

On-site Wastewater Management Training Course

Secondary Treatment

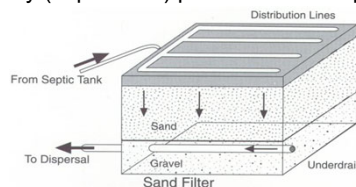
Sand Filters, Media Filters and Mound Systems

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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

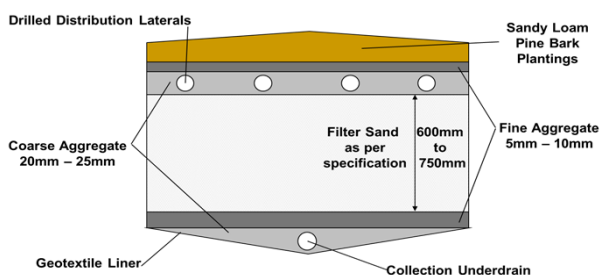


Source: NSFC

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Typical Form



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Typical ASF Installation

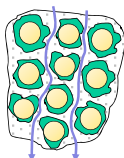
- Constructed within durable impermeable liner or container
- Installed above, partially above, or below ground
- Partial or full pressure distribution required
- Gravel (20-40mm washed aggregate) – used for underdrain and distribution bed
- Pea gravel (5-10mm) used for separation
- Filter surface may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

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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 pore spaces in media
- Treatment acquired in a single pass through media
- Effectiveness dependent on hydraulic and organic load



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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
- Excess organic loading (high BOD) can also significantly impact treatment performance (clogging, anaerobic conditions)

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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

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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

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Filter Sand Considerations

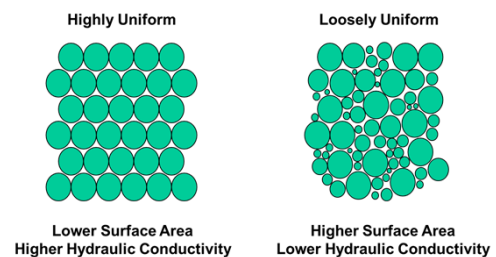
To achieve 20/30 (secondary) standard, sand-fill:

- 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

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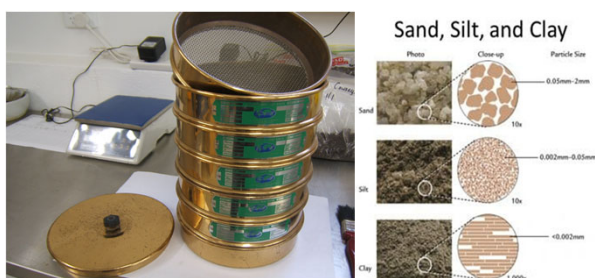
Media Size and Grading



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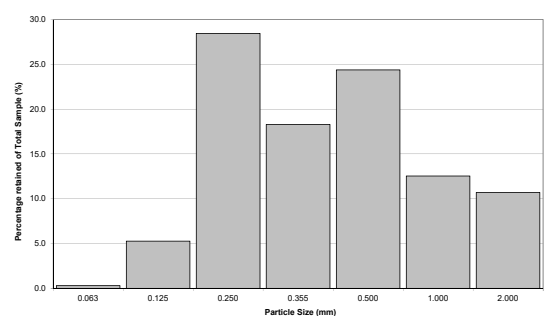
Sieve Analysis



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Histogram

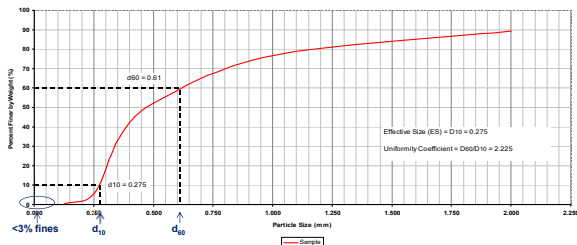


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Cumulative Frequency Curve

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



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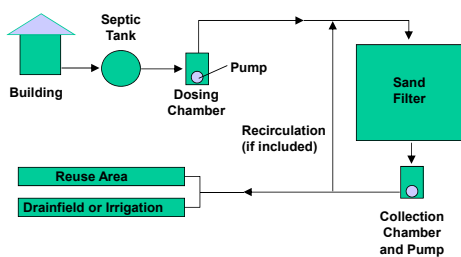
Improving Performance

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

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Typical System Configuration

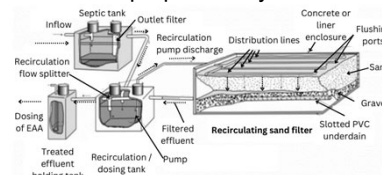


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Recirculating Sand / Media Filter

- 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

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Sand Filter Construction



Liner installation

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Sand Filter Construction



Underdrain and gravel bed

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Sand Filter Construction



Filter sand and distribution bed

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Drilling manifold 'orifices'

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Distribution manifold

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Testing Distribution System



Uniform squirt height

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Completed Sand Filter



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Completed Sand Filter



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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

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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

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Peat Filter



Source: AgriFlow

Peat Biofilter installation, VIC

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Coir Filter

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



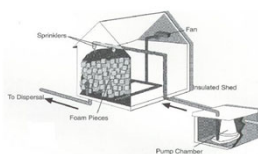
Source: Anua PuraFlow

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Foam Filter

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



Source: Quonics

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Fabric Filter

- Hydraulic loading rate = up to 1,000L/m²
- 96 'doses' per day (15 min intervals)
- Recirculation rate ~3-5 times



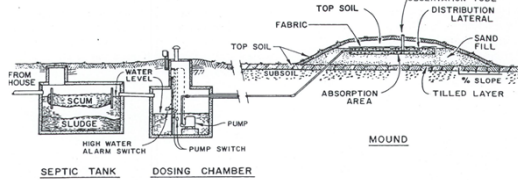
Orencia Advantex fabric filter

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Wisconsin Mound Systems

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



Source: Converse, 2000

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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

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Wisconsin Mound Systems



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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

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Sand Loading Rate

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

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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
 - 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

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Completed Wisconsin Mound



Source: B. Baiers

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Completed Wisconsin Mound



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Alternative Vegetation Cover



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Treatment Performance of Sand Filters and Mound Systems

	BOD ₅ (% 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 (1998)

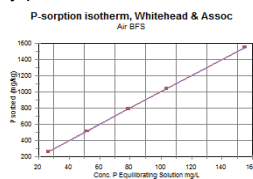
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Amended Soil Systems

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



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Ecomax System, WA



Source: Ecomax WA

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Ecomax System, NSW



Source: Ecomax NSW

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Ecomax System, NSW



Source: Ecomax NSW

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Amended Ecomax Design



Source: Ecomax NSW

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Ecomax Hydraulic Overload



Flat bed limits rainfall runoff and evapotranspiration

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References

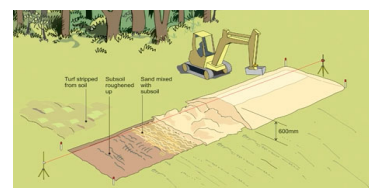
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- Cromer, WC (2013). Bottomless sand filters: Notes for designers, installers and regulators July 2013. Land application systems for domestic wastewater management. Unpublished report by William C Cromer Pty Ltd, 1 December 2013.
- Whitehead, J & Geary P (2009). Sand Mounds for Effective Domestic Effluent Management, Water 36, 1 (pp 27-32).

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References

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