BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

I HAVE A NITROGEN STANDARD, SO WHICH TECHNOLOGY SHOULD I USE?

PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

TN Design Parameters

- **Influent Concentration**
  - USEPA indicates a range of influent TKN from 26 to 75 mg/l while sampling of single house systems has found TKN levels of up to 120 mg/l - some states have a design requirement of 100 mg/l for on-site systems

- **Influent source**
  - Offices & schools high ammonia – low organics
  - Campsites & holiday homes – seasonal use - long periods of no flow
  - Restaurants – high BOD & FOG
  - Commercial / Industrial – inhibitory substances
  - Phased construction – potential carbon deficiency

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

TN Design Parameters

- **Project Design**
  - Permit requirements – % reduction or mg/l, grab or composite sample – absolute spot, average or %ile treatment standards
  - Design max daily flow & peak hourly flows – equalization tank
  - Consider the complexity of O&M and who will manage
  - Footprint, Sludge, Visual impact, Noise & Odor

- **Process Design**
  - Need to remove the BOD load first to allow the nitrifiers to dominate
  - Sufficient Hydraulic retention time & oxygen to nitrify the wastewater
  - Temperature – low <10 C affects biological activity, high requires a greater oxygen input
  - Alkalinity, 7.14 mg consumed per mg ammonia removed (recirculation will recover half alkalinity lost)
  - Sufficient carbon to denitrify - 2.72 mg BOD5 are required per mg of NO3-N removed
  - Anoxic tank to reduce DO to < 0.5 mg/l and allow denitrifying bacteria sufficient hydraulic retention time

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Nitrogen Reduction

– **Nitrification process** - aerobic

Ammonia —Nitrosomonas→ Nitrite

Nitrite —Nitrobacter→ Nitrate

– **Denitrification process** - anoxic

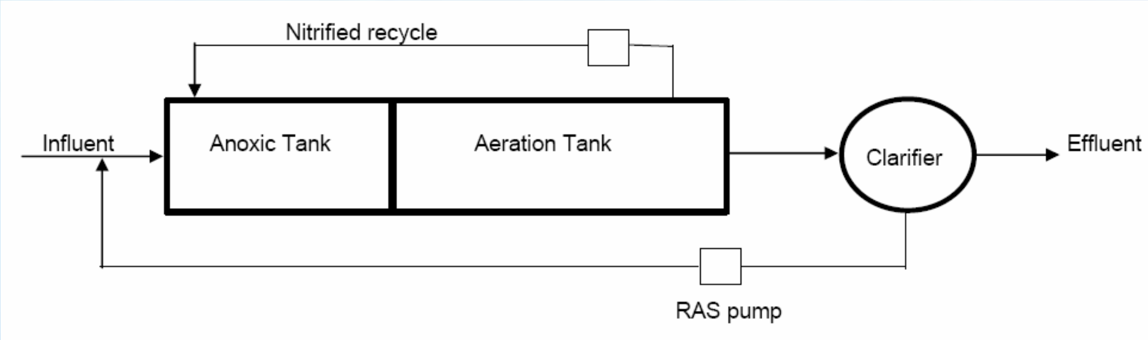
Nitrate → $N_2+CO_2+H_20$

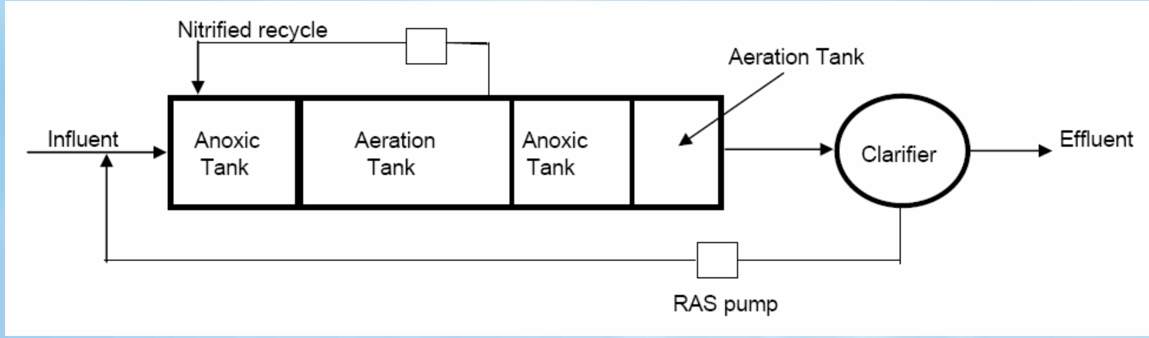
BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Suspended Growth Activated Sludge (ATUs)

Recirculation

Suspended growth activated sludge





- BOD reduction and nitrification in aerated reactor(s) with the nitrified effluent recirculated to an anoxic reactor typically at rates of up to 400% of the influent flowrate

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Suspended growth activated sludge using recirculation

- **Advantages include**
- Relatively simple and cost effective
- No requirement for supplemental carbon addition
- Recirculation allows recovery of alkalinity

- **Limitations**
- Carbon source is dependant on the influent (variable @ lower flows)
- Relatively large tank sizes required to maintain hydraulic retention time
- High strength TKN or tight permit standards requiring recirculation > 4-6 Q can become limiting
- Recirculation only provides a % reduction of the influent load
- Equalization tank required to maintain the nitrifiers in the aeration stage
- Poor performance for intermittent flows
- Pump limitations for low flows
- Reliance on a clarifier

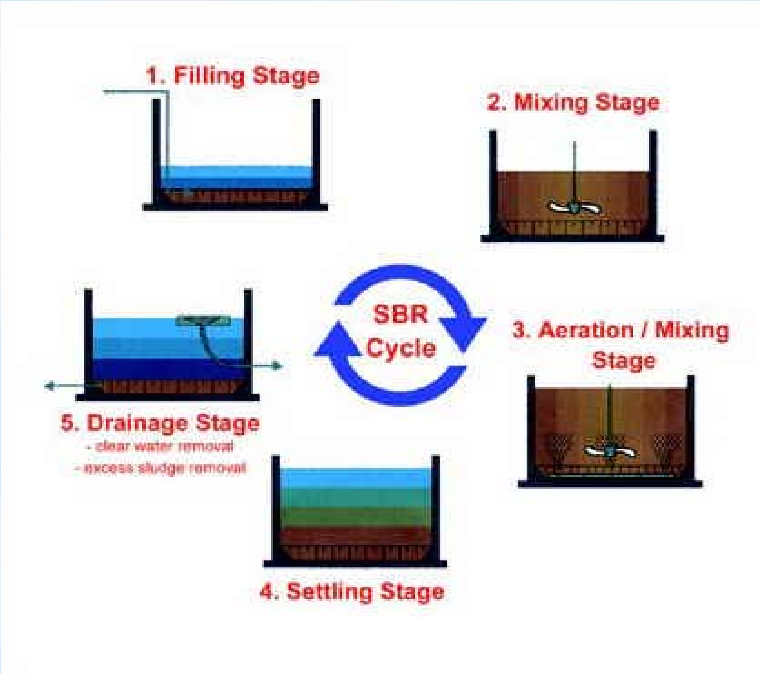
BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Sequencing Batch Reactor (SBR)

- The influent is batched and aeration and settlement is undertaken in the same tank

- Nitrogen reduction by increasing aeration for nitrification and adding an anoxic phase onto the batching cycle by turning the air off

- Effectively handles varying flows



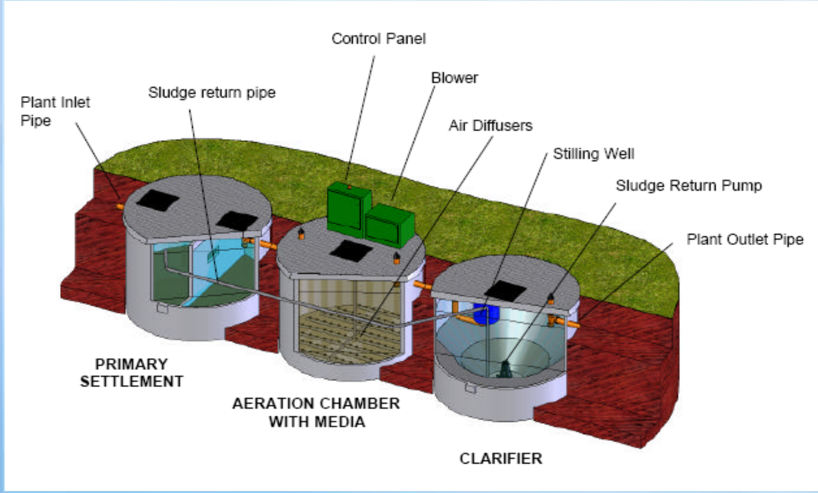
BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Fixed Film / Attached Growth Technologies

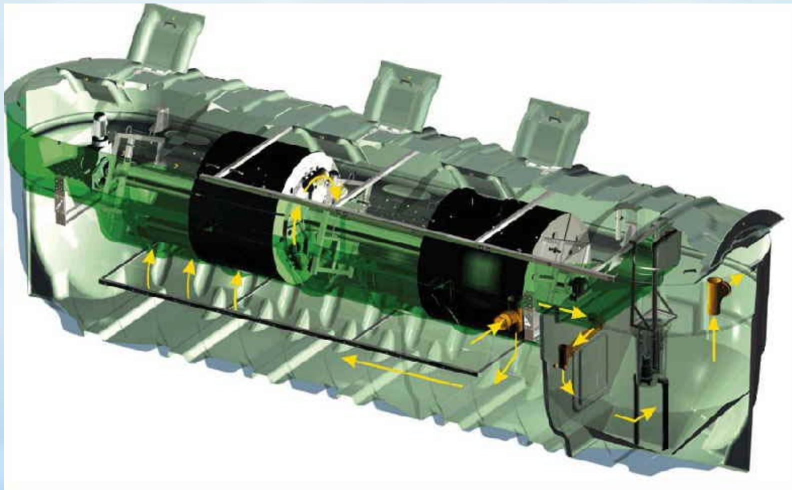
Post Anoxic Carbon Dosing

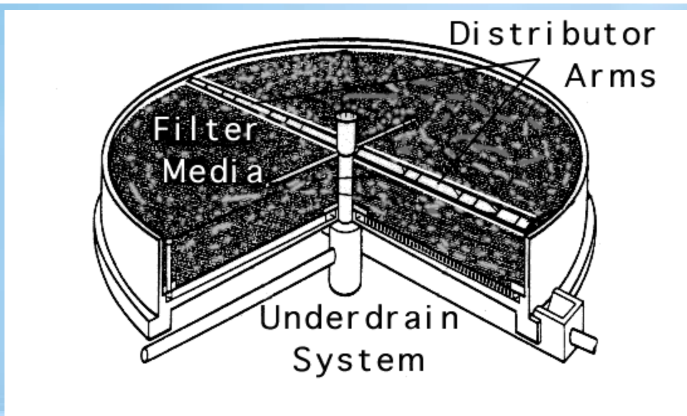
PERFORMANCE WASTEWATER SOLUTIONS

MBBR



RBC



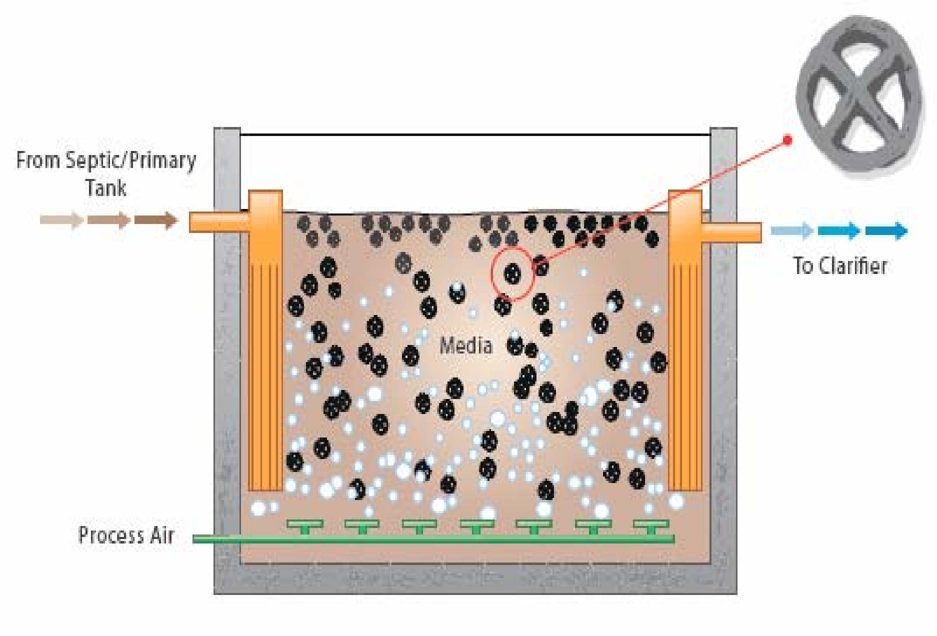


Trickling Filter

PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

MBBR



- **MBBR - Plastic media provides an extended surface area for bacteria**
- **Less risk of nitrifiers being washed out**
- **Does not require return activated sludge systems**
- **Sludge sloughs off and settles in clarifier**

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Treatment Performance

Parameters	Typical Values
BOD_5	<15 mg/l
TSS	<20 mg/l
Ammonia	<5 mg/l[1]
Total Nitrogen	< 10 mg/l[2]
Total Nitrogen	< 7.5 mg/l[3]
Phosphorus	<1 mg/l[4]

[1] Ammonia reduction design – decrease loading rate on media – two stage aeration to allow specialization of nitrifiers

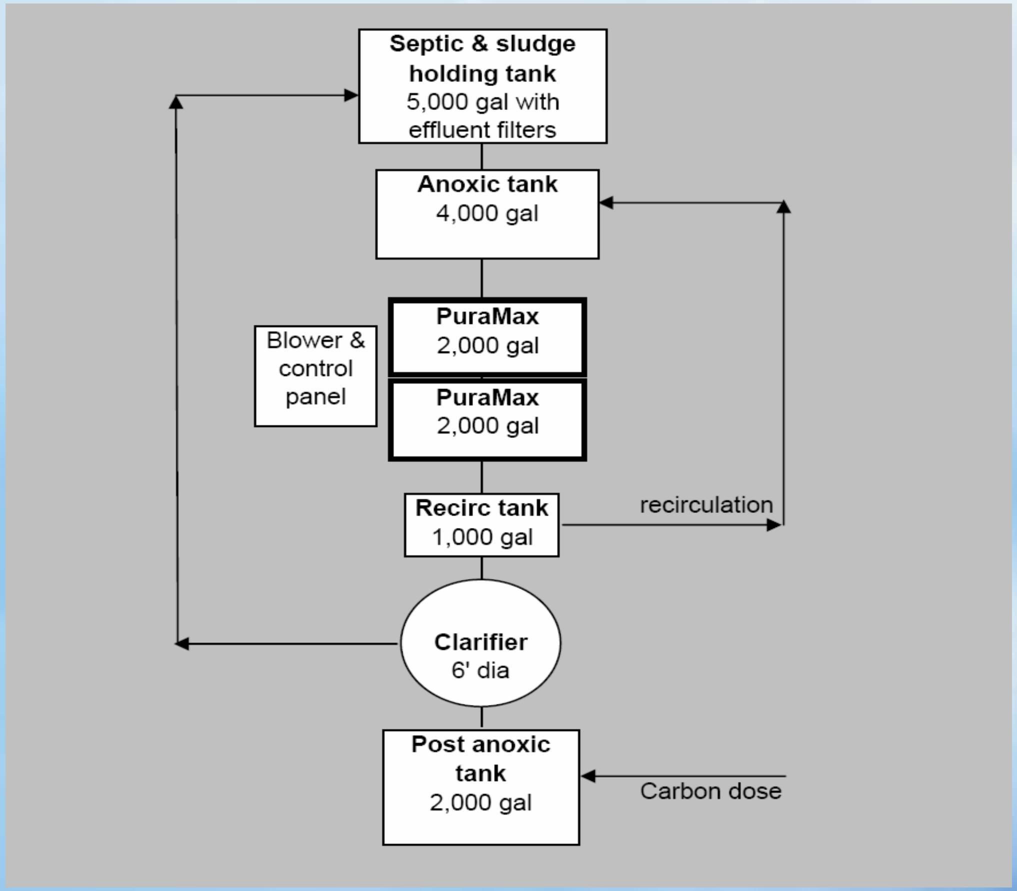
[2] With recirculation where influent is <50 mg/l

[3] With recirculation and a post anoxic reactor

[4] With a chemical dosing system

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Recirculation & post Anoxic Denitrification



BOD & TSS reduction

BOD reduction

Nitrification

Denitrification ↑

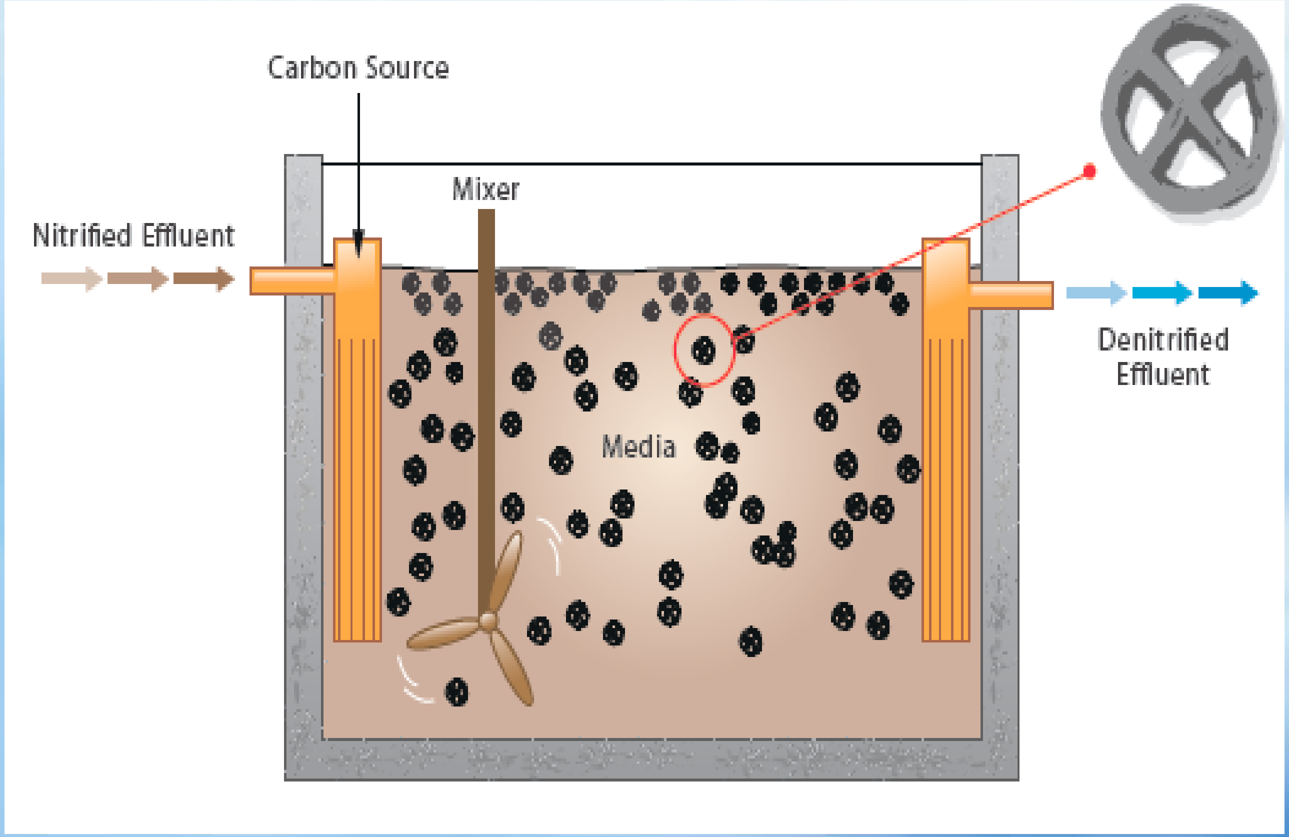
Solids removal

Denitrification

PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Post Anoxic Denitrification



PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Post anoxic MBBR systems

- **Advantages include**
- The carbon source is adjustable
- Resilience to shock loads as the nitrifiers are retained on the media
- Performs better than suspended growth activated sludge systems for intermittent flows and low carbon strength influents
- Small aeration reactor volumes for nitrification
- Ease of operation compared to suspended growth activated sludge systems as there is no RAS system

- **Limitations**
- For on-site systems a non-toxic carbon source would be required
- The carbon dose needs to be flow proportional to control the effluent BOD levels
- Alkalinity is not recovered as recirculation is not provided
- A post anoxic reactor may require re-oxygenation of the effluent where discharging to a surface water

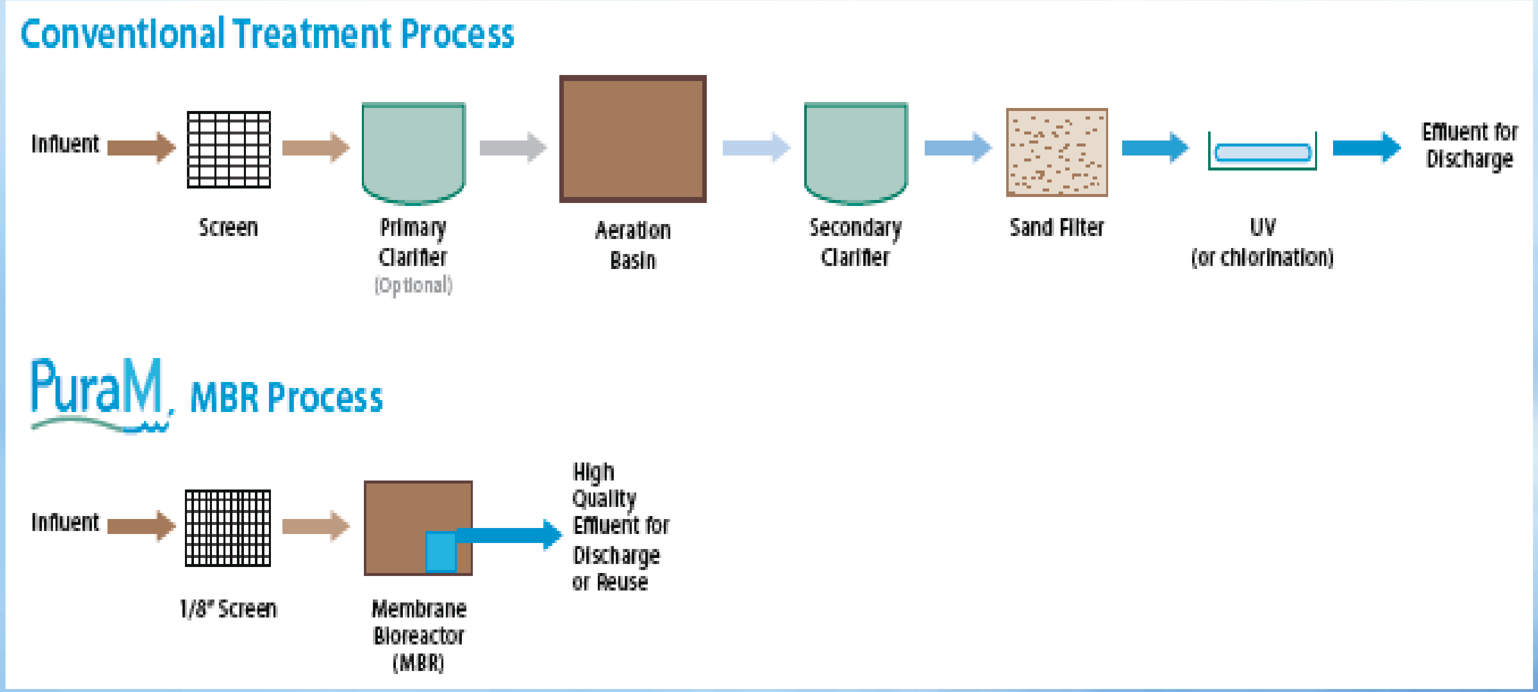
BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Membrane Bioreactor

PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Membranes compared to traditional Activated Sludge processes

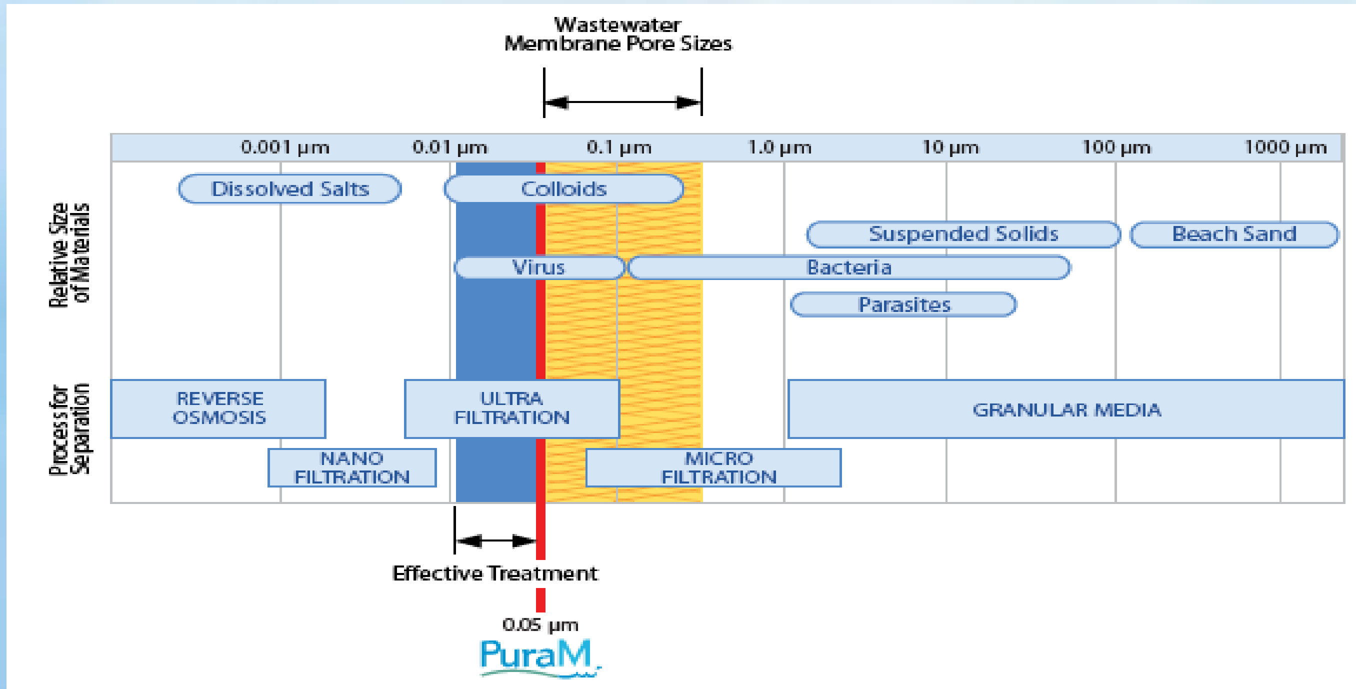


PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Membrane Pore Sizes

- Wastewater treatment in the micro & ultra filtration range
- Biofilm increases filtration capacity

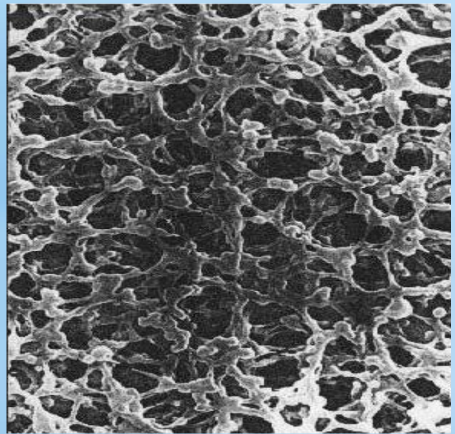


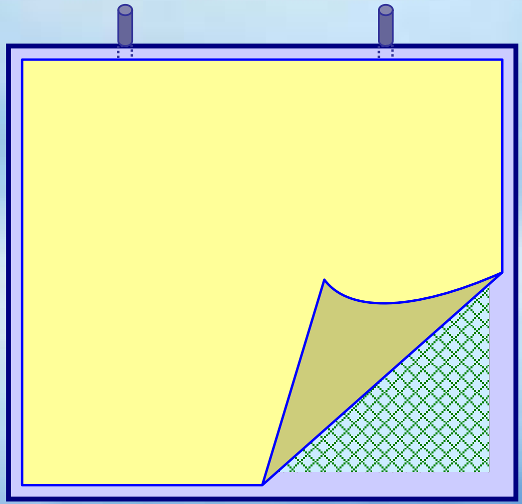
PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

PLATE DESIGN

- **Polysulphone membrane**
- **Plastic plate with spacer fabric**
- **Membrane ultrasonically welded to plate**

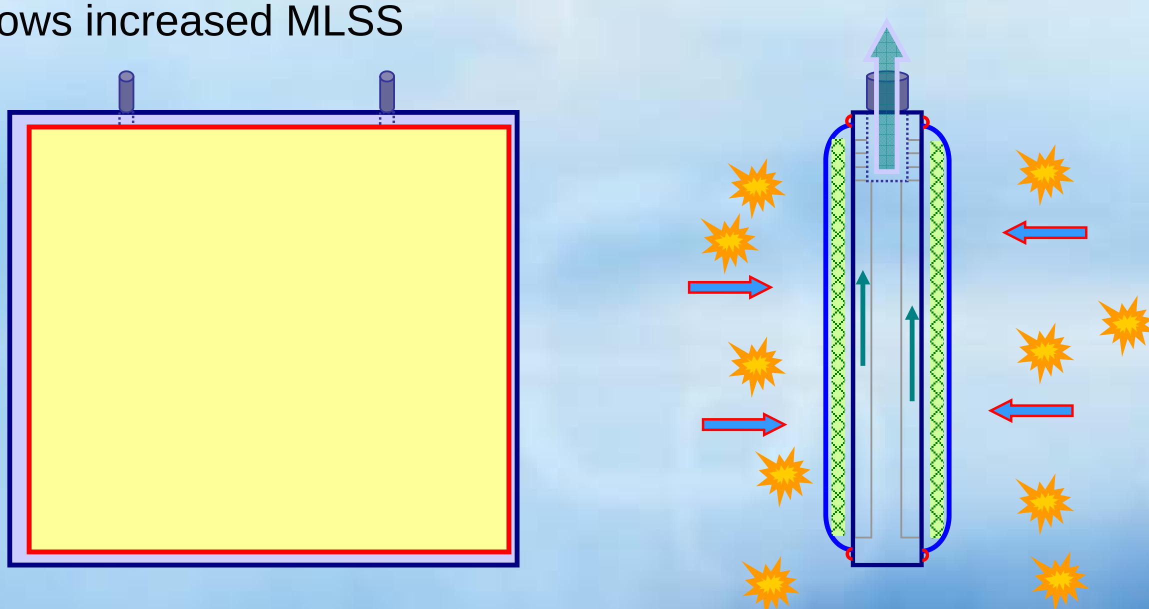




BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

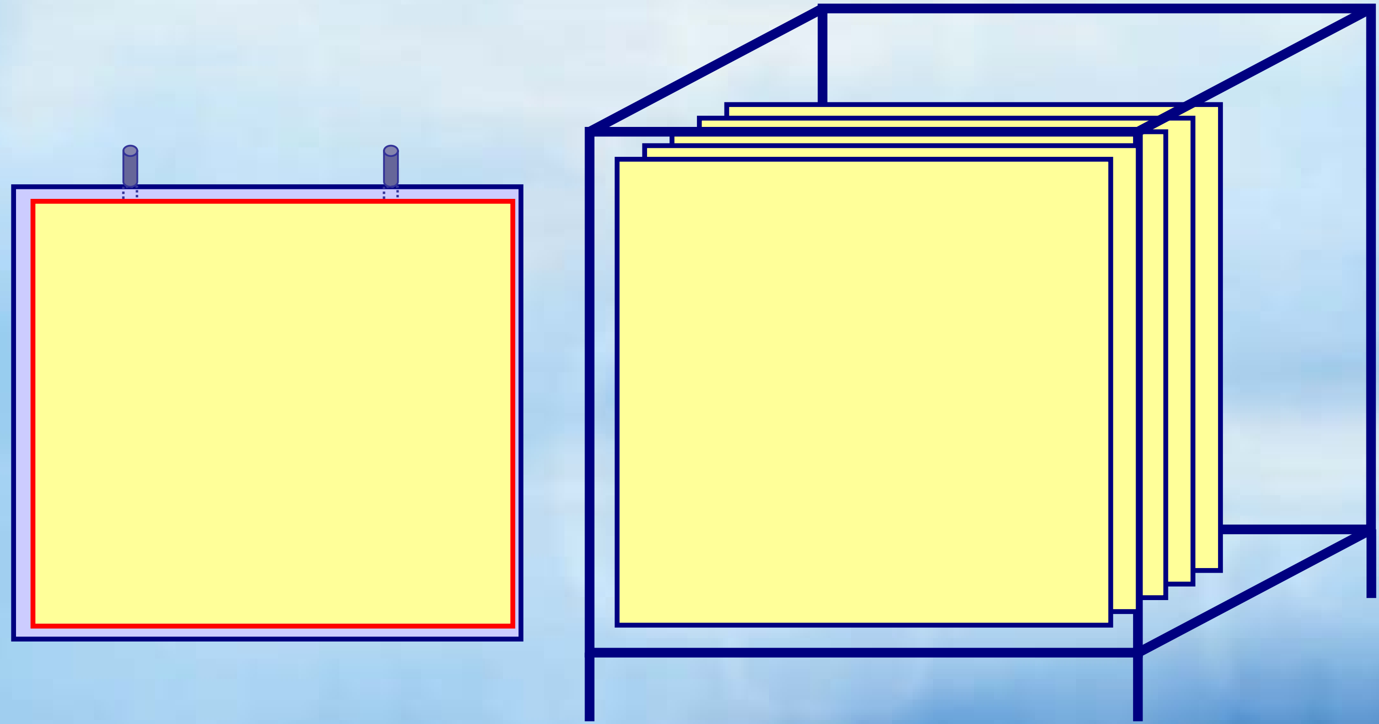
Membrane Operation

- **Outside to in flow**
- **Membrane provides absolute barrier**
  - Reduces affect of flow variation
  - Allows increased MLSS



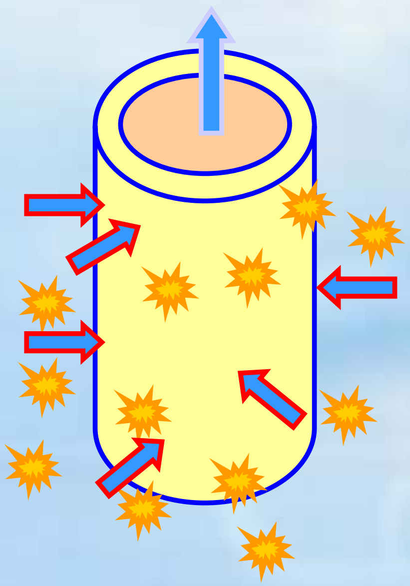
PERFORMANCE WASTEWATER SOLUTIONS

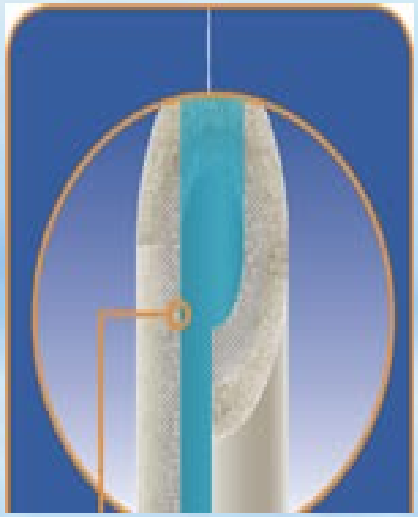
PuraM – Cassette



BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Hollow Fiber Membrane System

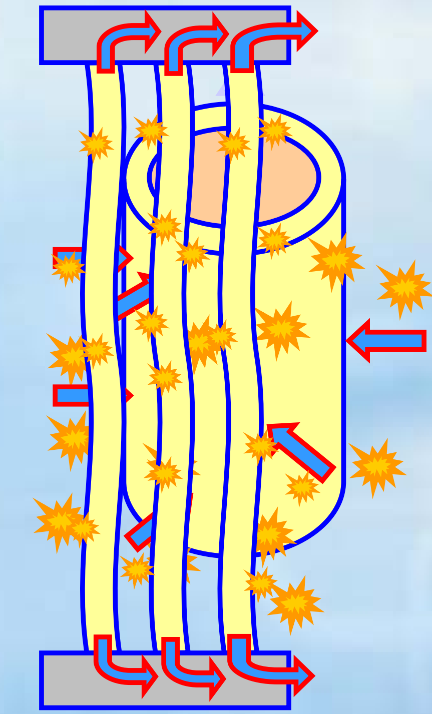




PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

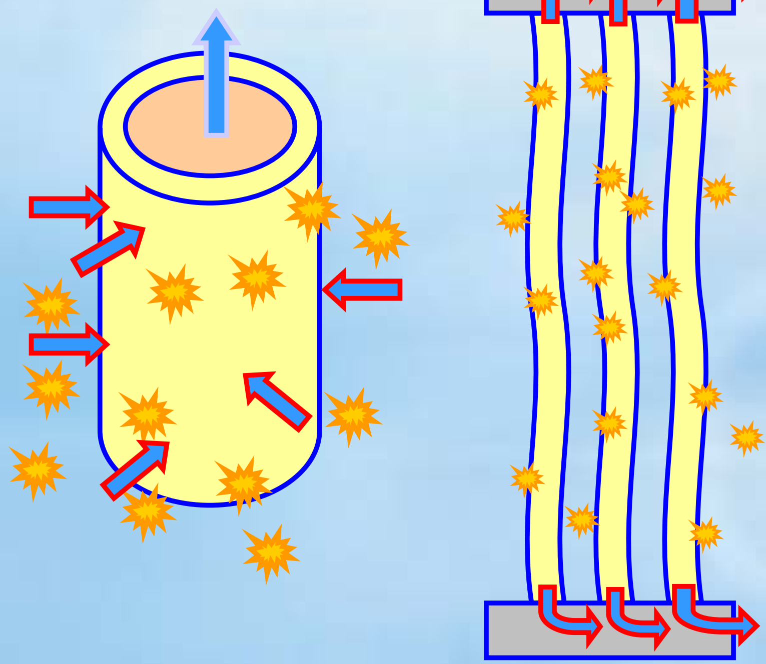
Hollow Fiber Membrane System



PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Hollow Fiber Membrane System



PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

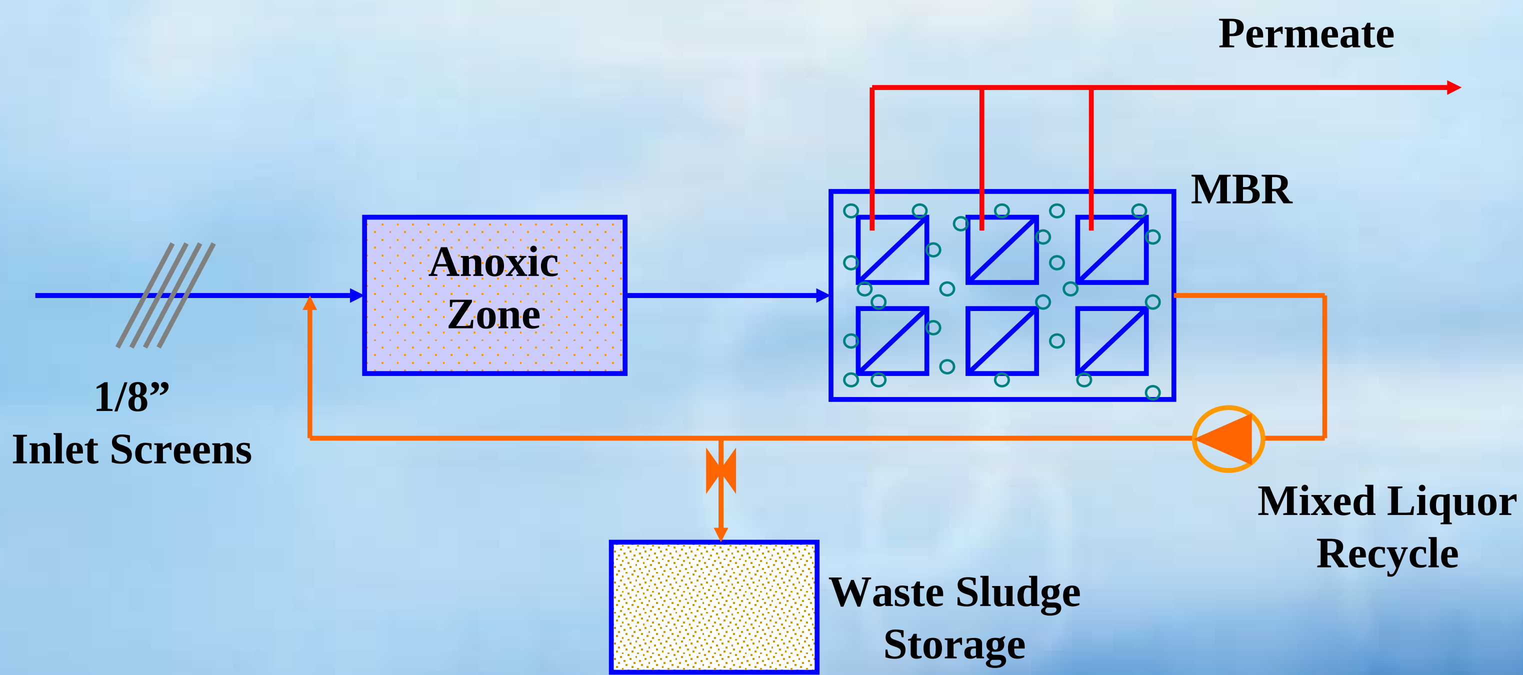
Membrane Selection

- Plate or Hollow Fibre?

	Plate	Hollow Fibre
Footprint	Very Good	Better
Screening	1/8 inch	up to 1/32 inch
O&M	Relatively simple	More Complex
Air requirement	High	High - Medium
Membrane cleaning	Infrequent 6 to 18 months	Regular (backpulse / chemicals daily)
Traditional Suitability	Small flows < 1 million gpd	High flows > 150,000 gpd

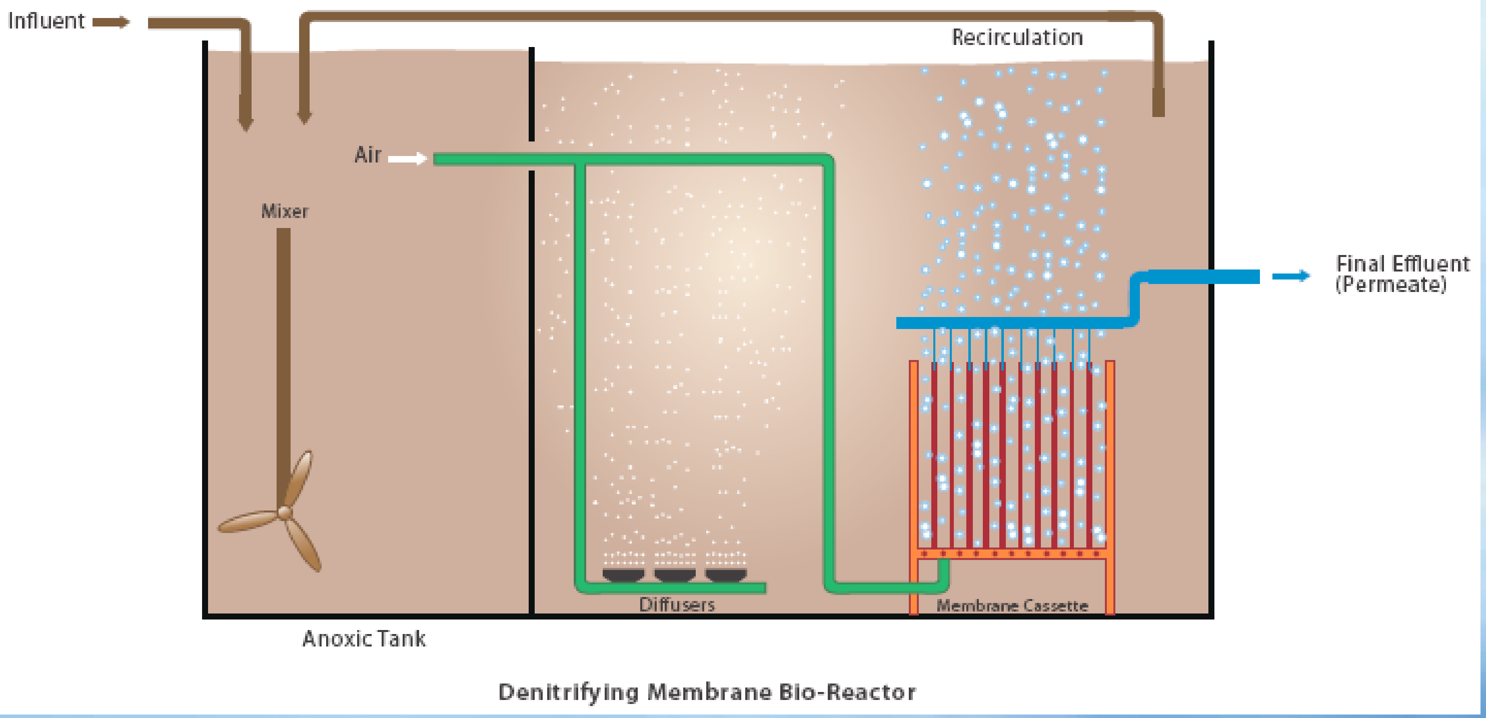
Denitrification by recirculation

Design for TN removal < 10 mg/l



BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

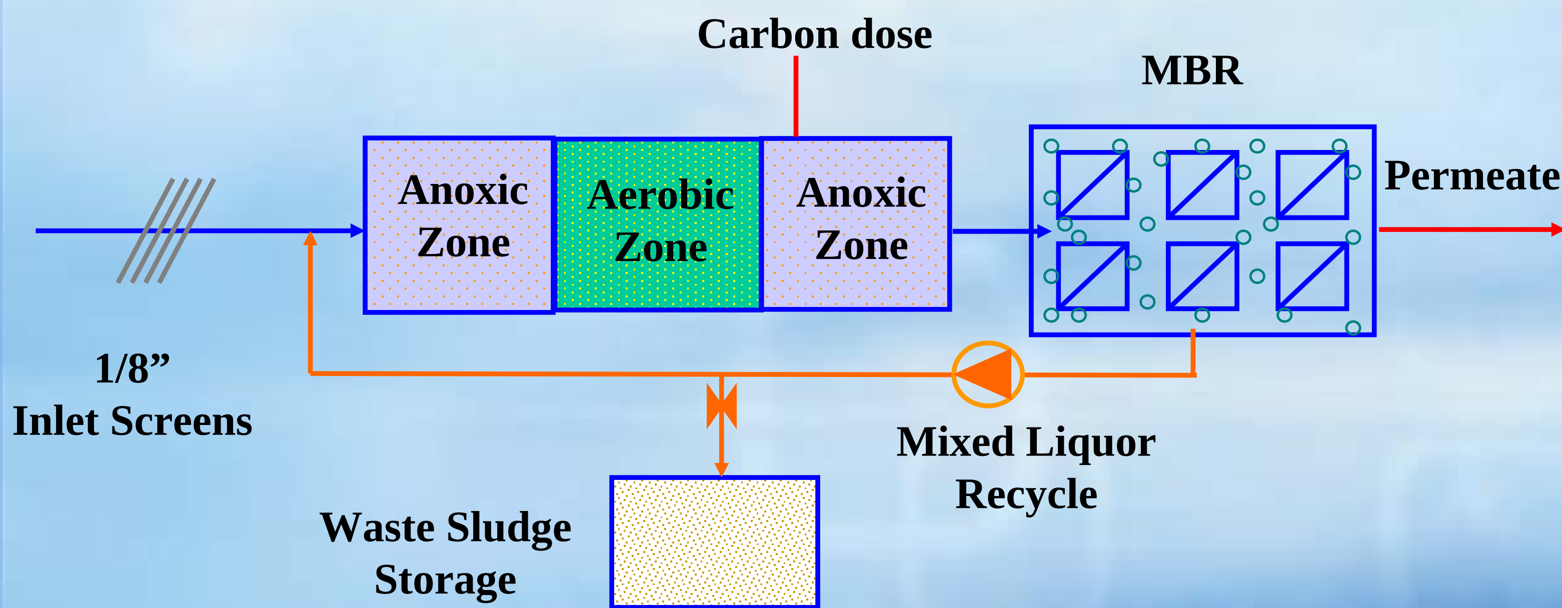
Denitrification by recirculation



BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Denitrification by recirc & carbon dose anoxic stages

Design for TN removal < 5 mg/l

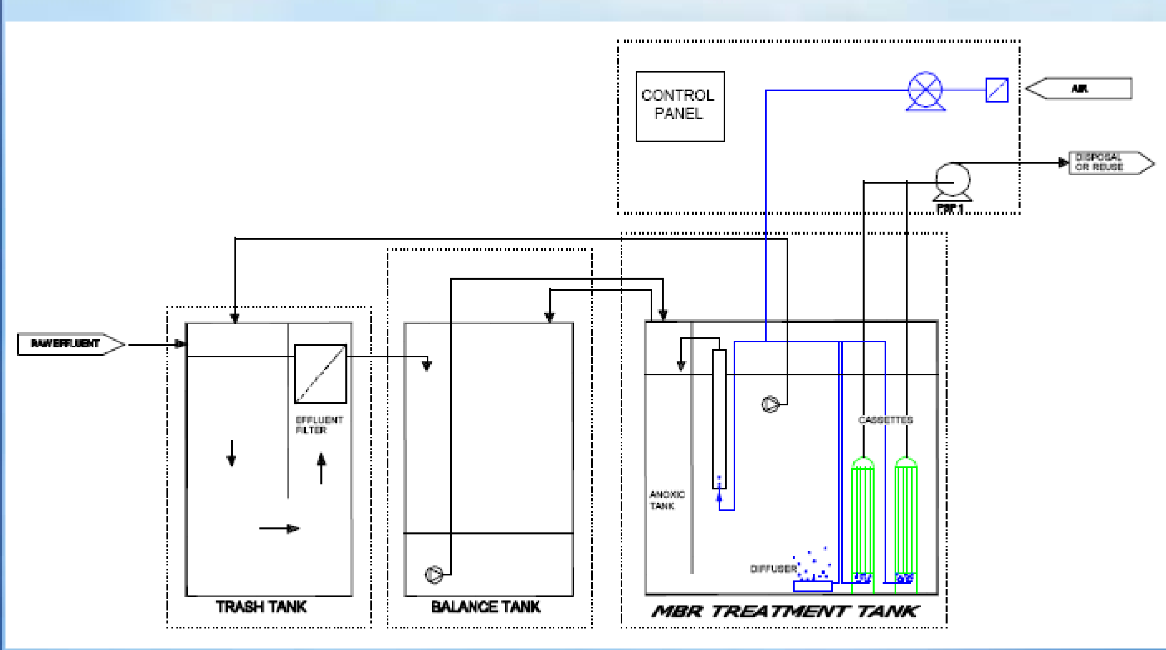


BORD NA MÓNA

BORD NA MÓNA ENVIRONMENTAL LIMITED

Compact Membrane

- Membrane for flows from 500 to 5000 gpd
- Integral or separate septic & equalization tank arrangements



PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Membrane Bio Reactors

- **Advantages include**
- Can provide the highest effluent quality when properly designed. Membrane systems are often chosen where a BOD of less than 5 mg/l is combined with total nitrogen levels of less that 10 mg/l.
- Small footprint area.
- Long solids retention times can be achieved allowing slow growing nitrifiers to establish
- Cost effective where strict ammonia and total nitrogen standards are required

- **Limitations**
- MBR systems may have higher energy costs
- A higher degree of operational input may be required
- The anoxic tank needs to be designed for the relatively high levels of DO in the mixed liquor recycle

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

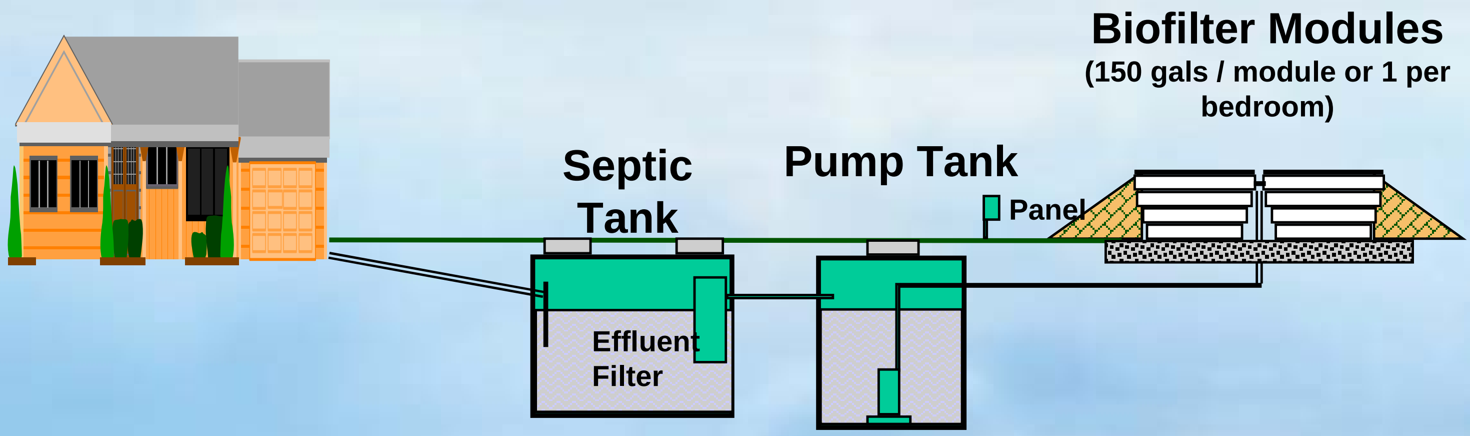
Media Biofilters

Include

- **Peat**
- **Textile**
- **Sand**
- **Coir**
- **Foam**

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Peat Biofilter



PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

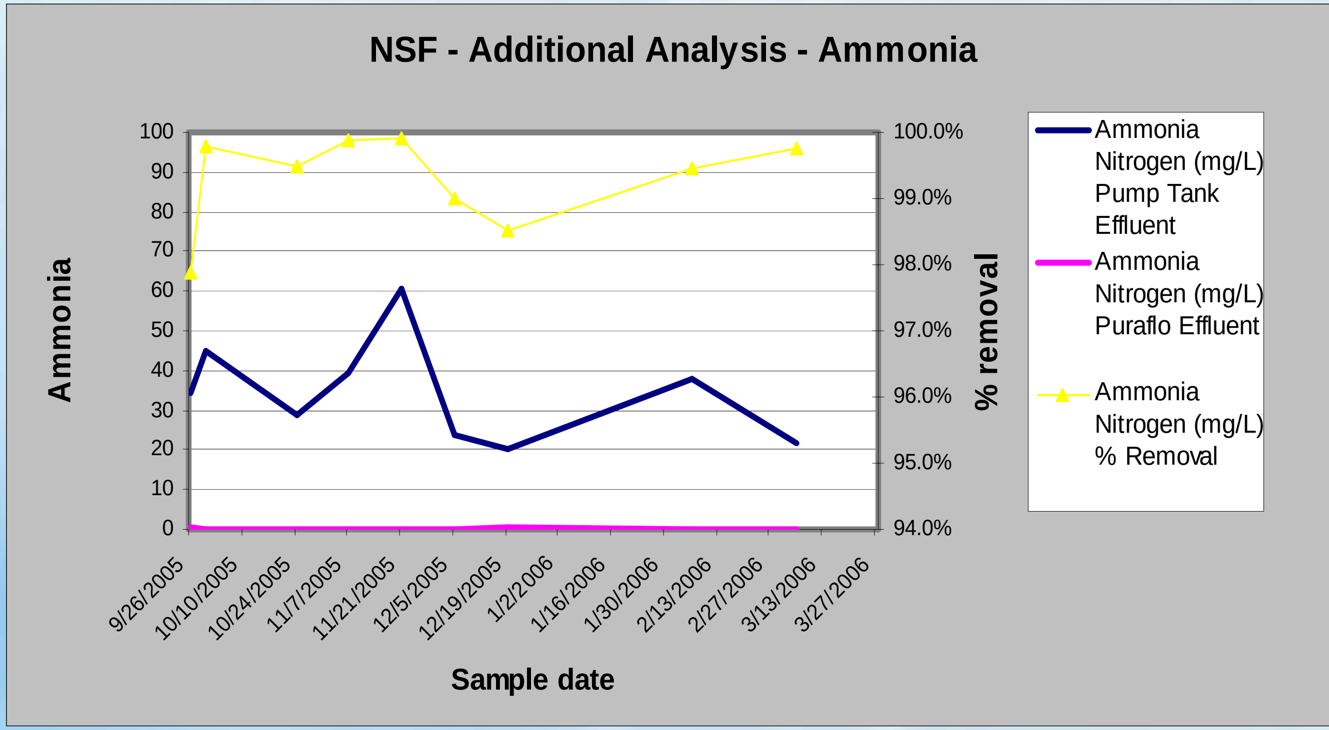
Puraflo® Peat Biofilter Performance

Parameter	Effluent	NSF Certified	%
BOD (mg/L)	<10	<2	96+
TSS (mg/L)	<10	<2	95+
NH_3-N (mg/L)	< 5	<1	90+
Fecal Coliforms (cfu/100 ml)	6000	3000*	99.9+
Total Nitrogen**	<10		

- *GEOMEAN
- ** WITH POST ANOXIC TANK

A proportion of remaining nitrogen will be absorbed through the soil / root systems

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

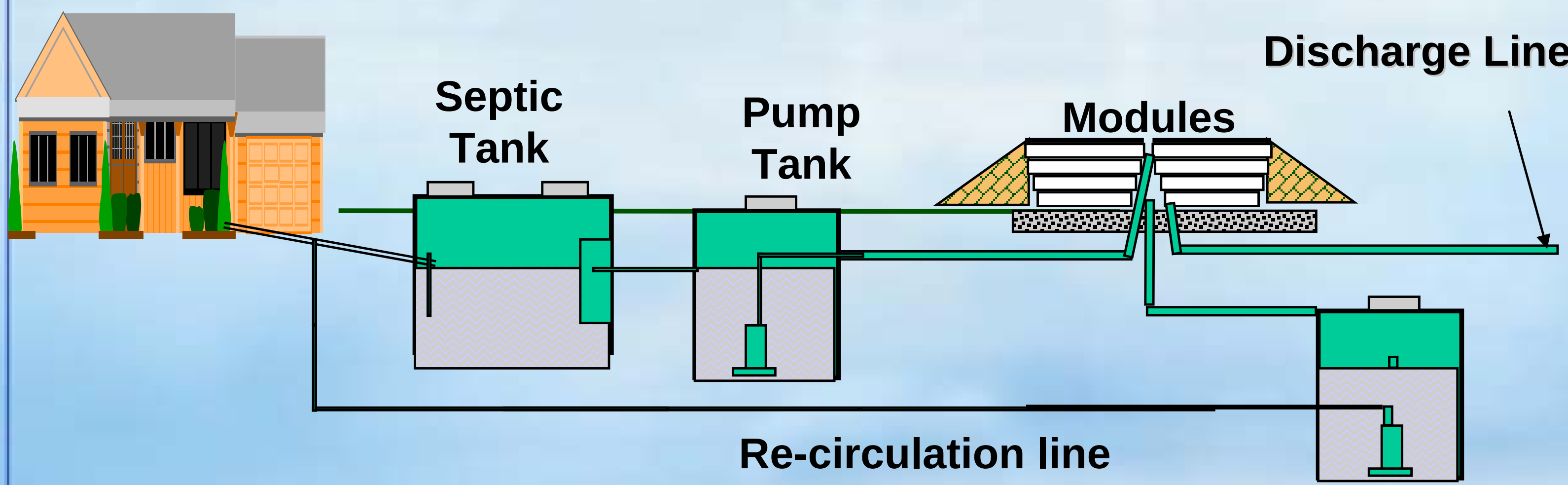


09/26/05	09/30/05	10/24/05	11/07/05	11/21/05	12/05/05	12/19/06	01/16/06	02/06/06	03/06/06
0.73	0.09	0.15	0.05	0.05	0.24	0.3	0.08	0.21	0.05

Nitrification occurs in the lower section of the media where the BOD level is lower allowing the nitrifiers to compete with the heterotrophic bacteria

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Puraflo® Nutrient Reduction

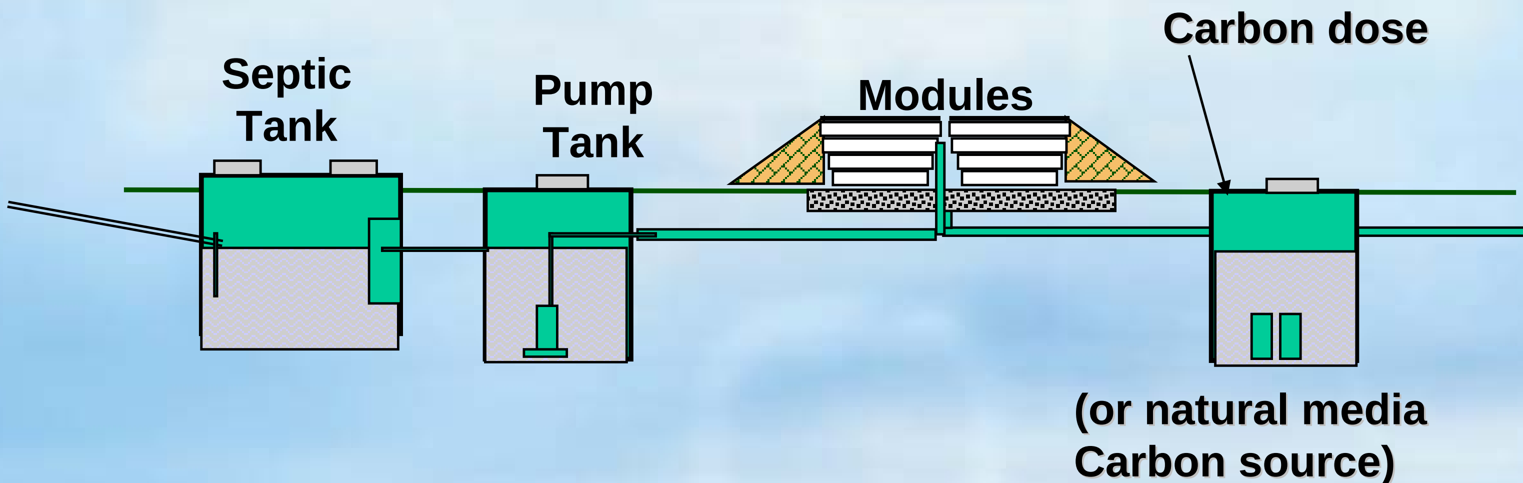


- 30% Nitrogen reduction in single pass time dosed system

- 50 to 70% Total Nitrogen reduction achieved by recirculating half to one times the design flow back to the septic tank

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

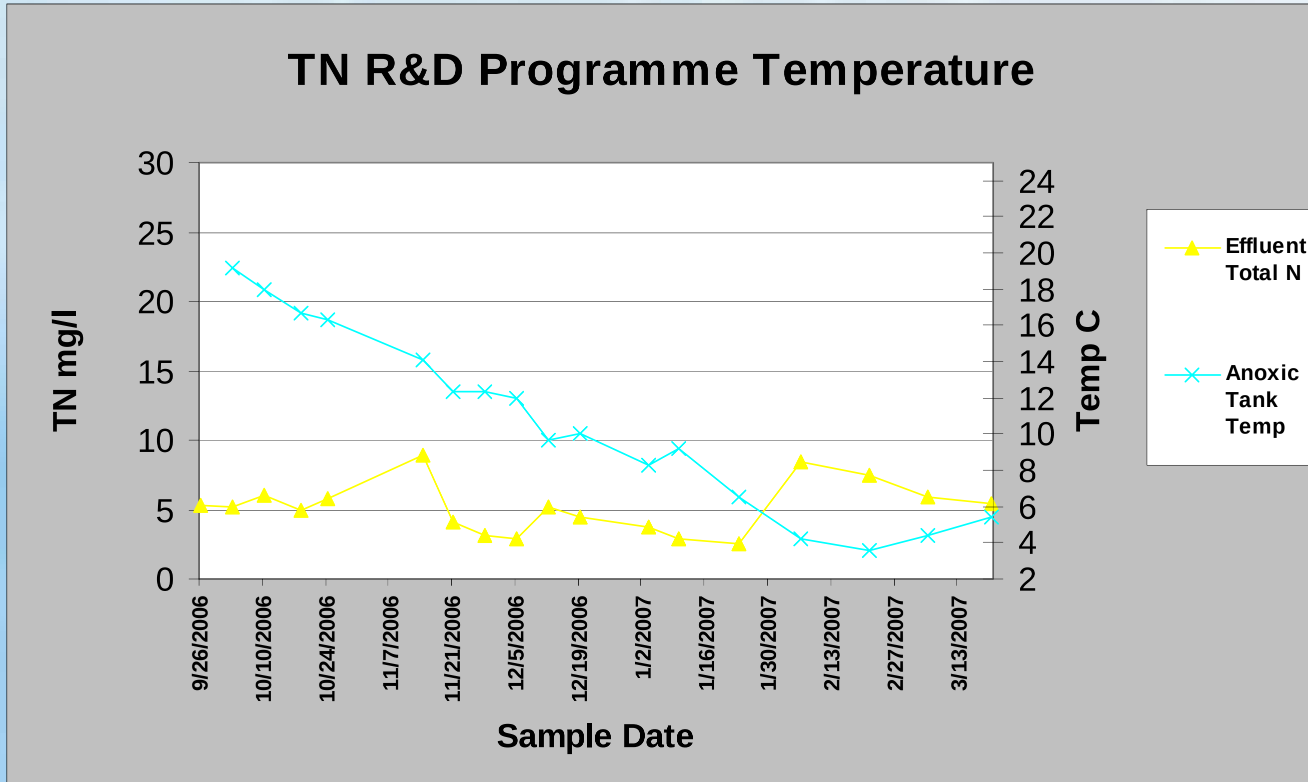
Puraflo® Nutrient Reduction



- <10 mg/l Total Nitrogen with post anoxic tank

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

3rd Party Winter Testing



Third party testing results

PERFORMANCE WASTEWATER SOLUTIONS

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Peat media biofilters

- **Advantages include**
- Naturally nitrifies making the systems attractive for ammonia standards
- Standard design incorporates flow equalization and time dosing
- Excellent for intermittent flows
- Low operational and maintenance requirements

- **Limitations**
- The footprint size is relatively large
- A post anoxic reactor may require re-oxygenation of the effluent where discharging to a surface water
- For on-site systems a non-toxic carbon source would be required. There are a number of chemicals commercially available.

BORD NA MÓNA
BORD NA MÓNA ENVIRONMENTAL LIMITED

Conclusions

- **The choice of technology is driven by**
  - the regulatory permit standards and assessment of influent load
  - the cost of the systems that can achieve the standards
  - the risk approach the manufacturers take in proposing a technology

- **On-site & decentralized plants suffer from wide variations in the influent TKN concentrations, large flow variations and a lack of operational attendance to adjust the plant to the conditions experienced - > need for robust process design for small flows**

- **Grab samples based on absolute effluent standards require equalization of flows**

- **Options to achieve a % reduction & reduce risk of low alkalinity**
  - Recirculation 0.5 to 6 x design flow – 50 to 90% reduction of TN

- **Options <10 mg/l, high strength or potential carbon deficiency**
  - Post anoxic tank with carbon dosing (Micro C) or natural carbon media eg wood chips
  - Use recirculation & post anoxic
  - Membranes for tight effluent standards