate. The data represented in the chart above indicates the bacteria settled fairly fast in the first 5 minutes of the analysis, but the settling rate decreased and experienced less compaction as time went on. Based on the chart the bacteria settled well in the first 10 minutes, a 70% reduction in volume, however only reduced in volume by 6% in the remaining 20 minutes. This break in the curve is the referred to as the "knee of the curve". The knee is the point at which the bacteria has settled sufficiently and should be returned back into the aeration tank by the RAS pump.



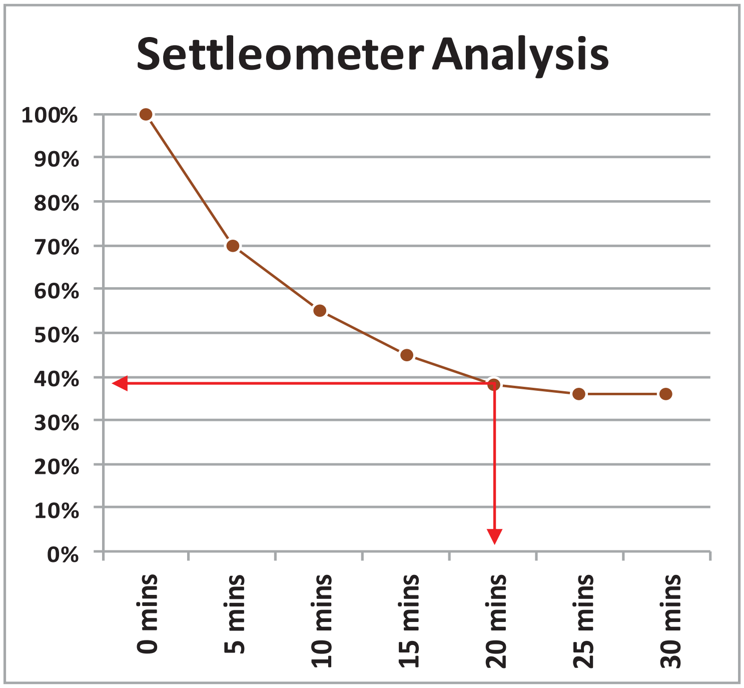
The settling curve could look significantly different when the bacteria settles slower. In the chart to the left the knee of the curve occurs at the 20 minute time frame and has not even reduced in volume by 50%.

The settleometer has no internal hydraulic currents to keep bacteria suspended. If the bacteria are settling this slow in a settleometer, it will settle even slower in the clarifier with an internal recycle from the RAS pump. A slower settling rate requires a slower RAS pumping rate.

<u>Return Sludge Pump</u>

Determining the pumping rate of RAS

Based on the settleometer data below, the bacteria settling rate does not significantly changes after the 20 minutes interval (knee of the curve).



Time, mins	Settled Volume %
0	100%
5	70%
10	55%
15	45%
20	38%
25	36%
30	35%

Since the bacteria has settled as effectively as possible at this point the RAS pumping rate should be removing the settled sludge from the clarifier after 20 minutes of settling. If so then the RAS pumping rate would match the bacteria settling rate.

Knowing the bacteria settling rate is the first step. Knowing that the RAS pumping rate needs to match the settling rate is also important. The last piece of information missing is determining what the actual RAS pumping rate is and that is done with the use of a centrifuge.

The centrifuge allows the operator to measure the solids concentration of the bacteria in the aeration tank and the clarifier RAS within 15 minutes.

By measuring these two locations for solids concentration and using the settleometer data, sufficient information is available to determine if adjustments are necessary to the RAS pumping rate.

Return Sludge Pump

Determining the pumping rate of RAS

Collect a sample of the aeration tank effluent and RAS being pumped into the aeration tank (left photo). Fill a centrifuge tube to the 100% mark on the centrifuge tube (center photo). Spin the centrifuge tube for 15 minutes and record the compacted sludge volume in centrifuge tube (right photo).

The centrifuge provides an estimate of the bacteria concentration in the aeration tank and in the RAS. The RAS pumping rate will be adjusted based on the bacteria concentration of the RAS and settling rate of the bacteria.

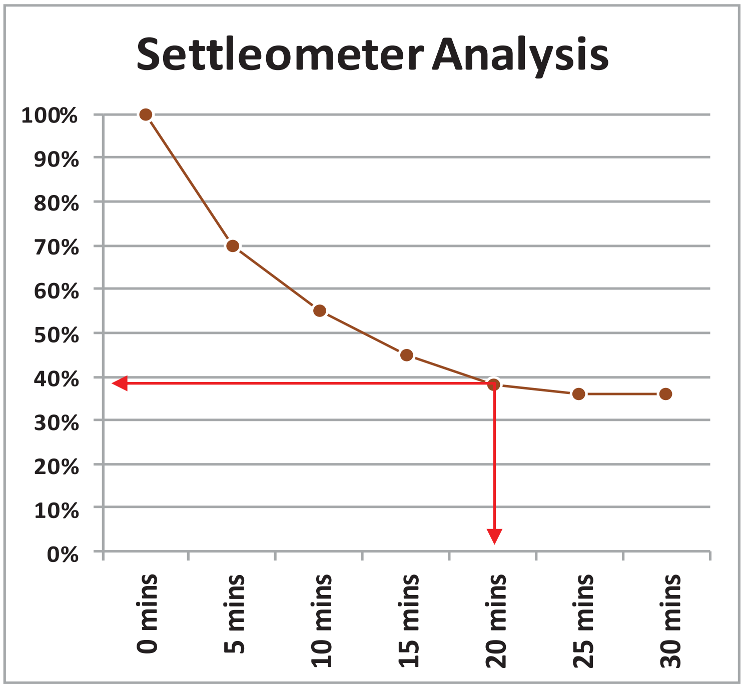
The Aeration Tank Concentration, (ATC), is the bacteria concentration of the aeration tank by percent volume. The Return Sludge Concentration, (RSC), is the bacteria concentration of the RAS by percent volume.

When performing the settleometer analysis, the bacteria settle and compact over time. As the bacteria compacts in the settleometer the concentration of bacteria increases. Eventually the bacteria reach the "knee" and the settling rate decreases significantly. It is at this point in the settling analysis that the return pump should be removing the bacteria and returning it back to the aeration tank.

We can perform a simple calculation to determine the bacteria concentration in the settleometer at this "knee". If the concentration of the RAS matches the concentration of the bacteria at the 'knee" then the RAS pumping rate is dialed in and does not need adjustments. If the RAS concentration is greater than the "knee" concentration, the RAS rate is too slow and the needs to be increased. If the RAS concentration is less than the 'knee" concentration, the RAS rate is too fast and needs to be decreased. If the RAS pumping rate is correct, but the sludge blanket in the clarifier is greater than 30% of the clarifier water depth, then most likely too many solids are in the system and wasting to the digester is

Return Sludge Pump

Adjusting the RAS pumping rate to match settling rate



Time, mins	Settled Volume %
0	100%
5	70%
10	55%
15	45%
20	38%
25	36%
30	35%

ATC (aeration tank concentration) = 2.5 %

RSC (return sludge concentration) = 5.5 %

Using the data above we can determine what the desired RAS concentration should be and if the RAS pumping rate needs to be adjusted.

Use the following formula to determine the desired RAS concentration:

$$\frac{\text{ATC x 100}}{\text{“knee value”}}$$

The "knee value" is the settled volume of the settleometer, which identifies where the bacteria have stopped settling. Drop all percent signs and use absolute values (i.e. (2.5 x 100)/38 = 6.5)

$$\frac{2.5 \text{ x } 100}{38}$$

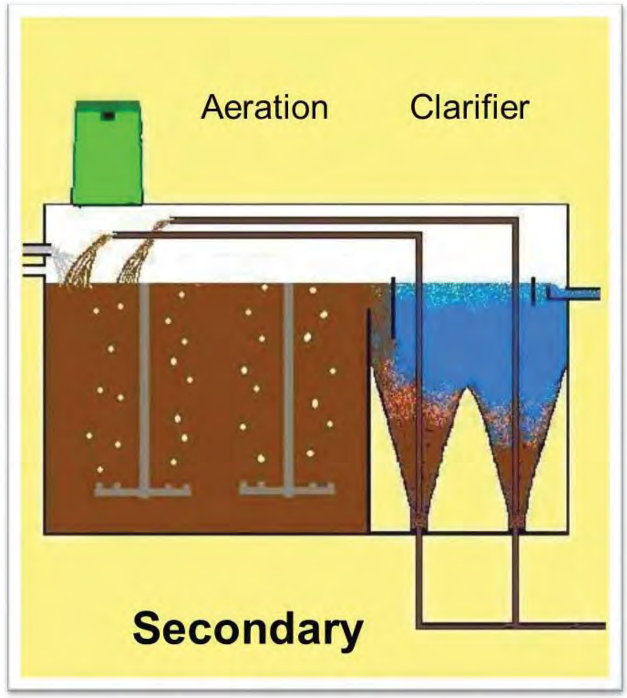
The settling characteristics indicate that when the bacteria in the settled sludge concentrates to 6.5 % by volume, the settled bacteria should be returned to the aeration tank.

If we compare the desired RAS concentration (6.5%) to the actual RAS concentration (5.5%), you can see the actual RAS is lower in concentration than the target RAS concentration. Increasing the RAS concentration would require the RAS rate to be reduced to allow for the sludge blanket in the clarifier to thicken and move towards the target value of 6.5% .

If the actual RAS concentration is greater than the target RAS concentration (based on settling rate of bacteria), then the RAS pumping rate is too slow and would need to be increased.

Measure the settling rate and RAS concentration, then adjust the RAS pumping rate to optimize the clarifier's performance.

Secondary—Summary



The two goals of the Secondary Stage are to completely convert pollutants into bacteria.

Under the proper environmental conditions in the aeration tank, the bacteria which are generated have the capability to flocculate or stick together and have sufficient density to settle in the clarifier.

The clarifier provides a quiet area for these bacteria to settle and compact, so that they can be returned back to the aeration tank to continue the conversion process.

The conversion process in the aeration tank is a biological process which requires chemical analysis to monitor and control. A simple field test kit can be used to determine if the conversion process is complete.

There are also visual indicators of the aeration tank to track the process.

Some of the visual indicators used to monitor the aeration tank are:

1. The color of the aeration tank bacteria.
2. Presence of foam on the aeration tank surface.
3. Mixing pattern of the aeration tank.

The clarifier is a physical process which also can be monitored by observations.

Visual indicators used to monitor the clarifier are:

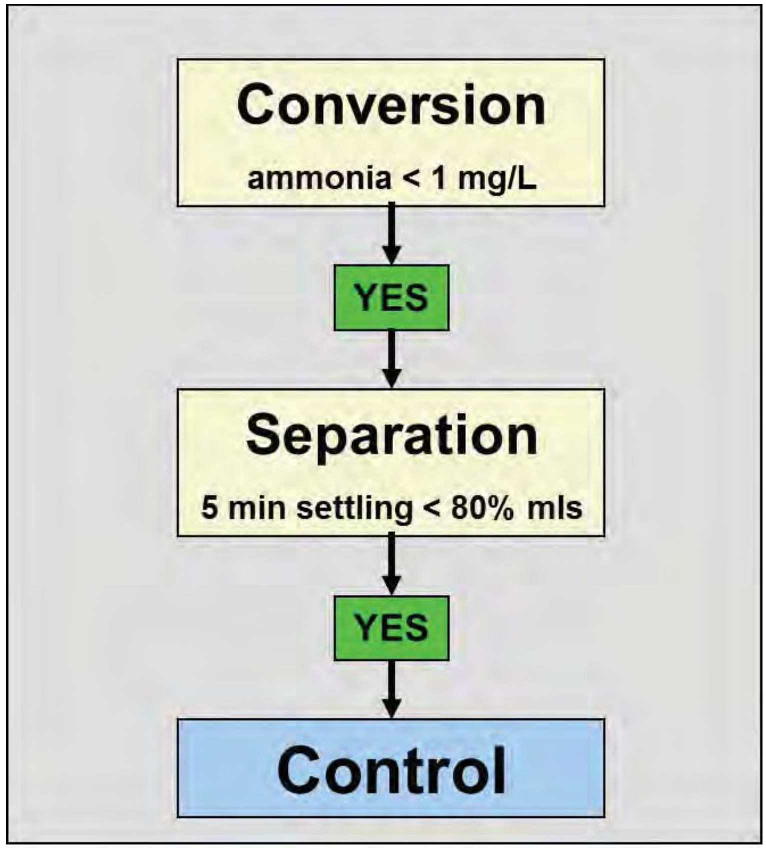
1. Scum accumulation behind the clarifier scum baffle.
2. Clarifier surface free from floating grease, denitrified sludge, plastic, and paper.
3. Surface skimmers and return activated sludge pumps are operational.
4. Clarifier weirs level and water flows over evenly.
5. RAS pumps adjusted to the settling rate of the bacteria.

Controlling the "heart" of the activated sludge treatment system is based on a simple objective of converting pollutants into bacteria which will separate, filter and compact in a clarifier.

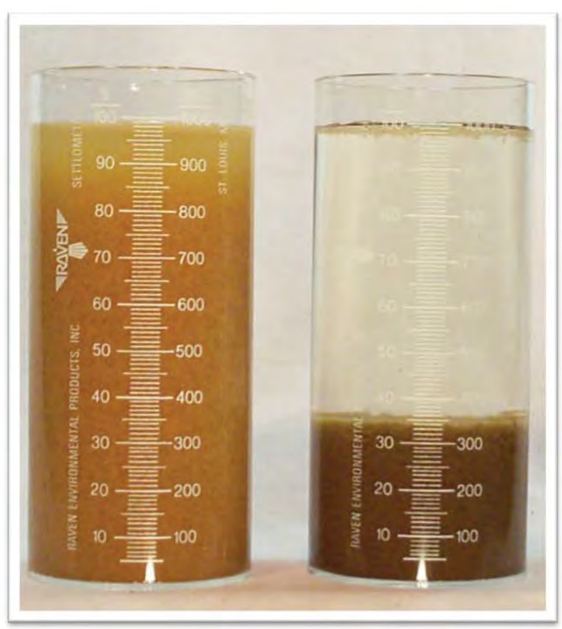
Secondary—Process Control

Two simple methods to determine if conversion is complete and the settling characteristics are desirable is to monitor the ammonia concentration from the clarifier effluent and to observe the settling rate of a sample from the aeration tank effluent.

In the conversion process, it is more difficult for the bacteria to convert the ammonia pollutants than the carbon pollutants. Because of this condition, if the biological system begins to experience difficulty in the conversion process it will first be identified by an increase in the ammonia nitrogen concentration in the clarifier effluent.



Monitoring ammonia nitrogen concentrations will provide an "early warning" when the system is being stressed and requires an adjustment. When clarifier ammonia concentrations are less than 1 mg/L, conversion is complete.

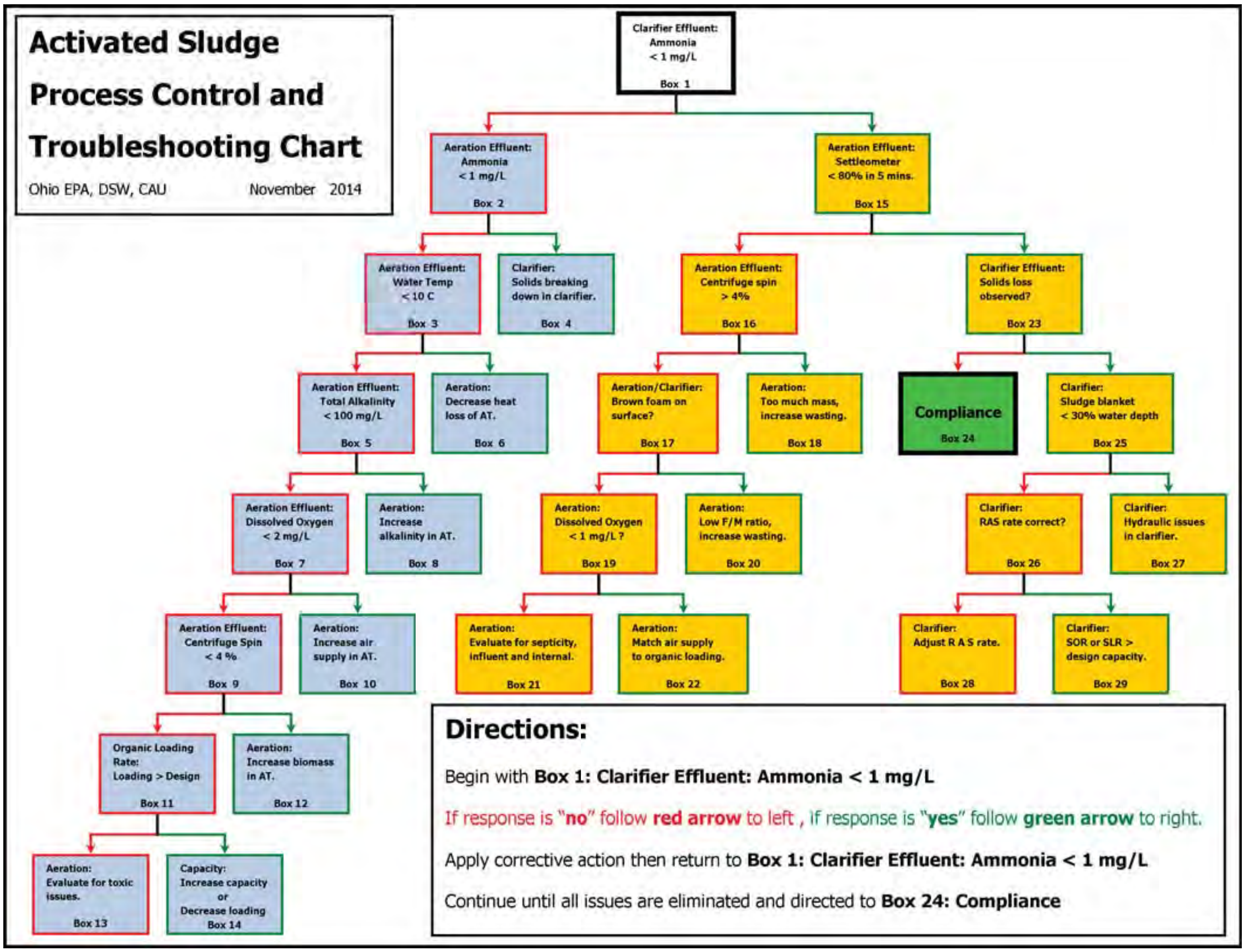


When the bacteria will not settle or flocculate in the clarifier, excess solids will be lost to the sand filter. Monitoring the settling characteristics of the bacteria will indicate when a problem is starting to develop. Making corrections to the treatment system before problems develop is "process control". Waiting until control is lost moves you into trouble-shooting and clean-up mode. The settleometer analysis will identify if the settling rate is an issue within 5 minutes.

Secondary—Process Control Methodology

The following ***"Activated Sludge Process Control and Troubleshooting Chart"*** methodology was developed by the Ohio EPA Compliance Assistance Unit based on lessons learned from experienced operators and is intended to provide a streamlined approach to *"diagnose"* problems associated with the activated sludge process. The techniques employed offer the opportunity to incorporate these simplified methods into the daily *"control"* of the various activated sludge processes.

This methodology evolved from many years of field work and was developed out of the necessity to quickly diagnosis process control problems and return wastewater treatment facilities to NPDES permit compliance. It is designed to confirm and/or eliminate potential process control issues with the least amount of time, effort, sampling and analysis.



How to Use the "*Activated Sludge Process Control and Troubleshooting Chart*"

The reader is to begin at the top (Box #1) of the ***"Activated Sludge Process Control and Troubleshooting Chart"***. Respond to the statement with a "yes" or "no" and follow the directions provided at the bottom of the chart. If the response to the question asked in the box is "no", follow the red arrow to the left to be directed to collect additional information to continue the diagnoses of the situation. If the response to the question asked in the box is "yes", follow the green arrow to the right to be directed to the cause and solution to the issue. A copy of the chart is attached.

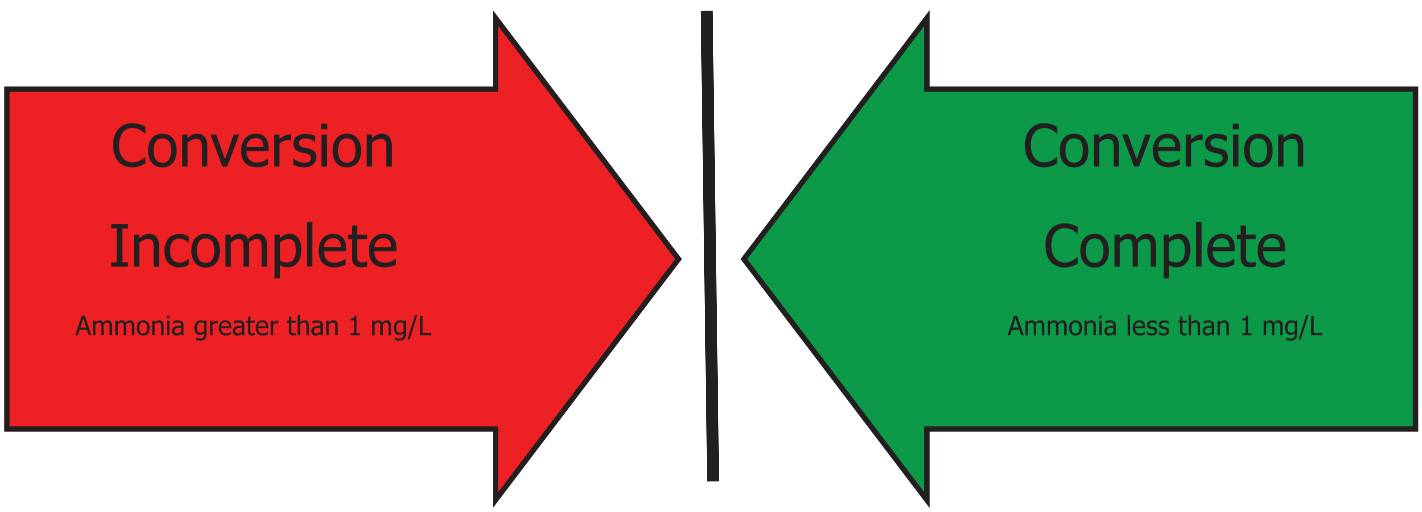
Activated Sludge Process Control and Troubleshooting Chart

Box # 1: Clarifier Effluent Ammonia < 1 mg/L

Wastewater contains pollutants in the form of carbon (cBOD) and ammonia nitrogen (NH_3). Bacteria in the aeration tank convert these pollutants into new bacterial cells (biomass) and more desirable forms of carbon (CO_2) and nitrogen (NO_3), thus preventing degradation of the receiving stream. Nitrifying bacteria in the aeration tank convert the incoming ammonia nitrogen to the less objectionable form of nitrogen called nitrate (NO_3).

These nitrifying bacteria are very sensitive to environmental conditions for growth. Due to this sensitivity, monitoring the conversion of ammonia to nitrate provides an "early warning" indicator of when an adjustment to the process is necessary. Anything which limits the effectiveness of the nitrifying bacteria to convert ammonia to nitrate will cause the aeration tank effluent ammonia concentrations to increase, an indication of loss of the conversion process (i.e. loss of control). Ammonia nitrogen is not removed in the clarifier therefore it will pass through to the Tertiary Stage.

Typically, if the ammonia nitrogen concentration from the aeration tank effluent is <1 mg/L, it is assumed that both of the major pollutants (cBOD and NH_3) have been successfully converted, therefore the treatment objective of the aeration tank (conversion) is now complete. If conditions are met, then the clarifier effluent will also have an ammonia concentration of < 1 mg/L.



The aeration tank "conversion" process must be completed first; therefore it is always the first measurement in the troubleshooting processes for activated sludge systems. If the ammonia nitrogen concentration from the clarifier effluent is greater than 1 mg/L, it indicates the aeration tank conversion process is incomplete <u>or</u> ammonia nitrogen is being generated downstream of the aeration tank in the clarifier. Ammonia nitrogen is only converted to nitrate in the aerobic environment of the aeration tank.

See "How do I . . . measure ammonia in the clarifier effluent?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 2: Aeration Effluent Ammonia: <1 mg/L

Ammonia nitrogen (NH_3) in the influent is converted to nitrate (NO_3) in the aeration tank. If this process is performing as designed, then the ammonia nitrogen should be < 1 mg/L in the aeration tank effluent. If the ammonia nitrogen is > 1 mg/L in the clarifier effluent, then one of two causes are possible. To determine the specific cause of the high ammonia, first measure the ammonia nitrogen in the aeration tank effluent.

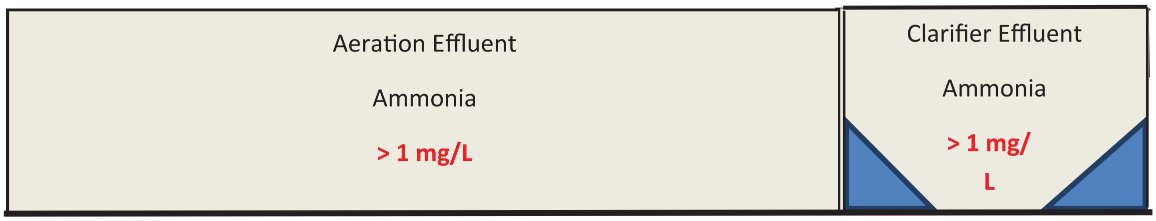


Figure 1: failure in aeration tank

If ammonia nitrogen is > 1 mg/L in the aeration tank effluent (Fig. 1), then the source (location) of the incomplete conversion is in the aeration tank. At this point the reason for the incomplete conversion must be identified and data will need to be collected from the aeration tank to identify the specific cause.

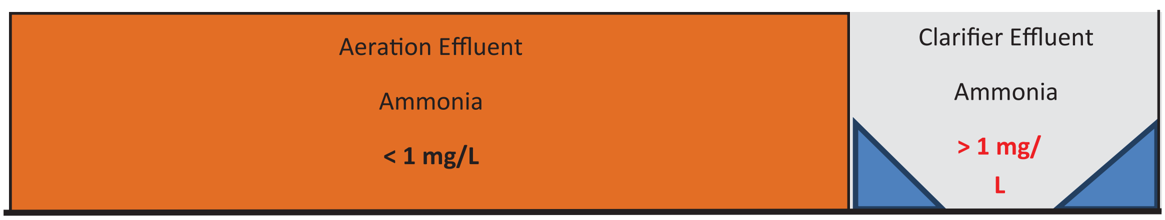


Figure 2: failure in clarifier

If ammonia nitrogen is < 1 mg/L in the aeration tank effluent, but > 1 mg/L in the clarifier effluent (Fig. 2), then the source (location) of the problem is in the clarifier. This situation indicates that all the ammonia was converted in the aeration tank, but is being generated in the clarifier. Data needs to be collected to identify the specific cause for the excessive ammonia nitrogen in the clarifier.

It is important to identify the location of the high ammonia value first, and then operational adjustments can be directed to the specific treatment unit of the activated sludge system causing the problem. Making adjustments to one unit of the treatment system when the issue is located in another unit is a common mistake in troubleshooting the activated sludge process.

See "How do I . . . measure ammonia in the aeration tank?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 3: Aeration Effluent: Water Temperature < 10 C

If the aeration tank effluent ammonia concentration is > 1 mg/L, then an environmental condition exists in the aeration tank that is limiting the complete conversion of the influent waste into bacterial cells.

Water temperature in the aeration tank has a direct impact on the growth rate of the nitrifying bacteria needed to convert the ammonia to nitrate. When aeration tank water temperatures decrease below 10 C, the nitrifying bacteria might not reproduce fast enough to maintain a sufficient population to convert all the influent ammonia nitrogen to nitrate.

As bacteria convert the waste in the influent to new bacterial cells in the aeration tank, heat is generated. This heat is transferred into the aeration tank environment and the water temperature typically maintains above 10 C. However, if the influent organic loading is low, less heat is generated. In addition, if more aeration is applied than necessary for the organic load, the aeration tank is being over-exposed to the colder ambient air, thereby causing heat loss. Over-aeration of low organically loaded systems can lead to aeration tank water temperatures decreasing below 10 C.

Measure the water temperature in the aeration tank effluent.

This dissolved oxygen meter is measuring over 2 mg/L of dissolved oxygen (DO) and a water temperature of 9.9 C. A reduction in the aeration would prevent heat loss and save on electrical expenses.

Aeration tank effluent DO concentrations of 2 mg/L should be sufficient to achieve complete conversion, however, if over aeration is lowering water temperature, a reduction in aeration run time would be required.

Activated Sludge Process Control and Troubleshooting Chart

Box # 4 Clarifier: Solids breaking down in clarifier (ammonia re-release)

Bacterial cells are made from carbon and nitrogen. When aerobic bacteria are in an environment without oxygen for an extended period of time, the bacteria die and break apart (lyse). When bacteria lyse, they release ammonia nitrogen back into the water column. If you measure higher ammonia in the clarifier effluent than the aeration tank effluent, the bacteria are likely breaking down in the clarifier. Dead bacteria typically turn black in color; therefore examine the clarifier sludge blanket for sources of decaying bacteria.

Possible Source: Scum Baffle

Biological foam can be generated in the aeration tank. These buoyant bacteria will migrate to the clarifier and accumulate behind the clarifier scum baffle. Eventually this biological foam begins to lyse and release ammonia nitrogen from the bacterial cells. Since the clarifier is not designed to remove ammonia, it passes through the clarifier to the plant effluent.

Solution: Clean the scum baffle area.

Possible Source: Clarifier Surface

If biological foam generation is excessive in the aeration tank, foam will eventually overload the scum baffle and migrate to cover the entire clarifier surface. Brown colored foam is typically associated with having more biomass in the aeration tank than necessary for the influent waste load (low F/M ratio).

Solution: See "How do I . . . eliminate the biological foam on the aeration tank?"

Possible Source: Clarifier Sludge Blanket

As the clarifier sludge blanket increases in depth, it becomes more likely for biomass to lyse and release ammonia in the sludge blanket. Since ammonia is soluble, it will release into the water column and pass through the clarifier to the effluent. A dark or black layer in the sludge blanket is a visual sign of potential ammonia release.

Solution: See "How do I . . . determine if ammonia is being released in the blanket?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 5 Aeration Effluent: total alkalinity <100 mg/L

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

Nitrifying bacteria convert ammonia nitrogen (NH_3) in the influent to nitrate (NO_3) in the aeration tank. During this conversion of ammonia to nitrate, the nitrifying bacteria also generate acids. If sufficient acids are generated, the pH of the aeration tank will decrease and eventually inhibit the conversion process.

Alkalinity is naturally found in water and acts as a buffer to the acids that are generated by the nitrifying bacteria. If sufficient alkalinity is available, the pH remains within the desired range for the nitrifying bacteria and conversion is completed. However, if the influent waste stream contains a significantly higher concentration of ammonia nitrogen and/or the influent wastewater is low in natural alkalinity, a decrease in pH could occur and inhibit the conversion process.

Measure the total alkalinity in the aeration tank effluent using a field titration kit.

If the total alkalinity is > 100 mg/L, then the conversion process has not been limited by alkalinity.

Continue to evaluate other possible causes for the incomplete conversion.

If the total alkalinity is < 100 mg/L, then it is more likely alkalinity is the limiting factor.

It is not sufficient to measure total alkalinity only one time, or at the same time each day. To develop a true picture of the total alkalinity, it is important to measure the total alkalinity at different times and different days of the week.

Monitoring the total alkalinity (and not pH value) is critical to prevent upset conditions. The pH will drop quickly when alkalinity is consumed in the nitrification process. The goal is to provide sufficient alkalinity to <u>prevent</u> the pH from dropping and causing an upset condition.

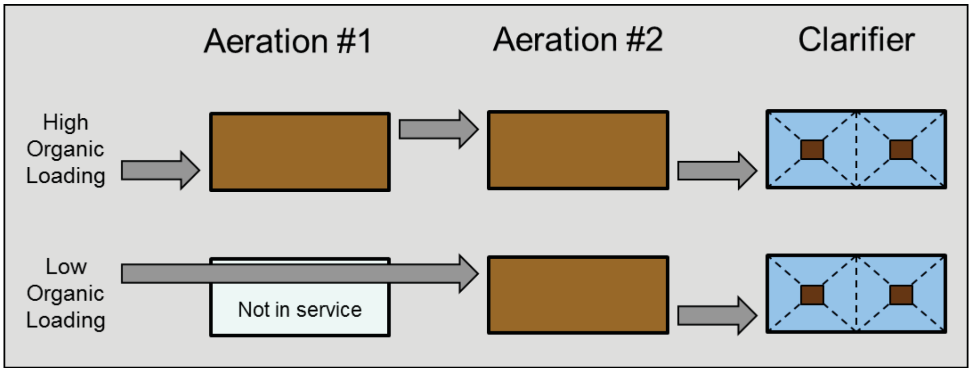
See "How do I . . . measure total alkalinity in the aeration tank?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 6: Aeration: Decrease heat loss of aeration tank

To prevent heat loss, match the amount of aeration applied to the waste load being received.

Reduce Heat Loss: Aeration Tank Capacity



Systems that are subject to seasonal flow variations (i.e. campgrounds, schools on break) could experience significant decreases of influent organic loadings during the colder winter season. If influent loadings decrease, one option is to remove an aeration tank from service if the system is designed with this flexibility.

DON'T ADD DOG FOOD TO INCREASE ORGANIC LOADING—spending money to purchasing food to feed bacteria and then paying to remove it from the waste stream is illogical.

Solution: See "How do I . . . determine how much aeration capacity is required?"

Reduce Heat Loss: Timers

Applying more aeration than necessary over-exposes the warmer aeration tank contents to the colder ambient air temperature and uses more electricity than needed. Reduce aeration timing cycles to prevent over exposure. *(Caution: Airlift return systems (RAS) are controlled by aeration "on" cycles.)* Consider

Reduce Heat Loss: Covers

When colder ambient air comes in contact with the warmer aeration tank contents, the heat from the aeration tank water is lost to the atmosphere.

Solution: Prevent heat loss by covering the aeration tank with an insulating tarp or some other type of insulating material. In extreme cold situations, also protect exposure areas upstream of the aeration tank (i.e. flow EQ basin).

Activated Sludge Process Control and Troubleshooting Chart

Box # 7: Aeration Effluent: Dissolved Oxygen (D0) < 2 mg/L

If the aeration tank ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting the complete conversion of the influent waste into bacterial cells.

The nitrifying bacteria, which convert ammonia to nitrate, require adequate DO throughout the aeration tank environment. If insufficient DO is available, the conversion process is inhibited and aeration tank effluent ammonia may be > 1 mg/L.

Field monitoring of the DO concentration throughout the aeration tank is required to determine if insufficient oxygen is the cause for the incomplete conversion. The DO concentration is very dependent upon aeration tank loadings. Therefore a “true” picture of the available DO requires monitoring of the aeration tank at different times during the day and different days of the week to identify both the peaks and the valleys.

A data logging DO meter will assist the operator to trend the DO levels in the aeration tank environment over an extended period of time.

If your DO meter does not data log, measure aeration tank effluent periodically throughout the day, and throughout the week, to develop a DO profile.

Measuring DO levels at different depths and locations within the aeration tank provides the best overall picture of the oxidative condition within the tank. However, the most critical sampling location for data logging DO concentrations is the aeration tank effluent. This is typically the location of the highest aeration tank DO value.

Solution: Increase the dissolved oxygen concentration of the aeration tank. It could be as simple as increasing the blower run times, opening partially closed valves on diffusers drop pipes or may require cleaning of aeration tank diffusers. If available, additional aeration tanks can be brought into service to increase the aeration capacity if necessary.

Activated Sludge Process Control and Troubleshooting Chart

Box # 8: Aeration: Increase alkalinity in aeration tank to >100 mg/L

Measure the total alkalinity of the aeration tank effluent.

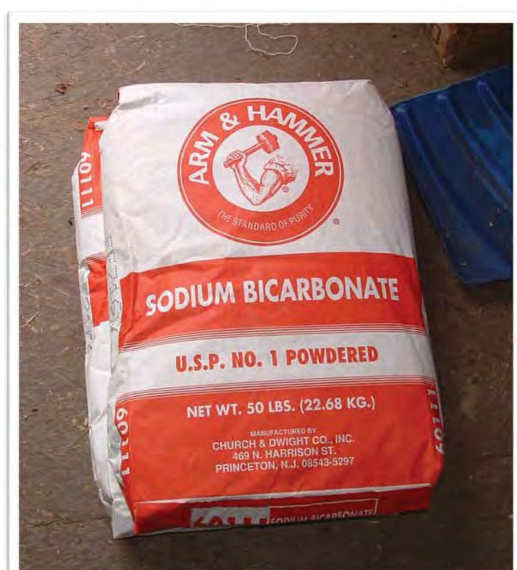
Field Measurement –"prevention" method

The nitrifying bacteria require more than seven times the alkalinity for each mg/L of ammonia nitrogen converted to nitrate. Thus, alkalinity concentrations can change rather quickly and adjustments need to be made without delay.

Use a simple titration method to estimate the total alkalinity on site. It is more important to measure the total alkalinity in the field, so adjustments can be made immediately.

Field Measurement – "post-mortem" method

When total alkalinity drops to < 100 mg/L, the biological environment is nearing a "cliff". When the alkalinity is consumed by the nitrifying bacteria, the pH can quickly drop off the "cliff". Since nitrifying bacteria cannot function at these lower pH environments, conversion is inhibited and ammonia concentration will increase. Monitoring total alkalinity allows time to correct the situation; monitoring pH informs you when it is too late. Aeration tank environments should not drop below 6.5 pH units.



Solution: Supplement Alkalinity

If the demand for alkalinity is greater than what is available, supplement with sodium bicarbonate.

If the influent ammonia load is excessive or if the natural alkalinity is insufficient, a stronger source of alkalinity than sodium bicarbonate may be required.

Activated Sludge Process Control and Troubleshooting Chart

Box # 9: Aeration Effluent: Centrifuge Spin < 4%

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

The cBOD and ammonia nitrogen entering the aeration tank is considered "food" for the bacterial cells (biomass). The bacteria must consume or convert all these waste products into new bacteria or harmless by-products before it leaves the aeration tank. When influent loadings increase, the available biomass (bacterial population) in the aeration tank must be adequate to insure complete conversion of the ammonia to nitrate before leaving the tank.

Estimating the amount of biomass in the aeration tank can be performed with a centrifuge. It is more important to know the relative concentration of biomass and its trending pattern (increasing/decreasing) than to know the exact amount of biomass. A centrifuge can determine biomass concentrations in 15 minutes and is sufficiently accurate for process control.

As the concentration of biomass in the aeration tank increases, the aeration tank can theoretically treat an increase in influent organic loading. However when the biomass concentration (as determined by the centrifuge) increases above 4%, the proper settling rate of the biomass can be inhibited or slowed down. When this happens, the clarifier sludge blankets can begin to rise. If allowed to continue, the blankets can rise to the point where the biomass (sludge blanket) can exit over the clarifier weirs and consequently enter the final effluent.

If ammonia concentrations in the aeration tank are > 1 mg/L and centrifuge data indicates the biomass concentration is too low, then increase the biomass concentration in the aeration tank. This is accomplished by decreasing the sludge wasting rate

Solution: Track the solids in the aeration tank

The centrifuge is very useful in quickly identifying the amount of biomass in the aeration tank.

If the RAS pump is not functioning properly, solids could be collecting in the clarifier. First, core sample the clarifier to confirm solids are not "hiding" in the clarifier.)

See "How do I . . . measure the solids in the clarifier?"

Typical aeration tank concentrations range between 2% and 4% by volume. The trending of the biomass concentration is valuable in process control decisions.

See "How do I . . . determine how much to waste?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 10 **Aeration: Increase air supply in aeration tank**

If insufficient aeration is being applied to the aeration tank, it can be an operational issue (increase blower run time) or a mechanical issue (evaluate blower output, restricted air flow).

Diagnosis

A snapshot picture of the DO (grab sample) in the aeration tank is not conclusive evidence that aeration is sufficient. Several measurements at different times and days of the week will provide a clearer picture. A data logging meter reveals all peaks and valleys of dissolved oxygen.

See "How do I . . . measure the DO in the aeration tank?"

Operational Issue: Timers

Aeration tank blowers are typically controlled by a timer. Increasing the aeration time can be achieved by either increasing the frequency of cycles and/or the duration of each cycle. Select a timer with more timer setting options for more flexibility.

See "How do I . . . determine how much aeration time is required?"

Mechanical Issue: Blowers/Motors/Diffusers

Mechanical equipment loses efficiency over time. In addition, influent organic loadings typically increase over time. Either of these situations can lead to insufficient aeration being applied to the aeration tank.

Items to evaluate:

1. Clogged valves/pipes/diffusers
2. Inadequate mixing can be caused by:

   *diffusers installed along width and not length of tank

   *course bubble diffusers replaced with fine bubble diffusers and not adjusted for full floor coverage
3. Blower discharge pressure

Activated Sludge Process Control and Troubleshooting Chart

Box # 11 System Loading Rate: Loading greater than design

Determine if the influent organic loading is greater than design loading of the treatment system.

To determine the influent loading rate, collect the following data; average influent flow and average influent BOD.

To calculate influent loading:

(Influent flow, MGD) x (influent BOD, mg/L) x 8.34 = pounds BOD/day

Example: Influent Flow = 15,000 gpd = 0.015 Million Gallons/day

Influent BOD = 200 mg/L

Actual Pounds of BOD/day = (0.015 MGD) x (200 mg/L) x (8.34) = 25 lbs BOD/day

Determine if the influent loading rate is greater than the design loading rate of the treatment system. Organic loading rates are calculated in pounds/day/1,000 ft^3 of aeration capacity. Once you have calculated the actual pounds of BOD per day being added to the aeration tank, you only need to divide this value by the 1,000 ft^3 of aeration tank capacity. For example:

Aeration Tank Dimensions: 12 ft. length, 6 ft. width, and 9 ft. water depth

Aeration Tank, ft^3 = (12') x (6') x (9') = 648 ft^3

Aeration Tank 1,000 ft^3 = 648 ft^3/ 1,000 ft^3 = 0.648 / 1,000 ft^3 aeration capacity

Organic Loading Rate = 25 lbs BOD per day / 0.648 (1,000 ft^3) = <u>38 lbs/d/1,000 ft^3</u>

A typical organic loading rate of an extended aeration package plant is 15 to 25 lbs BOD/day/1,000 ft^3 of aeration tank capacity. Review your design data to confirm your systems actual design organic loading rate.

Compare the actual organic loading rate to the design organic loading rate to determine if the treatment system is operating beyond its intended capability.

In our example, the actual organic loading rate is significantly higher than the design loading rate, which can result in incomplete "conversion" in the aeration tank.

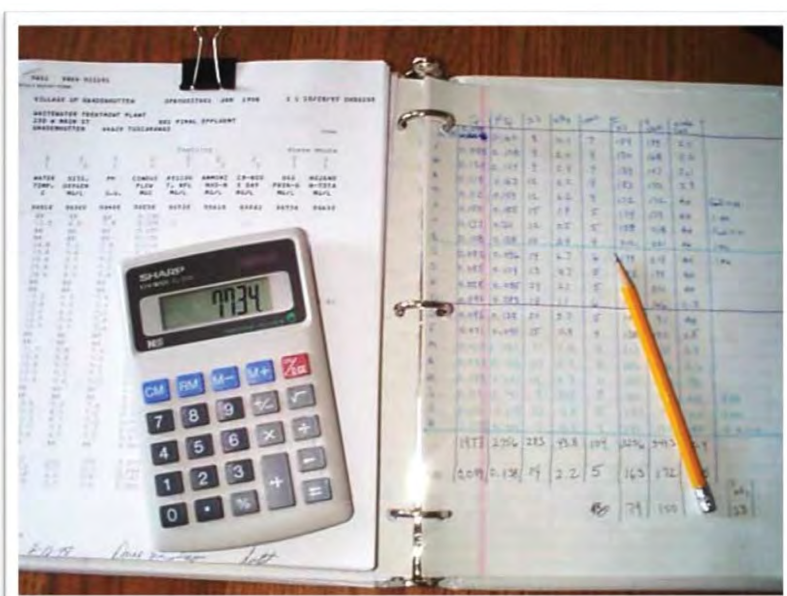
Actual loading rate:

38 lbs BOD/day/1,000 ft^3

Design loading rate:

15 lbs BOD/day/1,000 ft^3

If actual loading exceeds the design loading conversion can be incomplete.



Activated Sludge Process Control and Troubleshooting Chart

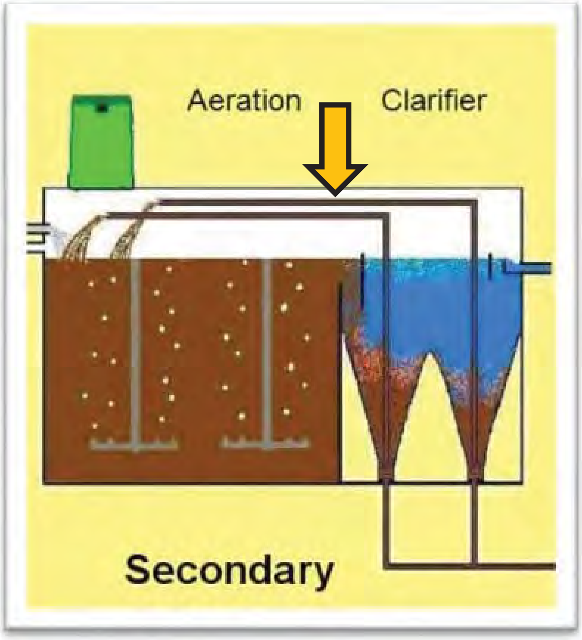
Box # 12 Aeration: Increase biomass in aeration tank

If the aeration tank effluent ammonia concentration is >1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

The concentration of biomass in the aeration tank is a function of the influent organic loading. The higher the organic loading in the influent, the more biomass is needed in the aeration tank.

Sample Aeration Tank Effluent

Sample the aeration tank effluent and perform a centrifuge spin to determine concentration of biomass.



Sample Aeration Tank Effluent

If the aeration tank biomass concentration is less than 4%, then increase aeration tank biomass concentration. As concentration increases, continue to monitor the aeration tank effluent ammonia concentration. The ammonia concentration should decrease as the biomass concentration increases if this is the cause for incomplete conversion.

Aeration tank concentrations which exceed 4% typically causes the bacteria to settle slower due to the increased concentration.

Increasing the bacteria concentration in the aeration tank will provide more bacteria for conversion, but too many bacteria in the clarifier negatively affects the settling rate.

See "How do I . . . measure biomass in the aeration tank?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 13 **Aeration: Evaluate for possible toxicity issues.**

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

If an activated sludge system which treats typical domestic waste is operating within its design organic and hydraulic loading capacity, and other operational limitations have been eliminated (i.e. temperature, DO, mass), then there are two probabilities for limited performance. In this situation there is either an internal side stream which is limiting conversion (i.e. digester supernatant containing high ammonia) or the possibility of a toxic or inhibitory substance in the influent which is impacting conversion.

Evaluate Potential Internal Recycle Streams

Aerobic digesters left un-aerated for extended periods of time can generate a high concentration of ammonia nitrogen. When this is decanted back to the head of the treatment system it can appear as if nitrification has been inhibited, when in actuality it was a slug loading from an internal side stream.

Evaluate internal recycle streams as potential sources of high ammonia concentrations. Check "inside the fence" first for internal recycles. A slug load of high ammonia could be a "self-inflicted wound" and appear as if the treatment system has experienced a toxic event.

See "How do I . . . identify internal side streams as sources?"

Inspect Collection System

Inspection of the collection system could provide an indication of an uncharacteristic (toxic) influent source.

Evaluate external sources (collection system) for potential sources. Evaluate conditions of manholes in the collection system. Examine for visual signs of corrosion, color, stains, or odors.

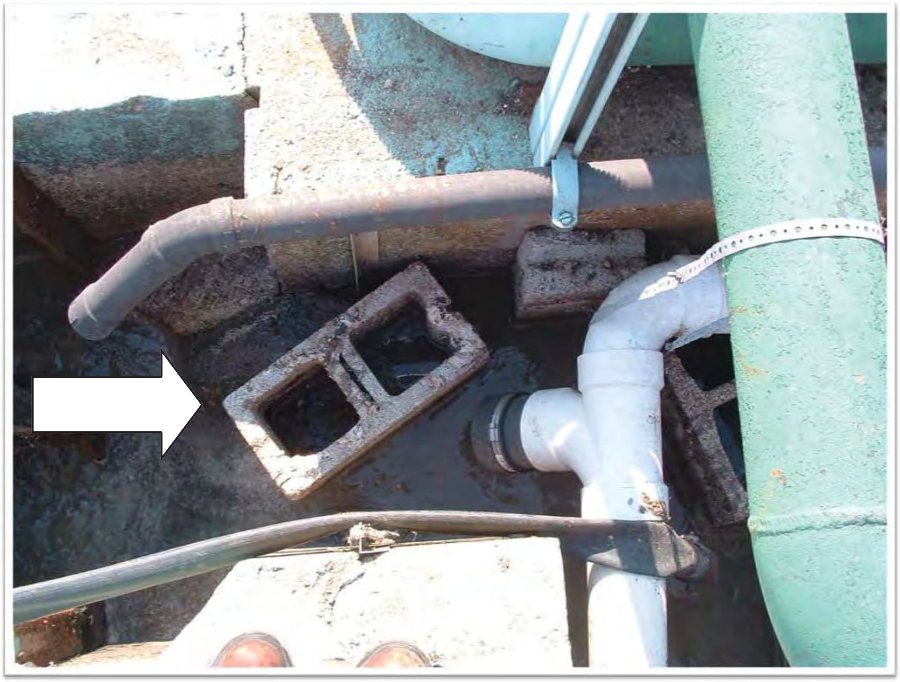
Other potential sources: septage receiving stations, and force mains with long detention times.

Activated Sludge Process Control and Troubleshooting Chart

Box # 14 **Capacity: Increase capacity or decrease loading to aeration system**

If the aeration tank effluent ammonia concentration is > 1 mg/L, then a condition exists in the aeration tank that is limiting complete conversion of the influent waste into bacterial cells.

It is possible that the average daily flow is within the system's design capacity, however the actual influent pumping rate could be in excess of the system's design. This issue can arise from at least two common problems. First, if the influent pumping rate is higher than the design flow rate of the system; and second, if the flow splitting device or flow equalization tank have an inferior design or are improperly adjusted. This causes the average daily flow to appear within design limits; however the system is actually exceeding its design flow rate each time the influent pump cycles on.



The "classic" flow splitting block operators use to equalize flow between parallel aeration tanks is not very effective. If influent flows are not split equally, then more treatment demand is placed on a the system. While the average daily flow may be within design, you could be only using 50% of the treatment capacity to treat a higher percentage of the flow.

If the influent pumping rate is exceeding the design flow:

Evaluate influent loading characteristics to determine if treatment modifications are necessary to achieve compliance with the discharge limits (i.e. improved flow splitting design, increased flow equalization capacity).

Evaluate pretreatment options to reduce potential high strength organic loadings from system dischargers.

Increase aeration efficiency by converting from course bubble diffusers to full floor fine bubble aeration diffusers.

Place additional aeration tanks into service to adequately process organic loadings.

Activated Sludge Process Control and Troubleshooting Chart

Box # 15 Aeration Effluent: Settleometer Analysis < 80% in 5 minutes

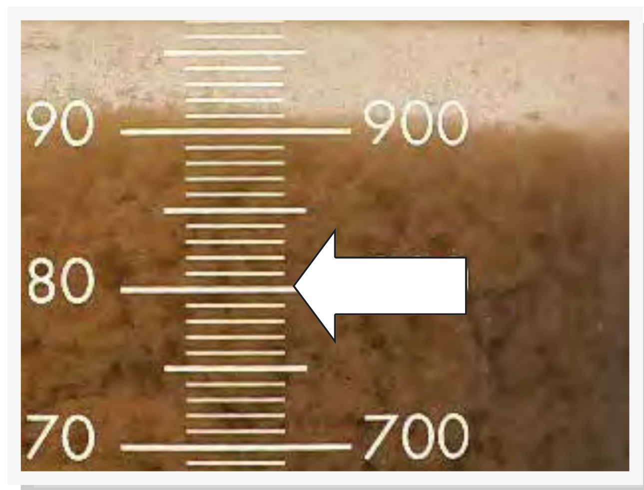
If the aeration tank effluent ammonia concentration is < 1 mg/L, the conversion of all influent organic waste into bacterial cells has been achieved. In short, the aeration tank has properly performed its function. The focus now moves towards separating the bacteria from the clean water in the clarifier. This is a function of the settling rate of the biomass, which must be maintained at the proper concentration to assist gravity settling in the clarifier. An evaluation of the settling rate is the first analysis to perform.

The settleometer test mimics the sludge setting characteristics within the clarifier. However, the settleometer represents a "perfect clarifier", meaning there are no hydraulic currents from influent or RAS flows, which can negatively affect the settling characteristics of the biomass.

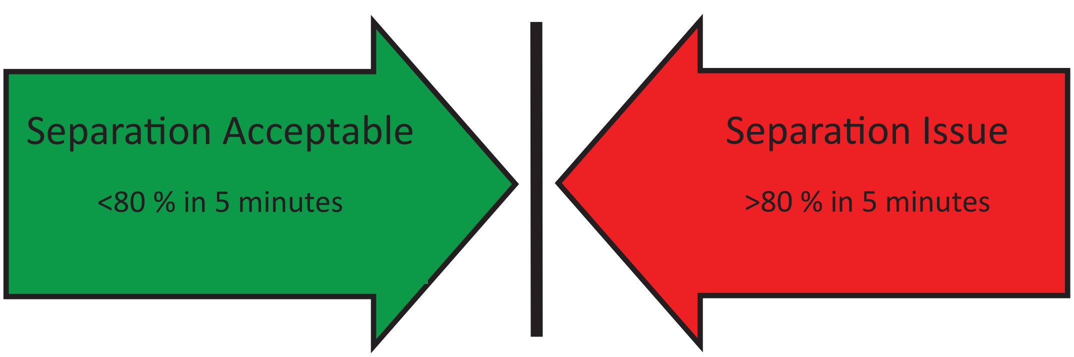
The settling characteristics are best reflected in the first five minutes of the settleometer test. As the biomass settles in the settleometer, the solids concentration increases in the settled sludge. As the settled sludge concentration increases, the settling rate decreases, therefore the first five minutes more accurately reflects the "true" settling characteristics of the biomass.

Settleometer Test

Within five minutes of the settleometer test, the settled biological mass should be below 80%. Biomass that settles slowly and cannot compact below this 80% mark is considered inhibited or "slow settling" and can be easily "carried" up and over the clarifier weir.



Settling rates of < 80% in 5 minutes should not cause solids loss in the clarifier, however this is a worst case scenario and can be adjusted to a lower percentage, (e.g. 70%), for a more conservative control parameter if desired. Maintaining a clarifier effluent ammonia concentration of < 1 mg/L is the first goal. Maintaining a sufficient settling rate is the second goal. Both are required for compliance.



Activated Sludge Process Control and Troubleshooting Chart

Box # 16 Aeration Effluent: Centrifuge Spin > 4%

If the biomass does not settle below the 80% mark within five minutes, there is a problem with the settling characteristics. This condition can lead to a loss of biomass from the secondary clarifier. The first step is to identify the cause for the slower settling biomass. There are typically two main causes, (1) the concentration of the biomass is too high, or (2) the density of the biomass is too low.

Diagnosis

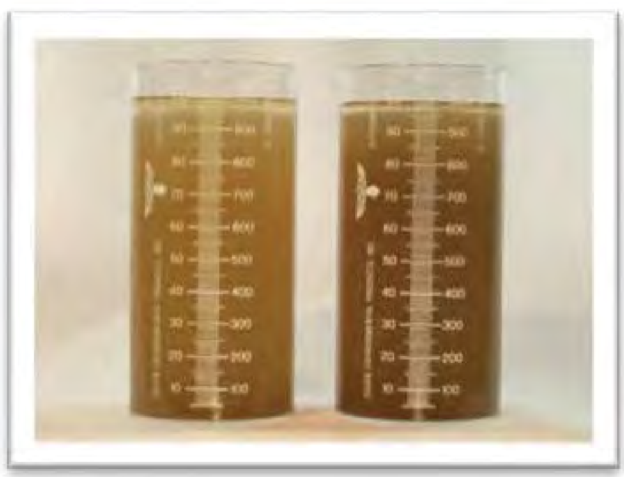
If the aeration tank biomass is too concentrated (i.e. high MLSS) then settling will be impaired. Typically when the aeration tank concentration exceeds 4% by centrifuge spin, slow settling is due to the high concentration of biomass.

The "two-minute diluted" settleometer test can also assist in identifying which of the two causes are at play.

Two-Minute Diluted Settleometer Analysis

Analysis: Concentration (left photo)

The diluted settleometer (on the left) settled significantly faster than the undiluted settleometer (on the right). The more significant the difference after two minutes indicates the slow settling is due to an excessive biomass in the aeration tank.



Analysis: Density (right photo)

The diluted settleometer (on the left) did not settle any differently than the undiluted settleometer (on the right). Concentration is not the issue here; however the biomass is "light weight" or of a low density. This is typical of a filamentous biomass.

See "How do I . . . evaluate settling with the two minute diluted settleometer analysis?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 17 Aeration or Clarifier: Brown foam on surface

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling then it is likely due to excessive filamentous bacteria growth in the aeration tank.

If there is excessive brown foam on the aeration tank and/or clarifier, this is a biological foam which grows in a low F/M aeration tank environment; high MLSS. Another possible indicator of low F/M growth conditions is very low effluent ammonia (< 0.3 mg/L), however this is not the most reliable indicator.

Aeration Tank Foam:

The observation of light brown/tan foam on the aeration tank is typical. If this foam is trapped in the aeration tank, it will accumulate and darken in color.

The foam can eventually become dried at the surface and resemble “floating soil”.

Clarifier Foam:

If the foam is generated in the aeration tank, it can migrate to the clarifier, eventually covering the clarifier surface.

In this photo, the weir baffle is preventing the foam from escaping the clarifier.

Settleometer Test:

Another clue to an excessive filamentous growth condition is when the biomass develops a depression, or cone, in the center of the settleometer test after 30 to 60 minutes.

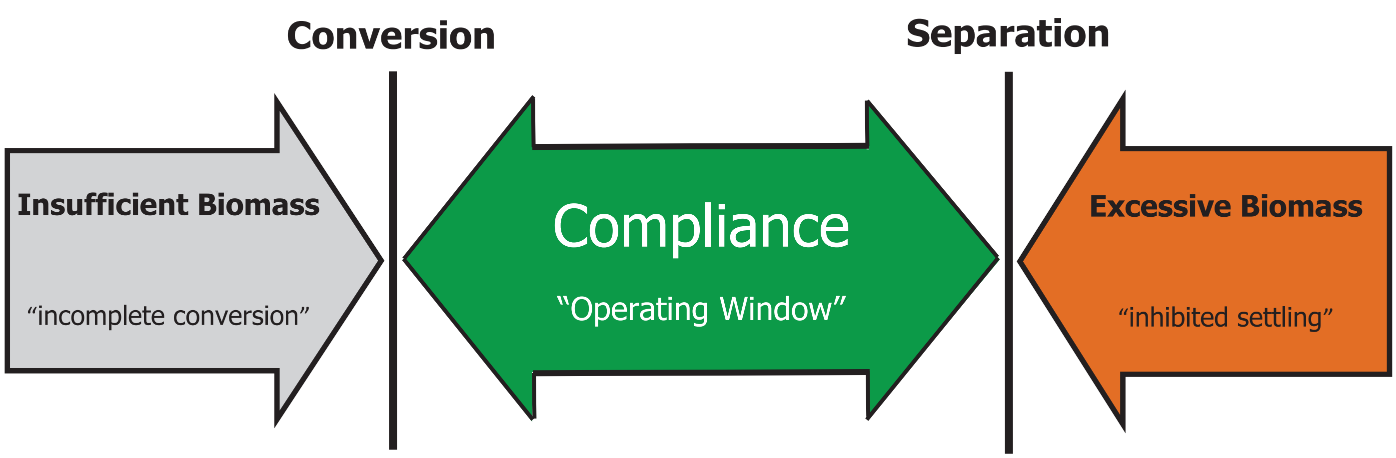
This cone develops because of the low density of the biomass caused by excessive filamentous bacteria. Also note the clarity of the supernatant in the settleometer. This clarity is also associated with a filamentous growth condition.

Activated Sludge Process Control and Troubleshooting Chart

Box # 18 Aeration: Too much biomass in system, increase wasting rate

Typically domestic activated sludge systems operate within a range of 2-4% concentration (v/v) based on a centrifuge analysis. Systems with aeration tank concentrations > 4% may begin to experience a slow settling rate due to a high concentration of biomass.

To correct, slowly increase the sludge wasting rate to reduce the aeration tank biomass. Continue to decrease the aeration tank biomass until the desired settling rate is achieved.



Establishing a wasting rate is simply a process of maintaining sufficient biomass to achieve complete conversion in the aeration tank (ammonia < 1 mg/L), while not maintaining an excessive amount of biomass to inhibit the settling rate in the clarifier (< 80% in 5 minutes).

The amount of biomass that provides complete conversion and does not inhibit settling is the target in which the treatment system performs the best. This aeration tank concentration typically ranges between 2% to 4% (v/v) based on a centrifuge analysis.

As the aeration tank concentration increases above the target value, increase the wasting rate to maintain the desired aeration tank concentration to remain within the proper operating window.

If the wasting rate is too excessive, the decreasing concentration of biomass in the aeration tank will be quickly identified by an increase in ammonia concentration leaving the aeration tank. Ammonia concentrations increase if too much biological mass is removed.

As influent organic loads increase or aeration tank water temperatures decrease, you may need to increase the target value by decreasing the wasting rate.

Activated Sludge Process Control and Troubleshooting Chart

Box # 19 **Aeration: Dissolved oxygen < 1 mg/L for extended period of time**

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling, then it is likely due to excessive filamentous bacteria growth in the aeration tank.

One of the more common aeration tank environments which generate filamentous bacteria is operating at a low DO concentration. Unlike the low F/M environment, which typically generates brown foam, low DO environments are typically absent of heavy brown foam.

Another indicator that the aeration tank is experiencing a low DO environment (and not a low F/M environment) is the aeration tank effluent could have ammonia values significantly greater than 1 mg/L.

To properly identify the DO concentration in the aeration tank, a data logging DO meter should be used to evaluate the DO concentrations and duration of time the system experiences concentrations of < 1 mg/L.

The aeration tank DO does not always need to be maintained above 2 mg/L. However, the lower and longer the DO concentration is maintained in the aeration tank, the more likely that low DO filamentous growth conditions exist.

Data logging the aeration tank DO will provide the best information to determine the possibility of a low DO growth environment. Measure daily diurnal swings and weekends/weekdays concentrations to obtain a complete DO profile picture.

See: "How do I . . . measure the DO in the aeration tank?

Activated Sludge Process Control and Troubleshooting Chart

Box # 20 Aeration: Low F/M ratio, increase wasting rate

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling, then it is likely due to excessive filamentous bacteria growth in the aeration tank.

One of the most common aeration tank environments that generate excessive filamentous bacteria is operating the aeration tank in a "starved" condition, which means having more bacteria (biomass) in the aeration tank than the influent food (BOD) source can support. This is commonly referred to as a low food to micro-organism ratio (low F/M).

Increase the sludge wasting rate (WAS) to reduce the aeration tank biomass concentration as measured by the centrifuge test. Continue to decrease the aeration tank biomass concentration until the desired settling rate is achieved. The settling rate will increase as the filamentous bacteria are wasted from the system and a more dense floc structure develops.

If the sludge wasting rate (WAS) is too excessive, the reduction in biomass in the aeration tank will be quickly identified by an increase in ammonia concentrations in the aeration tank effluent.

Remove accumulated foam from aeration tank and/or clarifiers <u>after</u> the aeration tank growth environment has been modified to the point where low F/M filamentous bacteria are no longer dominant. Stop the madness, then clean up the mess.

Activated Sludge Process Control and Troubleshooting Chart

Box # 21 **Aeration: Evaluate influent/internal side streams for septic sources**

If the five minute settleometer is > 80%, then the settling rate is too slow. If the aeration tank concentration is < 4%, or the two minute diluted settleometer analysis indicates slow settling, then it is likely due to excessive filamentous bacteria growth in the aeration tank.

Low F/M and low DO concentrations are common conditions for filamentous bacteria growth in activated sludge systems. However a third environmental condition, which could cause filament growth, is an influent loading or internal side streams containing by-products of septicity (i.e. organic acids, hydrogen sulfide).

Sources of influent septicity can originate from collection systems with long force mains, low flows resulting in solids deposition in the sewer pipe, industrial dischargers and/or internal flow streams (i.e. "anaerobic" digester supernatant).

Collection System:

Strong "rotten egg" odors in the influent can be an indication of septicity in the collection system. If you detect hydrogen sulfide odor in the influent, it is likely that products of septicity are being generated in the collection system. These by products of septicity can generate filaments.

Head works Condition:

Hydrogen sulfide is generated under septic conditions in the collection system. Significant corrosion could indicate products of septicity are contributing to filamentous growth in the aeration tank. Lift stations may also show signs of corrosion.

Influent Characteristics:

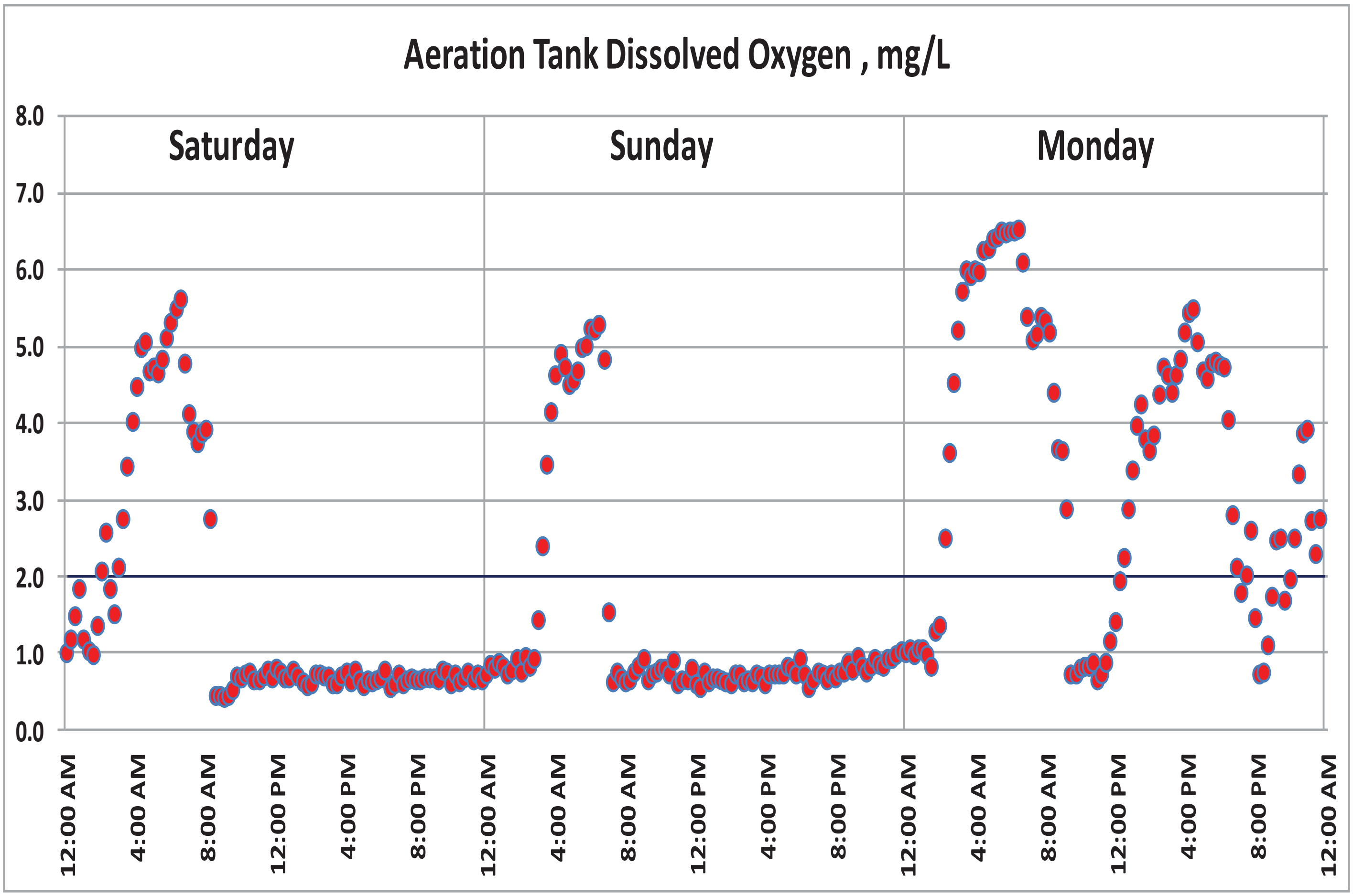
If you don't smell it, you still might see it. Influent domestic wastewater typically has a grey color. Influent flows which are more black in color are more likely to be from anaerobic environments or septic sources.

Activated Sludge Process Control and Troubleshooting Chart

Box # 22 **Aeration: Increase air supply to match organic loading**

If a low DO concentration is the cause of filamentous growth, the aeration being applied must be adjusted to more accurately reflect the influent organic loading.

Data logging will identify the aeration cycle periods that need to be adjusted. In the chart below, if low DO filament growth conditions exist in the aeration tank, they are most likely being generated during low DO conditions (< 1 mg/L) on Saturday and Sunday due to the extended, low DO environment.



Increase the aeration cycle periods or bring additional blowers on line during low DO conditions.

Evaluate the aeration distribution system for clogged diffusers, pipes and valves which could be restricting flow.

Evaluate the mixing intensity of the aeration pattern. Diffusers which are designed along the width of the aeration tank are more likely to experience mixing issues than diffusers which are designed along the length of the aeration tank.

The color of a healthy aerobic biomass is typically light to dark brown depending on concentration. Aeration tanks limited by DO and sufficient mixing intensity will appear more grey in color.

Activated Sludge Process Control and Troubleshooting Chart

Box # 23 Clarifier Effluent: Biomass observed leaving the clarifier

If the biomass settles below the 80% mark in five minutes, there is typically no problem with the settling characteristics (not a biological issue). However biomass can still be lost from the clarifier due to a hydraulic issue.

Observed Biomass Loss:

The most obvious sign is solids deposition in the receiving stream. Depending on the effluent sampling criteria (grab vs. flow composite), effluent sampling data may not identify the solids loss.

Biomass deposition in the clarifier trough is another indicator.

Another evaluation method is to use the clarifier core sampler to measure solids deposition in the dosing tank prior to sand filtration or solids deposition in the disinfection unit.

Life Expectancy of a Sand Filter

Systems with slow sand filters provide an obvious method to evaluate solids loss over time. The more biomass lost through the clarifier effluent, the shorter the life expectancy of the sand filter. Package plants using slow sand filters typically experience 2-3 months of operation. They must then be taken out of service and cleaned. If the sand filter is operating on less than 2-3 months of service, then loss of biomass from the clarifier is probably occurring.

Left Photo: Youthful - water filters through sand before reaching walls.

Center Photo: Aging - water reaching side walls, begins to cover entire floor.

Right Photo: Deceased - water ponding on surface

Does the sand filter survive at least 2 to 3 months?

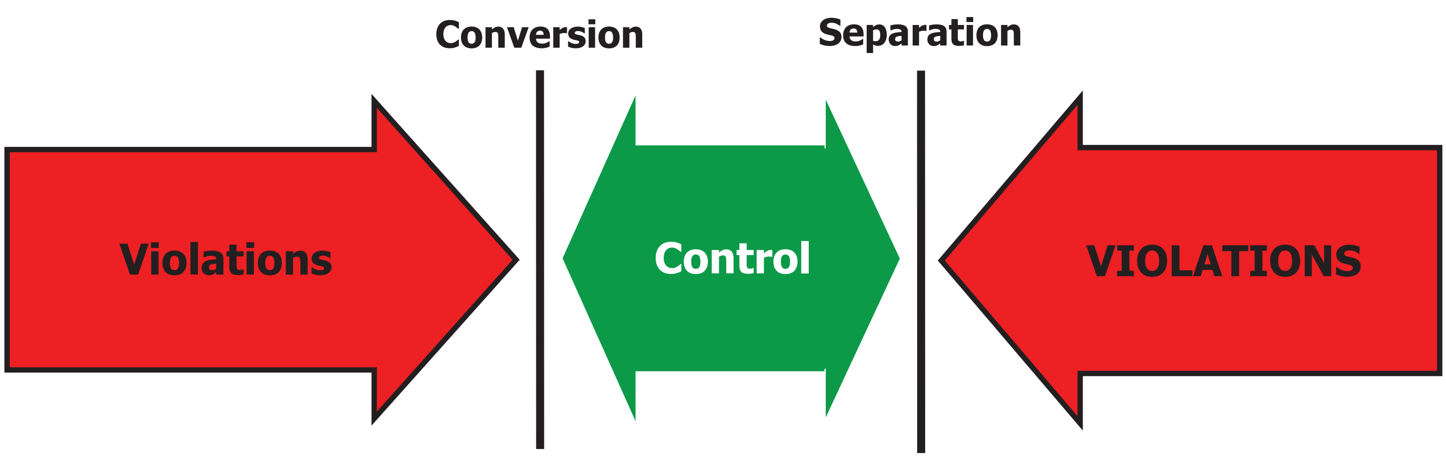
Activated Sludge Process Control and Troubleshooting Chart

Box # 24 Compliance

If clarifier effluent ammonia values are <1 mg/L, then conversion is complete. If the biomass will settle below the 80% mark in the settleometer in five minutes then separation is adequate. The area between these two process control criteria is the "operating window" in which the treatment system will perform most effectively and efficiently.

The ammonia and settleometer analysis establishes the "operating window". Maintaining the process between these two criteria provides the best effluent with the least amount of expense and effort. As organic and hydraulic loadings change, the operating window will also change. As more pressure is applied to the treatment system the window becomes smaller, but by measuring and adjusting the process you can maintain in the safest location; the "middle of the window".

As water temperatures change, the operating window will also change. Warmer temperatures typically expand the window, while colder temperatures contract the size of the window. Good operations begin with locating the system's current location and then adjusting the process to maintain a position in the middle.



Lack of monitoring the system leads to a smaller operating window. This results in an increase in violations and the system becomes more labor intensive to "correct" something which could have been prevented. Don't create more work for yourself. Small adjustments can prevent most upset conditions.

Activated Sludge Process Control and Troubleshooting Chart

Box # 25 Clarifier: Sludge blanket < 30% of clarifier water depth

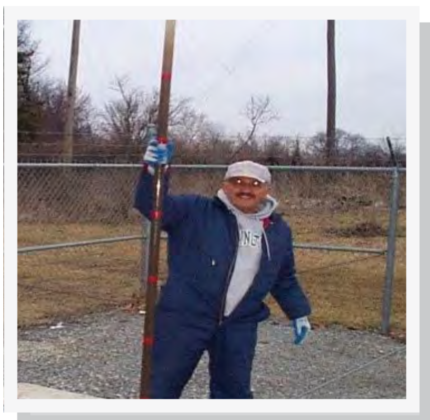
As the biomass settles in the clarifier, a concentrated sludge layer or "blanket" develops on the bottom.

As this sludge blanket increases in depth, clarifier capacity decreases. The closer the blanket is to the clarifier surface, the more likely biomass will be carried over the clarifier weir.

Sludge blankets can increase and/or decrease in depth based on high influent flows, return pumping rates and settling characteristics of the biomass.

Measure the sludge blanket depth with a "core sampler".

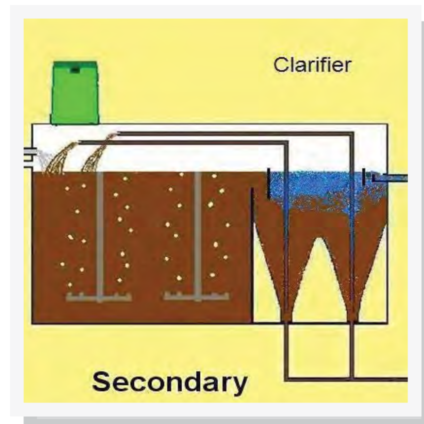
See: "How do I . . . measure solids in the clarifier?"

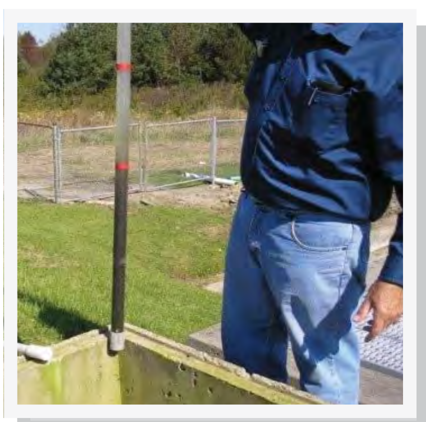


High Sludge Blanket Depth

The blanket is too close to the effluent weir.

Biomass entering the clarifier will travel across the top of the sludge blanket and be drawn out over the effluent weir.

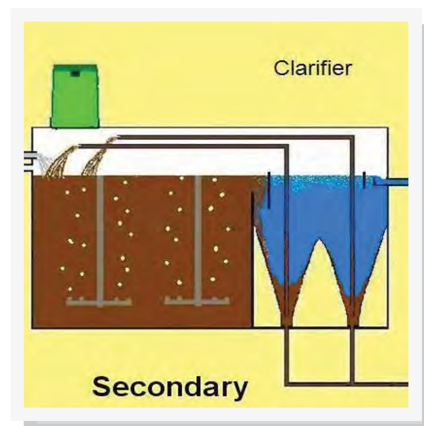




Normal Sludge Blanket Depth

The blanket is less than 30% of the clarifier water depth.

Biomass entering the clarifier has room to settle out and should not be drawn over the effluent weir.



Eliminating the sludge blanket depth as a cause for solids loss is easy to confirm with a clarifier core sampler.

See "How do I . . . interpret the core sampler results?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 26 Clarifier: Return Activated Sludge rate

Ideally, the return activated sludge pumping rate (RAS) needs to match the settling rate of the biomass coming from the aeration tank. A slow settling biomass requires a slower RAS rate and a fast settling biomass requires a faster RAS rate. Failing to match the RAS pumping rate to the biomass settling rate may cause solids to overflow the clarifier weir. Basing RAS rates on a percentage of influent flow is a common, but faulty, method.

The return sludge pump can only remove biomass that has already settled to the bottom of the clarifier. The biomass cannot be "drawn" to the bottom of the clarifier by increasing the RAS pumping rate.

An RAS pumping rate that is slower than the settling rate of the biomass creates a condition where more biomass is entering the clarifier than is being pumped out. This results in an accumulation of sludge (increased sludge blanket) in the clarifier. An increasing sludge blanket can result in decreasing clarifier efficiency and increasing solids loss.

An RAS pumping rate that is faster than the settling rate of the biomass creates a condition where excess water is being returned to the aeration tank. This results in additional hydraulic pressures (more flow) within the clarifier. Increased hydraulic pressures within the clarifier results in the biomass being unable to properly settle and concentrate into a sludge blanket. Biomass remaining in suspension in the clarifier will be more likely to be push out over the clarifier weir. This is exaggerated when filamentous bacteria (slow settling biomass) dominate in the secondary system.

Evaluate the RAS rate and then adjust the pumping rate to match the biomass settling rate.

If the biomass is settling well, but solids are observed leaving the clarifier, then there is a problem within the clarifier itself. A high sludge blanket (> 30%) will be the primary cause for potential solids loss. If the RAS pumping rate needs to be increased, then the loss of biomass from the clarifier should decrease. However if the RAS pumping rate is correct, then typically too much biomass is in the system and the sludge wasting rate should be increased.

See "How do I . . . determine the correct RAS pumping rate?"

Activated Sludge Process Control and Troubleshooting Chart

Box # 27 Clarifier: Hydraulic issues in clarifier.

If clarifier biomass loss is observed, but is not caused by a slow settling biomass (> 80% in 5 minutes in settleometer) or a sludge blanket which is > 30% of the clarifier water depth, it is possible there are unique hydraulic pressures within the clarifier "carrying" solids over the clarifier weir.

There are three common design features that can possibly lead to the loss of biomass in the clarifier; uneven flow splitting into the clarifiers, density currents within the clarifier, and weir locations/ elevation removing flow from the clarifier.

Flow Splitting

Devices that are designed to split the flow horizontally are incapable of equalizing loadings to downstream tanks. In this design, flow splitting is impacted as hydraulic flow rates change. That is why the strategically place "flow splitting brick" only performs well at certain flow rates.

See "How do I . . . correct a flow splitting issue into the clarifier?"

Internal Density Currents

Even if the flow is split evenly among the clarifiers, internal density currents can short circuit through a clarifier and cause solids loss.

See "How do I . . . eliminate a density current within a clarifier?"

Weir Location/Elevation

Effluent weirs located next to the back wall of a rectangular clarifier; or weirs which are uneven, will allow biomass to be drawn out of the clarifier. Weirs designed too close to a wall can be removed from operation by sealing off the weir area.

See "How do I . . . correct effluent weirs which are causing solids loss?

Activated Sludge Process Control and Troubleshooting Chart

Box # 28 Clarifier: Adjust return activated sludge (RAS) rate.

A quick and simple method to evaluate the proper RAS rate is to perform a centrifuge analysis of the aeration tank effluent and the RAS.

The aeration tank biomass concentration is typically between 2% and 4%. As the biomass settles in the clarifier, it will increase in concentration. A “rule of thumb” is that the RAS concentration should be at least 1.5 to 2 times the concentration of the aeration tank biomass. If the RAS is less than 1.5 times the aeration tank biomass, then the RAS rate is probably set too fast.

If the RAS concentration is twice the aeration tank concentration, then theoretically biomass is being returned at a rate which is slow enough to allow a 50% reduction in volume. A fast settling biomass can actually produce a RAS concentration 3 times the aeration tank concentration. RAS concentrations greater than 2 times the aeration tank concentration can be a very effective way to operate, resulting in reduced WAS volumes and longer biomass detention times in the aeration tank. However, RAS concentrations greater than 2 times the aeration tank concentration approach a condition which may allow an excessive sludge blanket to accumulate, resulting in reduced clarifier efficiency. Always use a “core sampler” to determine if the RAS flow rate is too slow for the biomass settling characteristics.

RAS Rates

A centrifuge is used to measure the aeration tank and return sludge concentrations. This data used with the results of a settleometer analysis can identify what the current RAS rate is and if it needs to be adjusted.

See “How do I . . . determine the correct RAS pumping rate?

Activated Sludge Process Control and Troubleshooting Chart

Box # 29 Clarifier: SOR or SLR in excess of clarifier design capacity

Clarifiers are designed to allow adequate detention time for the biomass to separate and concentrate by gravity. This separation process can be affected by either hydraulic pressure within the clarifier and/or biomass loading into the clarifier.

Surface Overflow Rate (SOR) is a measurement of the "overflow velocity" per square foot of the clarifier surface. As the upward, overflow velocity increases, it is more difficult for the biomass to settle to the clarifier bottom.

SOR

If only one clarifier is available, determine if it is exceeding its designed SOR during peak flows.

If more than one clarifier is in service, each clarifier should receive equal flow. Don't allow 50% of the clarifiers to handle more than 50% of the flow.

See "How do I . . . calculate the SOR in the clarifier?"

Solids Loading Rate (SLR) is a measurement of the "settling velocity" of the biomass per square foot of the clarifier surface. As the biomass loading rate increases, it is more difficult for biomass to settle to the clarifier bottom.

SLR

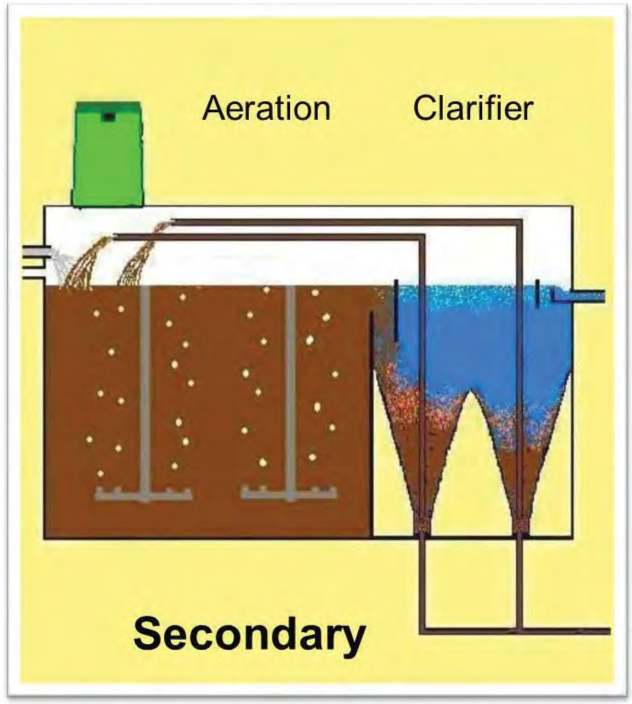
As biomass concentration increases, it will settle slower in the clarifier. Reducing the aeration tank biomass concentration or placing another clarifier in service will lower the SLR to the clarifier(s).

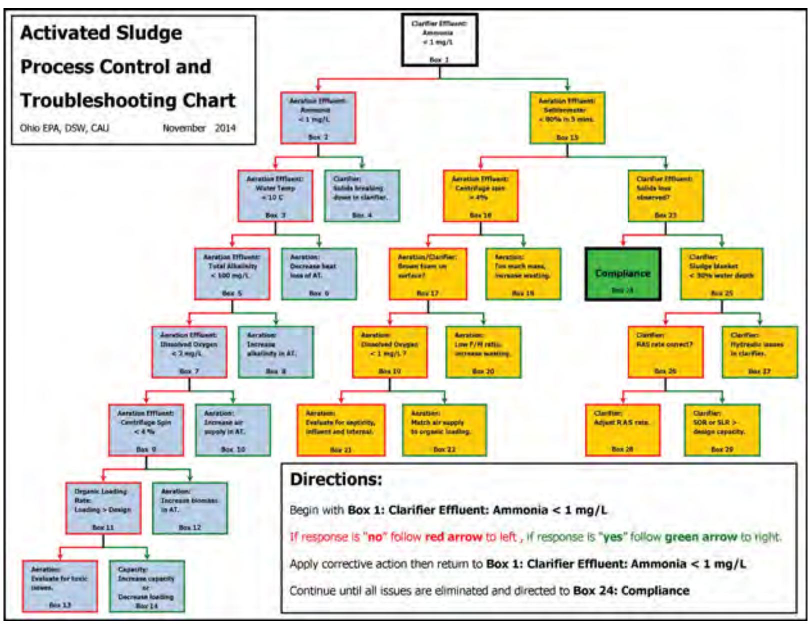
See "How do I . . . calculate the SLR in the clarifier?"

Secondary Stage—Summary

The secondary stage is a physical and biological process which will require visual observations for the physical processes and chemical analysis to monitor the biological process. The two units in the Secondary Stage, aeration tank and clarifier, work together to first convert dissolved and suspended pollutants to bacteria in the aeration tank and then to separate the bacteria from the water in the clarifier.

Visual observations assist in determining the condition of the secondary treatment process, however, chemical analysis must be performed to monitor the conversion of dissolved and suspended pollutant into bacteria and physical analysis is required to monitor the settling characteristics of the bacteria produced in the aeration unit.





Using the Process Control and Troubleshooting Chart will direct you to where the treatment performance is being limited and allow for the correct action to maintain compliance.

The treatment system operates on a few basic and dependable concepts. Understanding these concepts and their interaction allows you to correctly identify when the system is drifting outside its "operating window", so you can apply a corrective action to bring the system back to a more stable condition.

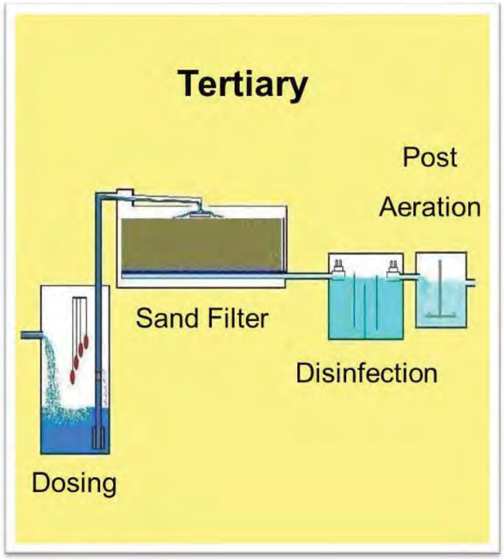
Identifying the operating window and maintaining a position in the center of the window provides the best effluent with the least amount of time and expense. It also provides a cushion before an upset occurs.

As the Secondary Stage performs its task of conversion and separation, the clarifier effluent will be low in pollutants and suspended solids which prepares the water for final treatment in the Tertiary Stage.

Tertiary Stage

The tertiary stage consists of a dosing tank, sand filters, disinfection, and post-aeration. All of the units in the tertiary stage are physical and chemical process which can be monitored by visual observation.

The dosing tank pumps the water to the top of the sand filters in doses. As the water travels through the sand media fine suspended solids are removed. The polished water from the sand filter is collected at the bottom of the sand filter and conveyed to a disinfection unit. Here either ultra-violet light or calcium hypochlorite is used to kill pathogens-disease causing organisms. Finally the water is aerated to increase the dissolved oxygen concentration before being discharged into the receiving stream.



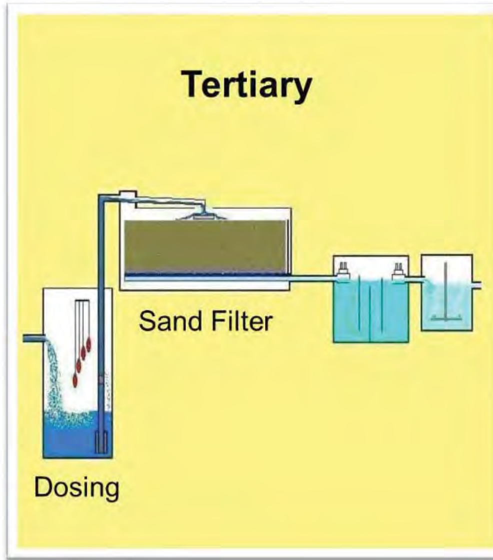
A visual walk-through will be the primary method of controlling the process if careful observations are made. The sand filters are typically the last domino to fall if there has been an upset to the treatment process.

Proper control of the upstream treatment units reduces the frequency of over loading sand filters, and the work required to clean them.

Tertiary Stage - Dosing Tank/Sand Filter

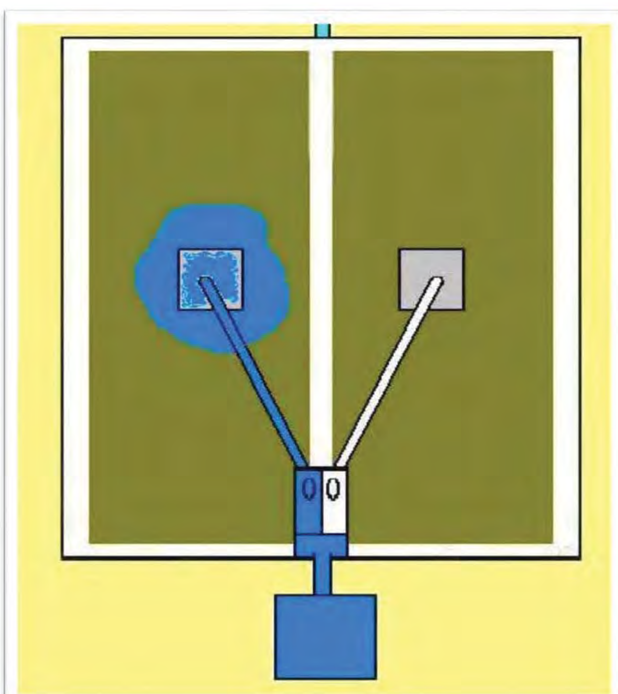
The dosing tank and sand filter work as a unit. Typically water flows by gravity from the flow splitting device of the preliminary stage through the treatment system to the clarifier of the secondary stage. A dosing pump receives the clarifier effluent flow and pumps it in "doses" to the top of the sand filter.

From this higher elevation the water can then continue to gravity flow through the tertiary stage and into the receiving stream. This also allows the sand filter to drain completely before the dosing pumps is activated again.



Dosing is required by many regulatory agencies because filters operate more efficiently. In extremely cold seasons, if water "ponds" too long on a filter it can freeze and seal off the filter. Dosing allows for filters to quickly drain to decrease the likelihood of freezing.

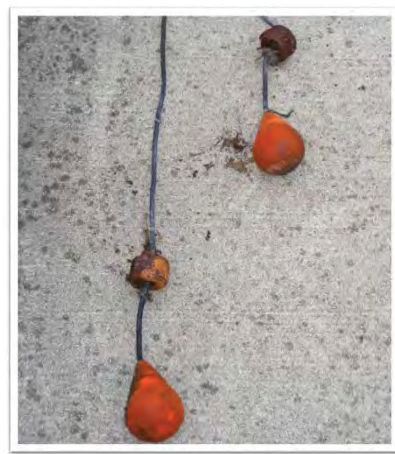
It is recommended to have only one filter in operation. This allows the filter which is out of service to dry and be cleaned by the operator.



Tertiary Stage - Dosing Tank/Sand Filter

A control panel above the dosing tank contains the electrical components to active the correct pumping sequences.

This control panel operates very similar to the flow equalization tank control panel. There are contacts to operate the pumps either manually ON (Hand), OFF, or based on the float switches (AUTO) located in the dosing tank.



The dosing tank pumps are controlled by a water level sensor when the controls are in the AUTO position. Typically float switches are used as level sensors to determine the operation of the dosing tank pumps.

When the pumps are activated a "run-time" meter records the minutes or hours of operation. This run-time data is important to track the hours of operation to determine when preventative maintenance is required on pumps.

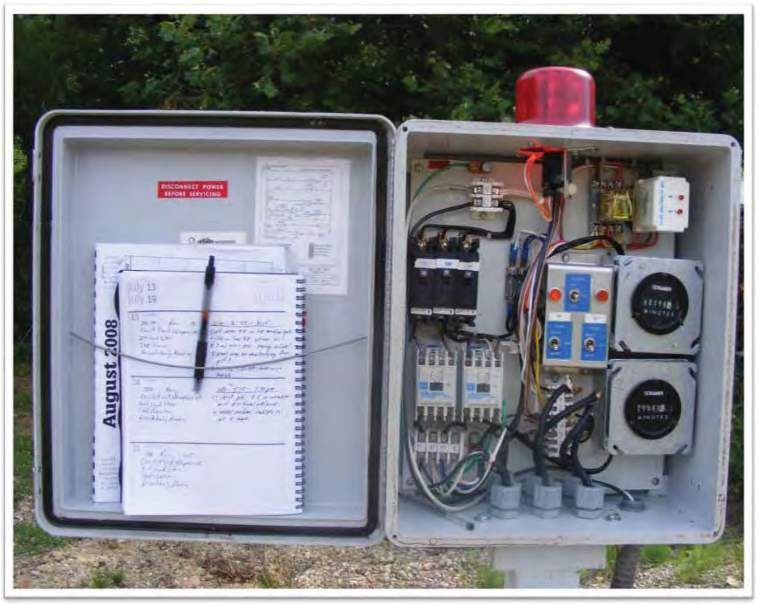
This data is also critical to measure the daily flow which passes through the treatment system. As an operator, it is important to determine if the daily flows are exceeding the hydraulic design capacity of the treatment system, but it can also be used for reporting the daily flow which is a requirement of the discharge permit.

Tertiary Stage - Dosing Tank/Sand Filter

A treatment system which receives twice the daily flow for which it was designed will experience difficulty in achieving compliance. In addition, systems which experience flows significantly lower than design can also be difficult to operate. Thus, calculating the flow through the treatment process is critical. A simple and approved method for reporting flow from the treatment system is to calculate flow based on the run time of the dosing pumps.

If you know the pumping rate of the dosing pumps, it is a simple calculation of multiplying the minutes of operation from the run-time meter in a 24 hour period times the gallon per minute pumping rate of the dosing pumps.

Flow, gallons per day = runtime meter, minutes x pumping rate, gpm



Here the operator has kept the operational log book for the treatment system in the control panel box. By recording the run time meter daily the operator can determine how many gallons were pumped from the dosing tank in a 24 hour period.

The equation does require the operator to know an accurate pumping rate of the dosing pumps. This is determined by a draw-down test. Once the pumping rate for each pump is determined, a periodic check of the pumping rate to determined if the pumping rate has change is all that is required.

<u>Draw Down Test</u>

To determine the pumping rate perform a draw down test of the dosing tank. This is accomplished by first measuring the surface area of the dosing tank. In this example the dosing tank is 4 foot in diameter. To determine the surface area use either of the following formulas:

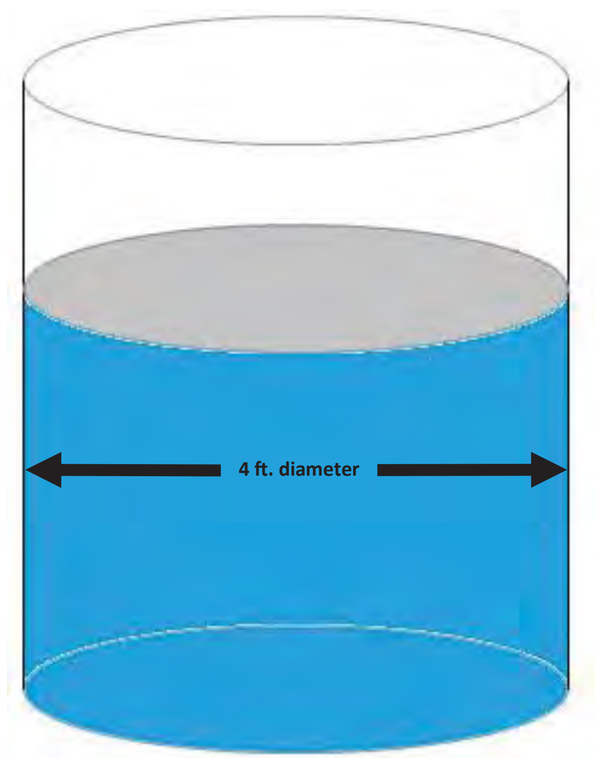
surface area = 3.14 x radius x radius

or

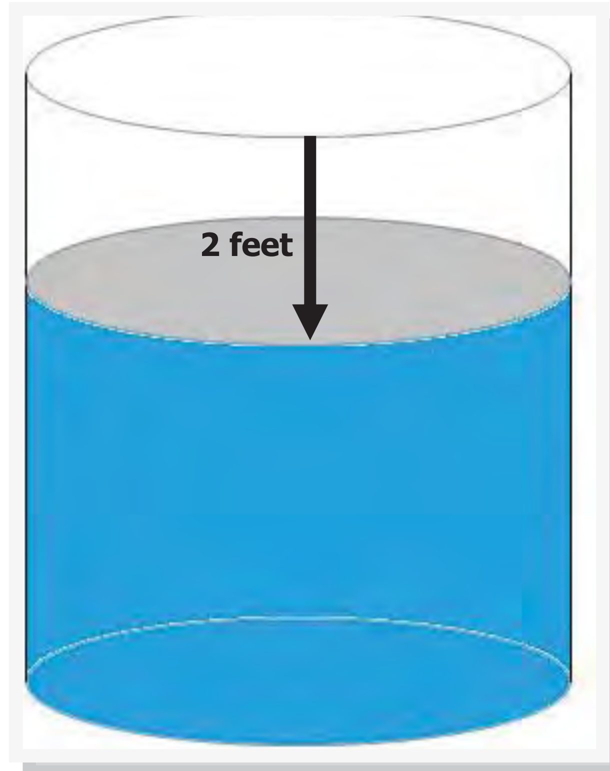
surface area = 0.785 x diameter x diameter

In this example the surface area is:

0.785 x 4 ft. x 4 ft. = 12.56 square feet

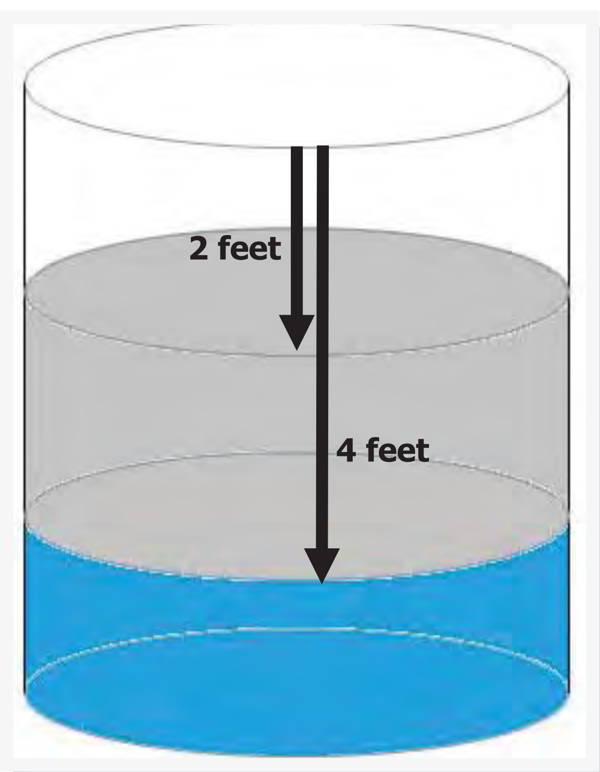


Tertiary Stage - Dosing Tank/Sand Filter



After the surface area is determined, measure the distance between the top of the dosing tank to the surface of the water. While the influent pumps are off and no flow is discharging into the dosing tank, turn one dosing pump to the ON position and draw the water down to the shut-off float (bottom float). With a stop watch record the time to draw the water elevation down.

The difference between the two water elevation measurements is the water depth pumped during the draw down test. If the first water elevation measurement is 2 feet and the second measurement after operating the pump is 4 feet, then then the difference in water elevation is 2 feet.



First we will determine the gallons of water pumped during the draw down test. Since we know the surface area of the dosing tank (12.56 ft^2), we can multiply the surface area by the change in water elevation (2 ft.) to determine the cubic feet of water pumped from the dosing tank.

12.56 ft^2 surface area x 2 ft. water pumped = 25.12 ft^3

Since 25.12 ft^3 of water was removed and each cubic foot of water contains 7.48 gallons of water, we can determine the exact volume of water pumped from the dosing tank by multiplying the cubic foot of volume pumped by 7.48 gallons.

25.12 ft^3 x 7.48 gallons/ ft^3 = 188 gallons pumped

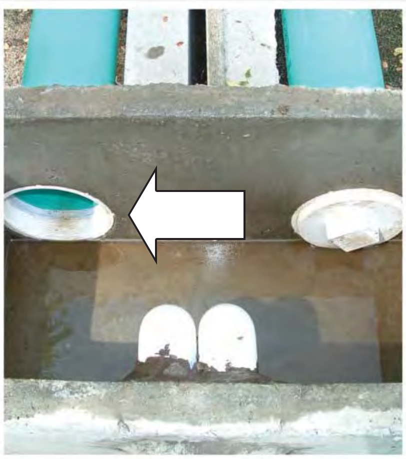
If you divide the gallons of water pumped by the time required to pump the water out, you will have an accurate pumping rate for the pump being tested. If in our example it required 5 minutes to pump the water down 2 feet then our pumping rate is:

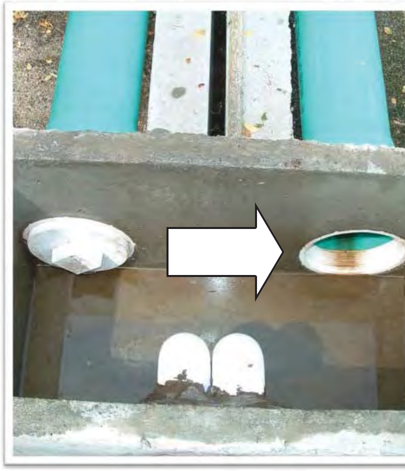
188 gallons of water pumped / 5 minutes to pump = 37.6 gpm pumping rate.

Tertiary Stage - Dosing Tank/Sand Filter

The dosing pumps lift the water to a flow diversion box to control which sand filter is in operation.

Flows leaving the flow diversion box are typically controlled by simple plugs or slide gates.





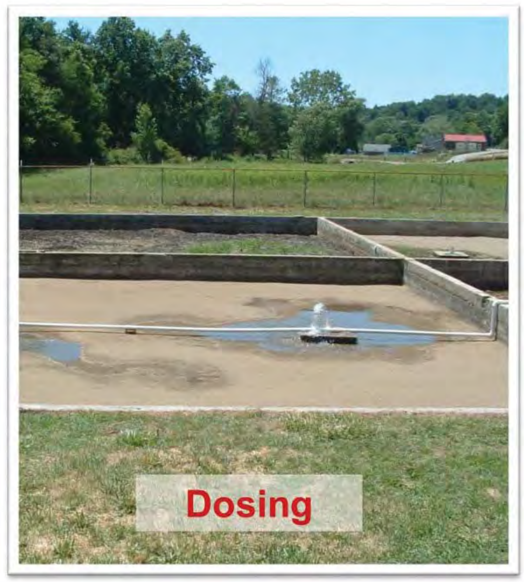
When a filter has reached the end of its life, then it is removed from service to allow for cleaning. Dried solids removed from the sand filter need to be disposed of properly. One method is to dispose of dried solids in a landfill.

Tertiary Stage - Dosing Tank/Sand Filter

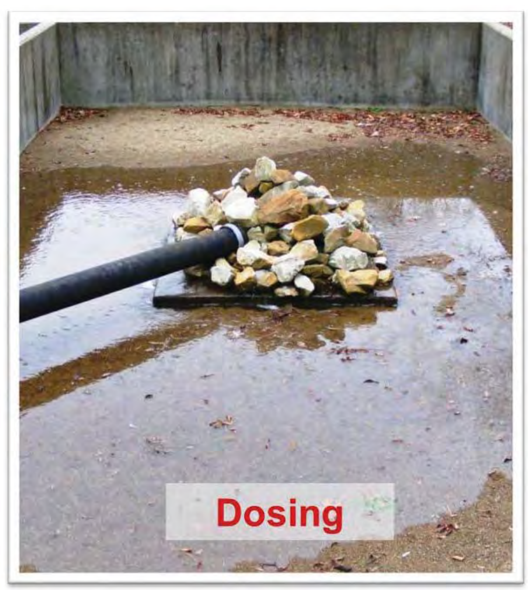
The Life Expectancy of a Sand Filter

If clean water is placed on a sand filter, it would theoretically operate forever and never need to be cleaned. However, even if a small concentration of suspended solids is passed through the filter, it would eventually become clogged and need cleaned. Typically systems which are operated effectively and not exposed to hydraulic flows greater that design can operate up to 3 months before needing to be removed from service. There is a way to "read" a filter to determine its stage in life and when cleaning will be required.

Infancy



A sand filter with clean sand and clean water from the clarifier effluent will filter through the sand media with little to none of the water reaching the side walls of the sand filter.

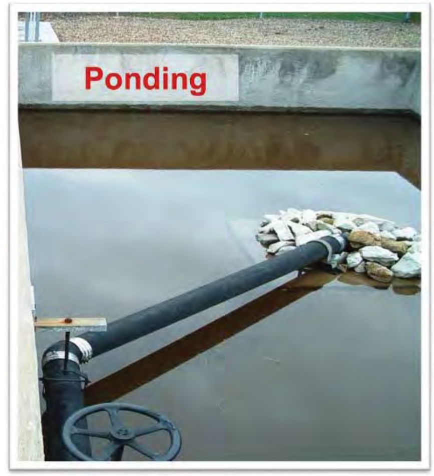


As the filter remains in operation and as the sand begins to clog, the flow from the dosing tank will reach more of the side walls before filtering through the sand.

Tertiary Stage - Dosing Tank/Sand Filter

Deceased

Eventually the water from the dosing cycle will reach the side walls of the sand filter and begin to climb up the wall. When the water does not filter through the sand media completely before the dosing pump cycles again, the filter is said to be ponding and should be removed from service for cleaning.



After taking the ponding sand filter out of service, the solids collected on the surface are allowed to dry. When the solids are sufficiently dried they can be scrapped or skimmed off the surface. After removal of the dried solids, a rake can be used to open the top few inches of the surface of the sand media. Raking will also provide a way of leveling out the sand media.

Once cleaned the filter is placed on stand-by to be brought back into service when the current filter in operation becomes deceased.

Tertiary Stage - Dosing Tank/Sand Filter

The velocity of the flow from the diversion box onto the sand filter can cause a scouring effect of the sand media. To prevent this high velocity flow from pushing away the sand media a splash plate is used to disperse the flow over the sand filter. A concrete pad will assist in spreading the influent hydraulic pressure horizontally.

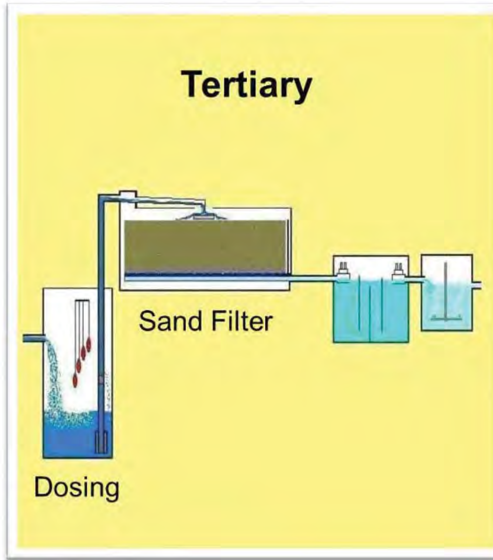
Some systems will direct the discharge pipe upward, so water has to over flow the pipe and flow down onto the splash pad. Remember to drill a drain hole in the bottom to the discharge elbow to prevent freezing during the winter months.

Often stones or gravel will be placed on the perimeter of the splash pad to disperse the influent velocity and prevent the scouring of sand.

As filters cycle through cleaning, sand media is lost along with the dried solids that are captured on the filter's surface. This becomes obvious when the sand media level drops below the splash pad.

As sand media is removed through the cleaning process additional sand must be brought in to maintain the intended media depth.

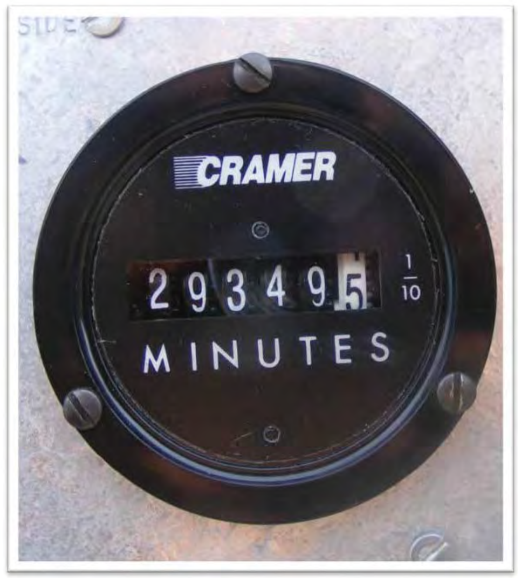
Tertiary Stage - Dosing Tank/Sand Filter



The beginning of the tertiary stage is a physical process of pumping and filtration to remove fine suspended solids.

One filter should be in operation, while the other filter is on standby. This allows time for a clogged filter to dry and be cleaned.

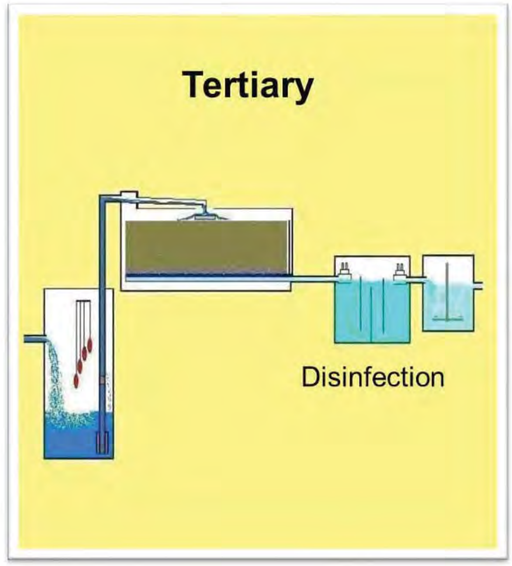
The dosing tank set up is similar to the preliminary stage's flow equalization tank. An electrical panel contains the equipment to control the pumping sequences (ON, OFF, AUTO) and also provide the run time of the pumps to determine the volume of flow which has passed through the treatment system. This flow data is critical in determining if sufficient treatment capacity is available; if too much treatment capacity is in service; and required to calculate daily flow for reporting purposes.



When upsets occur in the treatment system, the problem is multiplied through the system and eventually ends up on the sand filter. The sand filter is the last domino to fall and usually the biggest domino.

A sand filter has a specific life expectancy. The cleaner the water passing through the filter, the longer the life of the filter.

Tertiary Stage - Disinfection



After the fine suspended particles are removed through the filtration process, there still remain biological organisms (pathogens) which could cause human health issues if released into the receiving stream. These pathogens need to be prevented from entering the receiving stream. That is the purpose of the disinfection unit of the tertiary stage.

As water collects in the drain lines of the sand filter, it is next directed to the disinfection unit. Water enters the chlorine contact tank by passing through a tablet chlorinator.

The vertical tubes from the chlorinator can be removed so compressed tablets of calcium hypochlorite can be placed inside the tubes.

As water flows across the hypochlorite tablets in the bottom of the tubes, the calcium hypochlorite dissolves and a strong "bleach" solution is formed. This chlorinated water then enters the disinfection tank (also referred to as a chlorine contact tank) and the hypochlorite solution comes in contact with and kills the pathogens.

There are baffles within the disinfection tank to prevent short circuiting of the flow with the bleach solution for the most effective kill of pathogens.

A final effluent sample from the treatment system will be monitored for a type of coliform bacteria. The system must provide sufficient disinfection to be below the acceptable limit for coliform bacteria in the effluent. Violations of effluent coliform is usually due to inadequate hypochlorite tablets in use to achieve the desired disinfection necessary. Not using the tablet chlorinator as designed will lead to violations of the coliform limit and ineffective use of chemicals.

Tertiary Stage - Disinfection

Another possible cause for elevated coliform bacteria in the final effluent could be solids which have deposited in either the dosing tank or the chlorine contact tank. Over time, solids can accumulate within either of these tanks. As the settled bacteria begin to increase in volume and die in the bottom of the tank, they can become a demand on the disinfecting capabilities of the bleach in solution.

By placing a larger demand on the hypochlorite solution, it is more probable that coliform bacteria may pass through the disinfection unit. Using a clarifier core sampler to check for sludge deposits on the bottom of these tanks is a simple way to determine if solids are leading to coliform violations.

A pumping out of deposited solids will bring the system back into compliance with effluent coliform limits and reduce chemical costs, since fewer tablets will be required.

While we need to protect humans from pathogens entering the receiving stream, the system cannot discharge a high concentration of chlorinated water into the receiving stream because of its negative impact on the aquatic species.

Low levels of chlorine can have a detrimental effect on fish in the stream. In order to protect the aquatic species, another tablet feeder is designed into the effluent of the disinfection tank. The process is exactly the same as that is used for disinfection, except a different type of chemical tablets is used. Sodium sulfite is a reducing agent and when exposed to chlorine, an oxidizing agent, will neutralize the excess chlorine.

Tertiary Stage - Disinfection

Calcium hypochlorite is used for disinfection of the water prior to being discharged to the final effluent. Disinfection is adequate if you are maintaining compliance with the final effluent limit for coliform bacteria.

Sodium sulfite is used to remove excess chlorine in the water prior to being discharged to the final effluent. De-chlorination is adequate if you are maintaining compliance with the final effluent limit for total chlorine residual.

ULTRA-VIOLET DISINFECTION

Another method of disinfection is to use ultra-violet light instead of chemicals. Since we are not adding chlorine for disinfection, there is no need to add a de-chlorinating chemical. The ultra-violet, or uV disinfection process uses light to disable pathogens from reproducing. Since they are unable to reproduce, they are prevented from becoming a health hazard for humans in the receiving streams.

Systems which treat larger flows will typically have more uV bulbs available for disinfection. Above is a system with a lower flow design (1 bulb) than the system to the right (2 bulbs).

Tertiary Stage - Disinfection

Here is another type of uV disinfecting unit in which the water flows vertically around the uV lamp.

If the system is experiencing effluent violations for coliform bacteria then there is either insufficient uV light to inactivate the bacteria which pass through the uV channel, or something is obstructing the path of light from the uV bulb.

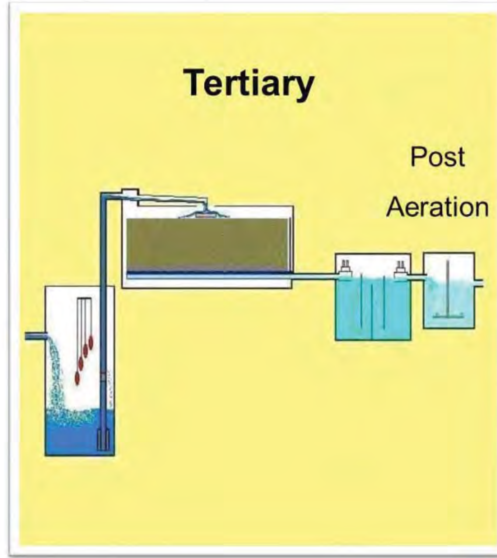
Overtime the uV bulbs develop a scale which restricts the uV light from reaching the bacteria in the water. These bulbs require periodic cleaning to allow for the most effective light transmittance in to the water column for the best disinfection of bacteria.

The uV bulbs also lose intensity over time, and like a regular light bulb in your office, will eventually dim and burn out. These bulbs need to be replaced after extended hours of service.

One other possibility of uV failure is if the water entering the disinfection unit is not clear. High turbidity from suspended solids or unconverted pollutants will hide or cover pathogens for the uV light path. This allows bacteria to leave the disinfection unit.

Tertiary Stage - Post Aeration

The last step in the treatment process before discharging into the receiving stream is to increase the dissolved oxygen concentration in the water. This is done by diffusing air into the water after the disinfection unit but before the final discharge.



If the air supply which is used to provide post aeration is connected to other air supply lines (aeration diffusers), care must be taken when making adjustments to the entire aeration system. The air will travel to the path of least resistance.

Adjustments to increased air flow to the aeration tank diffusers could reduce air flow to the post aeration diffusers. Insufficient air flow to the post aeration tank could lead to violations of the discharge limit for not maintaining a minimum dissolved oxygen concentration in the final effluent.

Tertiary Stage - Post Aeration

Aeration should be provided after any de-chlorination process. The sodium sulfite which is used to remove excess chlorine will also remove dissolved oxygen. De-chlorination units downstream of the post-aeration could lead to low dissolved oxygen concentrations in the final effluent.

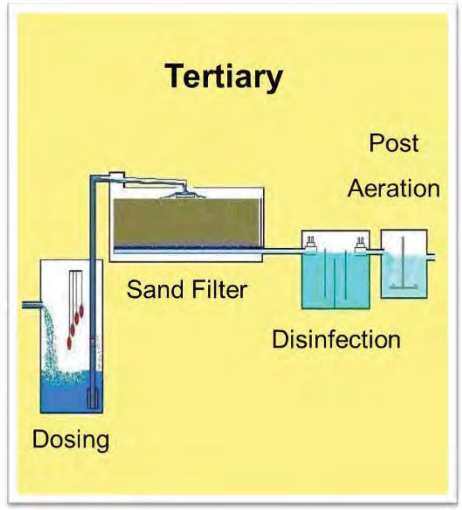
The design to the right has the post aeration after the de-chlorination unit. This prevents low DO due to chemical addition of sodium sulfite.

The design above has post-aeration prior to de-chlorination and could be the cause of low dissolved oxygen violations in the final effluent, due to the de-chlorinating chemical reducing the dissolved oxygen concentration.

Since the post aeration process is a physical process, it requires visual monitoring. If adjustments are made to the air flow in one part of the system, visually inspect to make sure it did not negatively impact the air flow to the post aeration. Of course the best assurance is to actually measure the DO concentration of the effluent.

Tertiary Stage—Summary

The Tertiary Stage is mainly a physical process which will require visual observations. The four units in the Tertiary Stage, dosing tank, sand filter, disinfection and post aeration, work together to provide a fine polishing of the water prior to discharge to the receiving stream.



The dosing tank also provides an accurate and simple method for monitoring the flow through the treatment system. Not only is the data critical for making operational decisions, it is also required to be reported to the Ohio EPA. Failure to report accurate flow values is a reporting violation.

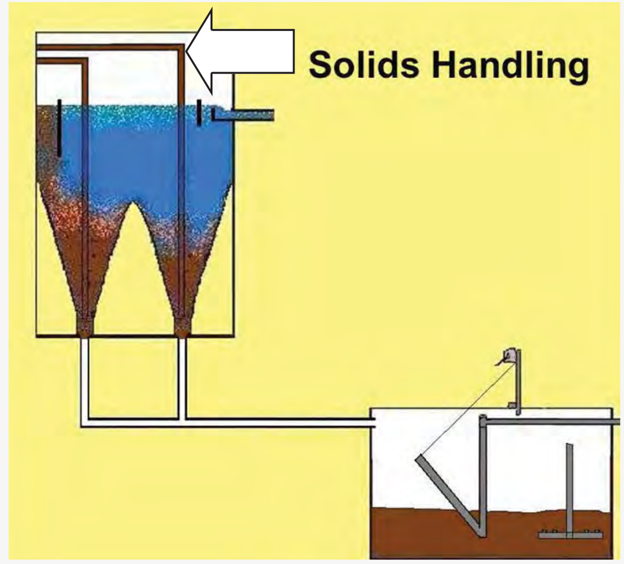
Sand filters have a limited life expectancy depending on the amount of suspend solids placed on the filter. The cleaner the water flowing on the filter the longer the life span. Typically a filter should be able to survive 2 to 3 months before needing cleaned. If the system losses control problems get magnified as they pass through, however, the sand filter is the "safety net" where most mistakes are captured.

Disinfection can be either accomplished chemically with the use of tablet chlorinators or biologically with the use of UV lamps. The purpose is to inhibit and/or kill pathogenic bacteria and prevent their regeneration in the receiving stream. If chemicals are used to disinfect, then chemicals are used to remove excess chlorine from the water due to its negative impact to the fish in the receiving stream.

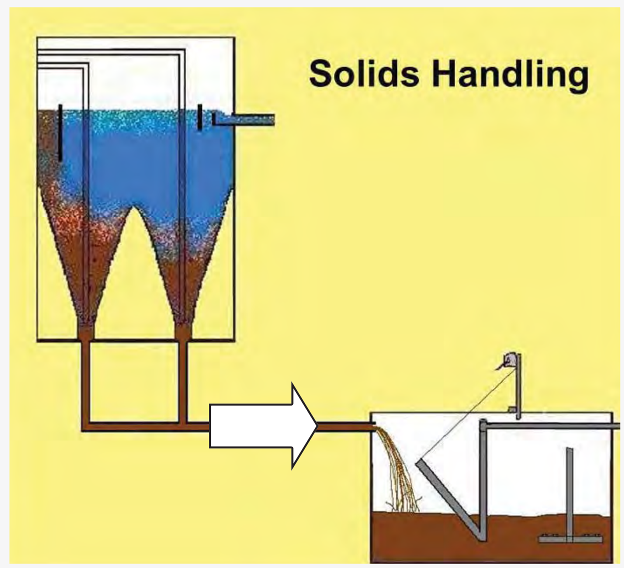
The permit requires a final effluent discharge of greater than 6 mg/L. If the post aeration is operational, this is typically not a problem. However, when adjustments are made to the lines which feed the post aeration, it is possible to lose the post aeration process. Measure with a DO meter to know if sufficient oxygen is available in the receiving stream.

Solids Handling Stage - Digester

The activated sludge treatment process is designed to convert dissolved and suspended pollutants in the aeration tank into bacteria, which will separate from the water by sedimentation in the clarifier. These settled bacteria are returned back into the aeration tank and continue to convert pollutants into more bacteria cells. This settled bacteria is referred to as Return Activated Sludge (RAS).



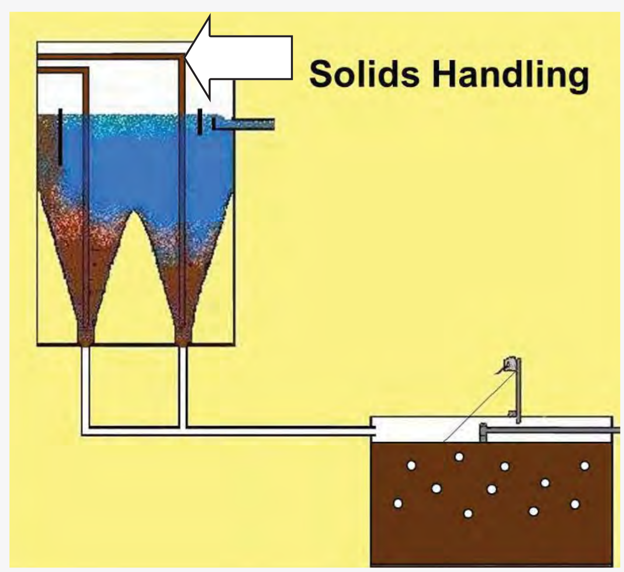
As pollutants continue to enter the treatment system, more bacteria are grown in the aeration tank. Eventually the bacteria concentration will become too excessive and the system will lose control. To maintain control, excess bacteria must be removed from the treatment system. This is usually performed by diverting the bacteria which is being pumped from the bottom of the clarifier back into the aeration tank to the digester or sludge holding tank. This removal of bacteria from the secondary stage is referred to as wasting (WAS).



When the proper amount of bacteria has been removed from the secondary stage, the wasting vales are closed and the return valve are open to allow for the bacteria to be directed to the aeration tank again.

The digester will hold excess bacteria to prevent upsets to the in-line treatment process. The bacteria in the digester need to be aerated to prevent them from becoming anaerobic.

Under anaerobic conditions the bacteria will create strong odor problems and will not allow for separation or thickening of the bacteria in the digester.

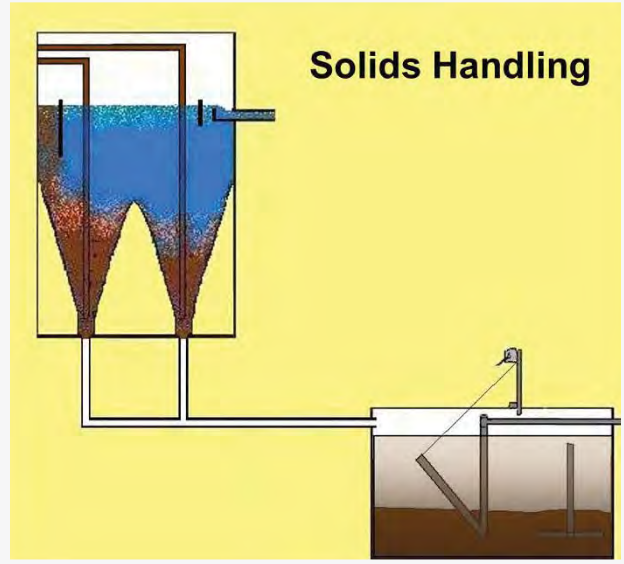


Solids Handling Stage - Digester

When the digester becomes full the air can be discontinued for a short period to allow for solids to separate.

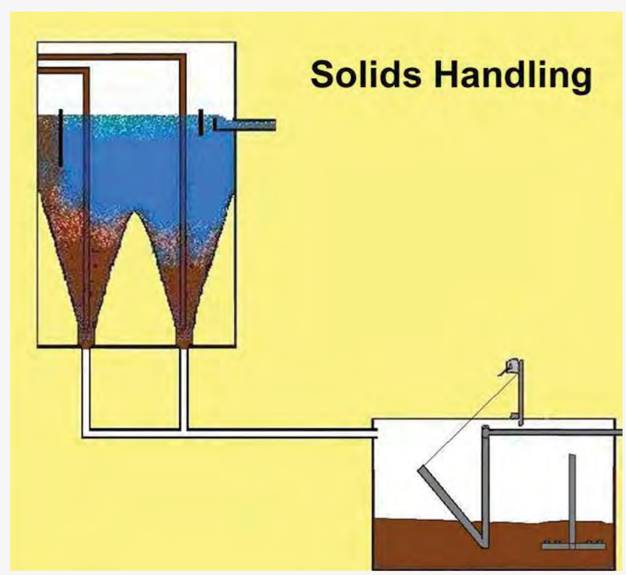
The supernatant, or clearer liquid on top, can be decanted and sent back to the head of the treatment system to be processed.

Decanting of the supernatant in the digester will allow you to extend the capacity, however, as the solids concentration increase in the digester separation becomes less effective.



Eventually the digester has to be emptied by the septic hauler. The higher the concentration of pollutants in the influent, the more solids the system will generate, the more frequently the digester will need to be pumped out.

Having capacity to "waste" excess bacteria into the digester is a critical control measure. If excess bacteria can not be removed from the Secondary Stage the treatment system will become upset and either will require cleaning of the sand filters due to solids loss or violation of the effluent permit limits or both. Knowing when and how much to waste is critical in controlling the treatment system, having digester capacity to waste into is just as critical.

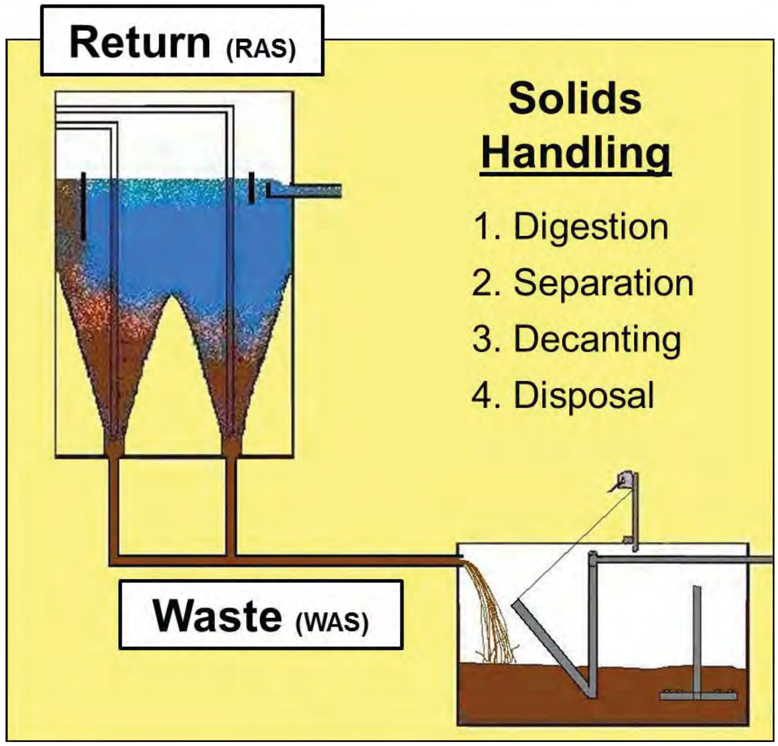


Solids Handling Stage—Summary

The Solids Handling Stage is an off-line process, referring to the main wastewater flow does not go through this stage. However, in order for the treatment system to perform properly, excess solids or bacteria must be consistently removed and stored in this off-line unit.

The digester is used to further digest bacteria, which converts them to carbon dioxide (gas) and water. This digestion process reduces the concentration of bacteria in the digester.

Eventually the digestion process can not significantly reduce the bacteria. If the aeration is temporarily discontinued, the bacteria will separate and allow for decanting of excess water from the digester. This creates additional storage capacity in the digester.



As the bacteria concentration increases, separation of water and bacteria becomes less effective. At this point the digester needs to be pumped out so digester capacity is available to prevent an upset to the treatment process due to high bacteria concentrations in the Secondary Stage.

Visual Inspection includes:

1. adequate aeration provided to maintain aerobic conditions in digester

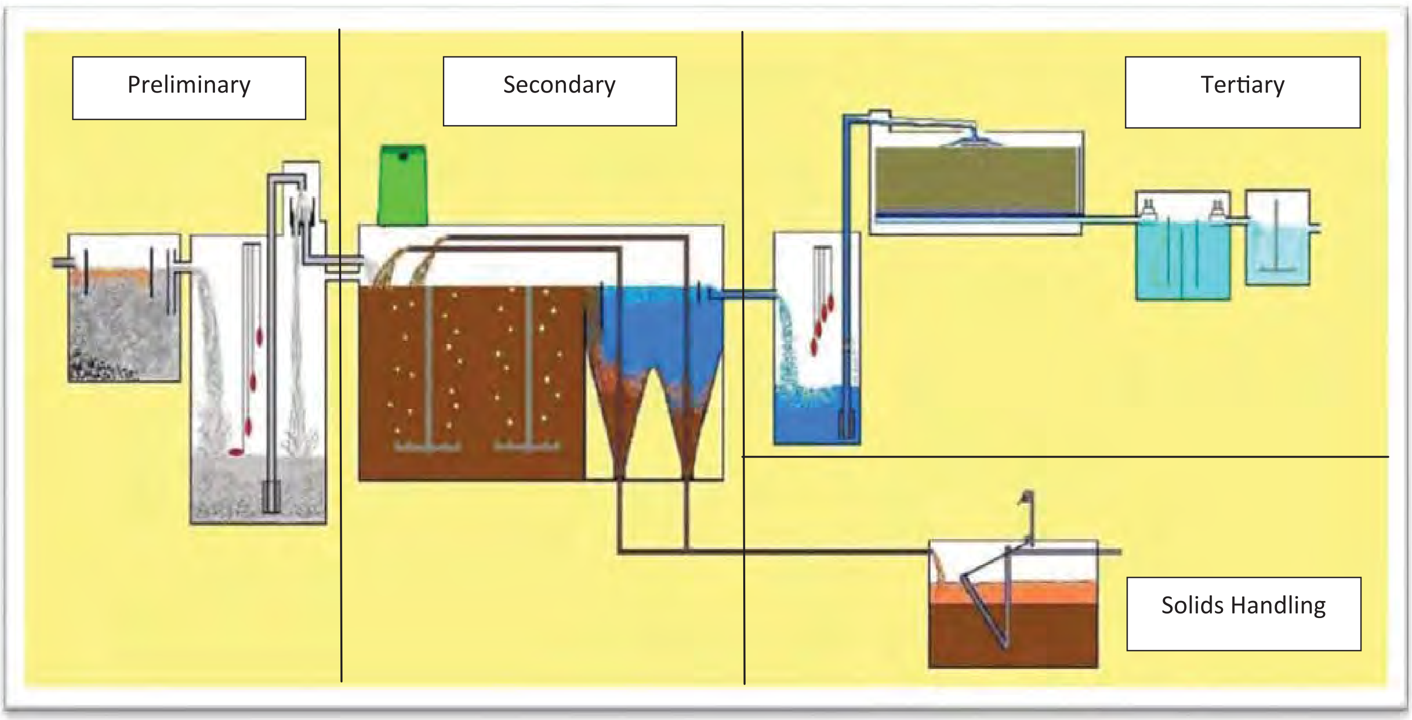
2. decanting mechanism operational to increase digester capacity

3. sufficient digester capacity available to not limit operational control of Secondary Stage (limited wasting capability)

Controlling the Process

Process control is monitoring the system and making minor adjustments to keep the process balanced and performing effectively. Troubleshooting is collecting data to identify the cause of an upset condition and making more significant adjustments to bring the system back into compliance. Both situations, process control and troubleshooting, use the same methodology for identification of the issue(s) limiting performance.

The type of monitoring required is mainly determined by the type of process used in the treatment system. Physical processes can be monitored by visual observations. Biological processes can be monitored by a simple chemical analyses. Knowing what to look for or what to test for is the first step. Interpreting the results accurately is the second. Since this treatment process operates on a few basic concepts, understanding these concepts and their interaction with each other provides the evidence to accurately identify causes of limited performance.



Monitor each stage separately. Adjust the process based on visual and chemical data collected. Implement the correct action which is required. Then monitor each stage to confirm the limiting performance was identified and a proper response was implemented for correction.

Each stage is designed to prepare the water for the next treatment stage. If this is achieved, the system will operate at its highest efficiency. High efficiency is defined as the cleanest effluent with the least amount of resources (time, money) invested. The individual stages can operate in sync with each other or spiral out of control. As the operator, you determine the direction of the process by monitoring what the system needs and providing timely adjustment. Either the gears mesh together for smooth performance or they can grind the system to a halt.