Long Island Sound Nitrogen Removal Training Program

Module 5
Optimization of Fixed Film Plant Performance

SUNY Farmingdale
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New York State
Department of Environmental Conservation

Stearns&Wheler, LLC
ENVIRONMENTAL ENGINEERS & SCIENTISTS

SUNY
Morrisville

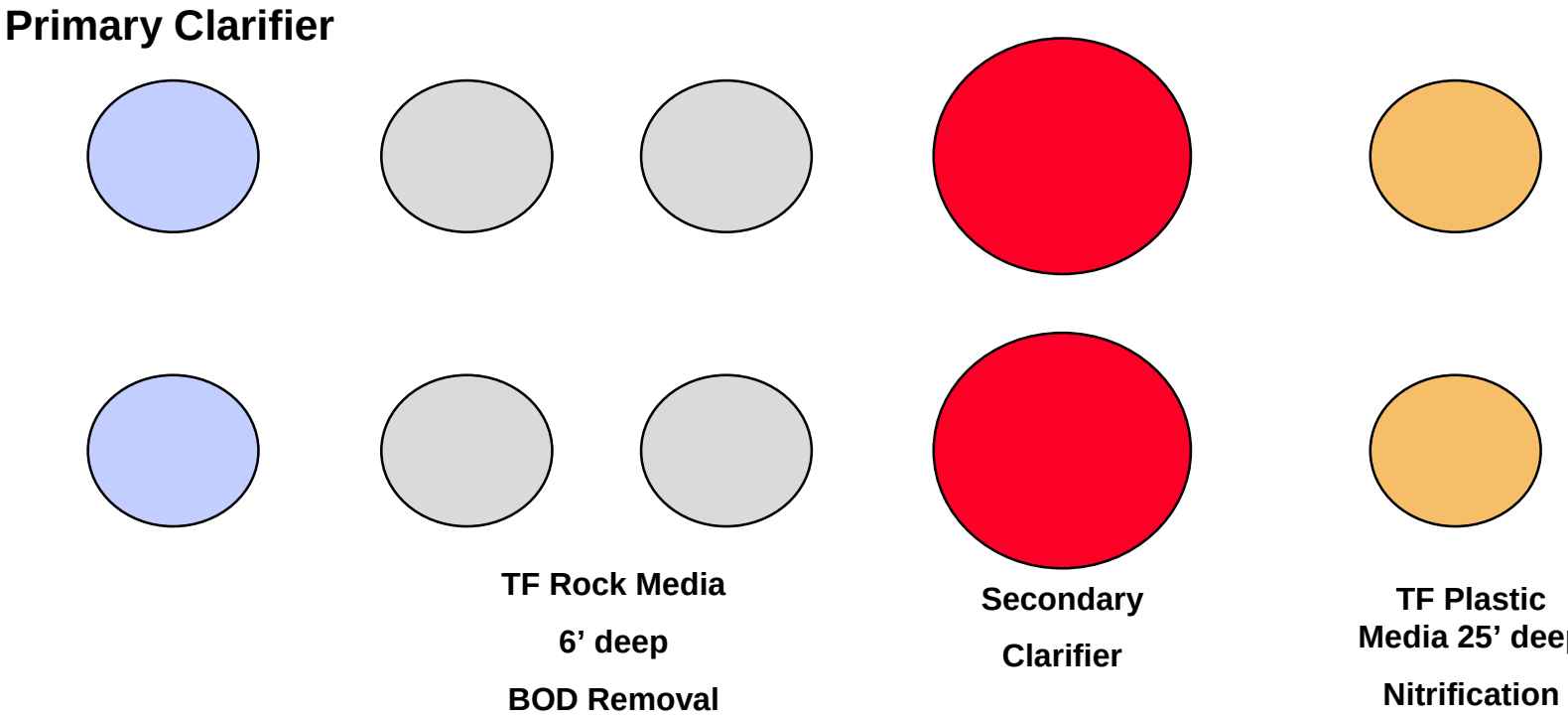
Types of Nitrification Filters

- **TF with Rock Media**
- **TF with Plastic Media**
  - **Recommend clarifier in between BOD removal and nitrification filters.**
- **Biological Aerobic Filters**
  - **Sand Media**
  - **Shale Media**
  - **Beads eg: Polystyrene**

Pumping Requirements

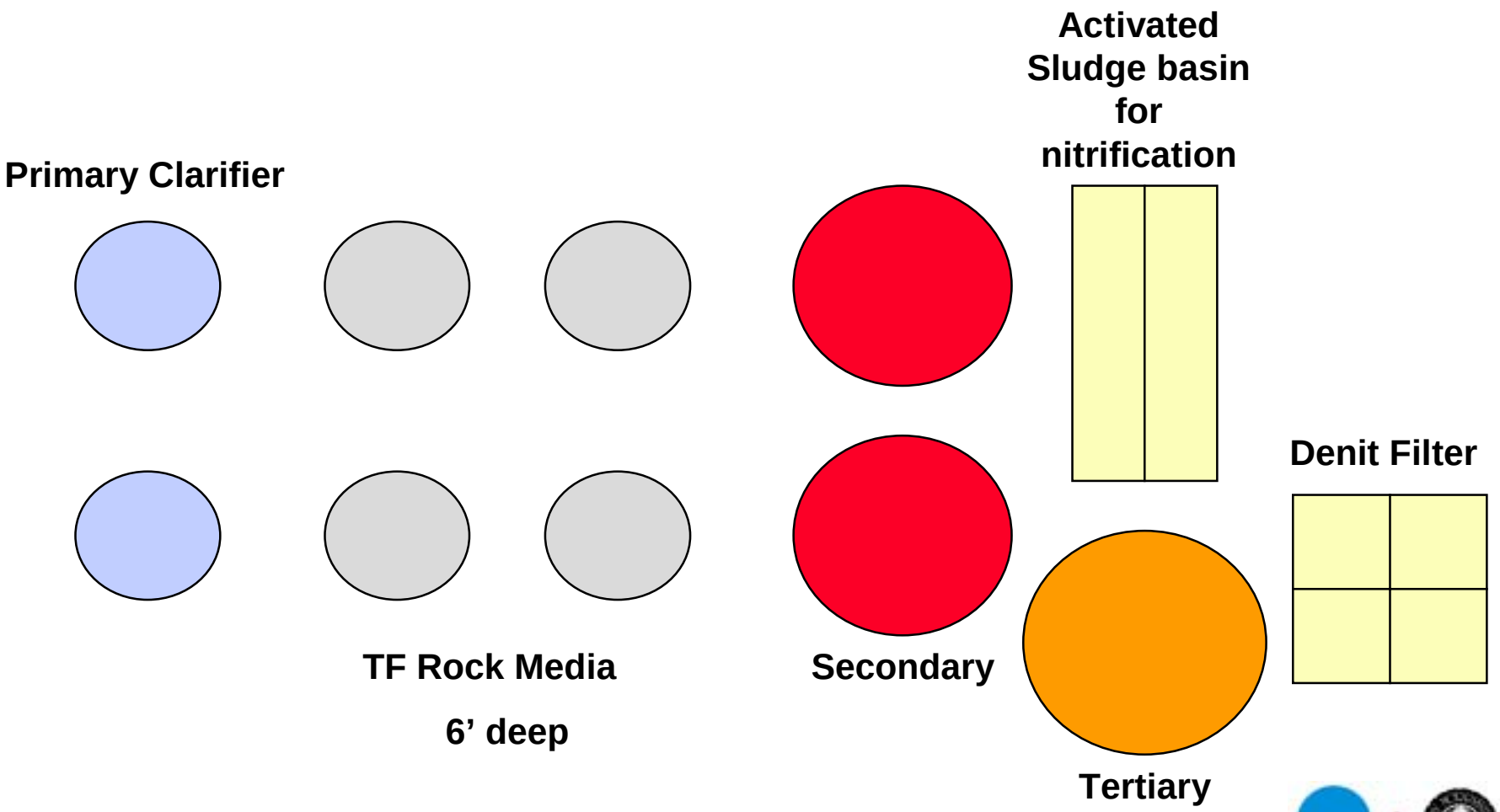
- **A) Pump up to nitrification TF, can require up to 25 feet of pumping.**
- **B) Pump “up through” Biological Aerated Filter requires 6+ feet of head.**

Space Requirements



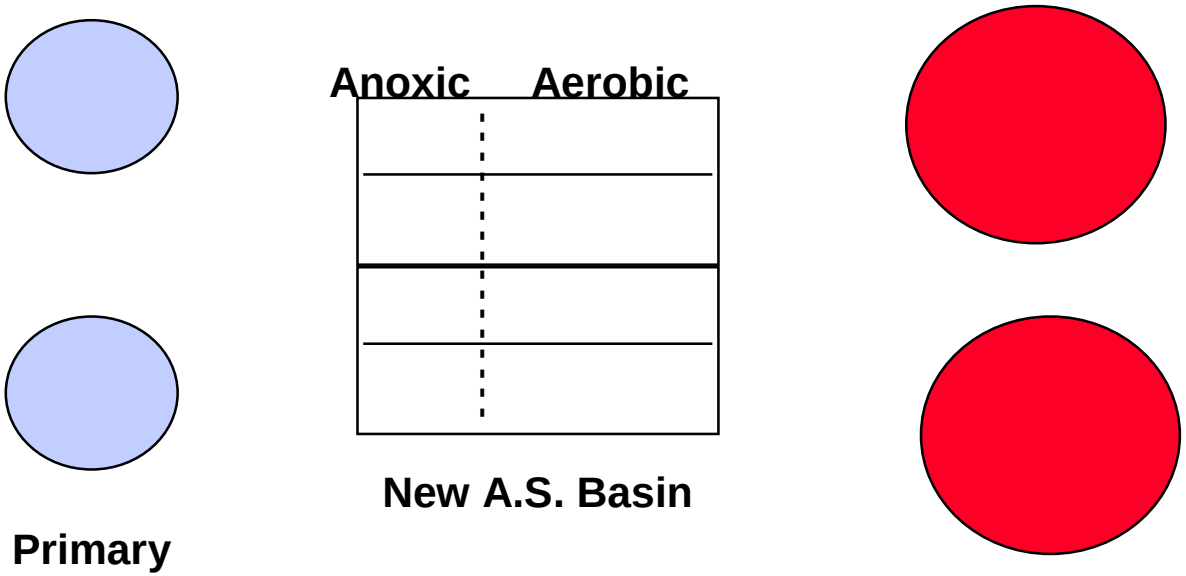
Module: 5
Unit: 1
Transparency: 1-3

TF/AS Process With Denitrification Filter

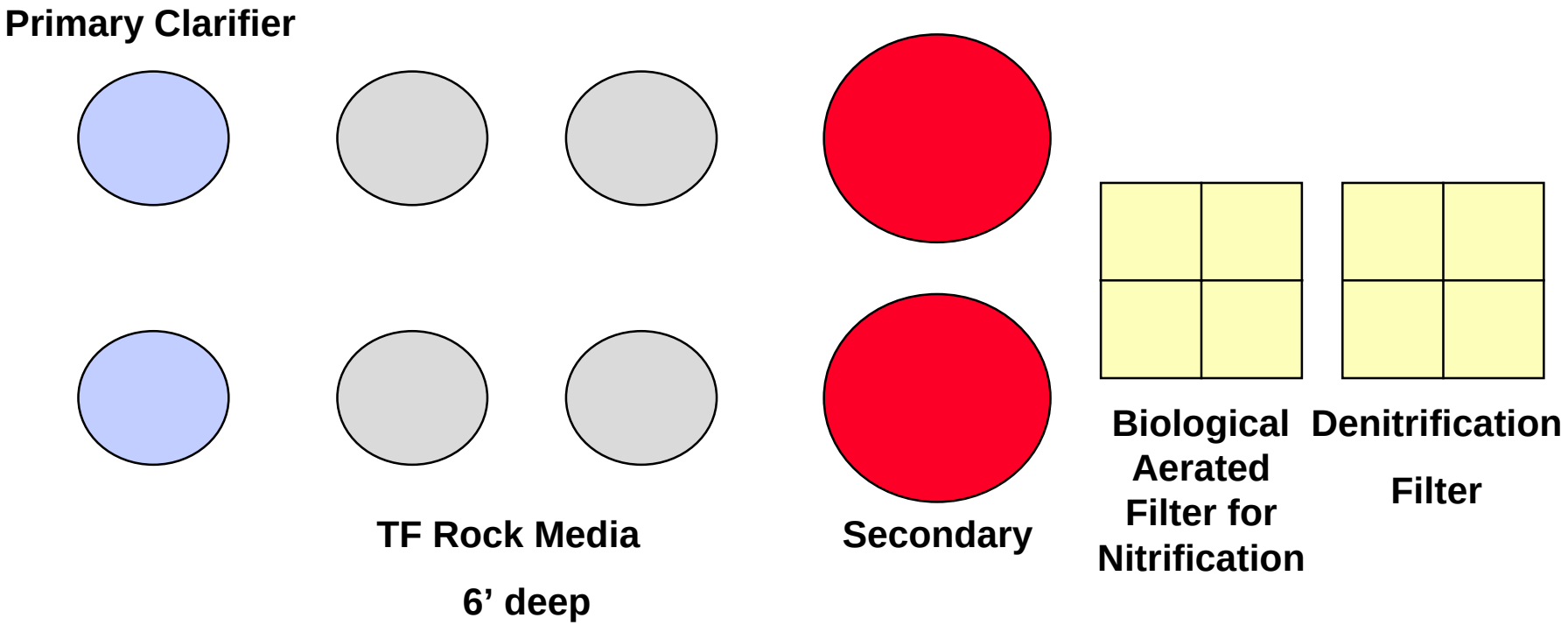


Module: 5
Unit: 1
Transparency: 1-4

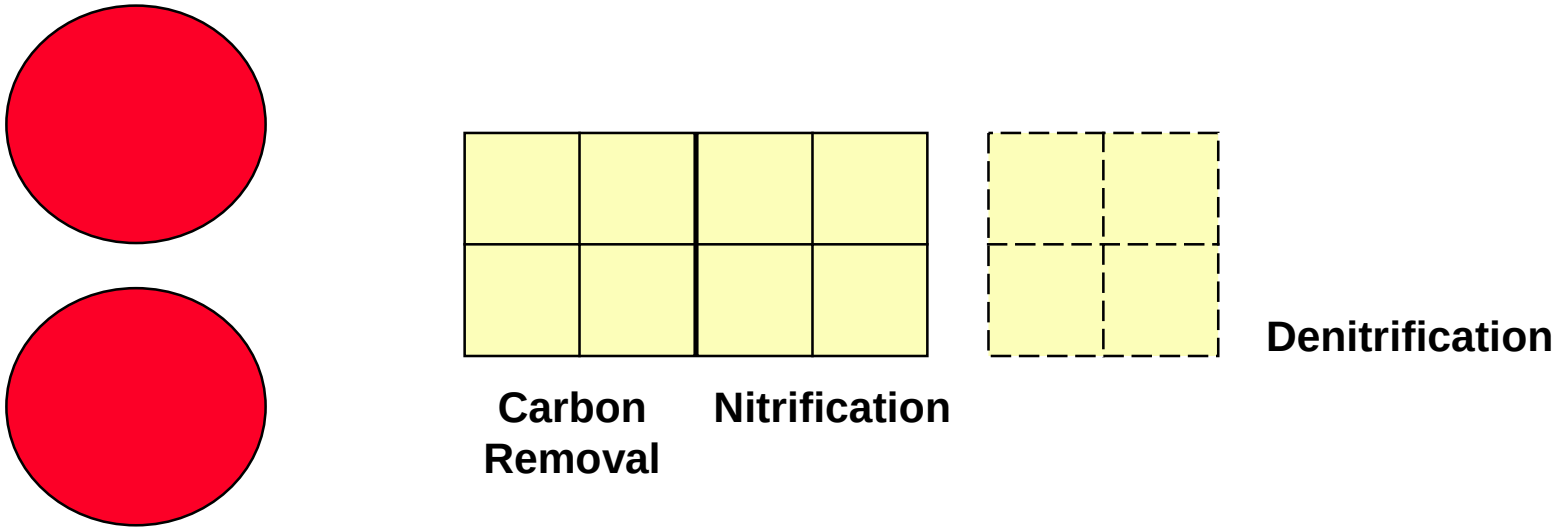
TF Replacement With Activated Sludge



Trickling Filter Followed by Nitrification and Denitrification Filters



Biological Aerated Filter Followed by Denitrification Filter



Biological Aerated filter

Aeration

- **Nitrifying TF**
  - **Aeration from liquid distribution arm**
  - **Forced air through filter**

    - Note: Air is cold in winter because it is not compressed. Low temperature can reduce nitrification rates.

Aeration

- **Biological Aerated Filters**
  - **Aeration is through coarse bubble diffusers**
  - **Air flows up through filter**
  - **Filter media is submerged in water**
  - **Blowers similar to activated sludge plants**
  - **Air heated by 80° - 90° F by compression through the blower**
  - **Oxygen transfer efficiency is a function of liquid depth and bubble rise time.**

Sludge Production

SLUDGE PRODUCTION

BOD_5 Removal	**0.5 kg VSS/kg BOD_5**	**Removed**
Trickling Filter (RBCs)	**0.5 kg VSS/kg BOD_5**	**Removed**
High Rate TF	**0.55 kg VSS/kg BOD_5**	**Removed**
Biological Aerated Filter	**0.5 kg VSS/kg BOD_5**	**Removed**

__NITRIFICATION

RBCs	**0.2 - 0.3 kg VSS/kg BOD_5**	**Removed**
TF	**0.2 - 0.3 kg VSS/kg BOD_5**	**Removed**
Biological Aerated Filter	**0.2 - 0.3 kg VSS/kg BOD_5**	**Removed**

Note: 1) 70-90% of BOD 5 removed is in the BOD_5 removal stage

2) Sludge production includes solids in effluent and backwash

Process Performance Monitoring

- **Plant influent**
  - **BOD/COD**
  - **TKN**
  - **Ammonia**
  - **Alkalinity**
- **Primary effluent**
  - **BOD/COD**
  - **TKN**
  - **Ammonia**
  - **Alkalinity**
- **Intermediate biological process (e.g. between stages of trickling filter)**
  - **BOD/COD**
  - **TKN**
  - **Ammonia**
  - **Nitrate/Nitrite**
  - **Alkalinity**
- **Secondary Effluent**
  - **BOD/COD**
  - **TKN**
  - **Ammonia**
  - **Nitrate/Nitrite**
  - **Alkalinity**

Process Monitoring Equipment

Ammonium - N	**ammonia gas sensing probe (filter, distillation not required)**		
Process Monitoring	**DR 700**	**Nessler**	**Low range**
	DR 2000		
TKN and SKN	**Digest, Distill, Titration, Probe Etc.**		
NO_2^--N	**Colorimetric**		
NO_3^--N	**Cadmium Reduction, Colorimetric**		
Process Monitoring	**DR 700, DR 2000**		

System Monitoring and Automation

	MONITORING	AUTOMATION	DEGREE OF CONTROL
Rock media TF for BOD_5 Removal	Low	Low	Low
Plastic media nitrification TF	Ammonia-N	Low	Low
RBC	Low	Low	Low - Moderate
Nitrifying RBC	Ammonia-N DO	Low	Moderate
Biological Aerated Filter for Carbon Removal	Moderate DO Loadings	High	Moderate
Biological Aerated Filter for Nitrification	Moderate DO, Nutrient &Loadings	High	High
Activated Sludge for BOD Removal	Moderate	Moderate	Moderate
Activated Sludge for BOD Removal & Nitrification	High	Moderate	High

Operational Issues - Trickling Filters

- **Predator control**
  - **snails**
  - **worms**
- **Dissolved oxygen control**
- **Incomplete wetting of media**
- **Erratic sloughing**

Operational Issues - RBCs

- **Predator control**
  - **snails**
  - **worms**
- **Dissolved oxygen control**
- **Erratic sloughing**
- **Fungus growth**

Operational Issues - Nitrifying Aerated Filters

- **Competition from heterotrophs**
- **Dissolved oxygen control**
- **Frequent headloss buildup and backwashing**
- **Valve maintenance**

Operational Issues - Denitrification Filters

- **Incomplete denitrification due to inadequate methanol feed and fluctuation NOx-N loads**
- **Frequent headloss buildup and backwashing**
- **Valve maintenance**

Relative Capital Costs

Activated Sludge	Trickling Filter Plastic media	RBC	Biological Anoxic Aerated Filter
Goal: Complete Nitrification in Cold Weather			
100	75 w/o clarifier	90 w/o clarifier	90
100	110 w/clar or filter	110 w/clar or filter	90
Goal: Complete Nitrification and Denitrification to 8 mg/L			
100	110 w/DN Filter	110 w/DN Filter	110
Goal: Complete Nitrification and Denitrification to 3 mg/L w/ DN Filter			
100	90	110	100

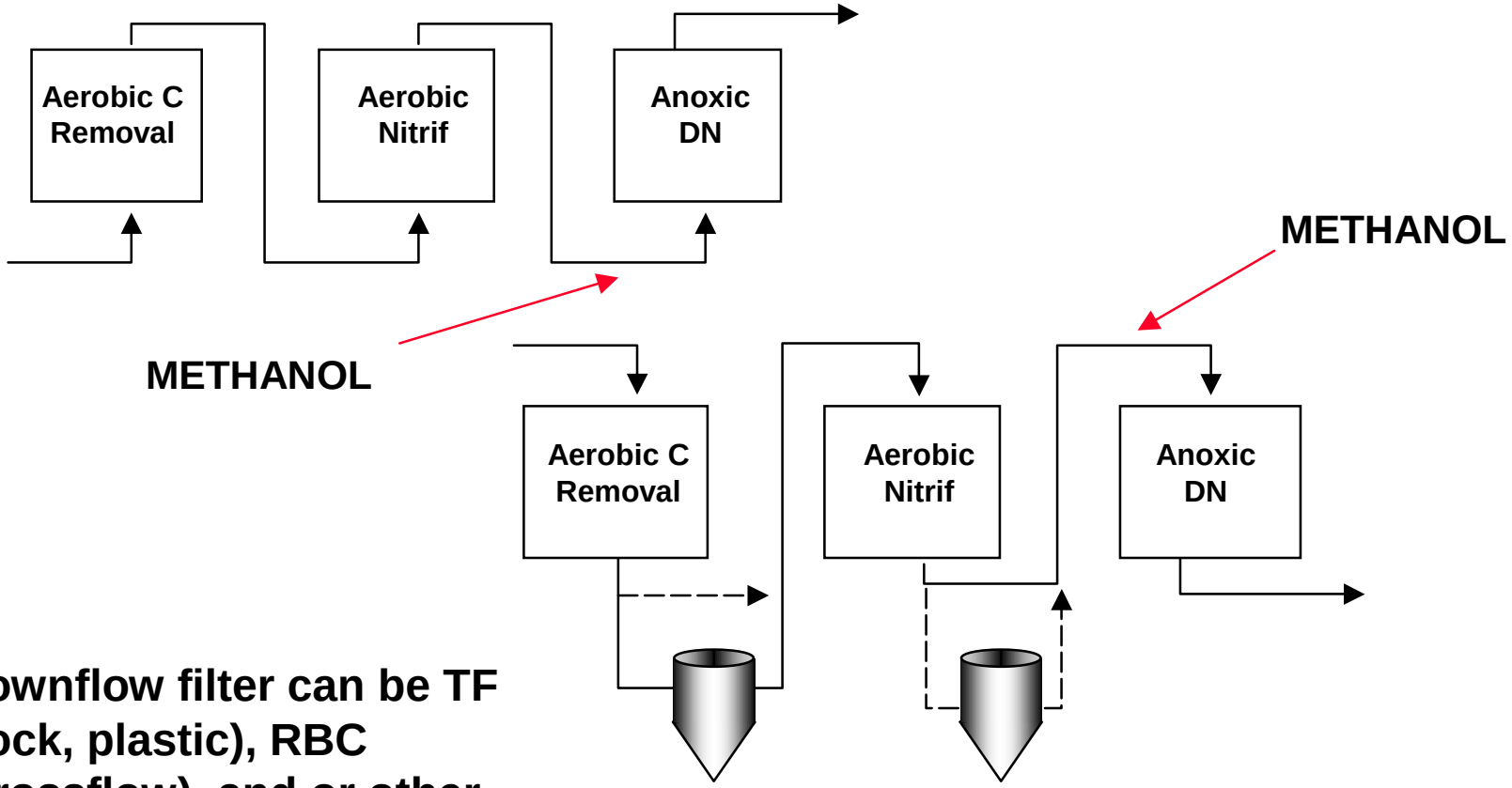
Relative O&M Costs

Activated Sludge	Trickling Filter Plastic media	RBC	Biological Anoxic Aerated Filter
Goal: Complete Nitrification in Cold Weather			
100	90 Pump 25'	80 w/o clarifier	100
Goal: Complete Nitrification and Denitrification to 8 mg/L			
100	110 w/DN Filter	110 w/DN Filter	100
Goal: Complete Nitrification and Denitrification to 3 mg/L w/ DN Filter			
100	110	110	100

Relative Land Requirements

Activated Sludge	Trickling Filter Plastic media	RBC	Biological Anoxic Aerated Filter
Goal: Complete Nitrification in Cold Weather			
100	40 w/o clarifier	60 w/o clarifier	30
Goal: Complete Nitrification and Denitrification to 8 mg/L			
100	60 w/DN Filter	70 w/DN Filter	40 w/Predenit
Goal: Complete Nitrification and Denitrification to 3 mg/L w/ DN Filter			
100	50	60	40

Biological Filter Configurations



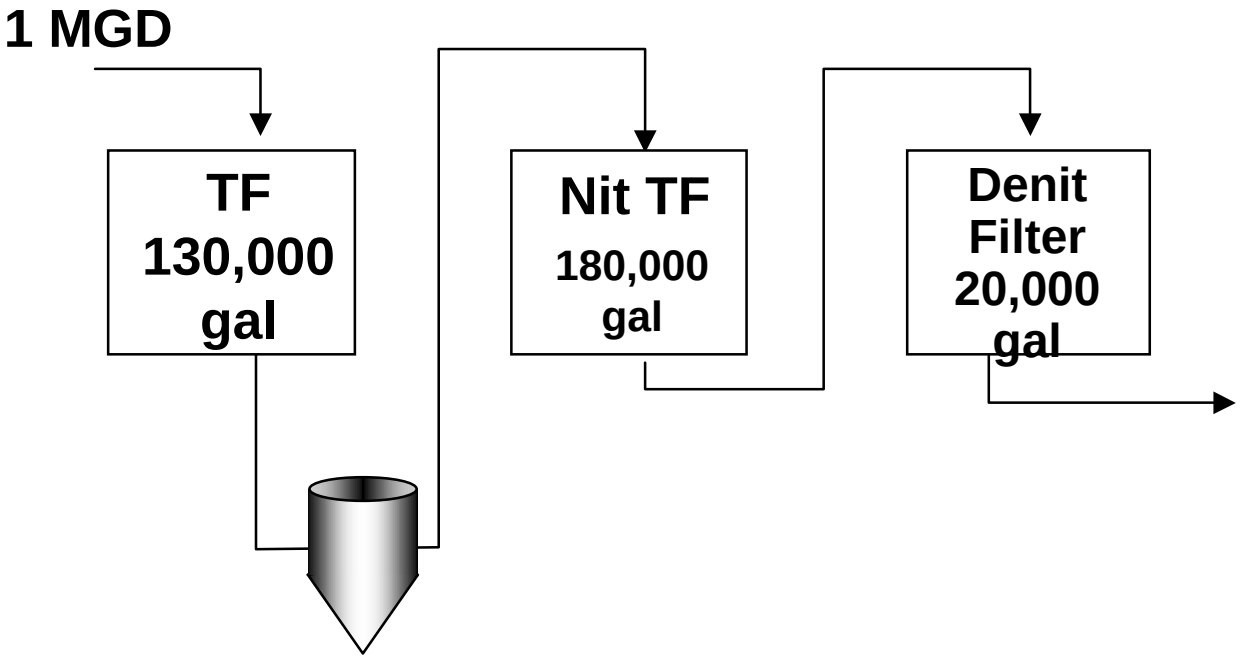
Downflow filter can be TF (rock, plastic), RBC (crossflow), and or other media.

Denitrification Filter Problem

	After Nitrification	After Post-Denit	
Flow (MGD)	1	1	
EFF NH_4^+-N (mg/L)	0.5	0.8	
EFF NO_X-N (mg/L)	15.0	2.0	
NO_XN Denitrified (mg/l)	N/A		
NO_XN Denitrified (lbs/day)	N/A		
COD required (lbs/day)	N/A		
Methanol dose (gpd)	N/A	45-60	
Sludge yield (MLVSS/mg COD)	N/A	0.20	
VSS (lbs/day)	25	133	
VSS (mg/l)	3	16	
Alkalinity (mg/l)			
Alkalinity (lbs/day)			
Denitrification Rate (g NO_X-N/m^2/d)		0.5-1.0	Depending on Methanol Concentration in Effluent
Biofilm Surface Area (m^2)		50,000-100,000	
Surface Area/Vol (m^2/m^3)		600-1000	
Volume of Reactor (m^3)		50-166	
Volume of Reactor (gal)		13,00-43,800	

Note: Denitrification rate will increase from 0 to 2g NO_X-N / m^2 day with biodegradable SCOD in Effluent from 0 to 30 mg/L. Expect DN Rate at 10 mg/L $SCOD_{bio}$ =0.66g NOxN / m^2 /day

Nitrification and Denitrification Filters



Four Filters, 37' dia
4' deep
Rock Media

Two Filters,
25' dia
25' deep
Plastic Media

Two Filters,
15' x 15' each
6' deep media
Sand Media
3 gpm/ft²