Land application systems
for domestic wastewater management

BOTTOMLESS SAND FILTERS

Notes for designers, installers and regulators

December 2013

Cover photo

Completed bottomless sand filter, southern Tasmania, 2012.
Photo: Chris Lewis

Citation

Refer to this document as

Cromer, W. C. (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 Unpublished report by William C Cromer Pty Ltd, 1 December 2013.

It replaces an earlier document of the same name

Cromer, W. C. (2013). Bottomless sand filters: Notes for designers, installers and regulators. Land application systems for domestic wastewater management. Unpublished report by William C Cromer Pty Ltd, 12 October 2013

Notes

This document is one of a series which attempts to disseminate design guidelines for land application systems for domestic wastewater. It was adapted from design specifications in Australian/New Zealand Standard 1547:2000 *On-site domestic-wastewater management*, other sources as cited, and more recently Australian/New Zealand Standard 1547:2012 *On-site domestic wastewater management*. Assessors, designers, regulators and installers in Australia and New Zealand should be familiar with the requirements of the later standard.

Subject to the requirements of local or national jurisdictions, the principles of wastewater management and the generic system designs described here ought to be globally applicable. For considerably more detailed information and guidance, the Excel-based software Trench®3.0, accepted Australia-wide since 1999, remains a valuable tool to help wastewater practitioners and regulators assess and size wastewater management systems. A free preview is available from www.williamccromer.com

This document aims to be a practical installation guide, and a discussion paper. It may be freely copied provided it or information in it is properly cited. Practitioners may have ideas on variations to the designs included here. Constructive comments are welcomed and ought to result in improved design guidelines.

No responsibility whatsoever is taken by William C Cromer Pty Ltd for the behaviour of any wastewater management system constructed from information in this discussion paper.

This document has not been reviewed by, and does not have the formal approval of, any regulatory body. There is no guarantee that any wastewater disposal system designed using the information in this document will be approved by any such authority.

People using this document should check that it has not been superseded by a later version.

> "This Standard does not preclude the use of any material, system, design or method of implementation provided the completed system and installation meet the performance requirements of this Standard…..Systems not covered by this Standard require advice from a suitably qualified and experienced person."
>
> Australian/New Zealand Standard 1547:2012 (Section 1.2.1.1)

Notes for Designers, Installers and Regulators in this series include

Conventional beds (2004)
Nonconventional beds (September 2013)
Bottomless sand filters (October 2013)

1. FUNDAMENTALS OF LAND APPLICATION SYSTEMS FOR WASTEWATER

1.1 Basic module

All land application (except some irrigation) systems for wastewater comprise a basic distribution module surrounded by soil.

The basic module comprises one or more perforated pipes or arches or both in a relatively thin bed of durable screened aggregate, with a filter cloth cover (Figure 1).

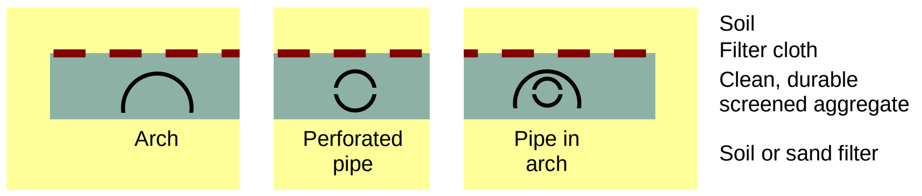
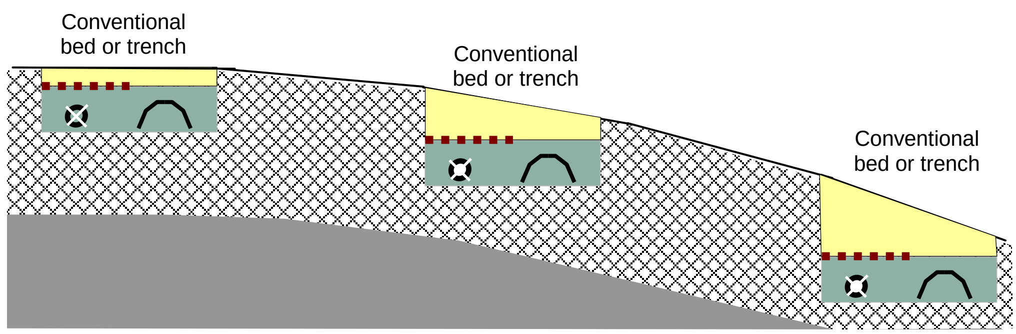


Figure 1 **Basic module (section view)**

The basic module may be wholly below the natural land surface, partly below natural surface, or fully above it Figure 2)



Above. If existing soils are sufficiently thick, beds may be acceptable on increasingly steeper slopes by installing the basic module deeper, and backfilling with extra topsoil or imported soil. The basic module remains the same, and the bed remains in-ground, but the thickness of the topsoil or imported soil varies.

Below. If existing soils are relatively thin, beds may be acceptable on increasingly steeper slopes by raising the basic module partly or fully above ground (by definition, a nonconventional bed). The module is surrounded by natural or imported soil, to provide an additional treatment medium and to physically support the system. Wisconsin Mounds and Bottomless Sand Filters are special cases of nonconventional beds.

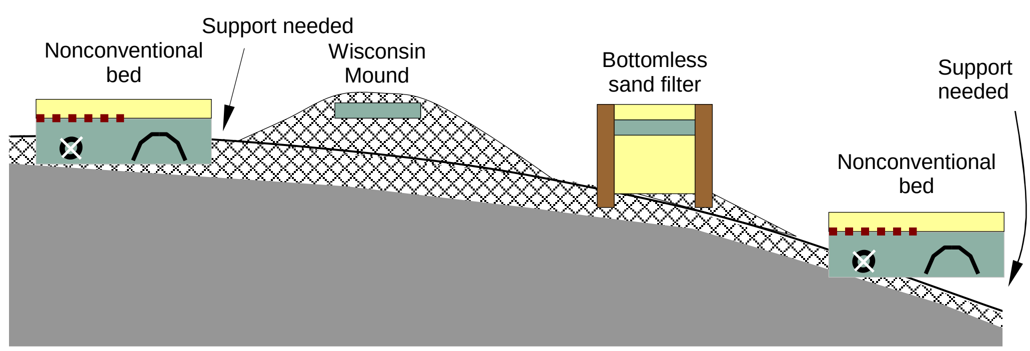


Figure 2. **Basic module in relation to the ground surface (section views)**

1.2 Wetted area requirements

The purpose of the basic module is to distribute wastewater evenly over a wetted area. The wetted area may be any shape in plan.

For trenches and beds, the wetted area (ie the basic module) must be sized according to the Design Loading Rate (DLR) of the underlying soil profile. From this is derived the concept of a *minimum wetted area requirement*.

For a Wisconsin Mound (WM) or Bottomless Sand Filter (BSF),

- the minimum wetted area requirement for the basic module is obtained directly from the DLR of the raised soil bed (usually "filter sand") immediately beneath the module,
- the length of the basic module is determined by the linear loading rate[1] of the soil beneath the toe of the structure, and
- the overfall footprint of the system (module + apron) is sized from the DLR of the underlying soil profile beneath and downslope from the basic module.

1.3 Primary and Secondary Disposal Areas

The Primary Disposal Area (PDA) is the wetted area of the basic module and any protective perimeter strip around it. The Secondary Disposal Area (SDA), if required, is the same size but not necessarily the same shape, as the PDA. The PDA may be divided into a number of subareas of any shape but wastewater must be delivered simultaneously to all of them.

1.4 Available Disposal Area

The Available Disposal Area (ADA) is the land area (eg of a typical residential lot) less all infrastructure, and after setbacks to downgradient, cross gradient and upgradient sensitive features have been applied. The PDA and SDA must both be wholly within the ADA, but may be anywhere within it.

The concepts of ADA, PDA, SDA, wetted area and setbacks are shown in Figure 3.

1.5 Soil categories

In Australia and New Zealand, AS/NZS 1547:2012 *On-site domestic wastewater management*, soil categories 1 – 6 are based on texture and structure (Table 1). Hydraulic loadings (Design Loading Rates, DLRs) or Design Irrigation Rates (DIRs) are then allocated. In Australia and New Zealand, DLRs and DIRs are expressed in terms of mm/day (equivalent to L/m^2/day).

The DLRs and DIRs can (and usually should) be amended to account for on-site permeability testing, or for limiting site conditions such as thin soil horizons, dispersive soils, a shallow water table, etc. In Tasmania, at local government level, Sorell Council has adopted a proactive approach[2] which requires that all soils with a limiting horizon in the top metre are classed as Category 6. This appears overly conservative but in practice it promotes lateral thinking and creative designs for difficult sites, and is inherently flexible. Aspects of it have been incorporated in a recommended approach to site assessment and wastewater management shown in Figure 4.

[1] See AS/NZS1547:2012 Appendix N Section N2.2, and Converse, J. C. (1998). Linear Loading Rates for On-Site Systems. Small Scale Waste Management Project, University of Wisconsin, August 1998. www.wisc.edu/sswmp/
[2] See Schedule 12 in http://www.sorell.tas.gov.au/planning-scheme

Table 1 Soil categories used in Australia and New Zealand for on-site wastewater management

Soil category	Soil texture
1	Gravel and sand
2	Sandy loams
3	Loams
4	Clay loams
5	Light clays
6	Medium to heavy clays

Notes
1. Adapted from Table L1 of AS/NZS1547:2012 *On-site domestic wastewatrer management*
2. Category 2 – 6 soils are further subdivided on the basis of soil structure

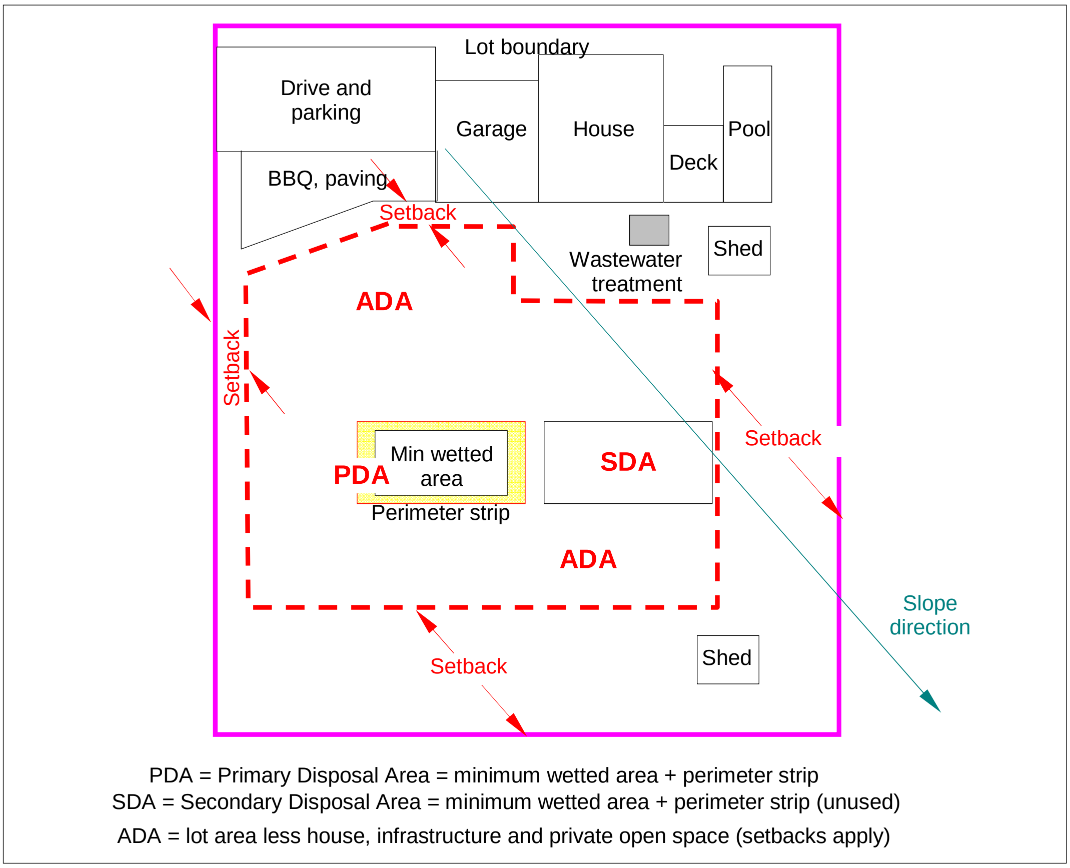
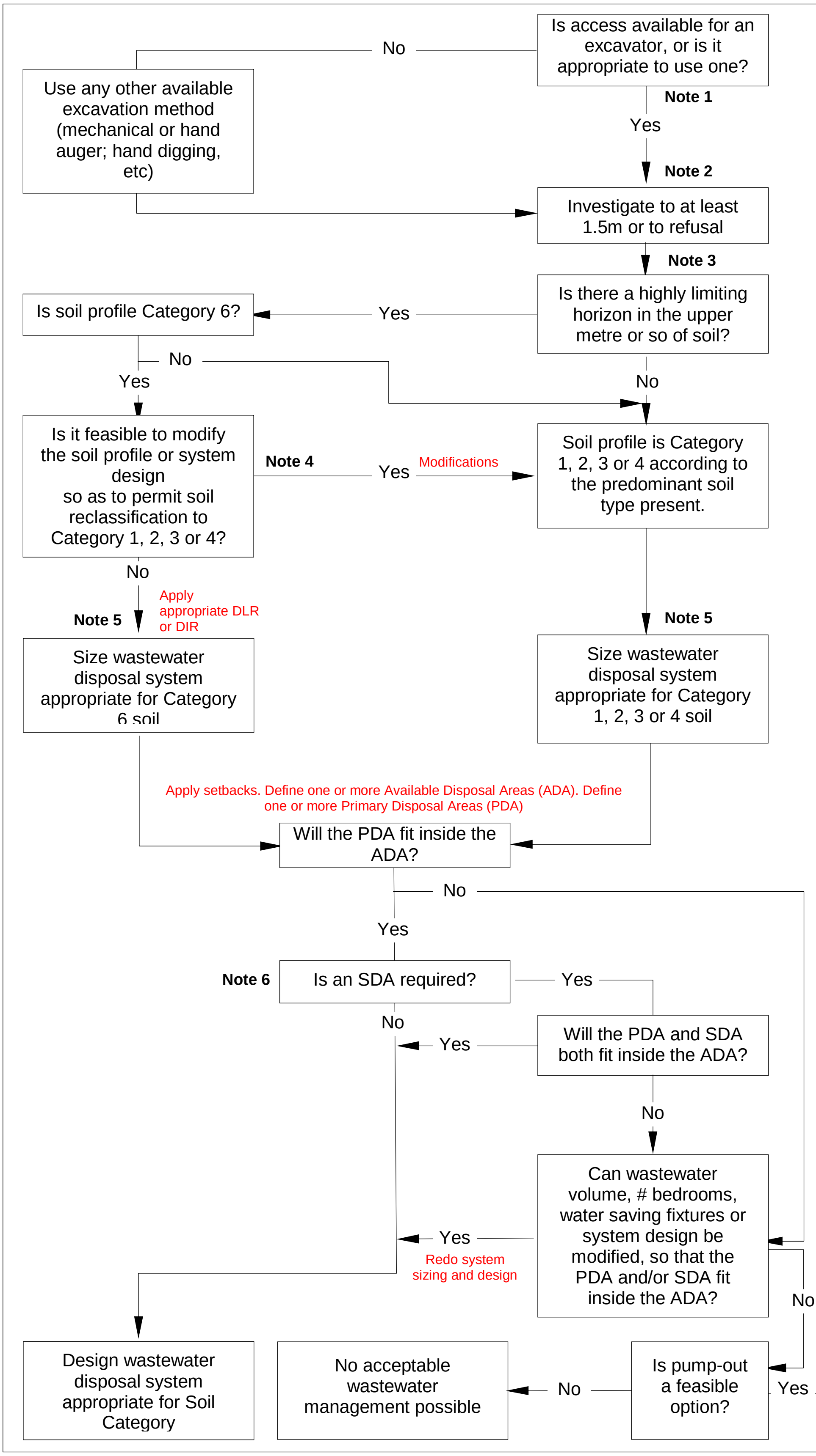


Figure 3 **Schematic diagram showing the relationship between lot size and various areas within the lot related to wastewater management. Setbacks are measured parallel to slope direction.**



Note 1. An excavator test hole provides much more information than a small diameter hole.

Note 2. Log, photograph, sample, test. Use USC system of classification and industry standard log sheets.

Note 3. Examples of highly limiting soil attributes include Category 5 and 6 soils, <u>and</u> any type of soil with permeabilities less than about 0.06m/day, such as many hardpans, dense to very dense clayey sands, sands, gravels, and weathered and/or fractured bedrock of many rock types. Also highly limiting might be shallow groundwater, depending on its quality.

Note 4. A common example of a modified soil profile is placing enough Category 1, 2, 3 or 4 soil over the Category 6 profile so as to cover the highly limiting horizon by about a metre or more.

Note 5. A DLR may be obtained from a selected Soil Category with reference to AS/NZS1547 (2012). These categories are indicative only and may be modified by experience, limiting soil horizons, soil permeability testing etc.

Note 6. Section 5.5.3.4 of AS/NZX1547 (2012) allows an SDA to be discretionary.

Figure 4 **Suggested flow chart for on-site wastewater assessment.**
Elements of this flow chart have been influenced by Schedule 12 of Sorell Council's Planning Scheme 1993 (amended 10 Aug 2011). Other approaches may be acceptable.

2. BOTTOMLESS SAND FILTERS (BSF)

2.1 Sites suitable for BSFs

BSFs can be installed at any site or on any soil, but are best suited (Figure 5) to sites with shallow, limiting conditions. With specific design detail, they may be suitable for sites with limited ADAs.

The main purpose of a BSF is to treat wastewater to a relatively high degree employing intermittent pressure dosing (preferably on a time rather than demand basis[3]) from a float-operated pump; pit, and vertical infiltration through a layer of filter sand[4]. The filter sand should meet or closely conform to the requirements of Clause N3.3.2 in AS/NZS1547:2012 ie the sand must be of medium grain size in the range 0.25 – 1.0mm with a uniformity coefficient (C_u)[5] less than 4 and less than 3% of fines passing a 0.074mm sieve, and be free of clay, limestone, and organic matter (Figure 6).

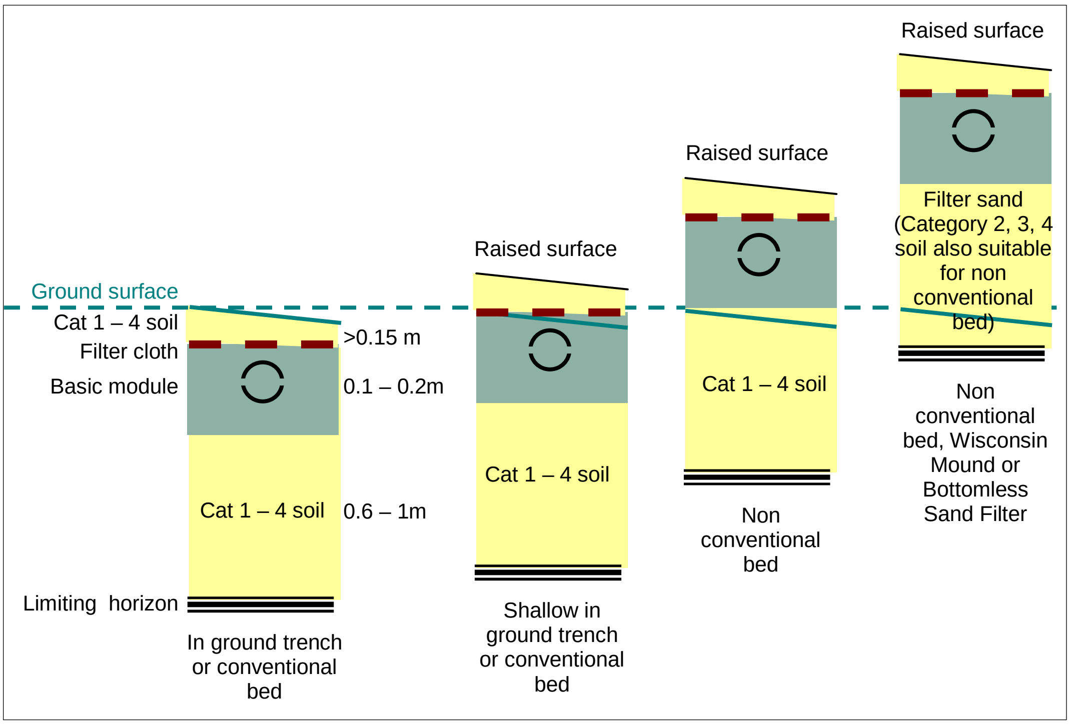
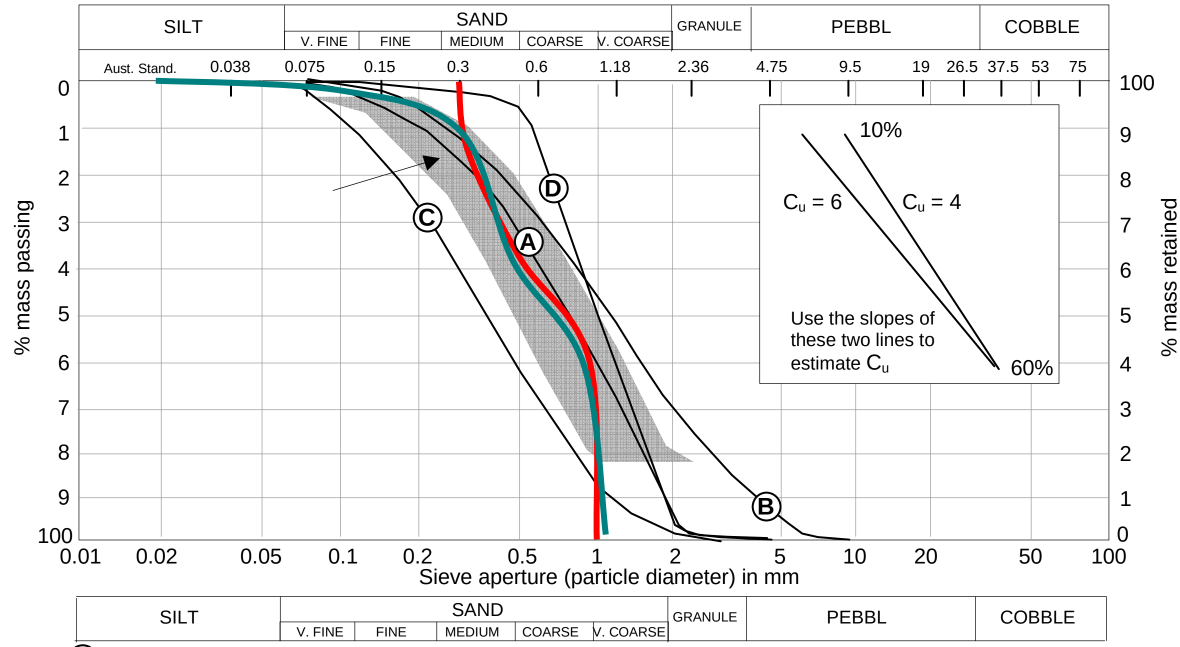


Figure 5. Cross sections of four wastewater disposal systems in relation to ground surface and the depth to a limiting horizon.
Adapted from Converse and Tyler (2000) and Cromer (2004)

[3] Demand dosing may result in most effluent arriving at the BSF in the mornings and evenings. Time-based dosing permits regular smaller doses during the 24 hour period, promoting biological activity and effluent treatment in the BSF.

[4] Converse, J. C. (2000). Pressure distribution network design. *Small Scale Waste Management Project, University of Wisconsin-Madison.* www.wisc.edu/sswmp/ and Converse, J. C. and Tyler, E. J. (2000). Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual. *Small Scale Waste Management Project, University of Wisconsin-Madison.* www.wisc.edu/sswmp/

[5] The uniformity coefficient (C_u) is the ratio of the sieve aperture sizes retaining 40% and 90% of the material. A sieve or grain size analysis is required to calculate C_U. A perfectly uniform sand, with every particle of the same size, would have a C_U of 1. A silty sand with grains ranging from silt to coarse sand would have a C_U of between about 2 and 4. A very poorly sorted material, with (say) equal amounts of silt, sand, granules and pebbles, would have a C_U of about 100.



(A) "Medium washed sand". Cu = 5; effective diameter = 0.2mm.

(B) "Coarse washed sand". Cu = 6.5; effective diameter = 0.25mm.

(C) "Normal coarse sand". Cu = 4; effective diameter = 0.12mm.

(D) "Propagating sand". Cu = 2; effective diameter = 0.6mm.

Figure 6. Grain size curves A – D for some Tasmanian commercial screened sand materials (modified from Cromer, 2004). The grey envelope approximately includes the range of sand specifications suggested by Converse and Tyler (2000) for a Wisconsin Mound. The red and green lines are two of a series of curves that comply with Clause N3.3.2 of AS/NZS1547:2012; in both cases, the C_u is about 3.3.

Figure 7 provides general guidance on the effectiveness of sand filters for removing biochemical oxygen demand (BOD), total suspended solids (TSS), total nitrogen (N), Total phosphorus (TP) and faecal coliforms (thermotolerant coliforms).

A minimum filter depth of about 0.3 to 0.4m is required, and there is evidence that increasing the filter sand depth beyond this does not significantly increase effluent treatment[6].

2.2 Hydraulic loading rates for BSFs

2.2.1 Hydraulic loading rate on the filter sand

Allow up to 40mm/day for primary treated effluent, and up to 80mm/day for secondary treated effluent.

[6]For example, Amador et al (2008) report ""The depth of soil below the absorption trench of a septic system is considered an important factor in protection of groundwater. We examined the effects of depth on the ability of intermittently aerated sand-filled leachfield mesocosms to renovate domestic wastewater. Mesocosms (*n*=3) consisted of lysimeters with a headspace O_2 concentration maintained at 0.21mol/mol and containing 7.5, 15, or 30cm of sand that were dosed with septic tank effluent every 6h for 328 days (12cm/d) . Sand depth had no effect on pH, dissolved O_2 , PO4 , NH4 , or BOD5 levels in percolate water. Nitrate levels in percolate water were higher for 30cm than for 7.5 and 15cm during the first 70d of the experiment, after which no differences were observed. Time-averaged removal rates of N, P, fecal coliform bacteria, and BOD5 were 22–28, 13–18, 81–92, and 81–99%, respectively, and were unaffected by depth. Wastewater renovation in intermittently aerated leachfield mesocosms appears to take place in a narrow zone (≤7.5cm) below the infiltrative surface, with the medium below contributing little to renovation." (Amador, J., Potts, D., Patenaude, E., and Görres, J. (2008). "Effects of Sand Depth on Domestic Wastewater Renovation in Intermittently Aerated Leachfield Mesocosms." *J. Hydrol. Eng.* 13, SPECIAL ISSUE: Interactions between Onsite Waste Water Systems and the Environment, 729–734.)

The former is obtained from AS/NZS1547:2012 Clause N2.2 in Appendix 2, which includes no variation for different levels of effluent treatment.

The latter is *from Wastewater Technology Fact Sheet: Intermittent Sand Filters* (US EPA 932-F-99-067 September 1999)[7] which comments that "High hydraulic loading rates are typically used for filters with a larger media size or systems that receive higher quality wastewater" and which in Table *1 Typical Design Criteria for ISFs* lists hydraulic loadings in the range 2 – 5gal/ft^2/day (80 – 200mm/day). In the current document, the upper limit to loading rate of 80mm/day is conservative.

2.2.2 Linear loading rate along the perimeter of the BSF

Adopt 50L/m/day if the flow of effluent beneath the base and toe of the BSF is mainly horizontal (ie the soil profile is limiting), or a linear loading rate of up to 125L/m/day if the flow is mainly vertical (ie in freely draining soils). See AS/NZS1547:2012 Appendix N, Clause N2.2.

2.3 Domestic wastewater flow rates

In Australia, AS/NZS1547:2012 (Table H1) allows 120L/day/person (for a house on a roof water tank supply) or 150L/day/person (for a house on a reticulated or bore water supply). Assume about 2 persons per bedroom, or 250L/day/bedroom and 300L/day/bedroom respectively. Rooms or spaces such as studies, offices, etc are regarded as bedrooms to estimate daily wastewater volume.

For Australian conditions, AS/NZS1547:2012 permits no variation to these figures for any water saving fixtures in a dwelling.

2.4 Sizing a BSF

There are three steps involved in sizing a BSF (Figure 8).

2.4.1 Calculate the minimum wetted area of the basic module

To calculate the minimum wetted area of the basic module,

- allocate a daily wastewater volume (V; L/day), and
- divide the daily wastewater volume by 40L/m^2/day for primary treated effluent, or 80L/m^2/day for secondary treated effluent.

Example 1

A four-bedroom equivalent house with reticulated water has a primary-treated wastewater volume of 1,200L/day (rounded). What is the minimum wetted area required for the basic module?

<u>Answer</u>

Minimum wetted area (A; m^2) of basic module is

$$A = V \div 40\text{L/m}^2\text{/day}$$

$$A = 1{,}200\text{L/day} \div 40\text{L/m}^2\text{/day} = 30\text{m}^2$$

The required minimum wetted area may comprise one, two or more separate sub-areas provided wastewater is supplied to each proportionately and simultaneously, and provided the recommended linear loading rate are maintained for each sub-area.

[7] Anon (1999). Wastewater Technology Fact Sheet: Intermittent Sand Filters. US EPA 932-F-99-067 September 1999. http://water.epa.gov/aboutow/owm/upload/2005_07_14_isf.pdf

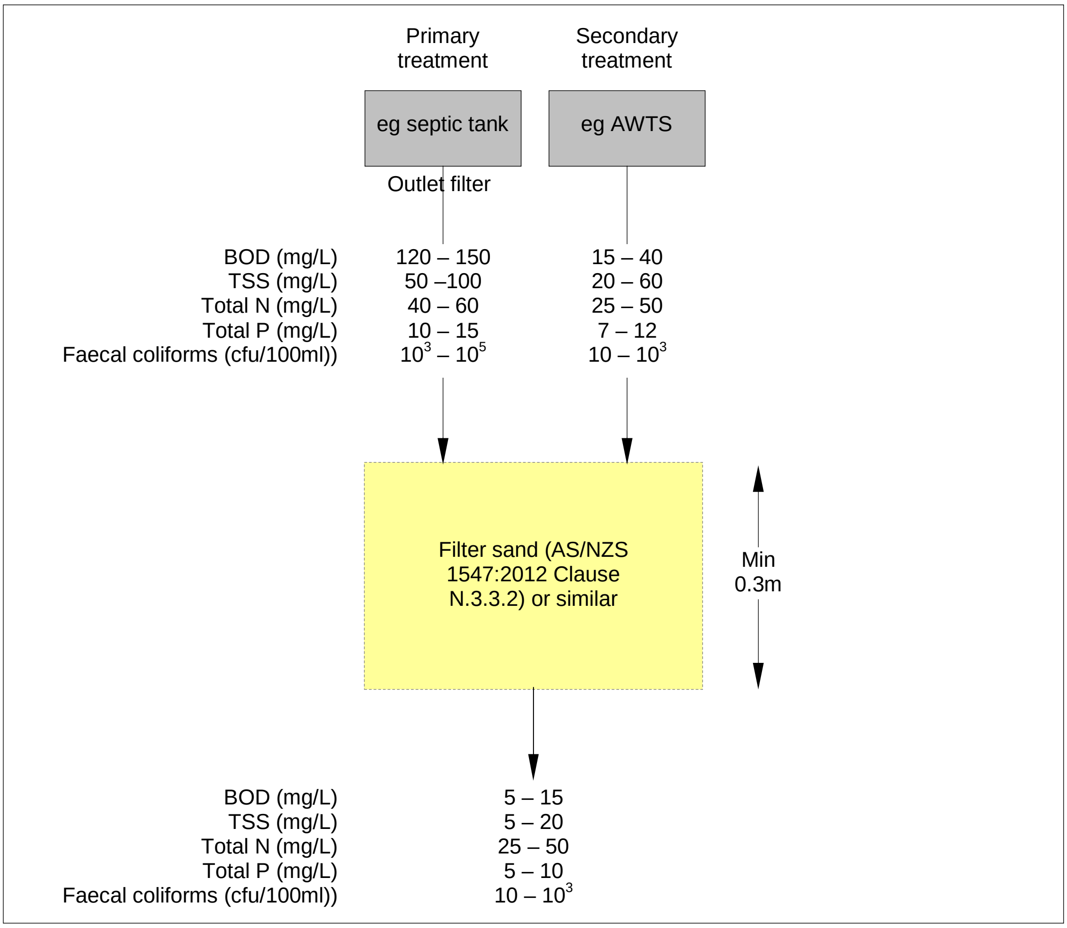


Figure 7. Approximate treatment efficiencies of filter sand

Constituent ranges in Figure 7 have been derived with reference to the following:

Amador, J., Potts, D., Patenaude, E., and Görres, J. (2008). Effects of Sand Depth on Domestic Wastewater Renovation in Intermittently Aerated Leachfield Mesocosms. *J. Hydrol. Eng.* 13, SPECIAL ISSUE: Interactions between Onsite Waste Water Systems and the Environment, 729–734.

Anon (1999). Wastewater Technology Fact Sheet: Intermittent Sand Filters. US EPA 932-F-99-067 September 1999. http://water.epa.gov/aboutow/owm/upload/2005_07_14_isf.pdf

Anon (date?). Sustainable Wastewater Management: A handbook for smaller communities. Part 3: Options for Wastewater Servicing. Minister for the Environment, New Zealand
http://www.mfe.govt.nz/publications/waste/wastewater-mgmt-jun03/html/part3-section10.html#table10-2

Information menu in Trench®3.0. See Cromer, W. C. (1999). Trench™3.0: A computer application for site assessment and system sizing, in Patterson, R. A. (Ed.) *On-site '99 – Proceedings of the On-Site '99 Conference: Making on-site wastewater systems work*. University of New England, Armidale, 13-15 July 1999, pp 85-88.

Rodgers, M., Walsh, G., Healy, M.G. (2011). Different depth sand filters for laboratory treatment of synthetic wastewater with concentrations close to measured septic tank effluent. *Journal of Environmental Science and Health*, Part A: Toxic/Hazardous Substances and Environmental Engineering 46(1):80-85.
http://aran.library.nuigalway.ie/xmlui/bitstream/handle/10379/2904/Aran_Rodgers_et_al._J.Env.Sci.Health.pdf.pdf?sequence=1

2.4.2 Calculate the length (and hence the width) of the basic module

To calculate the minimum length (L, m) of the BSF, divide the daily wastewater volume (V; L) by a linear loading rate of 50L/m/day or 125L/m/day depending on site conditions as stated in Section 2.2.2.

Example 2

A five-bedroom equivalent house has reticulated water and secondary-treated wastewater. Calculate (a) the minimum wetted area required for the basic module of a BSF on sloping ground, and (b) the minimum length required for the BSF if the soils beneath and downslope from it are freely draining.

<u>Answer</u>
Daily wastewater volume V = 1,500L

From Example 1, the minimum wetted area of the basic module is

$$A = V \div 80L/m^2/day$$

$$A = 1{,}500L/day \div 80L/m^2/day = 19m^2$$

From which the minimum length of BSF is

$$L = V \div 125L/m/day$$

$$L = 1{,}500L/day \div 125L/m/day = 12m$$

Since the minimum wetted area required is $19m^2$, the width (W) required for a length of 12m is 19/12 = 1.6m

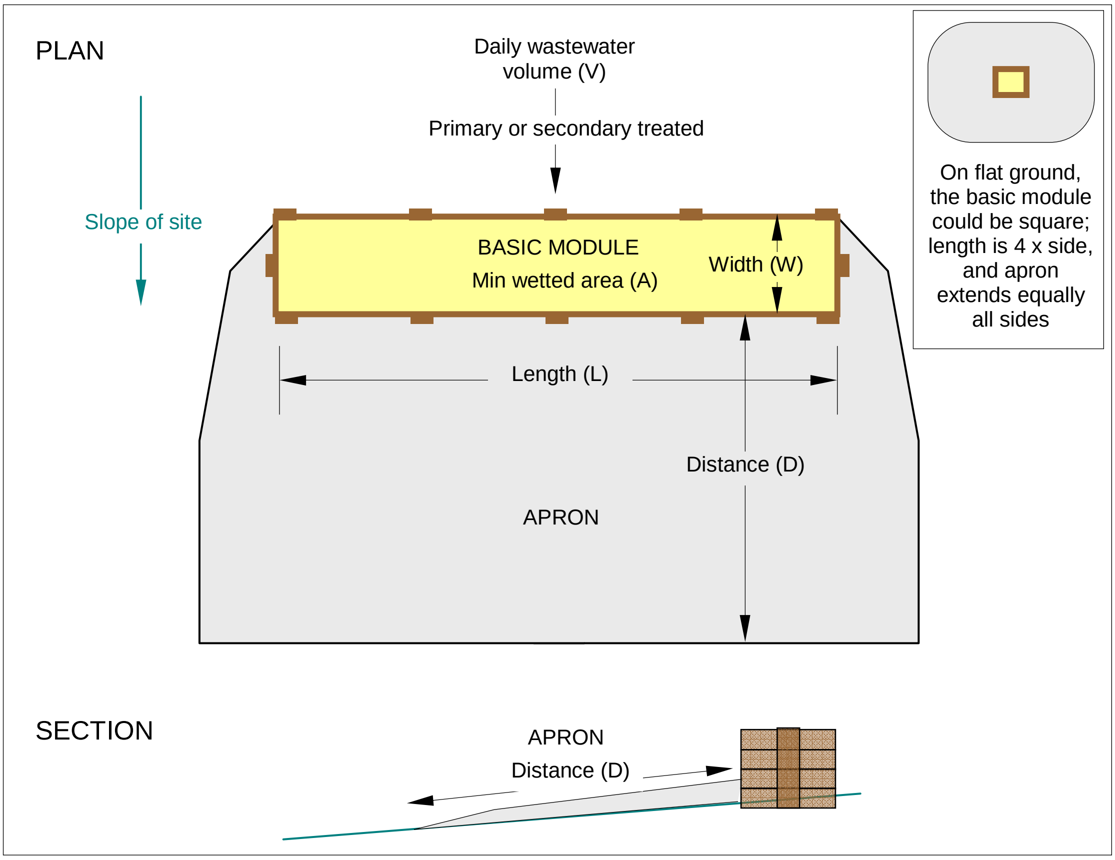


Figure 8. Schematic showing the basic module and apron of a BSF on sloping ground.

2.4.3 Estimate the area required for the basic module and apron

Divide the daily wastewater volume (V) by the DLR of the Category 1, 2, 3 or 4 surface soil beneath the disposal area. The soil must be at least 0.25m thick. If the soil is Category 5 or 6, import sufficient Category 1, 2, 3 or 4 soil to provide a layer of at least 0.25m thick over the Category 5 or 6 soil.

Example 3
The surface soil in Example 2 is Category 3, 0.4m thick, over Category 6 clay. If the area of the basic module is $19m^2$, what additional area of apron is required to accommodate the daily wastewater volume?

Answer

The DLR[8] of the Category 3 surface soil is 24L/m^2/day for Wisconsin Mounds in Table N1 in Appendix N of AS/NZS1547:2012.

The minimum wetted area for the whole system (basic module + apron) is therefore

Daily wastewater volume ÷ DLR

1,500L/day ÷ 24L/m^2/day = 62.5m^2

Since the basic module is 19m^2, the required minimum apron area is 62.5m^2 – 19m^2 = 43.5m^2. Since the length of the apron is 12m (ignoring the side extensions), the minimum width or distance (D) that the apron must extend downslope is 43.5m^2 ÷ 12m = 3.6m.

2.5 Construction and installation notes for BSFs

These construction and installation notes are derived from AS/NZS1547:2012 Appendix N, Cromer (2004)[9], discussions with and wastewater reports provided by Richard Mason ENHealth Consulting, and discussions with BSF installer Chris Lewis Plumbing. Chris Lewis Plumbing provided all photographs in Attachment 1.

ENHealth reports were consulted to help compile Figure 9a, b and c.

The following notes, specifications, diagrams and photographs are intended as guidance only for bottomless sand filters (BSFs). They may be amended to suit individual sites provided the system performance is not compromised. They may also be copied and used by interested parties.

General

1. Prior to construction, protect the site from vehicular access to avoid compaction. Determine whether underground services should be located and marked out.

2. Clear site of trees, shrubs. Remove stumps and backfill stump holes to ground level.

3. Comply with all regulations in relation to workplace safety.

4. Mark out and fence off the job. Work only in fine weather. Cover stockpiled filter sand to prevent rain erosion. Complete construction as soon as possible.

Construction (refer to Figures 9a, b and c, and the photographs in Attachment 1)

1. Beneath the basic module, plough or deep -rip the existing soil surface, parallel with the contour, to a nominal depth of 0.3 – 0.4m, or to the base of the topsoil layer if less than 0.3 – 0.4m thick.

2. If required, install an upslope cut-off drain.

3. In dispersive soils, gypsum may be applied during construction to the base of the disposal area at a rate of 1kg/m^2, or as otherwise advised after consultation with a soil specialist.

---

[8] DLR units in AS/NZS1547:2012 are mm/day. This is identical to L/m^2/day, which is a more intuitive way of expressing it.

[9] Cromer, W. C. (2004). Land application systems for domestic wastewater management – Notes for Designers, Installers and Regulators (Draft). Nonconventional bed. Unpublished discussion paper by William C Cromer Pty Ltd, May 2004.

4. If required, spread Category 1, 2, 3 or 4 soil (as specified)evenly over the ploughed area, and all around the proposed timber retaining structure so that the covered area is at least equal to the footprint (basic module and all apron areas) of the job.

5. Stake out the perimeter of the proposed timber retaining structure. Use reference stakes some distance from the perimeter in case corner stakes are disturbed.

6. Build the timber retaining structure as shown in the general diagrams in this section, to approved dimensions. Use 200mm x 75mm CCA treated pine sleepers throughout, for posts and fencing. Use pairs of sleepers at corners. Concrete in the posts to a depth equal to not less than a third of their height. Fix fencing to posts using galvanised batten screws. Provide a nom. 100mm gap underneath the downslope side of the structure. Line inside walls (but not base) with Fortecon or similar, attached by staples, and with abutting edges sealed. Leave a nom. 100mm gap underneath the plastic along the downslope side of the structure.

7. Place the sand filter (complying with specifications) inside the retaining structure. Place in successive layers nominally 100mm thick, lightly compacted, particularly around the edge with the plastic to prevent effluent escape. Level the finished top of the sand to a tolerance of about one centimetre.

8. Place 10 – 20mm durable screened aggregate on the filter sand to a nominal depth of 100mm, laid level to a tolerance of one centimetre.

9. Install Class 9 40mm UPVC distribution pipework laterals as a PVC-cemented grid over the aggregate. Perforate as specified with 4 – 5mm holes on top only, so that pipework is full at the start of each pump cycle thus ensuring an even distribution of wastewater rover the aggregate. The first, centre and last of each drill hole in each lateral should be drilled on the underside only so the system can drain between pump doses. Add inspection risers and screw caps at one end of grid.

10. Install the pump pit and pump; connect to the distribution grid. Observe pump manufacturer's commissioning recommendations. Provide for audible and visible alarms for the pump. Adjust the float switch to allow between 5 – 15 doses of wastewater per day to the BSF.

11. Test the distribution system under pressure using clean water before covering each lateral with an inverted half-pipe-pipe section cut lengthwise from nom. 90 – 100mm UPVC pipe. This prevents blockage of drill holes with the final aggregate cover, and enhances even distribution of wastewater.

12. Cover the 90 – 100mm half-pipe with screened 7 – 15mm aggregate.

13. Install horizontal 10mm galvanised rods across the width of the aggregate, between alternative pairs of opposite posts. Tension the rod to ensure posts are vertical.

14. Cover aggregate with durable geofabric/geotextile/filter cloth.

15. Cover geofabric with nom. 100 – 150mm of suitable loam. Plant appropriate (non-vegetable) shallow rooted shrubs.

16. Place Category 1, 2, 3 or 4 soil as an apron of specified thickness and area around and up to the retaining structure, along all sides where a gap has been left in the fencing and plastic liner. Grade and clean up. Grass or plant shrubs if specified.

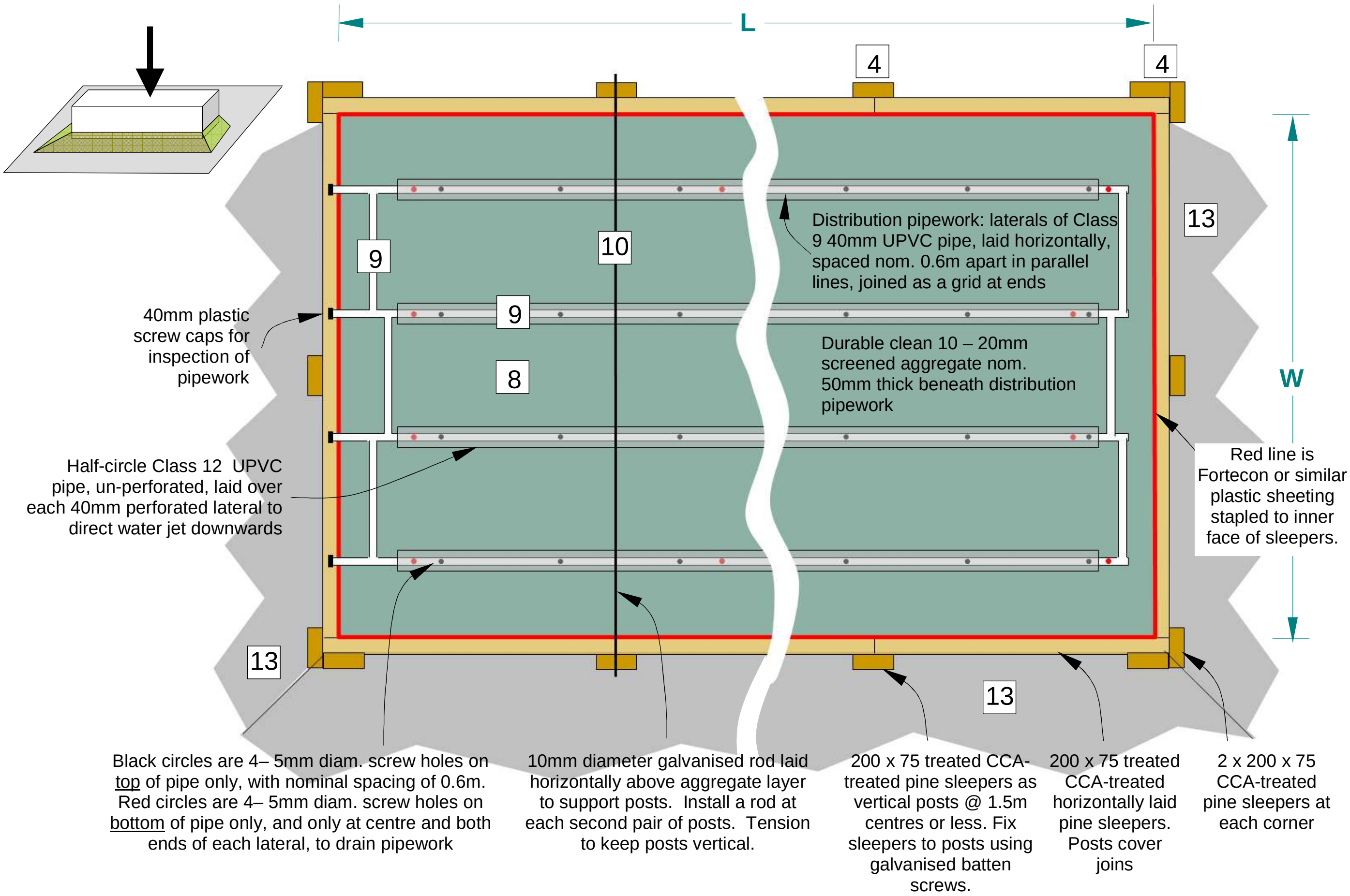


Figure 9a. **Generalised plan of a typical BSF. Refer to Table 2 for more information for, and typical dimensions of, the numbered and lettered features. Also use Table 2 to insert site-specific dimensions to assist in tendering and pricing BSFs.**

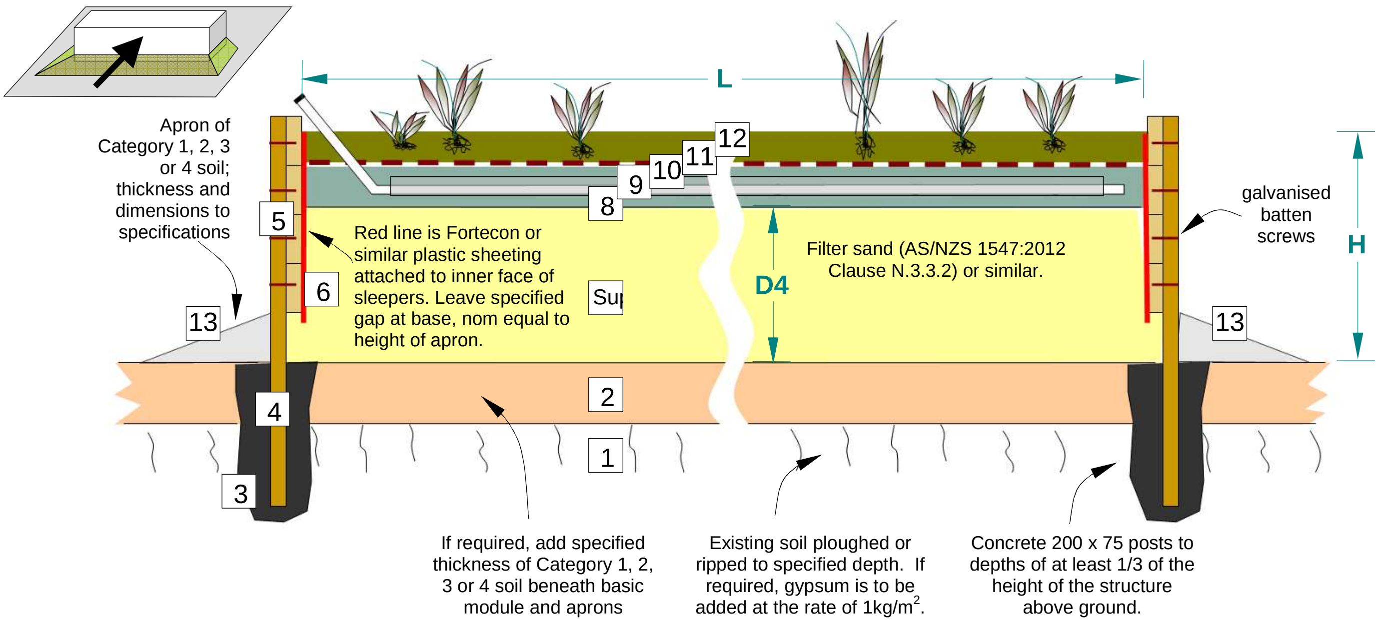


Figure 9b. **Generalised side to side section of a typical BSF along a contour. Refer to Table 2 for more information for, and typical dimensions of, the numbered and lettered features. Also use Table 2 to insert site-specific dimensions to assist in tendering for and pricing BSFs.**

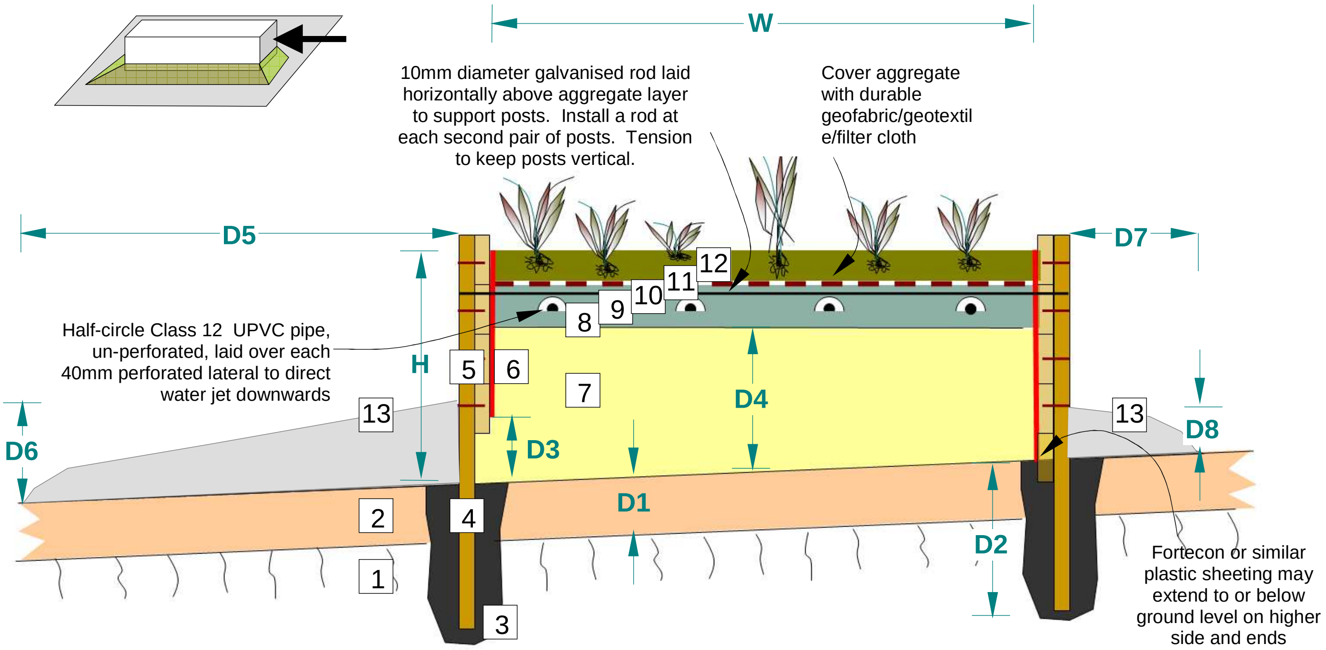


Figure 9c. **Generalised front to back section of a typical BSF. Refer to Table 2 for more information for, and typical dimensions of, the numbered and lettered features. Also use Table 2 to insert site-specific dimensions to assist in tendering and pricing BSFs.**

Table 2 **BSF materials and dimensions**

Refer to Figures 9a, 9b and 9c for item symbols and numbers

Item symbol	Item numbe	Description	Typical dimension(s)	This design	Remarks
L		Internal length of basic module along contour	5m to 15m		
W		Internal width (front to back) of basic module across contour	1.5m to 2.5m		
H		Internal height of basic module	0.5m to 1m		
	1	Existing soil. Rip or plough beneath BSF basic module. Add gypsum if specified at 1kg/m2.	0.3m or deeper if possible		
D1	2	On-site or imported Category 1, 2, 3 or 4 soil	0.25m		Avoid compaction other than walking
D2	3	Concreted post hole at 1.5m centres or less	one third of H (m)		
	4	Vertical posts of CCA treated sleepers at 1.5m centres or less	200mm x 75mm		Join pairs of sleepers at all corners
	5	Horizontal CCA treated sleepers on top of each other as a fence. Note no sleeper at base on lower side of basic module.	1.5m x 200mm x 75mm		Join butt ends of sleepers at posts. Fix sleepers to posts using galvanised batten screws.
D3	6	Staple Fortecon or similar sheeting to inside of sleeper fence. On flat ground, leave dimension D3 clear of plastic all round fence. On sloping ground, continue plastic to ground level or below on higher side of basic module	0.1m to 0.2m		On sloping ground, cut base of Fortecon so that it rises from ground level at higher rear side, to D3 at front.
D4	7	Filter sand, to specifications	0.3m to 0.6m		
	8	Durable clean 10 – 20mm screened aggregate			Lay initial layer nom. 50mm thick to receive distribution pipework.
	9	Distribution pipework: laterals of Class 9 40mm UPVC pipe, laid horizontally, spaced nom. 0.6m apart in parallel lines, joined as a grid at ends. Ends of all laterals raised to surface with screw caps for inspection and cleaning. Perforate leach lateral with 4– 5mm diam. screw holes on top of pipe only, with nominal spacing of 0.6m. Also perforate with 3 x 4– 5mm diam. screw holes on bottom of pipe only, at centre and both ends of each lateral, to drain pipework. Water test grid with pressurised wate rto ensure even distribution and pressure. If OK, cover with half-circle Class 12 UPVC pipe, un-perforated, laid over each 40mm perforated lateral to direct			Cover pipework with nom. 10 - 20mm layer of aggregate after 100mm half-pipe PVC laid
	10	Stiffen fence and posts with 10mm diameter galvanised rod laid horizontally above aggregate layer to support opposite posts. Install a rod at each second pair of posts. Tension to keep posts vertical.			
	11	Cover aggregate with durable geofabric/geotextile/filter cloth			
	12	1. Cover geofabric with suitable loam. Plant appropriate (non-vegetable) shallow rooted shrubs	loam thickness 100mm to 150mm		
D5, D6, D7, D8	13	Apron. Place Category 1, 2, 3 or 4 soil as an apron of specified thickness and area around and up to the retaining structure, along all sides where a gap has been left in the fencing and plastic liner. Grade and clean up. Grass or plant shrubs if specified.	On sloping ground D5: 3 to 10m D6 0.2 to 0.3m D7, D8: 0m; on flat ground D5 = D7 3 to 10m; D6 = D8 0.2 to 0.3m		

Compiled 3 April 2013. William C Cromer Pty Ltd

Attachment 1

Installing a BSF

All photographs courtesy of Chris Lewis Plumbing

Plate 1 (above). Posts (200 x 75mm sleepers) at no more than 1.5m centres concreted in holes at least one third of their height.

Plate 2 (below). Ripping soil over the base of the basic module. Filter sand in right foreground.

Plate 3 (above). Ripping completed.

Plate 4 (below). Fencing and plastic liner completed. Note vertical seal on liner.

Plate 5 (above). Placement of filter sand. Lay in nom. 100mm layers; walk over to slightly compact., especially against plastic around edges.

Plate 6 (below). Filter sand complete. Screened aggregate being placed.

Plate 7 (above). Screened aggregate complete

Plate 8 (below). Grid of 40mm Class 9 UPVC pipework in place, with raised inspection openings at far end.

Plate 9 (above). Inspection openings.

Plate 10 (below). Perforated pipework under test with clean water.

Plate 11 (above). Half-pipe 100mm Class 9 UPVC over 40mm distribution grid

Plate 12 (below). Pipework covered with aggregate. Horizontal galvanised 10mm rods tie each second pair of opposite posts together.

Plate 13 (above). Geofabric in place over aggregate

Plate 14 (below). Final loam layer in place prior to planting.

Plate 15 (above). Inspection openings

Plate 16 (below). Apron of Category 1, 2, 3, or 4 placed on downslope and sides of basic module.

Plates 17 (above) and 18 (below). Apron of Category 1, 2, 3, or 4 placed on downslope and sides of basic module. Shrubs and grass to be planted.