AFM®
ACTIVATED FILTER MEDIA

DRYDEN AQUA
SUSTAINABLE WATER QUALITY

AFM® Application In Aquaculture Systems

Refer to the AFM Information for Use document (IFU) for more details and AFM performance data



- Intake Water Systems
- Larvae & Culture Systems
- Hatchery Systems
- Brood Stock Systems
- Grow-out RAS
- Wastewater treatment
- Phosphate removal

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GENERAL - AFM® for use in Aquaculture Filtration Systems

Preamble

At Dryden Aqua, we believe in prevention rather than cure and our philosophy is to remove and eject as much organic contaminants as fast as possible, before they become a biological problem, needing post treatment to prevent algal proliferation or pathogen problems.

Source Water and Flow through systems

Water is never the same from any source. Different sources will contain different contaminants and, irrespective of contaminants, may have very different water chemistry. Filtration of incoming water is key to the biosecurity of any aquaculture facility. The bio-resistance, mechanical filtration performance and long term stability of AFM® media offers a simple treatment solution for a large proportion of incoming water filtration challenges. AFM® is not however the answer to all problems and, a knowledge of the incoming water chemistry is necessary in order to specify any complementary treatment that might offer e.g. high load TSS reduction, viral protection or, the ability to remove heavy metal contaminants.

Recirculation Systems

Many RAS schematics and filtration practices have evolved over decades to overcome inherent system's weaknesses. In different countries these have evolved in different directions and, in many cases have become part of a design culture. The fact that these have evolved in different ways in different continents demonstrates that there are a number of approaches to filtration of aquaculture water that can work and different species require different methods. The schematics that feature in this document should therefore be used for guidance only, in the knowledge that other approaches are possible.

AFM® can also offer significant advantages by reducing oxidation demand throughout the entire system resulting in better pH stability and, vast reductions in oxygen demand.

AFM® cannot substitute for biofiltration but, if correctly used, its efficiency in organics removal will substantially reduce the load on biofilters, allowing for smaller biofilters to be installed or higher stocking densities for the same systems. It will also significantly reduce oxidation demand, with consequent reductions in oxygen input and ozone demand.

As a result of AFM®'s filtration finesse, it is also possible to substantially reduce the turnover rates that have traditionally been applied in RAS, in certain scenarios, and to benefit from substantial energy savings.

Backwash velocity is the key to performance of any media filter and AFM® will provide a significant performance advantage over sand or non-activated crushed glass media. Even in systems where backwash flows are compromised AFM will still perform substantially better than all other media, but it will not perform as to full potential.

N.B. Media layering can be tailored to your specific system. All recommendation in this document are generalised to the standard LSS systems we have encountered world wide. If you have a specific challenge, we are more than happy to help you determine the best layering for your systems requirements.

Throughout this document we reference our AFM IFU as the source of detailed information on use of AFM. These documents can be found at:

- Metric version: https://www.drydenaqua.com/downloads/files/1005-afm-instructions-2023-metric/file
- Imperial version: https://www.drydenaqua.com/downloads/files/1879-afm-instructions-for-use-v23-4-imperial/file



Applications & Benefits of AFM® use in Aquaculture

AFM® will not support bacterial growth thereby improving pH stability

Sand filters are enclosed vessels and the available oxygen in the circulating water is insufficient to satisfy the needs of the autotrophic bacterial nitrification process. Available oxygen is consumed and, a reduction in pH is therefore inevitable. This initial reduction in pH then triggers a cascade effect that results in anaerobia in the filter bed and colonisation by unhealthy heterotrophs that exert even further downward pressure on pH. This process may take 3 to 6 months (depending on temperature and load) before it starts to impact on system performance but, it is inevitable in any sand filter.

With AFM's resitenace to bacteria growth, bacteria cannot settle and as long as our backwash protocols are respected, there is no colonisation of the filter, no biofilm development, no increase in oxygen demand, and no pressure on pH.

Reduced water consumption during backwash

Due to sand's density and the biological fouling that takes place in a sand filter, backwash flows of 50 to 60m/h ($m^3/m^2/h$) are required to effectively fluidise any sand bed to evacuate material trapped during the filtration phase. However, even at these flows, research has shown that a maximum of only 77% waste evacuation from the surface layers is achieved (Assessment methodology of backwash in pressurised sand filters, Fábio P. de Deus et.al.). To achieve a 15% bed expansion, as required to effectively remove the 77% debris levels, a flow of 70m/h is required (Study of the performance of Rapid sand filters after backwashing by Raw Water, Ahmed Fadel, et al.). Bacterial settlement is quickly followed by biofilm development which binds sand grains and prevents effective backwashing.

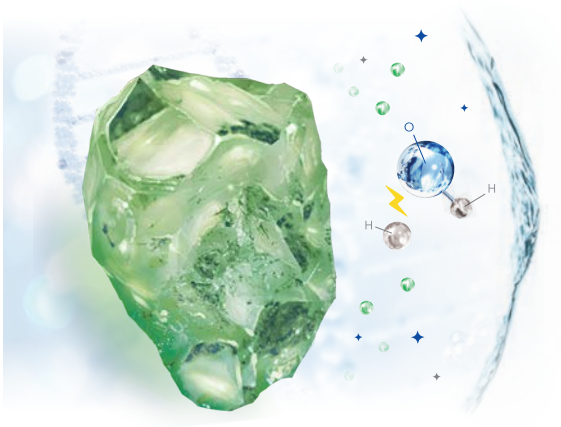
AFM® is less dense than sand and is bio-resistant. No bacteria => no biofilm => the media remains fluid => more efficient evacuation of >95% of particles during backwash. This is achieved with as little as 50% of the water required to backwash sand.

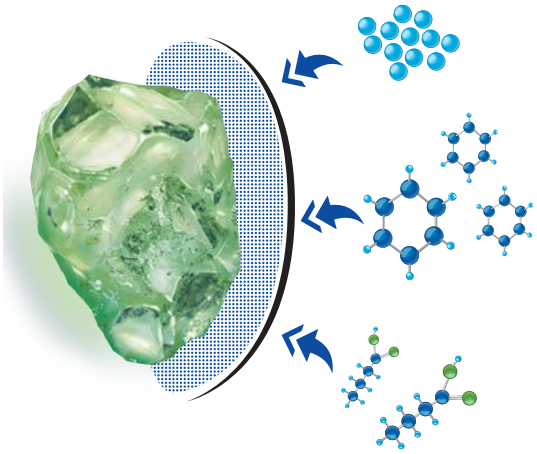
For many systems, especially in closed systems where salt is lost in backwash, Backwash water savings result in substantial water and salt cost savings.

Reduced energy consumption

As media bed filters start to capture particulates, the pressure differential between inlet and outlet increases, and this differential results in an increased energy consumption. AFM® captures particles not only by mechanical entrapment, but also by loose electrostatic and Hydrophobic adhesion of particles to the glass surface. As a result, filtered particles are retained throughout the bed and there is less pressure loss, while achieving more filtration of fines. The absence of biofilm and resultant clogging ensures that the pressure differential range remains consistent throughout AFM®'s 15 to 20 year lifespan.

Typical sand filter pressure loss throughout the run phase will be 0.3 - 1 Bar. This compares with 0.2 - 0.5 Bar max for AFM®.This equates an extra 2 - 3m of head and a substantial annual running cost. Pressure loss will also increase dramatically once sand media starts to clog.





Doubling the pressure quadruples the energy consumption!

To show our dedication to sustainability, we practice what we preach! AFM is made using wholly sustainability practices:

AFM® is manufactured from 100% recycled bottle glass from the region



Waste (metal, paper, plastic) and non-target product (flint glass, CSP, fines) are separated and recycled or used in other industries. Sludge is responsibly disposed of (incinerator)

The production process is 100% energy and water self-sufficient, using rainwater in a closed-loop filtration system and up to 850,000 kWh self-generated solar power per year

Once AFM® has reached its end of life, it can be returned to the Dryden Aqua factory where it will undergo the same process of cleaning and decontamination and is re-manufactured into new AFM®

Raw material in



AFM out



AFM® for parasite reduction in Systems

Introduction

Aquaculture installations around the world are often plagued by virus and parasite problems. Treatment can be difficult and often requiring vaccination either by hand or automated methods, both of which are costly exercises.

Disease or parasite outbreaks often result from stress factors which mostly often due to water quality related issues resulting from a range of factors, however, most of these factors start with poor organics removal from the systems. Efficient and effective particulate organics removal forms the basis of ensuring all the other components are able to focus on the aspects they are particularly designed to do.

Disease or parasite problems are often exacerbated by anaerobic zones in biofilters, due to high sludge generation and poor removal protocols. The excess sludge is as a result of the biofilter acting as an organics filter first and then as a nitrification site. Many viruses and parasites relish the low pH and DO zones of the sludge as a primary breeding site in the system.

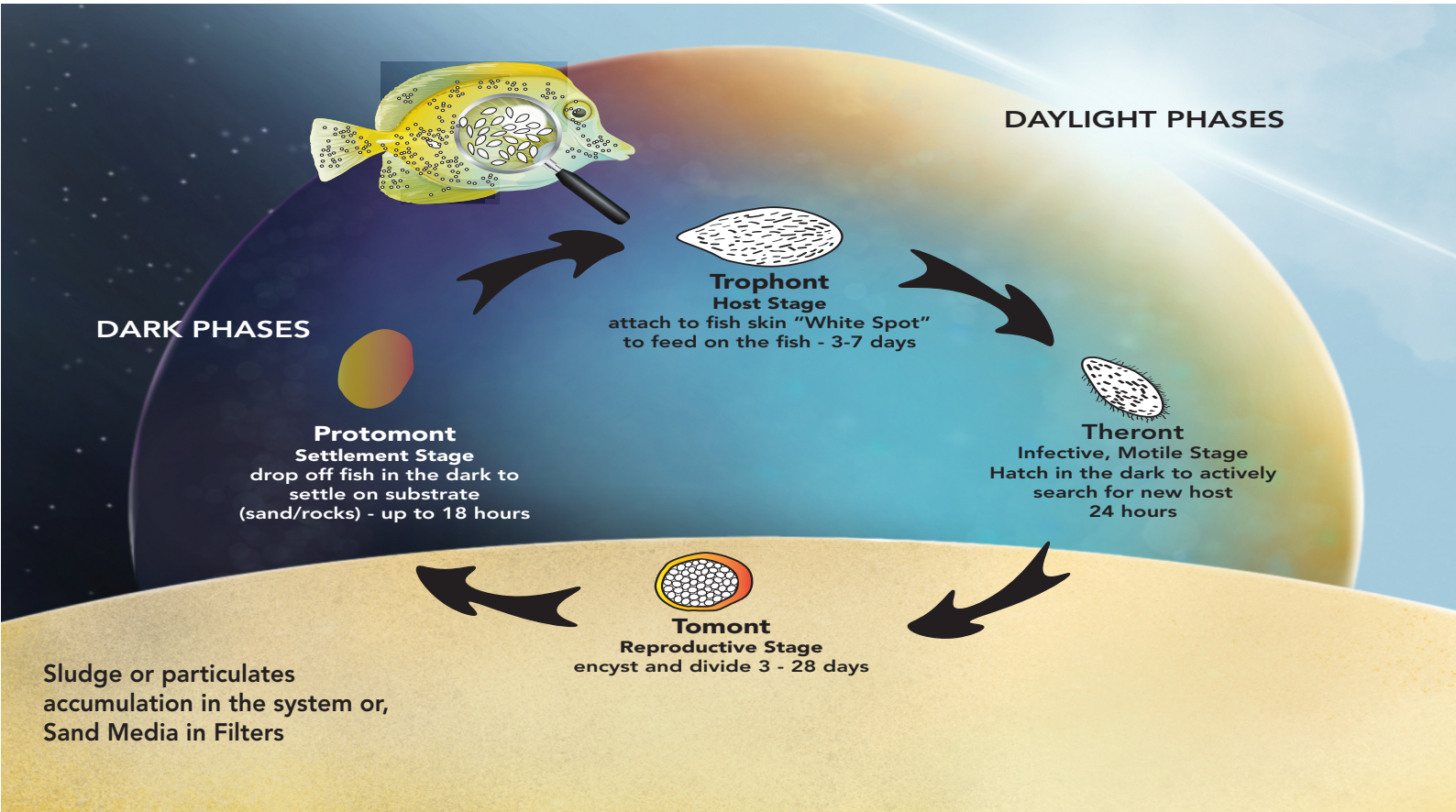
Dryden Aqua's philosophy is to treat the problem at source. AFM® is bio-resistant and will not support biological growth. As long as standard backwash protocols are respected, bacteria and pathogens cannot colonise the media and this source of perpetuation of infections is eliminated. The lack of bacteria and biofilm in the filter also ensures that primary protection is afforded, as filtration quality is both better (1 micron) and more stable, while preventing the accumulation of particulates in other areas of the system.

If infected fish are introduced into a system or, if other factors are driving infection rates, then AFM®ng's 1 micron filtration will reduce the parasite load by removing free swimming stages in parasite life cycles, such as the Theront stage of the Cryptocaryon life cycle.

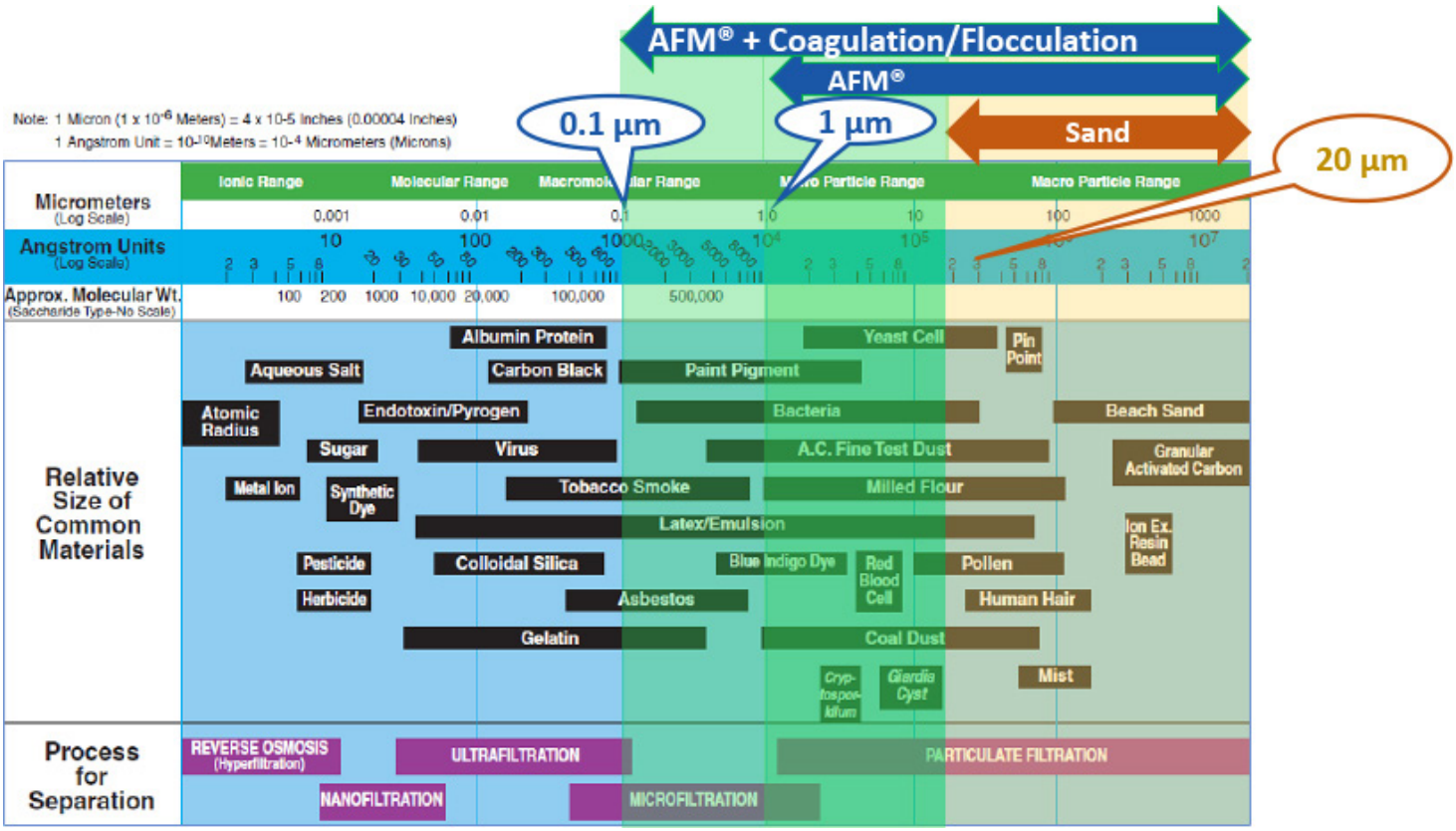
1 micron filtration with AFM® will easily and consistently remove the vast majority of motile or suspended bacteria and parasites in each filtration cycle. As AFM® is bio-resistant, the media will not support the subsequent growth and proliferation of sedentary or encysted forms, such as the Tomont stage of Cryptocaryon or Vibrio spp., that would otherwise colonise the filter. Proliferation of bacteria within an AFM® filter is limited by the bacteria's inability to attach to the AFM® grains and by their periodic evacuation in backwash water.

For example: Cryptocaryon life cycle

- AFM®ng's 1µ filtration will filter out all motile stages in the Cryptocaryon life cycle
- AFM® will not support bacterial growth and will not become a source of pathology via the Tomont, reproductive stage



The graphic below shows the particles size ranges of a various materials and the effective filtration to the 95% performances efficiencies.



AFM® application in RAS for Aquaculture - Summary

Application Type	Associated Processes	AFM® Type and Grades	AFM Flow %	Typical filtration velocity m/h Min/Max		Reduction %

Intake Systems
See: Application for use Intake systems
	• Heavy algal loads
	  • Drum filtration
	  • Cyclone separators
	  • Coagulation & Settlement tank
	• Metals removal
	  • Pre-aeration step - See IFU
	  • Coagulation/ Flocculation
	  • N.B. Only Aquaculture specific coagulants to be used
	• Post filtration UV
	• Temperature control
		• 150mm Anthracite
		• AFM®ng Grade 1 - 70% of remaining media depth
		• AFM®ng Grade 2 - 30% of remaining media depth
		• AFM®s Grade 3 to top of laterals
		• If TSS is greater than 20mg/l, include a 100mm layer and Anthracite N (0.8 to 1.6mm)
			100		<15	95%

Larvae/Food culture	• Alkalinity & Hardness >150 & <300
	• Make-up water filtered through AFM
	• Post filtration of 1microns
	  • Bag filters
	  • Cartridge filters
	• Post filtration UV
			100	5	20	95%

Brood Stock	• Alkalinity & Hardness >150 & <300
	• Large particulate removal
	  • Drum filters
	  • Cyclone separators
	  • Settlers/sedimentaion
	• Protein Skimmers
	• Biological filtration
	  • Trickling
	  • Moving Bed
	  • Reverse flow media
	• CO_2 degassing
	• Media filtration
	• Post filtration UV
	• Oxygen supplementation
	• Temperature control
		• AFM®ng Grade 1 - 80% of remaining media depth
		• AFM®ng Grade 2 - 20% of remaining media depth
		• AFM®s Grade 3 to top of laterals
			100	10	30	95%

Application Type	Associated Processes	AFM® Type and Grades	AFM Flow %	Typical filtration velocity m/h Min/Max		Reduction %

RAS/grow-out	• Alkalinity & Hardness >150 & <300
	• Large particulate removal
	  • Drum filters
	  • Cyclone separators
	  • Settlers/sedimentation
	• Side-loop Media filtration
	• Protein Skimmers
	• Biological filtration
	  • Trickling
	  • Moving Bed
	  • Reverse flow media
	• CO_2 degassing
	• Ozonation
	• Post filtration UV
	• Oxygen supplementation
	• Post filtration UV
	• Temperature control
		• 150mm Anthracite
		• AFM®ng grade 1 - 80% of remaining media depth
		• AFM®ng grade 2 - 20% of remaining media depth
		• AFM®s grade 3 to top of laterals
			10 - 20	10	15	95

Waste and Backwash water	• Large particulate removal
	  • Drum filters
	  • Cyclone separators
	  • Settlers
	• Belt filter with Coagulation & Flocculation
	• Media Filtration
	  • For reuse
	  • for backwash water
	  • To waste
	• Temperature control
			100	-	15	95

Points To Consider Sections

The points below are to be taken into account when defining a system specification or when it is planned to upgrade a system. They are meant as a guide in ensuring that the filtration/particulates removal performance is as good as possible, thereby ensuring that the rest of the system can perform as efficiently as possible. As there are so many different design options, the drawings below are meant as indications of what can be done and do not try to cover all the different options.

N.B.
Alkalinity and Hardness are important factors in filtration of particulates regardless of the media being used. We therefore recommend that the alkalinity and hardness are monitored and levels are maintained as per the below ranges to ensure the best filtration performance of fine particulates:

Alkalinity: 80 - 150mg/l
Hardness: 80 - 150mg/l

Levels of alkalinity and hardness below 40mg/l will have a large effect on filtration performance. This is due to the particulates being colloidal in nature with the result that they remain dispersed rather than binding together. In many fish farms the hardness is already buffered by the ingredients in the feed, but often the alkalinity can be low.

Please also note that metabolic activity will exert an alkalinity demand. It is therefore good practise to monnitor alkalinnity and to re-balance as nescessary by dosing sodium carbonate.

All Systems - Points to consider

- Particle size distribution is an important factor to considered, as components selection should be determined with this information in mind. i.e. Drum filters are useless if particles sizes are mostly below 30 micron in size.
- It is important to know what the TSS inputs are into any portion of the system.
- TSS levels between 30mg/l and 100mg/l require additional substrate (our recommendation is Anthracite N) to remove the large particulate while leaving the AFM to focus on the fines removal.
- High TSS levels > 100mg/l should be pre-treated to reduce the levels to <30mg/l or backwash frequency could be too high. However, these options are very dependant on the particles size range in your incoming water. Some possible options are:
    - Drum filters - tend to create fines due to facilities running them faster than they should or from the violent spray down mechanism resulting in higher particular load on the biological filtration.
    - Belt filters - better than drum filters but handle a lower flow rate so size and space is a concern.
    - Sedimentation - needs a lot of space for settlement chambers.
    - Cyclone separators - Best option depending on particle sizes and weights <1 min settlement time preferable
- The coarse filtration is good for >50 microns removal while protein skimmers are good for <5 microns removal. This leaves a gap in particles sizes between 5 to 50 microns removal and this is caught in the biological filtration, resulting in higher DO demands, large volume biological filters being required and larger fluctuations in alkalinity needing to be stabilised, while also increasing the overall sludge content in the system that needs maintenance/removal. Biological filters are not designed to handle particulate loads and removal of the particulates between these ranges will dramatically improve the performance of the biological filters, while reducing the DO demand, fluctuations in alkalinity and far less residual sludge needing removal.
- Very fine particulate removal can be achieved with coagulations and flocculation, resulting in 0.1 micron particle removal efficiencies. Only aquaculture certified coagulants and flocculants should be used or none at all.
- Aquaculture's soft organics often need slower filtration velocities than those specified by components normal operational ranges so soft organics are often forced through the screens or won't settle. Often this results in the creation of fines rather than the large particles being removed.

Media filtration

Please refer to the AFM IFU for the details on the below recommendations.

- Filtration velocities should not be higher than 15m/h ($m^3/h/m^2$)
- Backwash velocities should never be lower than 40m/h

- Always have a flowmeter installed so you can verify the flows
- Backwashing should be done at a pressure differential across the bed of 0.5bar
- Always have pressure gauges installed that can inform of the pressure differentials across each filter

Benefit of the use of AFM in these systems:

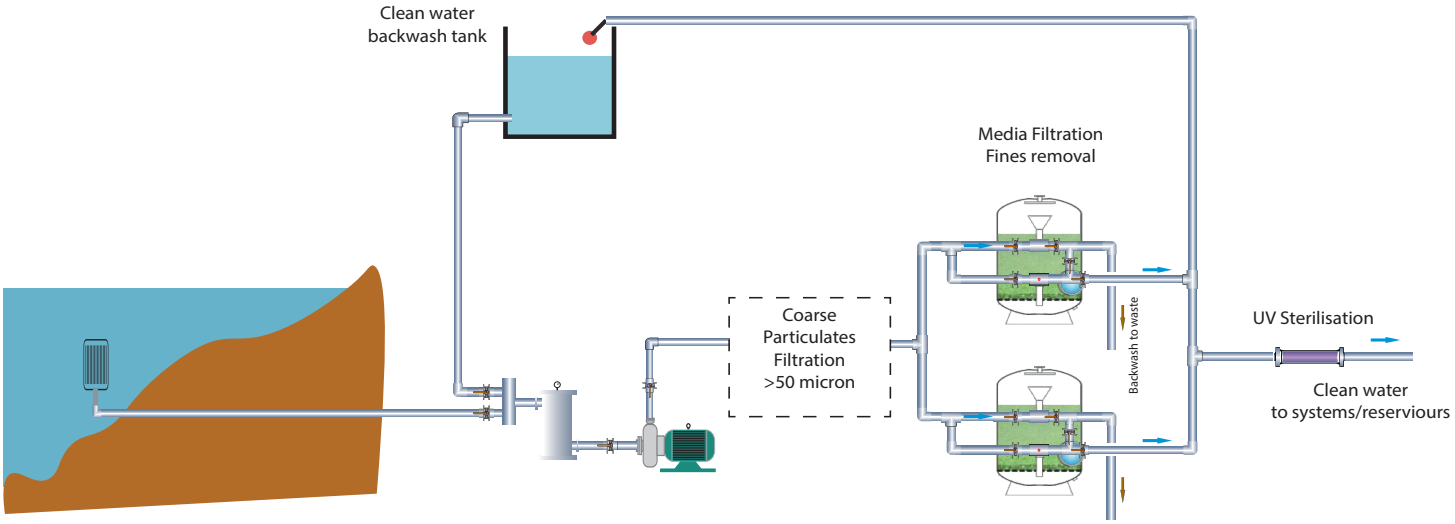
- High removal of Organic particulates
- Reduced load on the biological filters therefore reduced sludge production
- More efficient biological filters
- Increased pH stability
- Reduced Alkalinity buffering required
- Reduced nitrate build-up
- Less water exchange required
- Parasite reduction as the free swimming stage is filtered out continually
- With a well balanced system (all components working efficiently at what they are designed to do) and good organics particulates removal can lead to higher stocking densities being achieved.

AFM® for Intake Systems

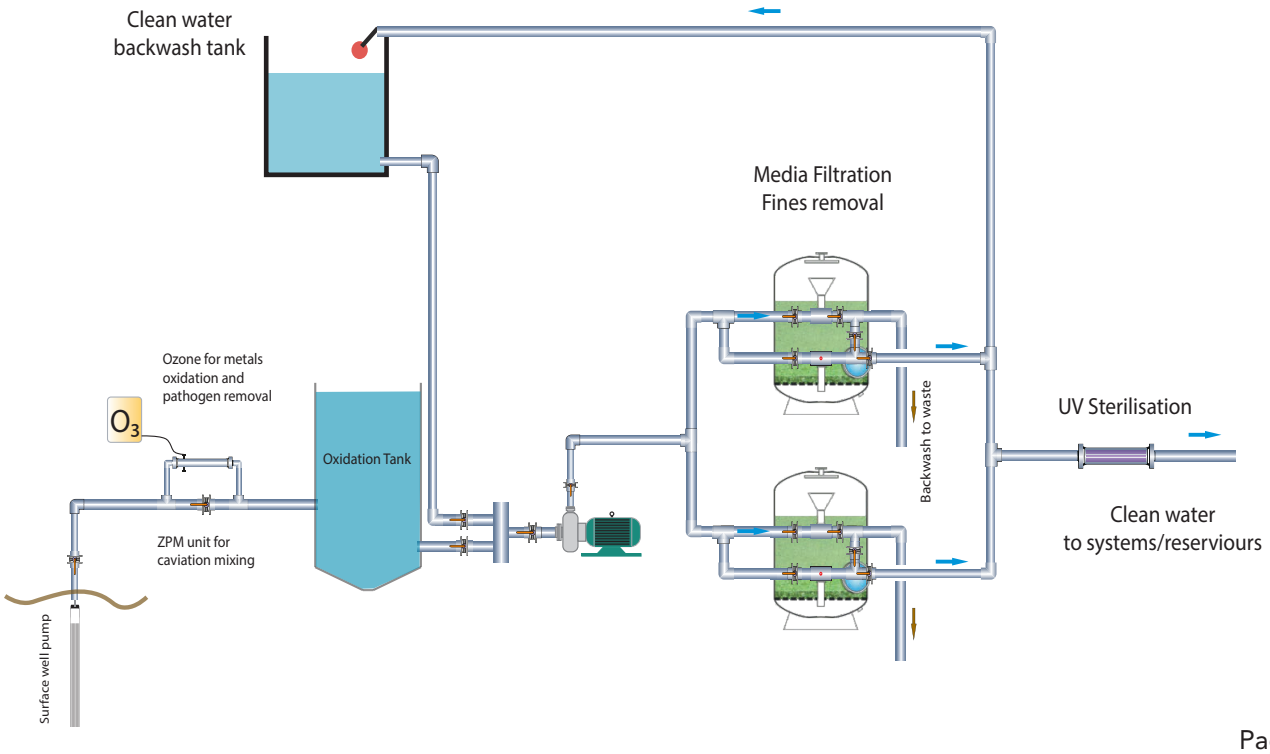
Points to consider

- Consider the water quality variables from the worst case scenario - storm surges or algal blooms.
- The inclusion of Anthracite N is generally recommend for heavily loaded intakes systems due to the possibility of seasonal/weather driven higher TSS loads.
- In the case of heavy metals in the incoming water, these can be removed if a pre-oxidation step is included - Refer to AFM IFU pg 33.
- Recommended post fines filtration - UV to ensure there are no residual parasite or virus coming into the system.

Aquaculture General intake water system



Aquaculture Well intake water system

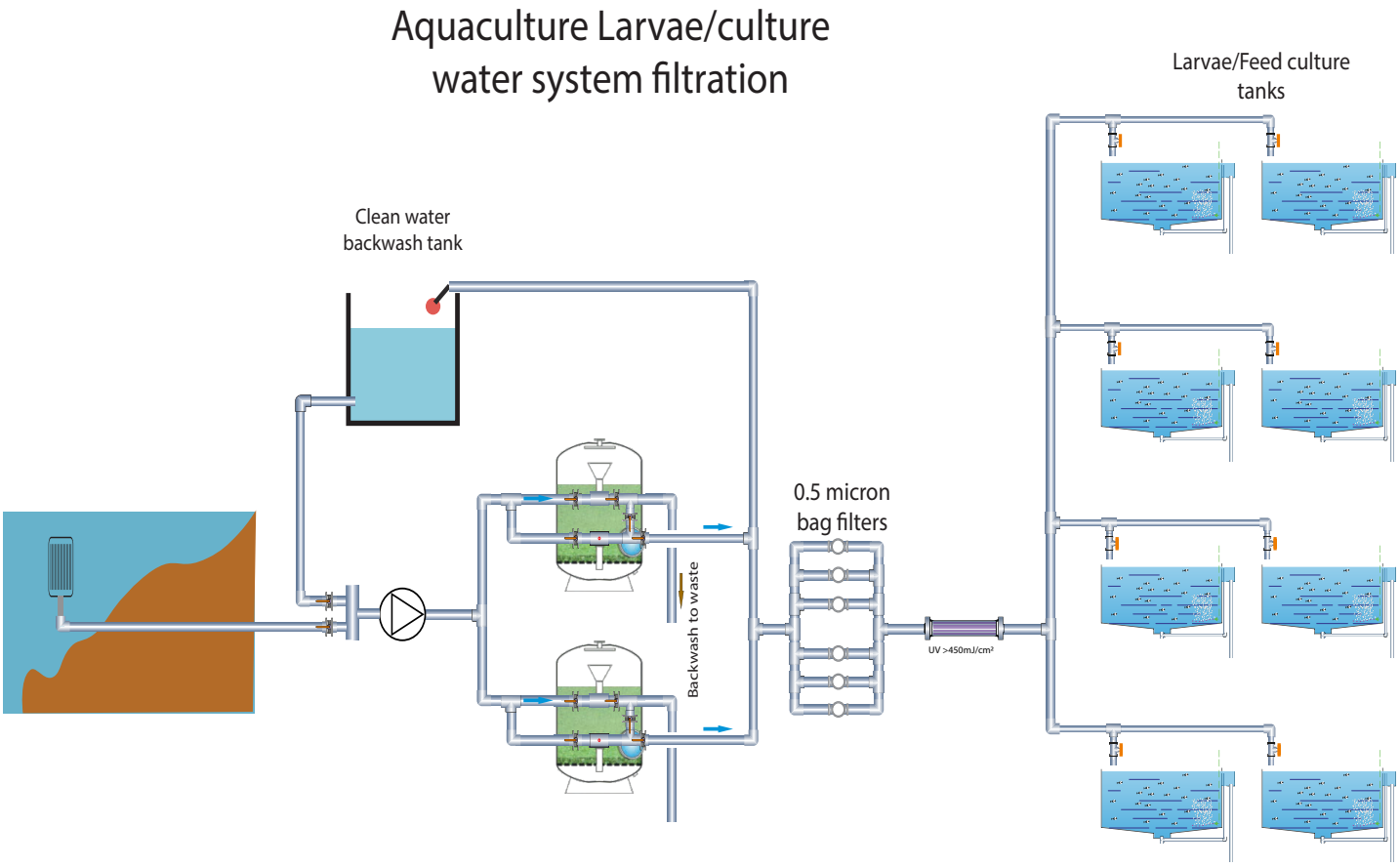


AFM® for Larvae/Culture Systems



Points to consider

- Generally these systems have intermittent flow-through water inlet, timed according to feeding cycles or very slow continuous flow make-up. Therefore the quality of the incoming water should be as good as possible.
- If incoming water is filtered by AFM, then we recommend an additional 0.5 micron cartridge/bag filter before a UV component.
- If the incoming water is not filtered by AFM, add a AFM filter in the feed to the Larval rearing area and follow the above point thereafter.
- Waste water from larval rearing can be filtered through AFM, 0.5 micron cartridge/bags, UV and then reused in the hatchery systems.

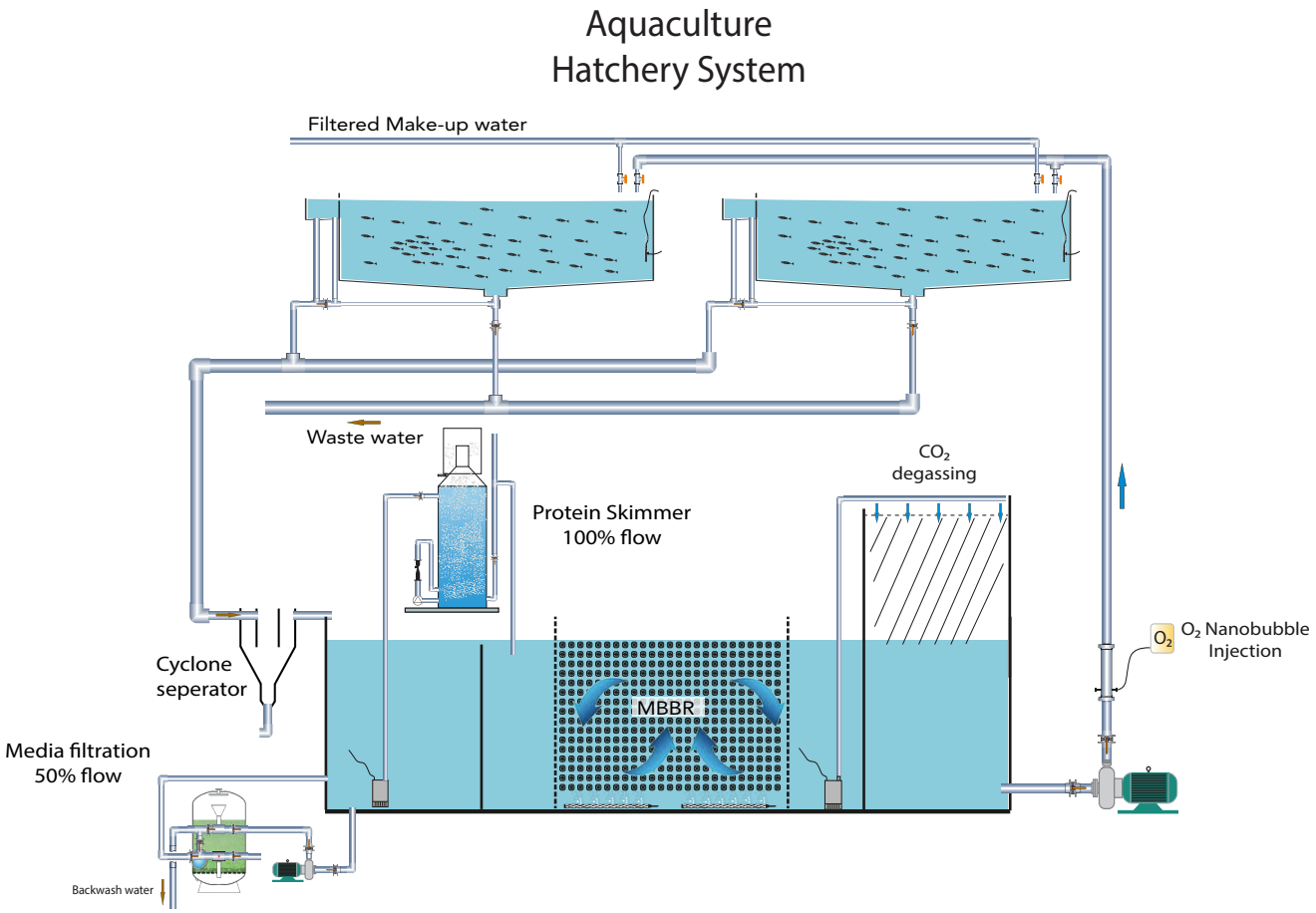


AFM® for Hatchery Systems



Points to consider

- Consider the water quality variables from the worst case scenario - i.e. highest bioload at the end of the growth cycle.
- Media filtration in a side loop of 50% flow can improve the overall system water quality and reduce the manual maintenance requirements on the system, while providing reduced pathogenic and parasitic problems in the system.
- Some facilities combine this with 100% flow through the protein skimmers thereafter and before the biofiltration component.

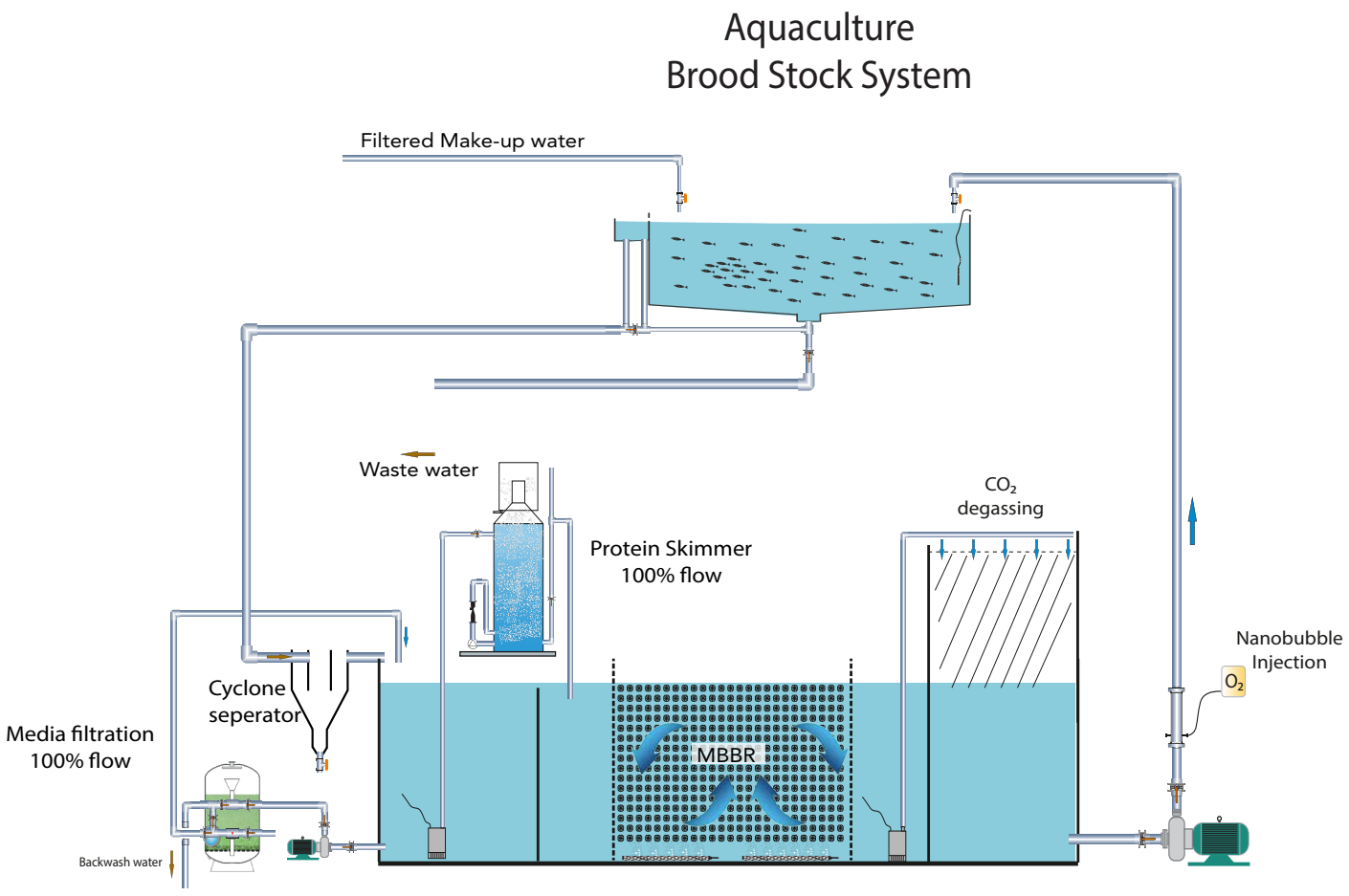


AFM® for Brood Stock Systems



Points to consider

- Brood stock systems are generally the lowest load systems, but often the most valuable to the farm. To ensure the viability of the stock and consistent spawning events, it is vital that the water quality remain as good and stable as possible.
- Unplanned stress should be avoided and being put onto the fish as possible.
- Media filtration of 100% flow can improve the overall system water quality and reduce the manual maintenance requirements on the system, while providing reduced pathogenic and parasitic problems in the system.
- Aeration in the tank is often adequate for oxygen supply and can be used to ensure surface water contaminants are guided to the overflows.



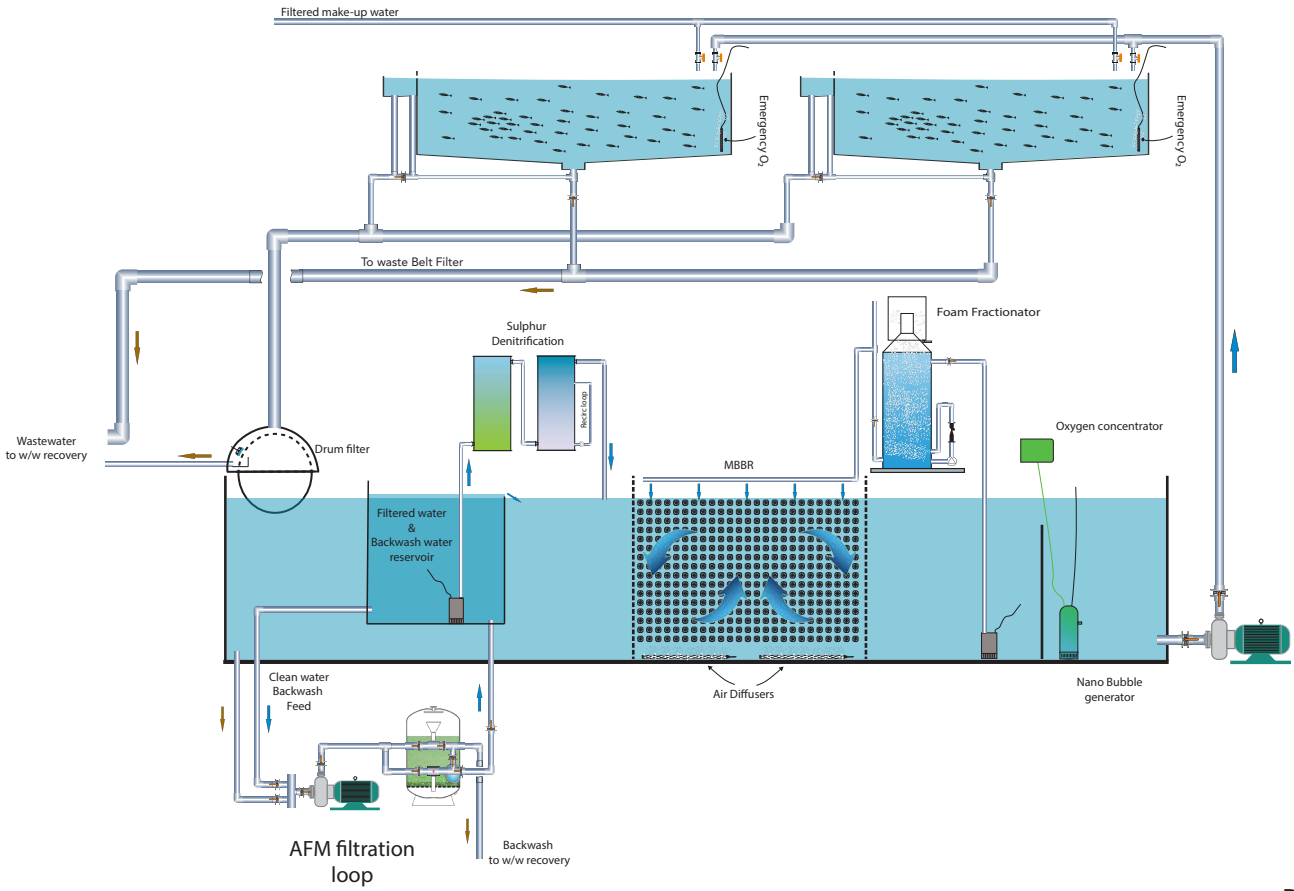
AFM® for Grow-out Systems



Points to consider

- Consider the water quality variables from the worst case scenario - highest bioload at the end of the growth cycle.
- These systems are often the most affected by the lack in removal of the particles sizes between 5 and 50 microns and therefore the increased DO demand and management of sludge removal in the biological filters. Removal of the particulates between these ranges will dramatically improve the performance of the biological filters, while reducing the DO demand, fluctuations in alkalinity and far less residual sludge needing removal.
- Therefore it is recommended that media filtration in a side loop flow of 10 - 20% will improve the overall system water quality and reduce the manual maintenance requirements on the system, while providing reduced pathogenic and parasitic problems in the system. 100% flow through media filters would be the ideal solution, but space and energy consumption requirements make this currently un-economical.
- The addition of a denitrification component as part of the RAS will help reduce the nitrogen removal requirements in the final wastewater treatment system.

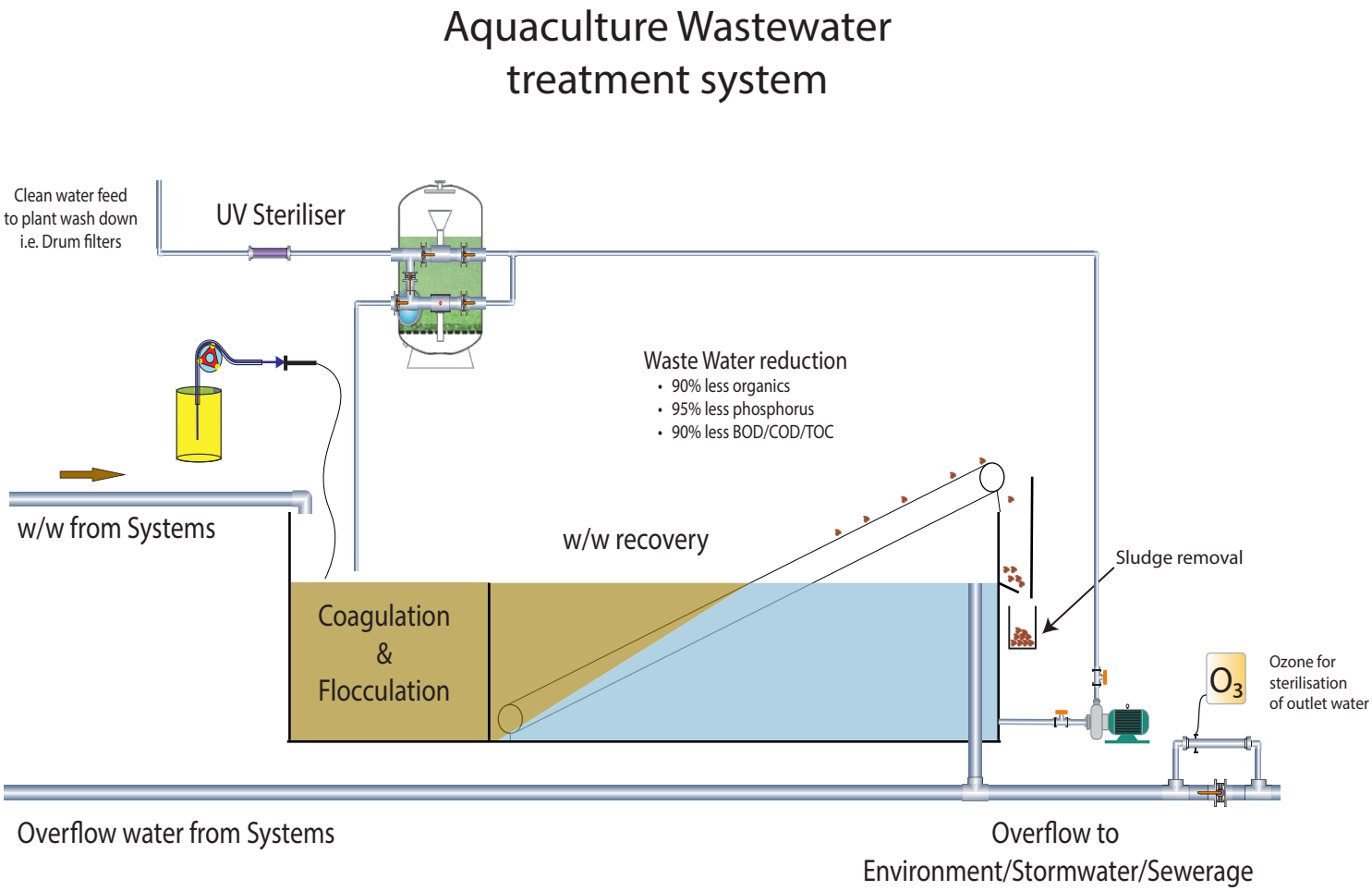
Aquaculture Grow-out
Filtration System



AFM® for Waste Water Systems

Points to consider

- Waste water quality requirements is becoming more and more prevalent around the world; with legislation already in place or legal frameworks in motion. This requirements will drive a higher and higher requirements for outlet water to be thoroughly cleaned and sterilised.
- Consider the water quality variables from the worst case scenario - highest bioload from all site applications/ water users.
- Design criteria to include TSS/BOD/COD/TOC/Nitrogen/Phosphorus removal to local waste water standards.
- A belt filter is generally used in this application due to its ability to remove TSS and TDS by using coagulants and flocculants. The effluent water is then within acceptable ranges for release into the environment or in the event that there are high nitrate levels, post nitrogen removal methods can be applied i.e. planted ponds etc.
- The effluent water can also be used for the facilities wash-down and flushing systems if it is filtered by AFM and sterilised by UV thereafter.
- If denitrification systems are included in the RAS, generally the nitrate levels are sufficiently low to allow for release directly into the environment.



AFM® for Phosphate Removal

Total phosphate analyses include phosphates in three forms;

1. Soluble reactive phosphate is referred to as free phosphates or orthophosphates.
2. Organic phosphates are found in plankton, algae and bacterial cell biomass.
3. Inorganic phosphates bound up in rocks and minerals or, compounds such as struvite.



Total phosphate can be analysed by wet chemistry in the lab but it is difficult to analyse in the field.

Orthophosphates are easily analysed in the field, but are literally only the tip of the iceberg. Organic phosphates are contained within the mitochondria of all cells and fuel the mechanism (ADP <=> ATP) for nutrient transport across cell membranes. All algae, bacteria and animal feed therefore contain phosphates. Oxidation or UV lysis of cell membranes will therefore simply release bound organic phosphates into the water as free orthophosphates.

In view of the above, any strategy for phosphates control must include both effective filtration and removal of organics, as well as control of free phosphates.

Points to consider:

- "Mature" sand filters will perpetuate rather than reduce phosphate levels, as biological activity in sand filters is uncontrolled and bacterial cell biomass increases over time.
- Aggressive use of ozone for sterilisation rather than flocculation will liberate organic phosphates into solution.
- UV irradiation will lyse algal and bacterial cells with the same effect.
- AFM®ng will provide stable filtration of 95% of particles >1µ and will remove a huge proportion of the organic phosphates that might otherwise be transformed into free phosphates.
- When coupled with pre-coagulation and flocculation, filtration efficiency can be further improved to 0.1µ.

In summary, prevention is better than cure and phosphates management starts by efficient cropping of organics by good AFM® filtration.

Water treatment to remove Orthophosphates

AFM® provides a sustainable and efficient primary means of removing phosphate from wastewater.

Animal systems can also have high phosphates input from the feed. AFM® filtration will efficiently remove bound phosphates from most sources but, will not, on its own, remove free phosphates from solution.

Chemical coagulation can, however, be used in conjunction with AFM® for removal of orthophosphates from the water. For animal systems, we recommend the use of our NoPhos product, which is lanthanum chloride based and can even be safely used with corals, so there is no safety concerns using it in mammals systems. The lanthanum chloride binds the phosphate into lanthanum phosphate extremely efficiently, making is removal by AFM a simple task, however if used in filters systems with sand media, the lanthanum phosphate will quickly bind up the sand into a concrete like block, making filtration impossible.



At Dryden Aqua we have been using Lanthanum salts (NoPhos) to remove phosphate in the aquarium and aquaculture industries for over 20 years. Lanthanum chloride is dosed into the water at a 1:1 stoichiometric ratio to bind free phosphates as lanthanum phosphate. 10ml of NoPhos will remove 1 g of phosphates. NoPhos should be dosed by dosing pump into the water prior to the AFM® filters using an aggressive cavitating static mixer such as a Dryden Aqua ZPM or dosing just before the pump, this ensures maximum efficiency in coagulation and the most economic use of NoPhos. The process is simple, reliable and sustainable when Lanthanum chloride (NoPhos) is used.

Ferric chloride is sometimes used, but is less efficient than lanthanum. The oxidation, by aeration, of ferric to ferrous will ensure coagulation of iron for more efficient removal by AFM® and will eliminate the risk of iron breakthrough.

Both Lanthanum and Ferric phosphates will rapidly clog any sand filter. As long as backwash protocols are respected with a slightly higher 45m/h backwash velocity for iron/phosphates removal, then AFM® will never clog.

The New AFM® factory in Switzerland







DrydenAqua.com