

## On-site Wastewater Management Training Course

### Secondary Treatment

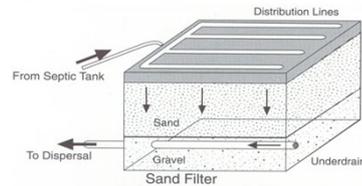
### Sand Filters, Media Filters and Mound Systems

Centre for Environmental Training



### Aerobic Sand Filters

- Historically gravity fed with demand dosing
- Can result in uneven distribution and may lead to creeping failure and clogging of media
- Primary (septic tank) pre-treatment required

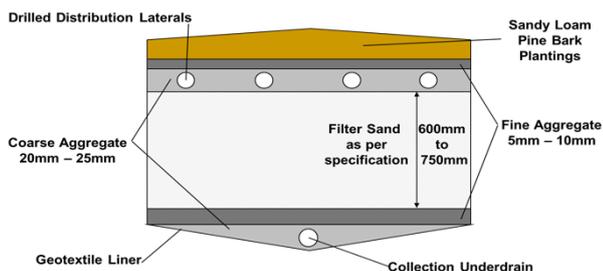


Source: NSFC

Centre for Environmental Training



### Typical Form



Centre for Environmental Training



### Typical ASF Installation

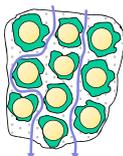
- Constructed within durable impermeable liner or container
- Installed above, partially above, or below ground
- Partial or full pressure distribution required
- Gravel (20-40mm washed aggregate) – used for underdrain and distribution bed
- Pea gravel (5-10mm) used for separation
- Filter surface may be open or covered – contact with atmosphere must be maintained

Centre for Environmental Training



### Treatment Process

- 'Passive' aerobic treatment provided by trickling (primary) effluent through 600mm - 900mm of select sand (packed bed)
- Biofilm develops on media surfaces
- Biofilm in contact with air in media pore spaces
- Treatment acquired in a single pass through media
- Effectiveness dependent on hydraulic and organic load



Centre for Environmental Training



### Treatment Performance

- Hydraulic Loading Rate (HLR) - rate at which effluent is added to the surface of the filter ( $L/m^2$ )
  - Significant effect on treatment effectiveness
  - If HLR too high, saturated conditions dominate and effluent may by-pass treatment, moving rapidly through the bed
- Organic Loading Rate – rate organic matter (BOD) is added to the filter surface ( $g/m^2$ )
  - Excess organic loading (high BOD) can also significantly impact treatment performance (clogging, anaerobic conditions)

Centre for Environmental Training



## ASF Sizing

- In sizing ASF, we apply 2 general rules for design:
- Hydraulic loading rate =  $50\text{L}/\text{m}^2/\text{d}$
- Organic (BOD) loading rate =  $25\text{g}/\text{m}^2/\text{d}$
- ASF sized using these criteria will typically achieve minimum secondary effluent standard
- BOD (20mg/L) / TSS (30mg/L), or better

## ASF Sizing - Example

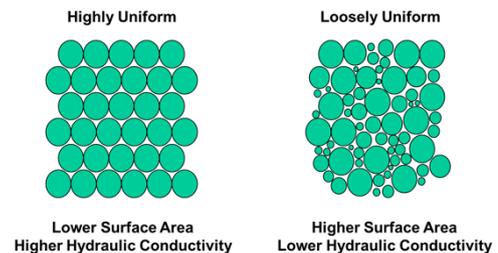
- Effluent Spec = 1,200L/day and 150mg/L BOD
- Hydraulic Load rule
  - $1,200\text{L}/\text{day} \div 50\text{L}/\text{m}^2/\text{day} = 24\text{m}^2$
- Organic Load rule
  - $1,200\text{L}/\text{day} \times 150\text{mg}/\text{L} = 180,000\text{mg}/\text{day}$
  - $180,000\text{mg}/\text{day} \div (1,000\text{mg}/\text{g}) = 180\text{g}/\text{day}$
  - $180\text{g}/\text{day} (\text{BOD}) \div 25\text{g}/\text{m}^2/\text{day} = 7.2\text{m}^2$
- Suitable L:W ratio (2:1 to 10:1)
  - Assuming ~3:1 – ASF dimensions = 3m x 8m

## Filter Sand Considerations

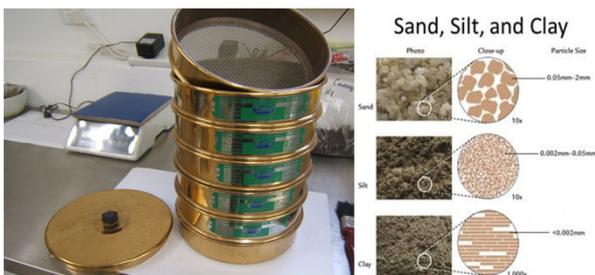
To achieve 20/30 (secondary) standard, sand-fill:

- Free of clay, limestone or organic matter
- Contain <20% particles larger than 20mm
- Contain <3% clay and fine silt (<0.074mm)
- Effective Size (ES) ( $d_{10}$  - smallest 10% diameter) between 0.25mm and 1.00mm
- Uniformity Coefficient (UC) ( $d_{60}/d_{10}$ ) <4
- Sand sieved for particle size analysis (PSA)
- Plot histogram and cumulative frequency curve

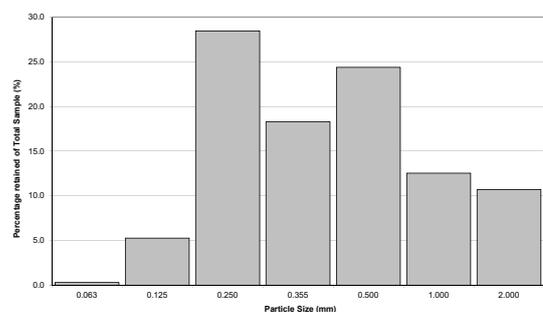
## Media Size and Grading



## Sieve Analysis

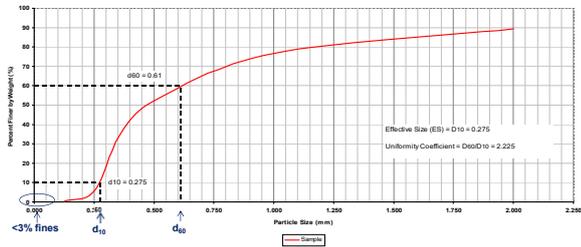


## Histogram



## Cumulative Frequency Curve

- <3% clay; ES = 0.25mm-1.00mm and UC = <4



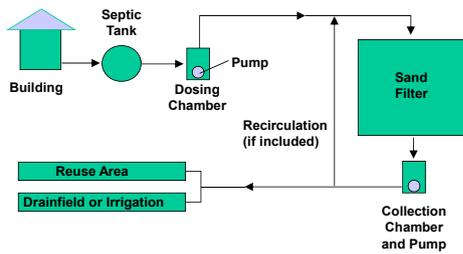
Centre for Environmental Training cet

## Improving ASF Performance

- Septic outlet filter
- Pressure distribution – pump / drilled manifold
- Timed-dosing
  - Smaller dosing volumes
  - Regular application throughout day (12-24 times)
- Recirculation

Centre for Environmental Training cet

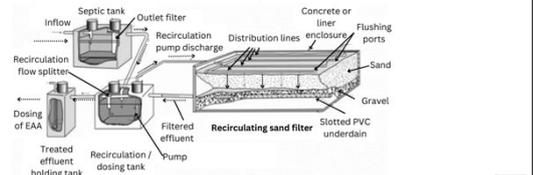
## Typical System Configuration



Centre for Environmental Training cet

## Recirculating Sand / Media Filter

- Allows treatment across several filter passes
- Higher hydraulic conductivity media – gravel
- Permits higher aerial loading rate
- Treated effluent proportionally released to LAA



Source: DPHI, 2025

Centre for Environmental Training cet

## Sand Filter Construction



Liner installation

Centre for Environmental Training cet

## Sand Filter Construction



Underdrain and gravel bed

Centre for Environmental Training cet

## Sand Filter Construction



Filter sand and distribution bed

Centre for Environmental Training



## Sand Filter Construction



Drilling manifold 'orifices'

Centre for Environmental Training



## Sand Filter Construction



Distribution manifold

Centre for Environmental Training



## Testing Distribution System



Uniform squirt height

Centre for Environmental Training



## Completed Sand Filter



Centre for Environmental Training



## Completed Sand Filter



Centre for Environmental Training



## Bottomless Sand Filter

- Single-pass ASF, with soil absorption
- Treatment and land application in single footprint
- Critical to consider hydraulic contrast at interface



Source: W Cromer

Centre for Environmental Training



## Alternative Filter Media

- Some modify or enhance performance of traditional sands and gravels:
  - Crushed glass / sandstone
  - Amended systems (i.e. adsorptive materials)
- Others are economically viable alternatives:
  - Peat
  - Coir
  - Foam
  - Fabric

Centre for Environmental Training



## Peat Filter



Peat Biofilter installation, VIC

Centre for Environmental Training



## Coir Filter

- Coconut husk fibres
- Very durable – high lignin content
- High specific surface area (90% void)



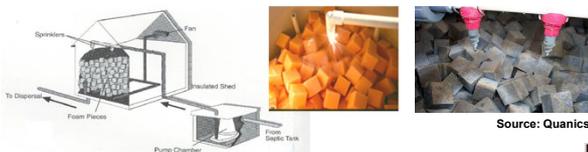
Source: Anua PuraFlow

Centre for Environmental Training



## Foam Filter

- Foam filters
- Provide some physical filtration
- Combine porosity and high surface area
- Main function as surface for biofilm growth



Source: Quantics

Centre for Environmental Training



## Fabric Filter

- Hydraulic loading rate = up to 1,000L/m<sup>2</sup>
- 96 'doses' per day (15 min intervals)
- Recirculation rate ~3-5 times flow



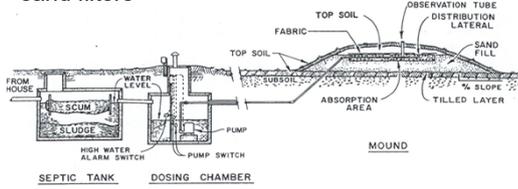
Orenco Advantex fabric filter

Centre for Environmental Training



## Wisconsin Mound Systems

- Developed in 1970s
- Over 30,000 Wisconsin mounds in Wisconsin
- In effect, bottomless intermittent (single-pass) sand filters



Source: Converse, 2000

Centre for Environmental Training



## Wisconsin Mound Systems

- Soil absorption systems
- Elevated above natural soil surface
- Uses suitable fill such as quality sand media
- Pretreated effluent is dosed to the mound
- Overcome site restrictions such as:
  - slowly permeable soils
  - shallow permeable soils (300-600mm) over porous bedrock or hardpan
  - permeable soils with high water table

Centre for Environmental Training



## Wisconsin Mound Systems



Centre for Environmental Training



## Sand Mound Design

Design considerations:

- Aligned on contour
- Ground suitably prepared
- Appropriate materials and construction
- Key Sizing Criteria:
  - Sand loading rate – at distribution manifold
  - Linear loading rate – across slope
  - Basal loading rate – on soil at base of mound

Centre for Environmental Training



## Sand Loading Rate

- Sand loading rate (SLR) – mm/day
  - at distribution gravel / sand interface
  - influenced by effluent quality
  - AS/NZS 1547:2012 suggests <40mm/day
  - acceptable range - 40 (primary) to 50 (secondary)
- Rate at which effluent contacts the sand surface (base of distribution)

Centre for Environmental Training



## Basal Loading Rate

- Basal loading rate (BLR) – mm/day
  - at sand / natural soil interface
  - from Table N1 in AS/NZS 1547:2012
  - select for the limiting soil layer below mound
    - 8 (light clay) to 32 (sand) mm/day
- Rate at which effluent will infiltrate the natural (underlying) soil
- Critical to ensure sufficient depth (~400mm) if topsoil BLR selected

Centre for Environmental Training



## Completed Wisconsin Mound



Source: B. Baiers

Centre for Environmental Training



## Completed Wisconsin Mound



Centre for Environmental Training



## Alternative Vegetation Cover



Centre for Environmental Training



## Treatment Performance of Sand Filters and Mound Systems

	BOD <sub>5</sub> (% removal)	TSS (% removal)	TN (% removal)	FC (% removal)
Intermittent sand filter / Mound	90-98	90-95	14-50	97-99
Recirculating sand filter	95-99	81-95	45-82	97-99

Source: Crites and Tchobanoglous (1999)

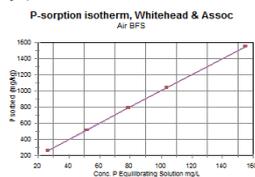
Centre for Environmental Training



## Amended Soil Systems

Use soil or alternative media for nutrient reduction

- P-sorption
  - Gypsum amended red mud (by-product of bauxite refining for aluminium)
  - Air-dried Blast Furnace Slag
- N reduction
  - Zeolite



Centre for Environmental Training



## Ecomax System, WA



Source: Ecomax WA

Centre for Environmental Training



## Ecomax System, NSW



Source: Ecomax NSW

Centre for Environmental Training



## Ecomax System, NSW



Source: Ecomax NSW

Centre for Environmental Training



## Amended Ecomax Design



Source: Ecomax NSW

Centre for Environmental Training



## Ecomax Hydraulic Overload



Flat bed limits rainfall runoff and evapotranspiration

Centre for Environmental Training



## References

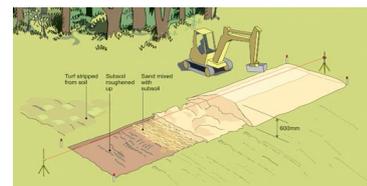
- Converse, JC & Tyler EJ (2000). Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual, #15.24, University of Wisconsin-Madison, Small Scale Waste Management Project. [https://soilsfacstaff.cals.wisc.edu/sswmp/SSWMP\\_15.24.pdf](https://soilsfacstaff.cals.wisc.edu/sswmp/SSWMP_15.24.pdf)
- Cromer, WC (2013). Bottomless sand filters: Notes for designers, installers and regulators July 2013. Land application systems for domestic wastewater management. Unpublished report by William C Cromer Pty Ltd, 1 December 2013.
- Whitehead, J & Geary P (2009). Sand Mounds for Effective Domestic Effluent Management, Water 36, 1 (pp 27-32).

Centre for Environmental Training



## References

- A guide to installing a sand mound to manage onsite wastewater, WaterNSW, <https://vimeo.com/72859822>



Centre for Environmental Training

