6.3 PROCESS CONTROL for CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND ($CBOD_5$) REMOVAL with the BIOCLERE SYSTEM:

Wastewater flows from the primary settling tank into a baffled chamber in the clarifier of the Bioclere. Dosing pumps located in this clarifier intermittently dose the PVC filter media bed with the wastewater.

In the Bioclere trickling filter the organic material in the wastewater is reduced by a population of microorganisms, which attach to the filter media and form a biological slime layer. Aerobic microorganisms accomplish treatment in the outer portion of the slime layer. As the microorganisms multiply the biological film thickens and diffused oxygen and organic substrate are consumed before penetrating the full depth of the slime layer. Consequently the biological film develops aerobic, anoxic and anaerobic zones.

Absent oxygen and a sufficient organic carbon source (CBOD5) the microorganisms near the media surface lose their ability to cling to the media. The wastewater flowing over the media washes the slime layer off the media and a new slime layer begins to form. This process of losing the slime layer is called “sloughing” and it is primarily a function of organic and hydraulic loading on the filter. This natural process allows a properly designed media bed to be self-purging and maintenance free.

The sloughed biomass settles to the bottom of the clarifier as sludge. This secondary sludge is periodically pumped back to the primary tank to enhance the digestion and denitrification processes, which is further discussed in ***Section 6.3.2 below.***

6.3.1 Bioclere Trickling Filter Dosing Rates:

The Bioclere uses two alternating dosing pumps to distribute wastewater over the trickling filter. It is critical to periodically clean the nozzles of excess biomass using a bottlebrush to ensure uniform distribution. The Bioclere dosing rates that were set at the time of commissioning are listed in ***Section 2.0*** of this manual. The dosing rates are set so that the flow of water and pollutants (CBOD5 and ammonium) over the biofilm are maximized. This in turn, will maximize the pollutant removal efficiencies and facilitate biomass sloughing through the filter. Therefore, it is **not necessary** to adjust the dosing timers. In fact, the dosing timers should only be adjusted if the Bioclere receives little or no flow for extended periods.

6.3.2 Bioclere Recirculation Rates:

Recirculation of sludge and treated effluent is accomplished in each unit using a submersible stainless steel pump controlled by a fully adjustable timer. The biological solids generated in the filter are returned to the sludge storage facility at regular intervals, typically every hour. Therefore, the sludge will not collect in the secondary settling tank and a sludge blanket will not form.

The benefits of sludge and treated effluent re-circulation are numerous and include: 1) removal of biological sludge from the Bioclere so that only the primary tank(s) need periodic pumping, 2) dilution of the influent pollutant concentrations, which results in a thinner and more effective biofilm on the media bed, 3) reduction or near elimination of odors in the primary tanks and the treatment components, 4) dilution of biological inhibitors (cleaning agent, sanitizers, etc.) that may exist in the wastewater, 5) attainment of nitrogen removal through denitrification due to the recirculation of nitrate to the primary tank.

The recirculation rates that were set at the time of commissioning are listed in ***Section 2.0*** of this manual. These rates may need adjusting depending on the 1) actual average daily flow, and 2) actual measured strength of the wastewater (concentrations of influent BOD5, TKN etc.). Please contact AQUAPOINT prior to adjusting the recirculation rates.

In a two stage Bioclere system the first unit is typically set to return only the biological sludge generated in the reduction of CBOD5. The second stage unit is set to run several minutes each hour to return biological sludge and treated effluent in order to maximize treatment efficiency.

6.4 PROCESS CONTROL for NITROGEN REMOVAL with the BIOCLERE SYSTEM (if applicable):

Below is a brief description of how nitrogen removal is accomplished in the Bioclere units. Generally BOD removal occurs in the first stage Bioclere unit and a majority of nitrification in the second stage Bioclere. However, if the actual wastewater flow is less than the design flow, signifigant nitrification will occur in the first stage Bioclere unit.

6.4.1 Nitrification:

Nitrification is the sequential biological oxidation of NH_4-N, first to nitrite (NO_2^--N) by *Nitrosomonas* bacteria then to nitrate (NO_3^--N) by *Nitrobacter* bacteria according to the following overall equation: **$2NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O$**

Oxidation of 1 mg/l of NH_4-N requires approximately 4.6 mg/l of dissolved oxygen and produces acid resulting in the consumption of approximately 7.1 mg alkalinity as $CaCO_3$/mg NH_4-N oxidized. Alkalinity is the inorganic carbon source nitrifying bacteria required to oxidize ammonia. ***Therefore it is critical that alkalinity is monitored on a regular basis to ensure complete nitrification.*** Alkalinity concentrations in the Bioclere effluent must remain above 75 mg/l as CaCO3 to allow nitrification to proceed. If the alkalinity drops below this value, it is likely that nitrification will be inhibited and the effluent will not meet permit requirements. It is best to measure the alkalinity in the Bioclere effluent using a field test kit each time you are onsite to inspect the treatment system. Bioclere effluent can be collected from the final pump chamber or the sampling port that is located on top of the Bioclere unit (see the Bioclere general arrangement drawing located in Appendix A for the sampling port location). The sampling port is a 4" diameter PVC pipe that extends approximately 10' through the trickling filter to the effluent in the clarifier. Effluent can be collected with a bailer.

Alkalinity is generally added in the form of baking soda (sodium bicarbonate). It can be purchased as a powder in 50-pound bags. A solution can be mixed using the alkalinity mixing setup that has been included with the treatment equipment. Solution dosing is accomplished using a variable speed Masterflex chemical feed pump, which is controlled with a timer in the Bioclere control panel. Dosing should be set to run several minutes each hour. For a detailed description of the chemical feed installation and operational requirements refer to the site plans and ***Appendix E*** of this manual. Contact Aquapoint if assistance is required to determine the alkalinity-dosing rate.

Please note that nitrifying bacteria require a stable and consistent environment because of their sensitivity to numerous inhibitory and toxic substances and an array of environmental factors including temperature, pH, dissolved oxygen, and alkalinity. If nitrification is not being achieved then it will be necessary to verify the influent average daily flow, pH, BOD5, TSS, TKN. It may also be necessary to conduct an inventory of the type and quantity of any and all cleaning and process solutions that are used that may impact the microorganisms in the Bioclere units.

6.4.2 Denitrification:

Dissimilating denitrification, the biological reduction of nitrate (NO_3^--N) to nitrite (NO_2^--N) and ultimately nitrogen gas in an anoxic environment (dissolved oxygen <0.5 mg/l), involves the transfer of electrons from a reduced electron donor (organic carbon substrate) to an oxidized electron acceptor (NO_3^--N). It is an important reaction as it restores approximately 3.57 mg alkalinity/mg of NO_3^--N reduced, and partially offsets the effects of nitrification in a combined nitrification/denitrification process. The microorganisms responsible for completing the reaction are facultative heterotrophic aerobes contained in the wastewater that are also responsible for $CBOD_5$ oxidation in the Bioclere.

Denitrification in the Bioclere system is accomplished by periodically recirculating secondary sludge and treated nitrified effluent to the septic tank which provides an anoxic environment. Recirculation typically occurs several minutes every hour via a timer in the control panel. See ***Section 2*** of this manual for Bioclere recycle and dosing rates. For typical residential strength wastewater, recirculation of treated effluent from the Bioclere to the septic tank will achieve <12 mg/l of total nitrogen. This is due to the fact that weight ratios of carbon to

nitrate, measured as **BOD:NO_3-N** in the influent wastewater are usually greater than the generally accepted ratio of **2:4** in which denitrification has been proven to proceed without an external carbon source such as methanol.

However, many commercial applications will require a carbon source such as methanol. If required, a carbon dosing rate of approximately 3:1 (COD carbon source: NO3 in wastewater) is required to complete denitrification.

Carbon is often added in the form of methanol or a 20% methanol solution. However many other organic carbon sources can be used including glucose (sugar), sodium acetate, soda syrup etc. If the carbon source is not purchased in pre-mixed drums, a solution can be made-up using the mixing setup that has been included with the treatment equipment. Carbon dosing is accomplished using a variable speed Masterflex chemical feed pump, which is controlled with a timer in the Bioclere control panel. Dosing should be set to run several minutes each hour. For a detailed description of the chemical feed installation and equipment operational requirements refer to the site plans and ***Appendix E*** of this manual. Contact Aquapoint if assistance is required to determine the carbon-dosing rate.

If the effluent dissolved oxygen concentrations from the anoxic reactor exceed 0.5 mg/l, denitrification may be inhibited. In isolated instances, this has been documented to occur during extreme cold weather periods. If this occurs, the Bioclere fan size can be reduced to compensate for the increased dissolved oxygen levels. If the condition persists, an oxygen scavenging agent can be dosed into the Post Equalization tank to uptake the residual dissolved oxygen. Please contact Aquapoint if this condition is experienced.

How do I know when a carbon source is needed?
You must monitor the nitrate in the septic tank effluent tee with a nitrate field test kit. When nitrate is consistently >3 mg/l in the septic tank effluent, it is necessary to add an organic carbon source to the influent side of the septic tank to achieve denitrification. You should also measure the dissolved oxygen. For denitrification to proceed a dissolved oxygen level of <0.5 mg/l is required in the septic tank effluent.