34 GROSS POLLUTANT TRAPS

34.1 PURPOSE AND DEFINITION

Gross pollutant traps (GPTs) remove litter, debris and coarse sediment from stormwater. Some designs also provide oil separation. These substances are collectively referred to as Gross Pollutants.

Gross Pollutant Traps may be used as the pretreatment for flow into a pond or wetland to confine the area of deposition of coarse sediments. This facilitates the eventual removal of finer sediments. Traps may also be used to keep coarse sediment out of ponds, protecting the vegetation at the head of the pond from the smothering effects of sediment. Traps may also be used to remove coarse sediment before the flow enters an infiltration device or filtration device, which would otherwise clog up prematurely. GPTs may also serve the purpose of capturing floatable oil, provided that they are designed appropriately.

The traps provide little, if any, flow attenuation.

Most GPTs will also provide some reduction in other pollutants. For example, trapping of coarse sediment may also provide:

- removal of particulate nutrients;
- trace metal removal;
- oil and grease removal;
- reduction in bacteria; and
- reduction in dissolved oxygen demanding substances.

All of the above substances can be partly bound to sediments, and will be removed along with the trapped sediment.

Booms and other types of litter traps are also included in this Chapter. These devices do not provide sediment removal.

34.2 PLANNING CONSIDERATIONS

34.2.1 Location

GPTs are provided at the downstream end of drains or engineered waterways which discharge to sensitive rivers, water quality control ponds or urban lakes to reduce sediment load, litter, oil and chemicals. Ponds receiving runoff from highways, parking areas or heavy industrial areas are particularly vulnerable.

By themselves, traps do not normally provide sufficient stormwater treatment – they should be used in conjunction with other treatment devices. Chapter 10 provides an overview of 'treatment trains'.

34.2.2 Planning Issues

A decision needs to be made between *centralised* and *dispersed* trapping strategies (see Figure 34.1). This would normally be done at the Master Planning stage – see Chapter 9. In general, large central traps are less suitable for staged development and are more difficult to clean and maintain.

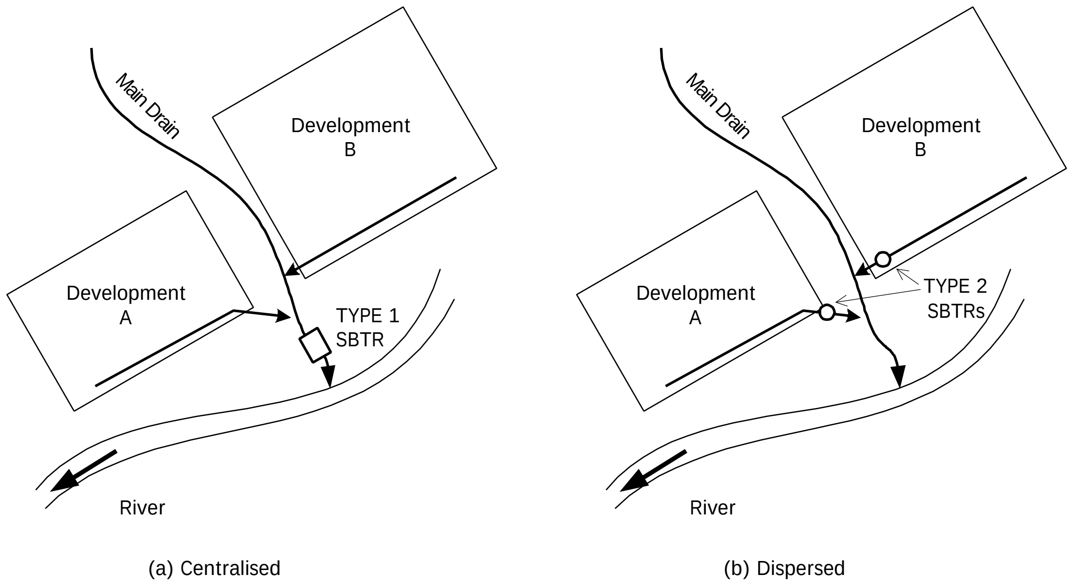


Figure 34.1 Centralised and Dispersed Trapping Strategies

Current overseas practice appears to favour the use of smaller underground devices, which can be located in roads, footpaths or other public areas. Note that the centralised and dispersed strategies are alternatives – it is not necessary or cost-effective to provide both.

In Figure 34.1, the Local Authority needs to make a decision whether to adopt Strategy (a) or (b). This decision involves engineering, planning and administrative considerations. Strategy (b) would be favoured if there is expected to be a time delay between developments (a) and (b), and if the traps are to be developer-funded.

Large open traps may be unsightly and require to be located away from public areas, screened by landscaping, or covered. Covering involves a considerable increase in cost and maintenance complexity.

34.3 CLASSIFICATION OF GROSS POLLUTANT TRAPS

There is a very wide range of devices for the treatment of gross solids. Selection of suitable devices depends on many factors including catchment size, pollutant load, the type of drainage system and cost.

Table 34.1 provides an overall classification of the types of GPTs that could be used in Malaysia, and the range of catchment areas for which they are suitable. This classification is followed in the text of this Chapter.

The Australian CRCCH (Co-operative Research Centre for Catchment Hydrology) markets a spreadsheet-based decision support system for GPTs (see Allison et al., 1998). This may be of assistance in selecting the most suitable types of traps, however it would require adjustment with local data. Contact details for the CRCCH are provided in Appendix 34.B.

Appendix 34.C provides a comparison of the relative pollutant removal efficiencies of different types of Gross Pollutant Traps. The traps are also compared with several typical housekeeping and educational quality control measures. The final columns give an indication of *relative* cost per hectare of catchment area, and of *relative* effectiveness.

No information is available on construction and operating costs of most structural devices under Malaysian conditions. Costs depend on a number of economic and social factors, the assessment of which is outside the scope of this Manual. It is expected that over time, information will be compiled to allow comparative cost assessments to be undertaken.

34.3.1 Floating Debris Traps

(a) Booms

Booms are used primarily on streams and rivers where there is permanent water. Booms have been used in Malaysia, including on Sg. Klang for more than ten years.

Table 34.1 Overall Classification of Gross Pollutant Traps

Group	Description and Function	Catchment Area Range	Purpose-built or Proprietary	Details in Section
Floating Debris Traps (booms)	Litter capture on permanent waterbodies	> 200 ha	Proprietary	34.3.1
In-pit devices	Litter and sediment capture in existing pits	0.1 – 1 ha	Proprietary	34.3.2
Trash Racks & Litter Control Devices	Hard or soft litter capture devices on drains	2 – 400 ha	usually purpose built from modular components	34.3.3
Sediment Traps	Sediment removal only, on drains	> 200 ha	Purpose built	34.3.4
'SBTR' Traps	Sediment and litter capture for drains or pipes	5 – 2000 ha	Purpose built	34.5
Proprietary devices	Range of devices, mainly for pipes	2 – 40 ha	Proprietary	34.6

Booms are only effective as a pollution control measure under certain conditions. The requirements for a suitable site include (Willing & Partners, 1989):

- favourable currents,
- location relative to major sources, such as tributary stormwater drains,
- access for maintenance,
- ability to handle the effects of water level changes,
- suitable locations for attachment and anchorage,
- no interference to river traffic.

Booms are generally not effective unless there is a steady current to force trapped material into the boom. Tidal flow reversals or strong adverse winds may disperse the trapped material, rendering the boom ineffective. The Bandalong Trap, discussed below, aims to overcome this problem.

Installation of the boom will mainly be governed by site conditions. Sufficient slack must be provided to allow the boom level to rise and fall with tide and/or flood water level variations.

The material collected in urban areas includes potentially offensive, hazardous or infectious wastes including discarded syringes which necessitates the implementation of arrangements for mechanical cleaning.

Nielsen and Carleton, 1989 concluded that the decision to install a boom or a trash rack was governed by a number of factors including:

(i) the type of trash to be collected. Booms were found to be effective in retaining both smaller floating and partially submerged objects and larger objects.

(ii) hydraulic considerations. The trash retaining performance of booms decreases at higher flows because trash is forced under and over them. The minimum flow velocity at which trash escapes by being forced underneath a boom depends largely on the weight of the boom and has been observed to be as low as 1 m/s.

(b) Bandalong™ Trap

Bandalong traps are a type of floating boom for collected litter and debris being transported in rivers, streams and estuaries. The trap is typically moored to the bank of a stream, river or canal. In plan view the trap is "fish" shaped with floating litter and debris being funnelled (via the tail) into the main body of the trap where it is caught. A floating gate at the throat of the entry closes when a tide reverses direction to ensure that floating debris is retained. These traps originated in Australia where a number have been installed on rivers and urban creeks.

34.3.2 In-Pit Devices

These litter and sediment traps are located in inlet pits. While their effectiveness is limited, they are economical to use in locations where they can be installed in existing inlet pits.

The application of inlet pit traps in Malaysia is likely to be limited, at least in the near future, as most of the existing urban drainage systems do not have inlet pits.

(a) Trap Gully Pits

Trap gully pits are deeper than standard pits to store trapped sediment. Some designs also direct flows beneath an underflow weir to trap floating trash and debris. In North America they are known as ‘catchbasins’.

Trap gully pits are of course only useful where the drainage system contains pits – i.e. a piped system. Their effectiveness is limited because of the tendency for high flows to entrain and wash out the collected sediment and litter.

(b) Litter Baskets

Several local authorities in Australia, including North Sydney Council and Banyule City Council in Victoria, have developed simple perforated or mesh baskets that are installed in existing side entry pits to collect leaves and litter. The size of the basket is chosen to suit the existing inlet pit dimensions: baskets are smaller than the side entry pit area so when the baskets clog or fill with litter stormwater overflows the edge of the basket thus reducing the risk of flooding. Their low cost and easy installation make them attractive in existing piped drainage systems. Materials can be either plastic or steel. This type of device is mainly intended for pipe systems.

34.3.3 Trash Racks and Litter Control Devices

A variety of trash racks have been trialled in several locations in Australia. The trash racks have ranged from relatively small screens installed at the outlets of stormwater pipes to large steel trash racks on rivers and open channels and more recently "soft" trash racks (litter control devices) that are installed in open channels and at the outlets of piped drains.

(a) Trash Racks

Since 1979, fixed steel trash racks have been installed in the stormwater drainage systems in the ACT (Australian Capital Territory) to trap trash and debris. The trash rack arrangement, which has evolved over recent years, is a vertical trash rack with vertical bars at 60 mm centres. A range of trash racks has been trialled (Figure 34.2). It has also been suggested by a number of researchers that a trash rack with horizontal bars set at an angle to the flow should be self-cleansing, since the flow would push debris towards the sides of the rack. The effectiveness of such an approach would appear to depend on the shape and surface finish of the bars and their angle relative to the flow.

Figure 34.2 Trash Rack

Nielsen and Carleton, 1989 also undertook laboratory tests to try and establish the necessary conditions for trash racks to be self-cleansing. The laboratory investigation failed to identify a self-cleansing design.

Design principles for fixed trash racks are the same as described under SBTR-type traps, in Section 34.5.5.

(b) Litter Control Devices

More recently a number of litter control devices have been installed in open channels and at the outlets to piped drains in Australia. These devices collect litter, as do trash racks, and they therefore can be described as "soft" trash racks. "Soft" trash racks are a series of nylon mesh "socks" which are attached to a rectangular metal frame that is mounted vertically and perpendicular to the flow.

The "sock" is laid out downstream of the metal frame parallel to the direction of flow. A series of these socks are mounted side by side across a channel to form a "soft" trash rack. The nylon socks have been found to effectively capture and retain floating litter, debris and vegetative matter. The litter and debris is captured in the "socks" and is retained even if the trash rack is overtopped.

The socks are cleaned by removing each sock in turn, undoing the tie at the base of the sock and dumping the collected material into a truck. The base of the sock is then re-tied and it is slotted back into place. Due to the effectiveness of the socks it has been found that during periods of rainfall that the soft trash racks may need to be cleaned every two to three days.

(c) Fish Net (Net Tech)® Device

The Fish Net (Net Tech) device consists of a frame that installed on a pipe headwall with a net "sock" attached. The sock fills with litter until it becomes so full that a release is triggered and the sock is released. While the sock is still attached to the unit it ties itself and falls free of the stormwater flow (subject to there being sufficient room for the sock to be displaced away from the stormwater flow). After the sock is cleaned it is re-attached to its frame.

34.3.4 Sediment Traps

Sedimentation traps function by providing an enlarged waterway area and/or reduced hydraulic gradient to reduce flow velocities and allow bedload sediment to be trapped and suspended sediments to settle out of suspension. They do not provide litter removal.

Prior to the late 1970s, a number of sedimentation basins were constructed in Australia (primarily the ACT) using primarily gabions or masonry walls to create unlined sedimentation ponds. Difficulties were experienced in de-watering and de-silting these structures. Until the construction of a series of GPTs and water pollution control ponds upstream of the pond, it also acted as a sedimentation basin.

The design of sediment traps is not covered in detail in this Manual, as they would mainly be used outside urban areas. In urban areas, the presence of litter makes it preferable to build a 'SBTR'-type GPT.

34.3.5 'SBTR' type GPTs

SBTR traps combine the functions of a Sedimentation Basin and a fixed Trash Rack. The device is named after the initial of the two components. 'SBTR' type traps have previously been referred to in some literature as GPTs.

The difficulties in de-watering and de-silting the sedimentation basins in Canberra led, in 1979, to the construction of the first major SBTR trap in Canberra, Australia. The trap was a major concrete lined basin that was designed to both intercept litter, debris and coarse sediment during storm flows and to act as an efficient retarding basin. This trap drew on the previous experience of sedimentation basins but also incorporated additional features to intercept trash and debris. It marked the commencement of the development and refinement of gross pollutant traps in Australia.

The on-going development of SBTR type traps in Australia has focused on improving these facilities for ease of maintenance and simplifying the design elements to reduce capital costs.

Figure 34.3 Type 1 SBTR Trap

Major SBTR (Type 1) traps are typically located in major channels and engineered waterways to intercept medium to high stormwater flows from large urban catchments. They are visually unattractive and generally should be placed away from residential areas, or screened (see Figure 34.3).

Covered in-ground (Type 2) traps are used at the downstream end of pipe or open drains. They are less visually intrusive and hence are more suitable for residential or urban areas. Due to the cost of the structure they are usually smaller in size than Type 1 traps and are only suitable for treating small catchment areas, mainly on pipe drains.

Indicative 'standard' arrangements for Type 1 and Type 2 SBTR traps are given in Figures 34.4 and 34.5, respectively. Many design variations are possible to suit site conditions. Design principles for the SBTR type traps are discussed in Section 34.5.

34.3.6 Proprietary Traps

The realisation that large numbers of traps are needed to control water pollution has led to commercial development of a range of devices for trapping gross pollutants.

Some of the proprietary GPTs that are currently available overseas are described in Section 34.6.

34.4 GENERAL DESIGN CONSIDERATIONS

34.4.1 Data Collection

Design of GPTs requires data on:

- Catchment area,
- Hydrology of inflows,
- Survey details of the site,
- Hydraulic conditions at the GPT outlet, which may create tailwater,
- Soil type, and
- Estimates of sediment loads and other pollutant loads from the catchment.

34.4.2 Hydrology

Peak inflows shall be computed using the Rational Method or one of the hydrograph methods in Chapter 14. Normally these calculations will be done as part of the hydraulic design of the drainage system. The shape and volume of the hydrograph is not important for GPT design.

The magnitude of sediment and other pollutant loads will determine the frequency of cleaning. Pollutant load calculations, if required, can be performed using the methods described in Part D, Chapter 15.

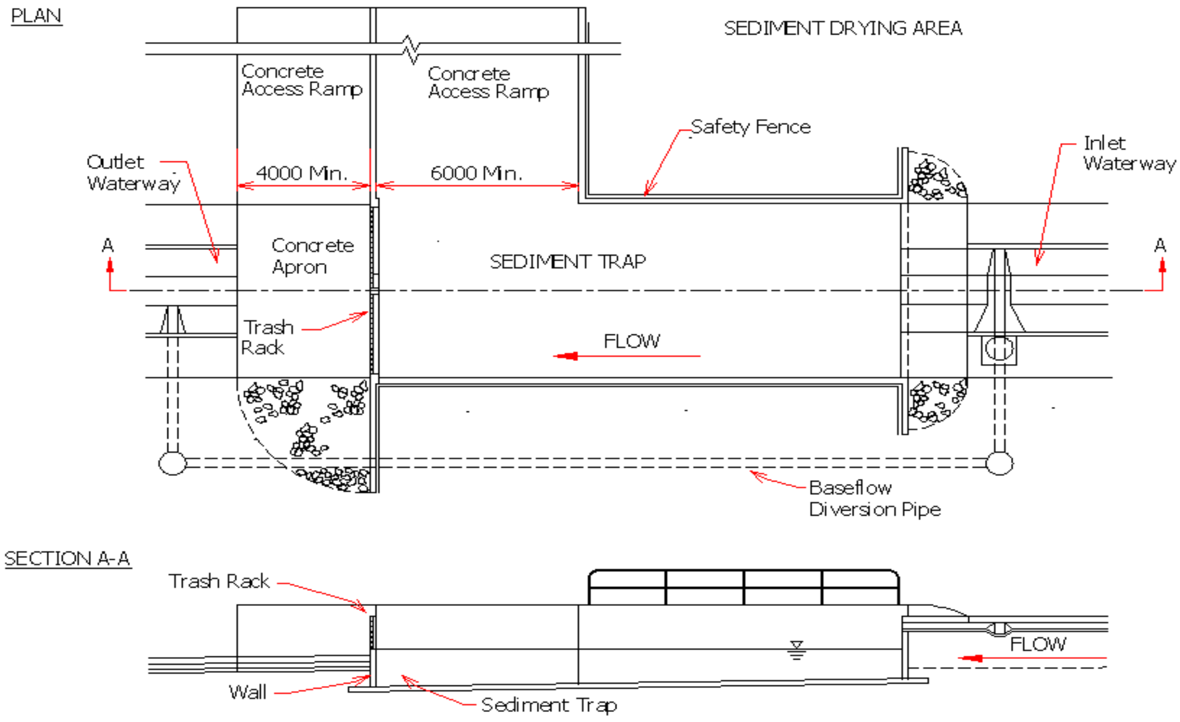


Figure 34.4 Type 1 SBTR Trap Configuration

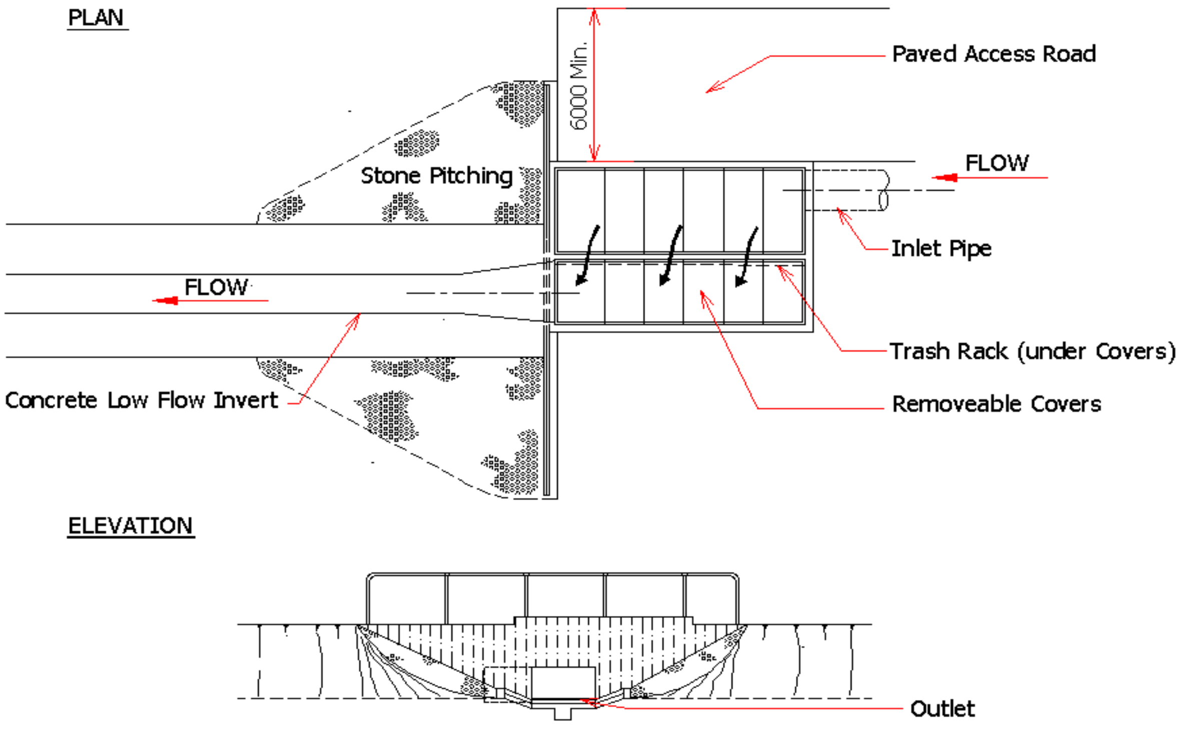


Figure 34.5 Type 2 SBTR Trap Configuration

34.4.3 Design Criteria

For each GPT, albeit as part of a "treatment train", a primary treatment objective or performance criteria related to a specific pollutant shall be ascribed. This is the target pollutant that is to be reduced to a nominated level.

34.4.4 Hydraulic Design

The GPT must be designed so as to prevent any additional surcharge in the stormwater system in the event of partial or complete blockage. Tidal influence and backwater effects must be considered. Refer to Chapter 10 and 16 for a discussion of stormwater system design.

The pollutant reduction performance must be maintained up to the design discharge. If design flows are exceeded, the GPT should not allow any significant re-mobilisation of trapped material.

34.4.5 Ease of Maintenance

Sediment must be removed from the traps on a frequent basis. In the past, the design has often not allowed for easy cleaning. Problems with cleaning can be partly overcome by appropriate design.

Maintenance considerations should be addressed during the preliminary design stage of a GPT, to ensure:

- cost effective maintenance;
- maintenance staff to follow occupational health and safety procedures. This includes the avoidance, where possible, of entry by personnel into the device;
- avoidance of direct human contact with debris and trapped pollutants;
- minimisation of environmental impacts during maintenance (e.g. the disposal of water in the GPT);
- avoidance of the necessity for routine maintenance during storm events, although emergency maintenance (e.g. unblocking the outlet structure) may be required;
- monitoring the pollutant build-up to enable maintenance before the GPT becomes overloaded;
- provision of disposal facilities for debris and liquid pollutants during maintenance; and
- provision for additional, non-programmed maintenance if problems arises (e.g. odours).

Adequate provision for road access to the site by maintenance vehicles and equipment must be made. Suitable walkways, ladders and plinths shall be provided within the structure for access.

34.4.6 Health and Safety

Open GPTs can present a hazard because of:

- Sudden drops into deep water;
- Sudden changes in flow velocities or water levels; and
- Raised structures that children can fall off.

Therefore GPTs should be fully enclosed if possible, or fenced off. Such fencing should be designed so that it does not interfere with the hydraulics of the flow structure.

Provision shall be made to minimise mosquito hazard as follows:

- keeping the sediment trap wet with a low or trickle flow; or
- using biodegradable slow release larvicides (note: full environmental impact assessment of the larvicide would be needed prior to the adoption of this alternative).

34.5 DESIGN OF SBTR TRAPS

The Type 1 SBTR traps are designed as open traps on large, open channels or engineered waterways where they are installed at or below ground level.

The Type 2 SBTR trap is enclosed, and is installed below ground. Type 2 traps are intended for pipe drainage systems.

SBTR traps permit coarse sediment to settle to the bottom by decreasing the stormwater flow velocity by increasing the width and/or depth of the channel.

The trash rack is intended to collect floating and submerged debris. Experience has shown that it should be located at the downstream end of the sediment trap.

34.5.1 Design Standard

The 'SBTR'-type GPTs should be designed to retain all litter and debris in the water quality design storm of 3 month ARI, and to comply with the size requirements in Design Chart 34.1.

Traps designed according to these criteria are expected to remove, on an annual average basis, 70% of the sediment with a grain size = 0.04 mm. This sizing criterion may not be attainable in the case of very fine-grained soils (silts and clays). A further discussion of sizing criteria is given in Chapter 4.

The pollutant removal efficiency h of a trap is calculated as:

$$h = \left(\frac{AMC_{proposed}}{AMC_{existing}} \right) \tag{34.1}$$

where AMC = annual mean concentration. The determination of average annual load and annual volumetric runoff will be normally be required to obtain AMCs (annual mean concentration) for the existing and proposed situations. Methods of doing this calculation are described in Chapter 15. Alternatively, computer modelling methods can be used as described in Chapter 17.

34.5.2 General Design Parameters

The 'SBTR' trap relies on reducing the flow velocity sufficiently to allow settling by gravity. These principles apply to both Type SBTR-1 (major) and SBTR-2 (minor) traps.

- The ratio length: width of the sediment trap should be between 2 and 3.
- Velocity though the sediment trap should not exceed 1.0 m/second, to minimise re-suspension.
- For a sediment trap volume greater than 5 cubic metres, a sediment drying area with a minimum area equal to 1.5 square metres for each cubic metre of trap volume shall be provided, where sediment may be dried prior to transportation. The area shall be surfaced with 300 mm of compacted gravel or other approved surfacing;
- Bar spacing shall be capable of retaining a small plastic bottle or an aluminium drink can, with a maximum clear spacing of 50 mm between bars;
- Trash racks shall be sized to operate effectively whilst passing the design flow without overtopping and with 50% blockage;
- Trash racks shall be structurally stable when overtopped by flood events up to the major design storm when fully blocked;
- Trash racks and their supporting structures shall be designed to withstand log impact together with drag loads or debris loads (100% blocked); and
- The design must allow water to flow past or over the trash rack when the trash rack is blocked.
- Vehicular access must be provided for maintenance, in accordance with Section 34.5.7.

34.5.3 Size Calculation

The sediment basin size is determined using the following procedure. A flowchart of the procedure is given in Figure 34.6.

The procedure was developed for a 'Reference Soil' which is a silty loam. The grading of the Reference Soil is defined in Table 34.2. The efficiency of the trap will vary with soil type. Adjustment factors for different soils are given in Design Chart 34.2 in Appendix 34.A. The chart shows typical soil gradings and the relevant adjustment factors F_A and F_V.

Table 34.2 Grading of Reference Soil used in GPT Design Procedure

Grain Size (mm)	% finer
0.004	12
0.01	25
0.063	60
0.30	92
1.18	100

Sediment Trap

1. Determine the required removal efficiency of coarse sediment ≥ 0.04mm diameter, $P_{0.04*}$.

2. Determine the catchment area A_c (m^2) served by the sediment trap and the applicable degree of urbanisation [*U*] within that catchment. Allow for future catchment development, if appropriate.

3. Select a trial trap area ratio *R*:

$$R = \frac{A_t}{A_c} \quad (34.2)$$

4. Find $P_{0.04}$ for the reference soil from the appropriate Design Chart 34.1 in Appendix 34.A, and Factor *F1* from Design Chart 34.2. Calculate actual trap removal efficiency for the site soil:

$$P_{0.04*} = P_{0.04} \times F1 \quad (34.3)$$

   Adjust *R* if necessary by trial and error to obtain the required performance.

5. Select the length L_t (m) and width W_t (m) of the sediment trap to give the required area A_t such that the length to width ratio is between 2 and 3 and the width is not less than 2 metres.

Depth of the Sediment Trap

6. Determine the average annual export *M* (tonne) of sediment with grain size = 0.01 mm from equations in Chapter 15.

7. Determine the average annual percentage retention $P_{0.01}$ of sediment = 0.01 mm for the reference soil from the applicable Curve B in Design Chart 34.1 for the selected trap area ratio (A_t / A_c). Then determine the adjusted average annual percentage retention $P_{0.04*}$ of sediment = 0.01 mm from the equation:

$$P_{0.01*} = P_{0.01} \times F2 \quad (34.4)$$

   where,

   F2 = Factor from Design Chart 34.2.

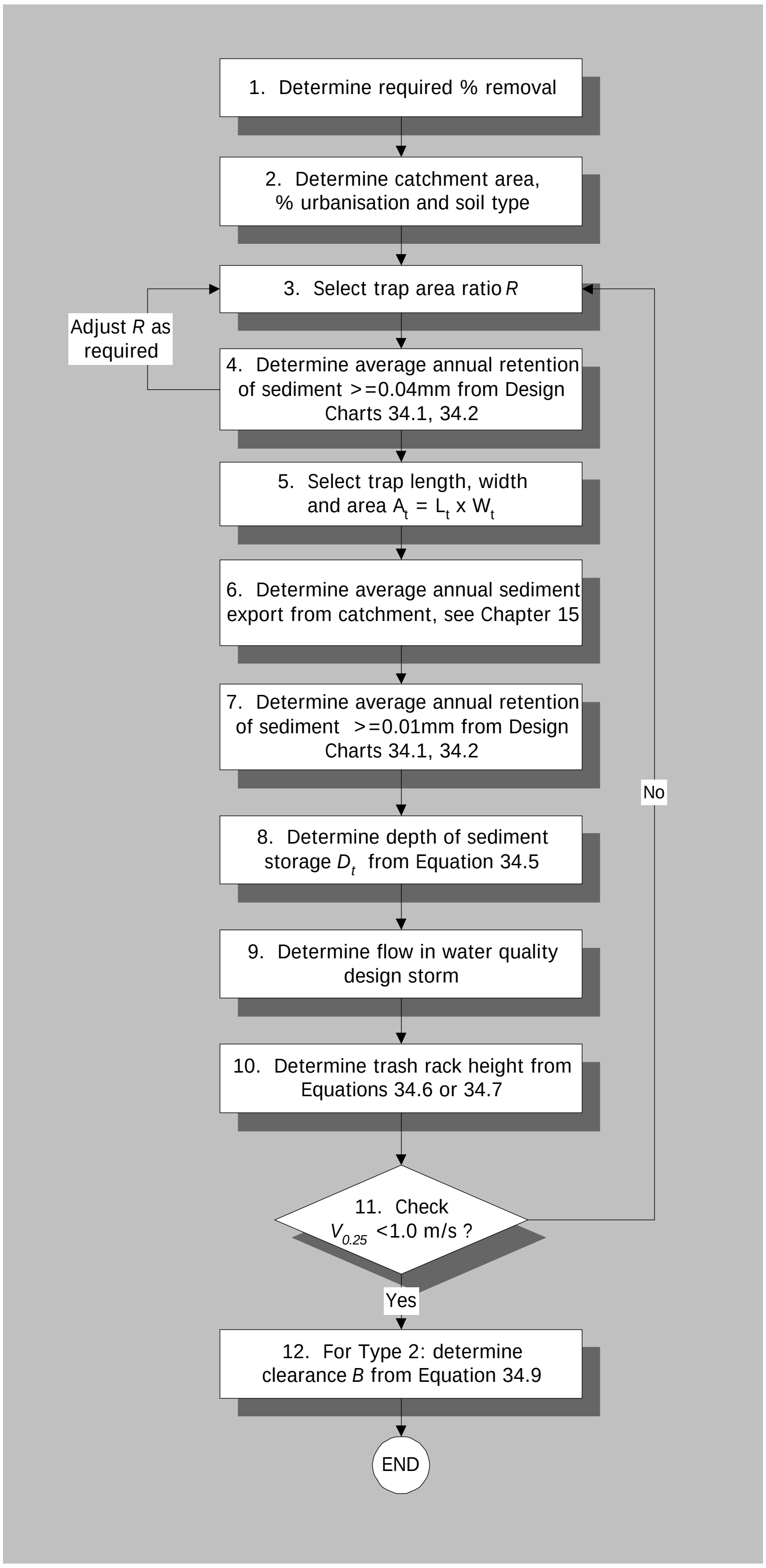


Figure 34.6 Flowchart for SBTR Trap Size Calculation

8. The required sediment trap volume is a function of the average frequency of cleaning. Assuming that the trap is cleaned two times per year and that it is half full when cleaned, the required depth D_t is given by Equation 34.5:

$$D_t = 0.0065 \times P_{0.01*} \times M \;/\; A_t \tag{34.5}$$

where,

D_t = depth of the sediment trap below trash rack (m)

This relationship is based on a sediment density of 2.65 tonnes/m^3 and a sediment porosity of 0.42.

9. Determine the design flow in the *water quality design storm* using any of the recommended methods in Chapter 14.

Sizing of Trash Rack

10. Determine the trash rack height, based on the rack not being overtopped in the water quality design storm when the rack is 50% blocked.

The presence of a downstream hydraulic control can lead to the downstream submergence of the trash rack and an increase in the pool level upstream of the trash rack. Under these conditions the trash rack height should be sized by an hydraulic analysis of the site and the trash rack.

The sizing method for a standard vertical-bar trash rack is as follows (Willing & Partners 1992):

Under unsubmerged conditions, the required height of the trash rack [H_r] is twice the depth at critical flow [y_c] through the unblocked trash rack.

$$H_r = 2y_c$$

$$= 2\left(\frac{Q_{0.25}^{\;2}}{g \cdot L_e^{\;2}}\right)^{1/3} \tag{34.6}$$

where,

H_r = required height of trash rack (m),

$Q_{0.25}$ = the design flow (m^3/s),

G = gravitational acceleration = 9.8 m/s^2

L_e = the effective length of flow through an unblocked trash rack (m)

Using a standard design of vertical 10 mm galvanised flat steel bars at 60 mm centres and a coefficient [C_c] of 0.8 to account for contraction of flow through the trash rack, gives:

$$H_r = 1.22\left(\frac{Q_{0.25}}{L_r}\right) \tag{34.7}$$

where,

H_r = the required height of trash rack (m),

$Q_{0.25}$ = water quality design storm flow (m^3/s),

L_r = actual length of the trash rack (m)

11. Adjust the sediment trap dimensions to ensure that the velocity through the sediment trap when it is full does not exceed 1.0 m/sec in the water quality design storm, to minimise the re-entrainment of deposited sediment.

Determine the nominal design flow velocity $V_{0.25}$ in the water quality design storm using,

$$V_{0.25} = \frac{Q_{0.25}}{(D_w + H_r)W_t} \tag{34.8}$$

where W_t is the width of the sediment trap, normal to the direction of flow. Increase the dimensions of the sediment trap pool or increase the track rack height if the resulting velocity is greater than 1.0 m/s.

12. An additional step is necessary for covered (Type 2 traps) to minimise the potential for upstream surcharge. Provide a minimum overflow clearance B above the trash rack that is sufficient to discharge the flow of the inlet pipe even if the trash rack is fully blocked (see Figure 34.7). The required clearance B is given by Equation 34.9. B must be a minimum of 0.35 m.

$$B = \left(\frac{Q_p}{1.7\,L_r}\right)^{2/3} \tag{34.9}$$

where,

L_r = length of trash rack, (m),

Q_p = inlet pipe capacity (m^3/sec).

Submergence Effects

Where possible a step shall be incorporated at the outlet of the SBTR trap to minimise submergence effects at any trash rack provided. The step should be determined using hydraulic principles but should desirably be 80 mm or greater.

Energy dissipation

An energy dissipation device shall be provided at the inlet to the SBTR trap where the velocity of the inflow stream under design flow conditions exceeds 2 m/s. Excessive inlet velocities and turbulence will inhibit sedimentation action in the trap.

34.5.4 Special Design Considerations

(a) Type SBTR-1 (Major) Traps

- The longitudinal axis of the trap should be as close as possible to the centreline of the incoming drain or engineered waterway. Eliminate unnecessary angles in the flow. Long, straight basins are best;
- For Type 1 traps, a baseflow bypass shall be provided around the sediment trap to divert low flows during cleaning. The bypass shall operate under gravity and shall have a minimum diameter of 300 mm to prevent blockage;
- The floor of the sediment trap shall be graded to a dewatering sump located at the side of the sediment trap but clear of vehicle or equipment paths;
- Provide side walls to reduce scour of the surrounding banks when the trash rack is overtopped. The minimum level of the top of the side walls shall be the greater of: (i) the level of the 3 month ARI flow when the trash rack is fully blocked, or (ii) 300 mm higher than the top of the trash rack;
- Provision shall be made for a plinth or access walkway 800 mm wide immediately upstream of the trash rack to allow access for cleaning or raking of collected material from the trash rack;
- Reduce the effect of wind-induced turbulence. Large open water surfaces are affected by wind, which produces cross-and countercurrents that hinder settling and may resuspend bottom deposits;
- Suitable landscaped screening should be considered.

(b) Type 2 (Minor) SBTR Traps

- Pipe entries shall, where possible, be either parallel (preferred) or perpendicular to the major axis of the sediment trap;
- Low-flow bypasses are not normally required on minor (Type 2) SBTR traps;
- The maximum allowable depth from the top of the surround to the lowest level of the sediment trap is limited by the reach of the equipment that will be used for cleaning. For an extended-arm backhoe, this is approximately 4.5 metres;
- The top of the structure should be at least 150mm above the surrounding ground level and/or protected by barriers to prevent vehicles from being driven over the trap;
- Provide lockable, removable covers for access and maintenance;
- Step irons shall be provided for access, in a position, which will not interfere with the operation of the cleaning equipment.

Figure 34.7 defines the dimensions of a SBTR Type 2 GPT.

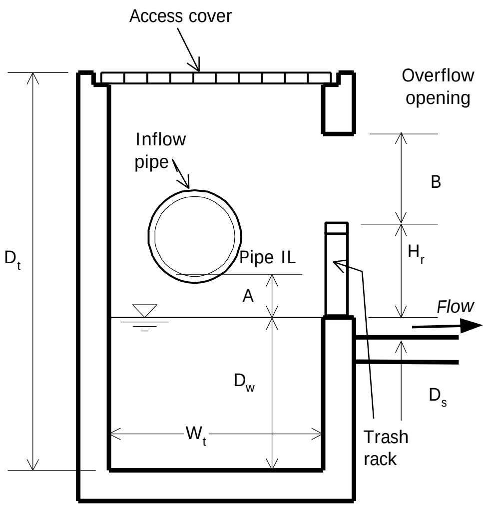


Figure 34.7 GPT Type 2 Trap Dimensions

34.5.5 Design of Trash Rack for an SBTR Trap

Trash Racks are located at the downstream end of the GPT. They form a physical barrier in the stormwater path retaining pollutants larger than the bar spacings. As material builds up behind the trash rack finer material also accumulates.

Bars may be vertical, horizontal or angled. A typical arrangement which has been found to perform satisfactorily in Australia is shown in Figure 34.8.

The following is based on a standard trash rack with vertical 10 mm galvanised flat steel bars at 60 mm centres. A coefficient of 0.8 to account for contraction of flow through the trash rack has been assumed.

(a) Key Issues

- Overtopping (with potential remobilisation) due to blockage;
- Can cause upstream flooding;
- Can cause erosion immediately downstream due to increased flow velocity;
- Re-suspension can occur under tidal influence;
- Can generate odours due to pollutant breakdown;
- Are difficult to maintain and required frequent manual maintenance;
- Need to provide suitable access for maintenance;
- Public Safety (e.g. children during storm events); and
- Aesthetics/visual screening of the trash rack and trapped litter.

(b) Trash Rack Sizing

(i) Length

The length shall be assessed in conjunction with the trash rack height and the space available. It is desirable to construct the trash rack in panels of standard lengths. Local authorities may determine a standard trash rack panel size for use in their area. The length of individual panels shall be chosen such that they can be conveniently lifted by backhoe (i.e. maximum weight 300 kg).

The required length of trash rack may exceed the width of the trap. Methods of accommodating a longer trash rack include a V-shape (see example 34.D1), a zig-zag or labyrinth shape, or a wrap-around shape.

(ii) Height

The trash rack height is given by Equation 34.6, which is based on the rack not being overtopped by the water quality design storm (usually 3 month ARI) flow when the rack is 50% blocked.

34.5.6 Structural Design

The installation must be designed to accept all prevailing loads including but not limited to:

- soil pressure;
- traffic loads;
- hydrostatic and buoyancy effects;
- hydrodynamic loads;
- trapped debris loads;
- impact loads;
- overturning or unbalancing effects;
- construction, maintenance & operation loads.

(a) Durability

All elements must be designed to achieve the designed life after allowance for material erosion and corrosion under the prevailing flow velocities.

(b) Trash Rack

The trash rack and supporting structure should be designed to withstand hydraulic loads imposed during overtopping, loads imposed by debris trapped on the trash rack, and loads due to impact by floating objects in appropriate combination. Impact loads during floods can be large due to objects such as tree trunks in the flow.

Because of the potential for damage, trash racks should be designed with bolted joints so that they can be dismantled and replaced without the necessity of demolishing the entire structure.

34.5.7 Vehicular Access

An all weather access roadway shall be provided to allow access for cleaning by mechanical equipment such as a front-end loader, backhoe, bobcat and truck. The access roadway shall be designed to allow a truck to be loaded within close proximity to the trap with adequate area for the loading equipment to manoeuvre from the trap to the truck (refer Figure 34.9). The all weather access roadway shall have a minimum clear width of 3.5 metres and a maximum longitudinal grade of 1(V) : 6(H).

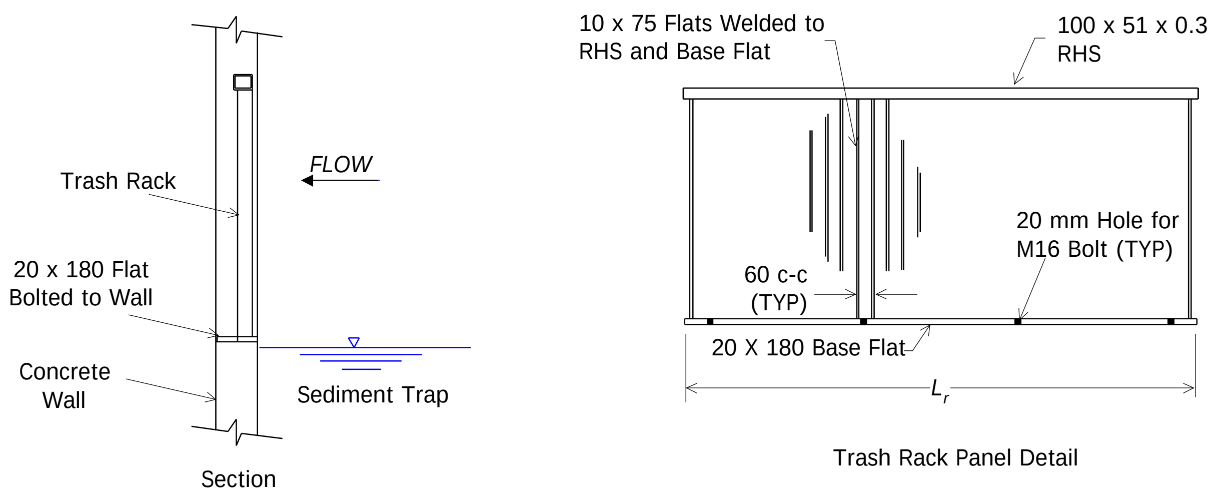


Figure 34.8 Typical Trash Rack for SBTR Trap

Type SBTR-1 traps shall be provided with access ramps to allow machinery to enter the open sediment trap. The access ramp into the sediment trap should have a minimum longitudinal grade of 1(V) : 6(H) and a maximum clear width of 6 metres extending from the floor of the trap to the end of the side wall returns. Where possible, an access ramp and apron should also be provided to the downstream side of the trash rack and shall have a minimum clear width of 3.5 metres and a maximum longitudinal grade of 1(V) : 6(H). Transitions in vertical alignment shall be provided at the crest and toe of the ramps. Adequate space shall be provided to allow vehicles to manoeuvre on and off the ramps.

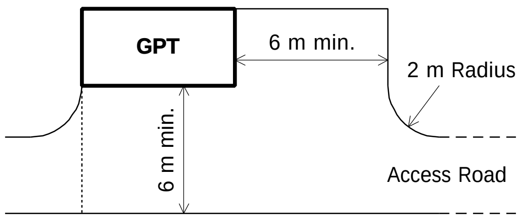


Figure 34.9 Access Requirements for SBTR Trap Type 2 (source: ACT City Services, 1994)

34.6 PROPRIETARY DEVICES

A number of proprietary designs for gross pollutant traps have been developed. Some examples are shown in the following pages.

Most of the proprietary devices developed to date are intended for use on piped drainage systems, rather than open channels.

This Manual seeks to encourage the development and application of suitable proprietary devices in Malaysia. Manufacturers seeking to market GPTs in Malaysia should provide full details, together with design guidelines and testing to DID or the local authority.

Companies may offer a complete service to customers including the design and construction/installation of their traps e.g. CDS, Bandalong, etc. These organisations may charge a fee to undertake the sizing of their trap and the preparation of a fee estimate to design and construct the selected trap.

This may require the Client to provide information on the catchment area, conduit size, its depth, estimated ARI capacity of the system, soil type, pollutant loading if known, and the required performance (% removal). Most of the devices include an internal bypass arrangement designed by the manufacturer.

34.7 MAINTENANCE

34.7.1 General Maintenance

Appropriate maintenance is essential to ensure the long-term pollutant trapping efficiency of all GPTs.

It is important in planning a catchment wide strategy for installing pollution control devices to make adequate provision for maintenance. A written maintenance plan should be prepared.

(a) "Soft" Trash Racks/ Litter Collection Devices (LCDs)

The "soft" trash racks/ LCDs are cleaned by removing each sock in turn, undoing the tie at the base of the sock and dumping the collected material into a truck. The base of the sock is then re-tied and it is slotted back into place. Due to the effectiveness of the socks it has been found that during periods of rainfall the LCDs may need to be cleaned every two to three days.

(b) Modified Trap Gullies

Modified trap gullies are suited to cleaning using eduction. While modified trap gullies can be maintained as part of a regular maintenance program particular attention should be given to assessing the need to clean trap gullies after storm events to ensure that trapped material is not flushed from the trap gully during a subsequent storm event. Experience to date suggests that trap gullies should be maintained on average monthly in urban areas and or more frequently in commercial areas.

(c) 'SBTR' Gross Pollutant Traps

The SBTR-type GPTs can be cleaned out using front-end loaders, backhoes and standard tip trucks. SBTR type 2 traps in Australia have been generally cleaned out with a Massey Ferguson "slide arm" backhoe with extendable hydraulic arm of 6m maximum reach and standard tip trucks. Eductor trucks, if available, can also be used to clean SBTR Type 2 traps.

The sizing guidelines given in Section 34.5 are based on the trap being cleaned out twice per year.

A comprehensive review of the maintenance issues including maintenance equipment, de-watering, access for maintenance equipment and cleaning, inspection program and cleanout frequency, costs and safety is most recently given in the "Background Report on the Design Guidelines for Gross Pollutant Traps" prepared by Neville Jones & Associates for Brisbane City Council in 1994.

(d) Proprietary Traps

The appropriate cleaning frequency for proprietary traps should be discussed with the trap suppliers and where possible the experiences of operators should be reviewed to gain an understanding of the plant, manpower requirements and the likely frequency of cleaning required.

34.7.2 Maintenance Provisions

Maintenance provisions should be considered at the design phase of the GPT.

(a) Clean-out (ease, frequency and timing)

GPTs should be inspected monthly, as well as after every major rainfall event, to ascertain whether clean-out is required.

Cleaning frequencies depend on the sediment and litter loading generated in the catchment. The design procedure for SBTR traps in Section 34.5 are based on cleaning twice per year, on average. Suggested cleaning frequencies for other types of GPTs are to be determined from operational experience under Malaysian conditions.

More regular cleaning may be required to facilitate ease of removal (i.e. if trapped material becomes compacted and hard to remove; or if specialised equipment is not available), or if litter loads are excessive.

(b) Need for Special Equipment

Designs should be based on cleaning operations being undertaken with plant and equipment including:

- eductor truck;
- backhoe or front-end- loader;
- truck;
- pump and generator; and
- truck mounted crane.

Some designs require more specialised equipment, such as eductor trucks. Such equipment may be introduced into Malaysia during the life of this Manual, subject to discussions and approval by the local Authority to suit local conditions and contractor's expertise.

(c) De-watering

GPTs will need to be de-watered from time to time either as part of their general operation or for maintenance purpose. Usually this is done with portable pumps. Water released to stormwater drains or directly to receiving waters should not threaten environmental values and should therefore be consistent with locally applicable water quality objectives.

Prior to pumping out the supernatant water, the SBTR may be dosed with a non-toxic flocculating agent to promote settling of colloidal particles.

The following methods are alternatives that can be used for the disposal of poor quality supernatant water that is retained within the trap.

(i) Via Infiltration or Filtration On-site

The trap may be designed to allow supernatant water to be pumped to a de-watering area on site. The water could either be infiltrated on a grassed area, or filtered through geo-fabric and allowed to drain back to the waterway. An infiltration trench may be included to enhance water polishing and/or permit groundwater recharge.

Such design shall:

- have a suitable de-watering and sludge handling or drying area;
- have stabilised banks to prevent erosion; and
- not constitute a health hazard.

(ii) Direct to Sewer

The SBTR trap may be designed, if necessary, to allow de-watering by pumping supernatant water to a nearby sewer (with the approval of the local sewerage agency). Where there is a sewer line within 200 metres of the facility, the sewer should be extended to provide a manhole with a bolt-down lid adjacent to the SBTR. This will enable the decanted supernatant to be pumped to the manhole and thence to the sewer.

(iii) Via Tanker

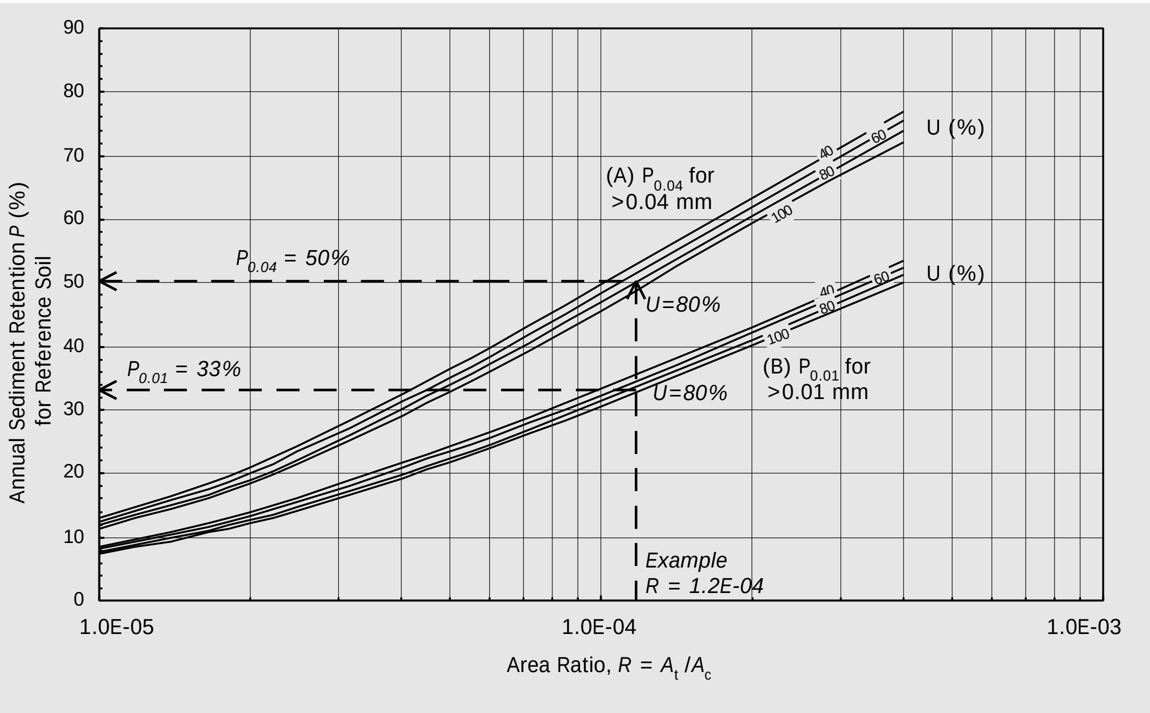
Where there is no sewer available, provision shall be made for the decanted supernatant to be pumped to tanker for treatment and disposal by a licensed waste management operator.

APPENDIX 34.A DESIGN CHARTS FOR 'SBTR' TYPE GPT

34.A.1 Average Sediment Retention against Area Ratio *R*

Design Chart 34.A1 shows the average annual sediment retention percentage as a function of the trap area ratio *R*, and the degree of urbanisation in the catchment. Curve group (A), for particles =0.04 mm is used to select the trap area A_t in order to achieve the specified design criteria. Curve group (B), for particles =0.01 mm is used in calculating the trap volume for the sediment storage. In each case use the curve appropriate to the catchment urbanisation factor, *U*.

The curves were derived for Malaysian conditions, using local rainfall data for representative catchments and the Reference Soil grading given in Table 34.2.



Design Chart 34.A1 Average Annual Sediment Retention against Area Ratio for Reference Soil

<u>How to Use the Chart</u>

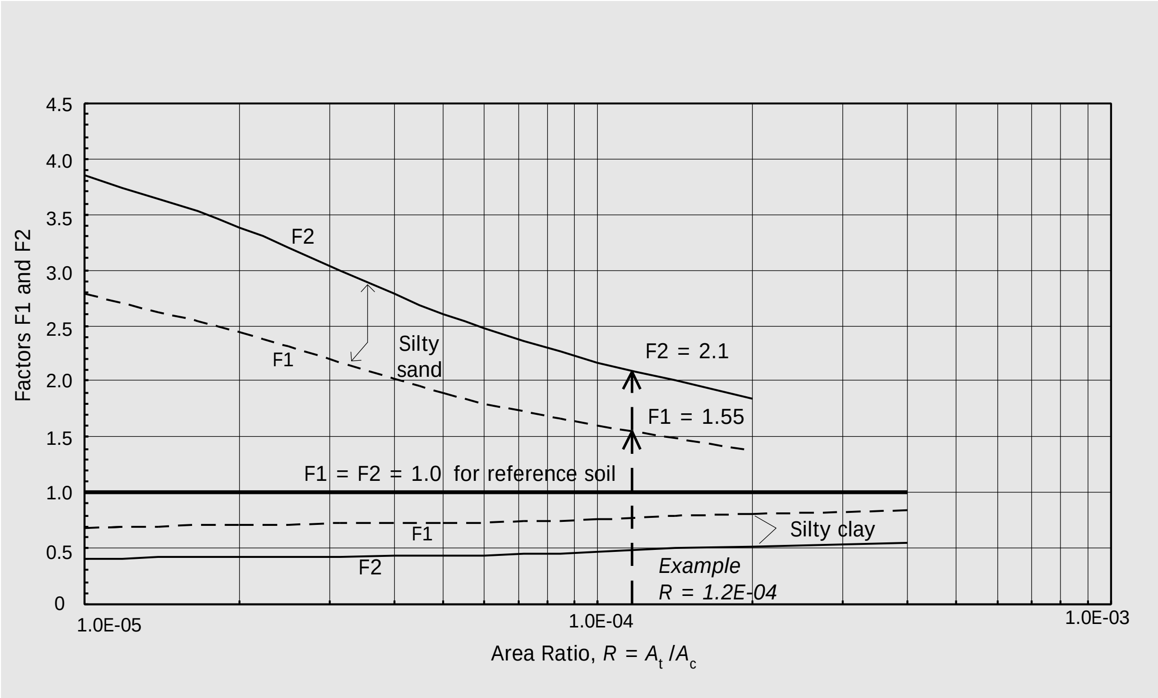
An example is shown where the required annual removal of sediment = 0.04mm is $P_{0.04}$ = 50%.

For *U* = 80%, the trap area ratio *R* = 1.2 E-4 and the predicted removal of sediment = 0.01mm is $P_{0.01}$ = 33%

34.A.2 Soil Type Adjustment Factors *F1* and *F2*

$$\text{Factor } F1 = \frac{\text{Vol. sediment} \geq 0.04\text{mm for reference soil}}{\text{Vol. sediment} \geq 0.04\text{mm for site soil}}$$

$$\text{Factor } F2 = \frac{\text{Vol. sediment} \geq 0.01\text{mm for reference soil}}{\text{Vol. sediment} \geq 0.01\text{mm for site soil}}$$



Design Chart 34.A2 Soil Type Adjustment Factors for Trap Area and Sediment Volume

Design Chart 34.A2 gives recommended values for the soil type adjustment factors *F1* and *F2* as a function of the soil type in the catchment.

These factors have been derived by repeating the calculations for Design Chart 34.A1, for other typical soil gradings.

To use the Chart: Estimate the *average* soil type in the catchment, allowing for any changes due to urbanisation. Read factors *F1* and *F2* from the curves for the chosen trap area ratio R. Interpolate between curves if necessary for other soil types.

APPENDIX 34.B PROPRIETARY GROSS POLLUTANT TRAPS

34.B.1 List of Available Devices

Humeguard™

The Humeguard Trap is marketed by CSR Humes in Australia. It comprises a specially shaped (floating) boom which diverts material entrained in stormwater flows from the separator into an adjacent holding chamber which can be installed in piped drainage systems. The chamber is baffled to ensure that litter and floating debris is retained and does not escape with the outflow from the chamber. While it is particularly suited to retro-fitting within existing piped drainage system there is a limitation on the maximum size of pipe on which the device can be installed. An illustration of a Humeguard™ trap is given in Figure 34.B1.

Figure 34.B1 Humeguard™ Trap

Downstream Defender™

The Downstream Defender is a vortex-type treatment device designed to capture settleable solids, floatables, oils and grease from stormwater runoff. It is marketed by Rocla Australia. It consists of a concrete cylindrical vessel with a sloping base and internal components. Stormwater is introduced tangentially into the side of the cylinder and spirals down the perimeter allowing heavier particles to settle out by gravity and the drag forces on the wall and base of the chamber. As flow rotates about the vertical axis, solids are directed towards the base of the chamber where they are stored in a collection facility. The internal components then direct the main flow away from the perimeter and back up the middle of the vessel as a narrow spiralling column rotating at a slower velocity than the outer downward flow.

Cleansall™ Trap

The Cleansall trap is installed using pre-cast elements marketed by Rocla Australia. A diversion weir deflects the treatable flow into a circular chamber in which are seated four quadrant baskets. Litter and other debris are captured by the baskets as stormwater flows through the mesh baskets and out a depressed outlet at the base of the chamber. A sediment sump is located immediately downstream of the chamber where the stormwater wells up to re-join the stormwater conduit. Features of this system are that it can be installed underground and in such a way as to minimise head loss in flood flows and that high trapping efficiencies are predicted from laboratory tests.

StormCeptor™, HumeCeptor™

The StormCeptor trap is an in-line device for removing oil and sediment from stormwater. It is marketed in Canada under the name StormCeptor, and in Australia by CSR-Humes under the name HumeCeptor. It replaces a conventional manhole in the stormwater system. The HumeCeptor comprises a (circular, lower) treatment chamber and an (in-line) by-pass chamber.

Stormwater is directed through the bypass chamber. Low flows are diverted into the (lower, sealed) treatment chamber by a weir and a drop pipe arrangement that directs the water tangentially along the treatment chamber wall. Water flows through the treatment chamber to the (submerged) outlet pipe and back up into the bypass chamber downstream of the weir. The stormwater then flows back into the downstream piped system. Oil and other liquids with a specific gravity less than water rise in the treatment chamber and are trapped beneath the roof of the treatment chamber. Sediment settles to the bottom of the chamber.

During high flows, stormwater overtops the weir and is discharged directly into the downstream piped system. Their application appears to be most suited to developments such as service stations, bus depots, roads and industrial and commercial parking areas. An illustration of a StormCeptor trap is given in Figure 34.B2.

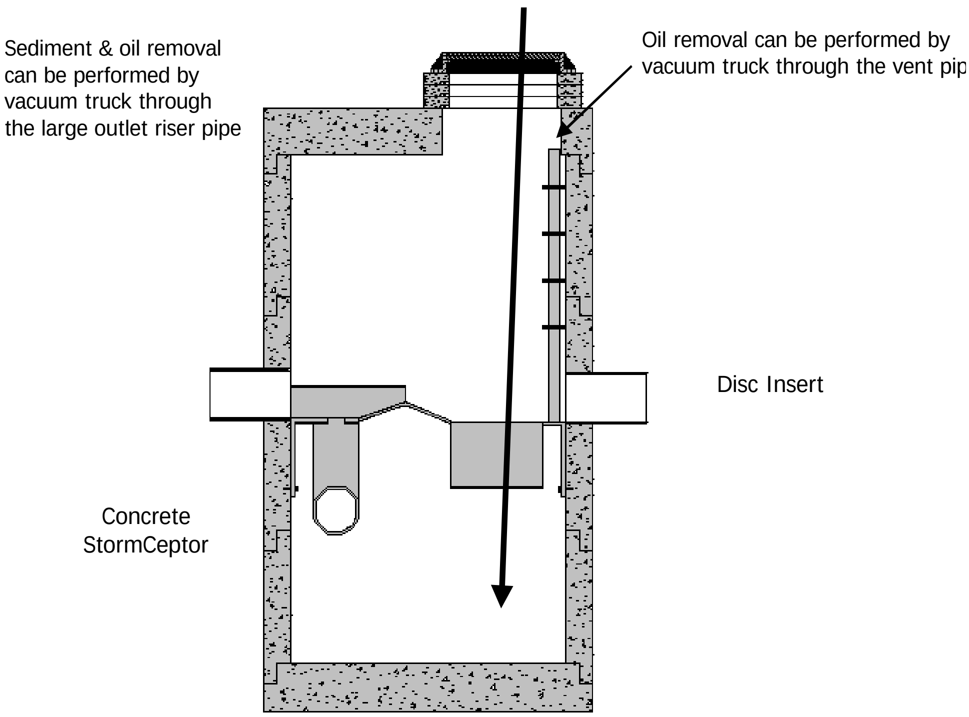


Figure 34.B2 StormCeptor™ Trap

Continuous Deflective Separation™ (CDS) Trap

The CDS™ trap consists of an on-line stainless steel perforated separation plate placed in a hydraulically balanced chamber. Solid pollutants are retained in a central chamber under a mild vortex action, and drop into a basket for later removal and/or for removal using a grab bucket or using eduction. Features of this system are that it can be installed underground and in such a way as to minimise head loss in flood flows and that high trapping efficiencies are predicted from laboratory tests. An illustration of a CDS™ trap is given in Figure 34.B3.

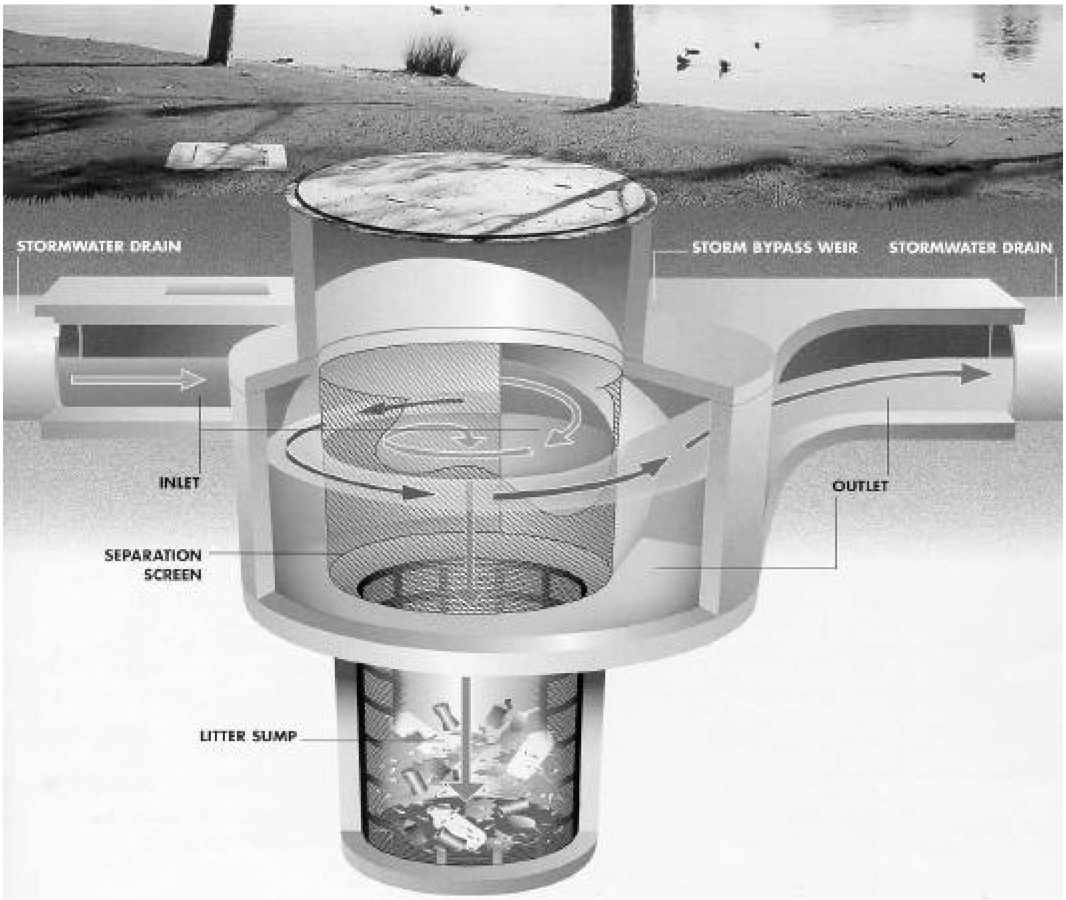


Figure 34.B3 CDS™ Trap

Ecosol™ Traps

Ecosol Pty Ltd has developed a range of stormwater treatment devices. The RSF 4000 trap can be fitted to any size or shape of pipe and consists of two parallel channels working together, namely a filtration/collection unit and two overflow/by pass channels. The unit filters capture all gross pollutants equal to or greater than the screen aperture size although solids significantly less than the screen aperture size are routinely collected. The configuration of the unit creates a hydraulic barrier that deflects stormwater into the unit. When the screen becomes blocked the hydraulic barrier dissipates allowing flows to bypass the unit. An illustration of a RSF 4000 trap is given in Figure 34.B4.

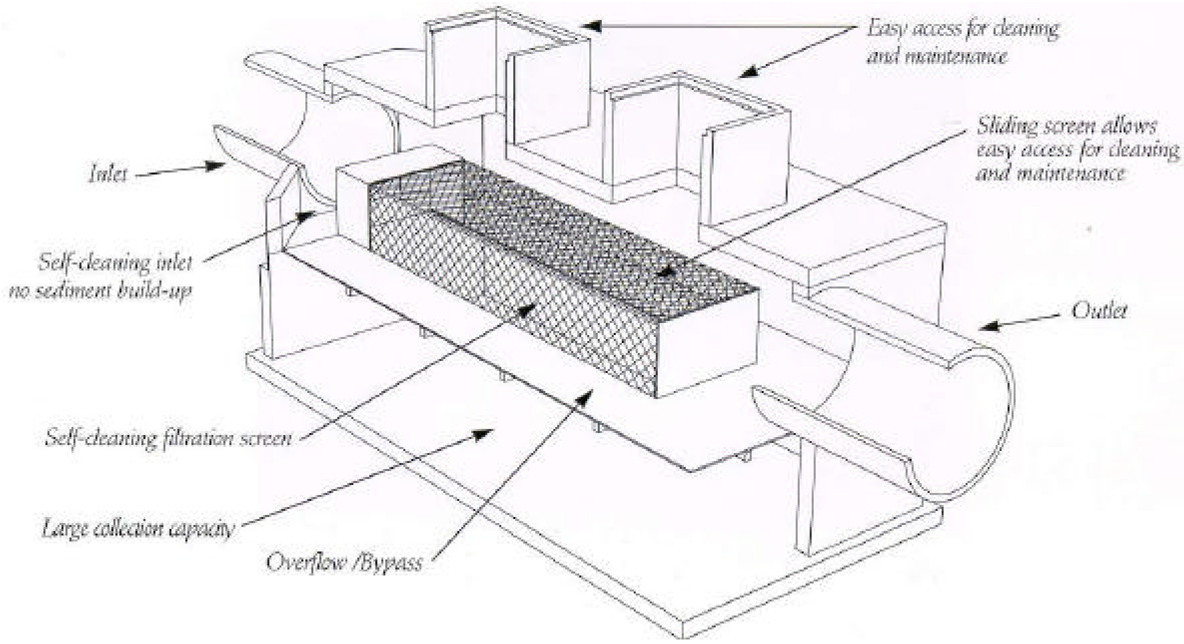


Figure 34.B4 Ecosol™ RSF 4000 Trap

Baramy™ Trap

The Baramy Trap is an end-of-pipe trap that separates stormwater from litter and debris by directing the outflow from a stormwater pipe down an inclined screen. The majority of the water falls through the screen and is discharged either around or beneath the litter chamber into the downstream (open) drainage system. A portion of the stormwater flow pushes the litter and debris down the screen into a collection chamber which is screened to allow collected stormwater to drain away. This trap was developed in the Blue Mountains outside Sydney, Australia where urban drainage system on the plateau discharge into incised heavily vegetated valleys.

A general arrangement of a Baramy trap is given in Figure 34.B5.

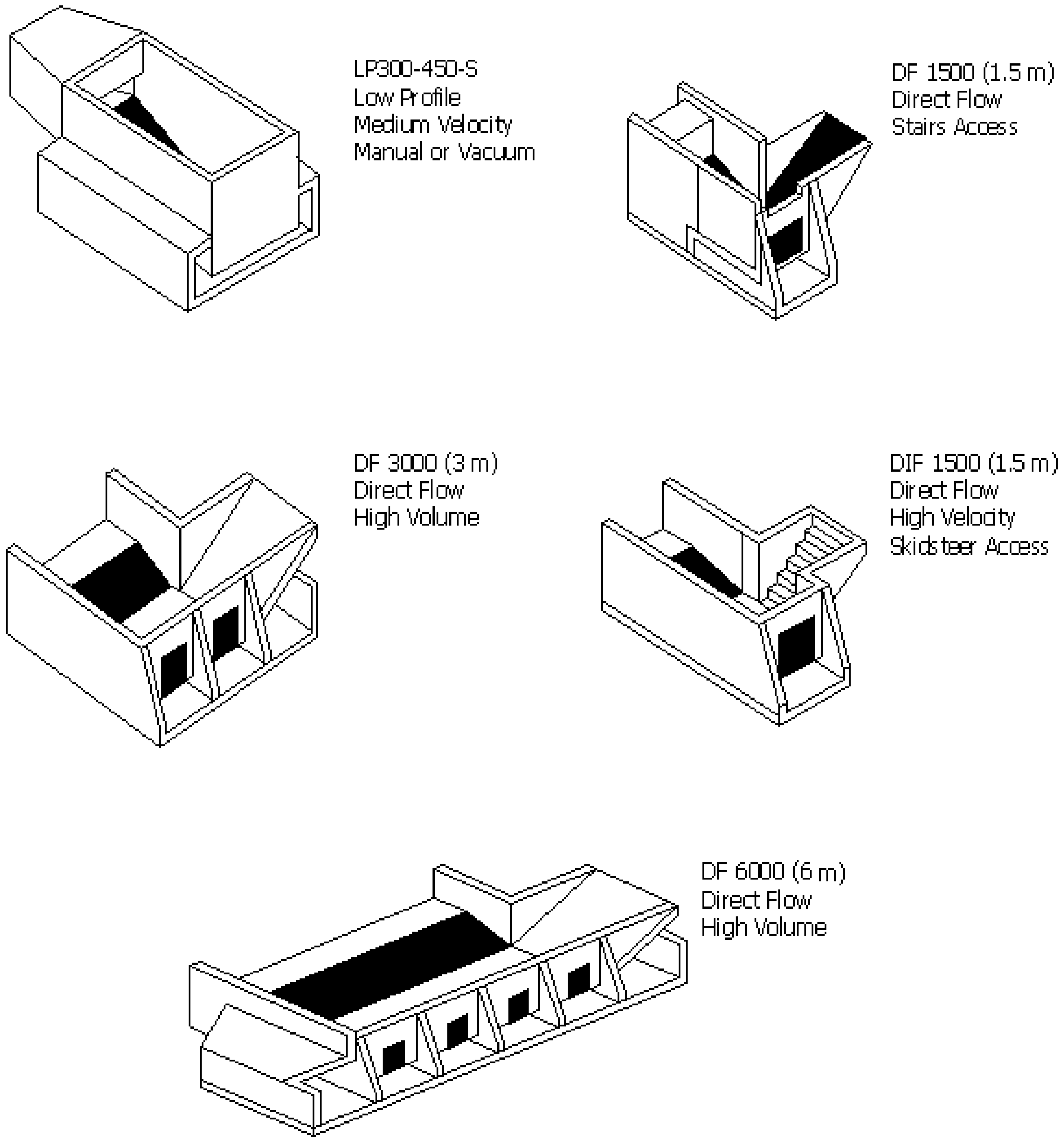


Figure 34.B5 Baramy™ trap

Nicholas Ski-Jump® Trap

The Nicholas Ski-Jump trap is also an end-of-pipe trap which captures litter, debris and sediment transported by stormwater. It comprises:

(i) a perforated screen to screen low flows and to direct higher flows into a litter receiver,

(ii) a perforated flume cover to contain litter during higher flows,

(iii) a modular set of fine-meshed, interlocking litter baskets,

(iv) a mesh covered sediment well,

(v) provision for an absorbent pillow to collect surface oils during low flows, and

(vi) a permeable silt gate to maintain a stilling pond above the well and to promote settlement of solids.

This trap was developed in Australia and has been installed on several drainage outfalls for major highways and freeways.

A schematic arrangement of a Nicholas Ski-Jump trap is given in Figure 34.B6.

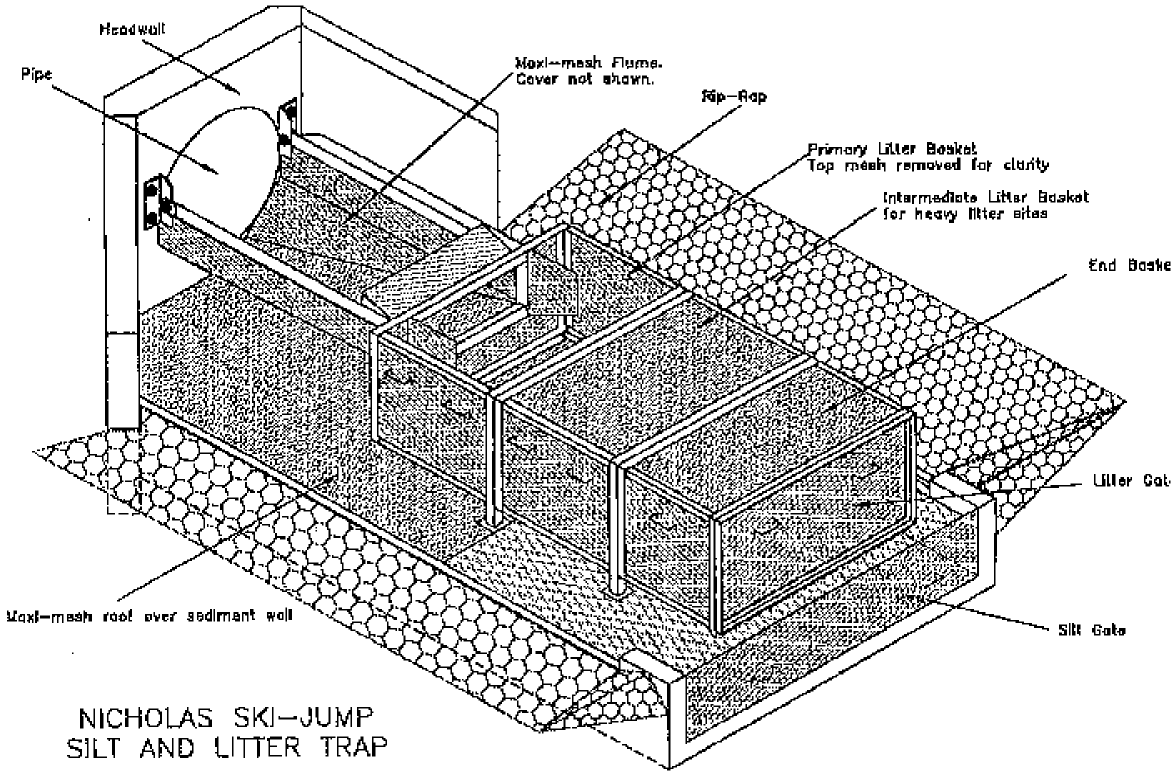


Figure 34.B6 Nicholas Ski-jump Trap

34.B.2 Sources of Further Information

It is not practicable in this Manual to provide full information on the range of devices. The devices are being continually improved and new devices developed. Further information on various type of devices may be found in:

1. ACT City Services, Stormwater Section (1994) "*Urban Stormwater Standard Engineering Practices*", Edition 1, AGPS, Canberra, Australia.
2. Allison, RA, Chiew, FHS and McMahon, TA (1998) "*A Decision-Support System for Determining Effective Trapping Strategies for Gross Pollutants*" CRC for Catchment Hydrology, Report, No. 98/3, Australia.
3. Angkasa GHD Engineers Sdn Bhd (1998) "*Putrajaya Stormwater Management Design Guidelines"*
4. Auckland Regional Council (1992) "*Design Guideline Manual for Stormwater Treatment Devices*", First Edition, prepared by Beca Carter Hollings & Ferner Ltd, November, Auckland NZ.
5. Department of Environment, Land and Planning (1992) "*Gross Pollutant Trap Guidelines",* Final Report, Prepared by Willing & Partners Pty Ltd for the ACT Planning Authority, Canberra.
6. Environment Protection Authority, NSW (1997) "*Managing Urban Stormwater - Treatment Techniques*", Final Report", November, Australia.
7. Neville Jones & Associates (1994) *"Design Guidelines for Gross Pollutant Traps – Background Report"*, Prepared for Brisbane City Council, Australia.
8. Willing & Partners (1995) *"Stormwater Design Guidelines for Homebush Bay"*, August, Australia.

Contact details for the Co-operative Research Centre for Catchment Hydrology (CRCCH), developers of the Gross Pollutant Decision Support System for gross pollutant traps, are as follows:

Co-operative Research Centre for Catchment Hydrology (CRCCH)

address: Monash University, Wellington Road, Clayton 3168 Australia

phone: +61 (3) 9905 2704, fax +61 (3) 9905 5033

website: http://www-civil.eng.monash.edu.au/centres/crcch

Information on Proprietary Devices may be obtained from the relevant manufacturers listed below. This list is not inclusive, and listing does not imply endorsement by DID.

Baramy Pty Ltd, Australia. phone: +61 (2)

website: http://www.baramy.com.au/

CDS's, franchisee: Bisleys Environmental Ltd., New Zealand. phone: +64 (7) 843 8283

website: http://www.bisleys.net/

CSR-Humes, Australia. phone: +61 (2) 9832 5555

website: http://www.csr.com.au/product-homeswork/construct/humes/humes.asp/

Ecosol Pty Ltd, Australia. phone: +61 (2) 9560 2802

website: http://www.ecosol.com.au/

Rocla Pty Ltd, Australia. phone: +61 (2)

website: http://www.pipe.rocla.com.au/

StormCeptor, Canada. phone: +1 (800) 565 4801

website: http://www.stormceptor.com/

APPENDIX 34.C RELATIVE EFFECTIVENESS OF GROSS POLLUTANT TRAPS AND OTHER BMPs MEASURES

	Pollutants						Combination of Pollutants													Cost-effectiveness	
	Litter	Organic Matter	Sediment	Oils and Grease	Metals	Nutrients	Litter, Sediment	Litter, Oils	Litter, Organics	Litter, Nutrients	Organics, Sediment	Organics, Nutrients	Litter, Organic, Oils	Litter, Sediment Oils	Litter, Organic, Sediment	Litter, Sediment, Nutrients	Litter, Oils, Organic, Sediment	Litter, Oils, Organics, Metals	Litter, Organics, Sediment, Nutrients	Relative Cost	Relative Effective-ness
GPT STRUCTURES																					
Floating Debris Trap: boom, Bandalong	5	3	1	7	1	1	3	6	4	3	2	2	5	4	3	2	4	4	3	low	low
In-pit devices	5	5	3	1	1	1	4	3	5	3	4	3	4	3	4	3	3	3	4	low	low
Litter Control Device: Net-tech	7	7	1	1	1	1	4	4	7	4	4	4	5	3	5	3	4	4	4	medium	medium
Trash rack	7	7	6	1	6	1	7	4	7	4	7	4	5	5	7	5	5	5	5	medium	medium
SBTR trap	7	7	7	4	7	5	7	6	7	6	7	6	6	6	7	6	6	6	7	medium	high
Proprietary devices: Baramy	8	8	4	1	4	2	6	5	8	5	6	5	6	4	7	5	5	5	6	medium	medium
CDS	9	9	7	6	7	2	8	8	9	6	8	6	8	7	8	6	8	8	7	high	high
Ecosol	8	8	6	3	6	2	7	6	8	5	7	5	6	6	7	5	6	6	6	high	high
HumeCeptor	2	3	6	8	6	3	4	5	3	3	5	3	4	5	4	4	5	5	4	high	high
Cleansall	7	7	4	3	4	2	6	5	7	5	6	5	6	5	6	4	5	5	5	high	high
Downstream Defender	5	5	6	5	6	2	6	5	5	4	6	4	5	5	5	4	5	5	5	high	high
HOUSEKEEPING, CONSTRUCTION AND EDUCATION BMPs																					
Improved cleaning & maintenance	7	7	6	5	6	3	7	6	7	5	7	5	7	6	7	6	7	7	6	medium	high
Education program	5	4	5	4	5	4	5	5	5	5	5	4	4	5	5	5	5	5	5	low	medium
Point source controls	6	5	6	5	6	4	6	6	6	5	6	5	5	6	6	5	6	6	5	medium	high
Construction controls (ESCP)	3	3	6	2	6	2	5	3	3	3	5	3	3	4	4	4	4	4	4	medium	medium
Mechanical street sweeping	7	7	4	1	4	2	6	4	7	5	6	5	5	4	6	4	5	5	5	low	low
Stormwater Management Plan	8	6	4	3	3	4	6	6	7	6	5	5	6	5	6	5	5	5	6	low	high

Source: adapted from Middle Harbour Stormwater Management Plan" by Willing & Partners (NSW), 1999. Relative costings are subject to confirmation for Malaysian conditions.

Note: Rating for the effectiveness of GPT is ‘1’ for the Least Effective and ‘9’ for the Most Effective.

APPENDIX 34.D WORKED EXAMPLE

Example for Sizing of SBTR type 1 Trap

Problem: Determine the size required for the SBTR type 1 GPT in the Sg. Rokam example of a community-level stormwater system, as used in Example 16.B.1.

Solution:

1) Determine the required removal efficiency. In accordance with Table 4.5 the trap will be sized to trap 70% of sediment = 0.04 mm diameter.

2) Determine the catchment area, % urban area and soil type in the catchment

   From the data in Chapter 16, we obtain: A_c = 113.8 ha, U = 80% and soil type = 'silty sand'.

3) Select a trial trap area ratio R. First use a trial area ratio R = 1.2 E-4.

4) Calculate the required trap area by trial and error:

   Design Chart 34.A1, Curve A, gives $P_{0.04}$ = 50% for the reference soil and Design Chart 34.A2 gives $F1$ = 1.55. Substituting these values in Equation 34.3 gives:

   $P_{0.04*}$ =50% x 1.55 = 79%. This is more than required so the trap size can be reduced.

   Try R = 0.8 E-4. For this value of R, Design Chart 34.A1,Curve A gives $P_{0.04}$ = 43% for the reference soil and Design Chart 34.A2 gives $F1$ = 1.65; so the calculated removal efficiency for the site soil is 43% x 1.65 = 71%. This is acceptable.

   Therefore the required minimum trap size is:

   $A_t = R \times A_c$ = 0.8E-4 x 113.8E4 m^2 = 91 m^2

5) Determine the trap length and width to give a ratio $\frac{L_t}{W_t}$ of between 2 and 3.

   The following trial dimensions are selected: L_t = 14.0 m, W_t = 7.0 m.

   Then $\frac{L_t}{W_t}$ = 2.0, and actual trap area A_t = 98 m^2. (Although this area is more than is theoretically required, the trap will need to be slightly over-sized so that the trash rack can be fitted in as discussed later).

6) Determine the average annual sediment export using Chapter 15 or other local data:

   From Table 16.B3, annual sediment load allowing for upstream controls is:

   M = 116,998 kg, say 117 tonne.

7) Determine $P_{0.01}$, the average annual pollutant retention = 0.01 mm diameter for the reference soil from the relevant Curve B in the lower part of Design Chart 34.A1, and Volume Factor $F2$ from Design Chart 34.A2:

   Pollutant retention for reference soil $P_{0.01}$ = 33%, and $F2$ = 2.1.

   Pollutant retention for site soil (Equation 34.4) $P_{0.01*}$ = 33% x 2.1 = 69%.

8) Determine the required minimum sediment trap depth from Equation 34.5:

   $D_t = 0.0065 \times P_{0.01*} \times M \;/\; A_t$ = 0.0065 x 69 x 117 / 98

   = 0.535 m.

9) Determine the rainfall in the *water quality design storm* (usually 3 month ARI) from Chapter 13. Calculate the peak flow, $Q_{0.25}$ (m^3/sec) using any suitable method from Chapter 14.

   In this case, the flow calculations were done using the time-area method in XP-SWMM as shown in Chapter 16, Example 16.A.1. For the GPT site at node 6F1/2, $Q_{0.25}$ = 11.5 m^3/sec.

10) Determine the trash rack height from Equation 34.7. Try a trash rack length L_r = 7.0m to match the width of the sediment trap:

$$H_r = 1.22\left(\frac{Q_{0.25}}{L_r}\right)^{2/3} = 1.22 \times \left(\frac{11.5}{7}\right)^{2/3} = 1.7 \text{ m}$$

This height is excessive and impractical because it would increase flooding upstream, therefore the design has to be revised. Considering a trash rack length L_r of 10.0 m gives H_r = 1.34 m which is reasonable. The longer trash rack can be achieved by adjusting the design to use an V-shaped trash rack (in plan).

11) Determine the nominal flow velocity $V_{0.25}$ in the water quality design storm using Equation 34.8. Increase the dimensions of the sediment trap pool or increase the track rack height if the flow velocity V is greater than 1.0 m/s, to minimise the re-entrainment of deposited sediment.

$$V_{0.25} = \frac{Q_{0.25}}{(D_w + H_r)W_t}$$

$$= \frac{11.5}{(0.535+1.40) \times 7.0} = 0.85 \text{ m/s, which is acceptable.}$$

12) For a Type 2 (covered) SBTR trap, determine required clearance above the trash rack from Equation 34.9:

In this example, the trash rack is open (Type 1) so this step is omitted. The open trash rack will be overtopped in floods greater than the 3 month ARI flood (if 50% blocked) and the open channel must be designed accordingly.

The resulting 'theoretical' concept design for the SBTR trap is as shown below. This concept was used for Worked Example 16.A.1 in Chapter 16. In reality, the concept and dimensions may have to be adjusted if required to suit site conditions.

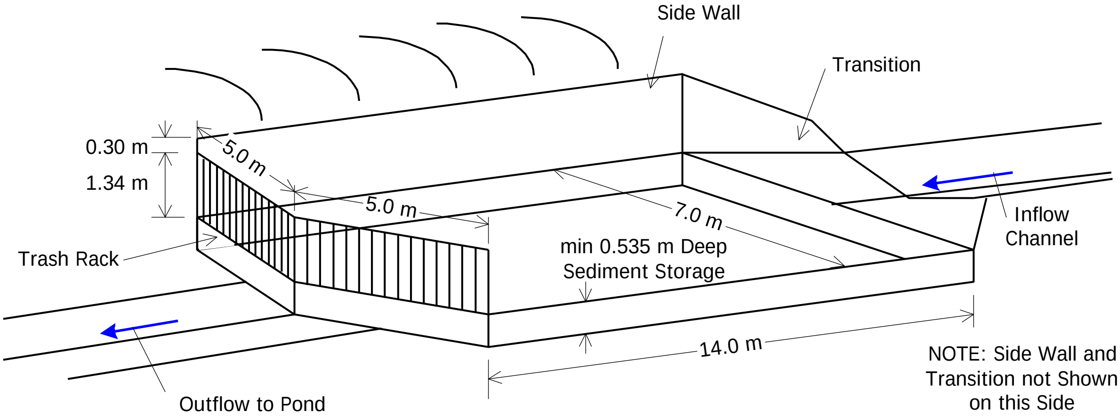


Figure 34.D1 Diagrammatic Layout of Proposed Type 1 SBTR Trap for Sg. Rokam example