Sediment Trench

SEDIMENT CONTROL TECHNIQUE

Type 1 System		Sheet Flow	✓	Sandy Soils	✓
Type 2 System	[1]	Concentrated Flow	✓	Clayey Soils	✓
Type 3 System	[1]	Supplementary Trap		Dispersive Soils	

[1] Performance of the sediment trap depends on the type of outlet structure and the settling pond surface area.

SS

Symbol S S S S S

Photo 1 – Sediment trench located at the base of a fill batter on a road construction project (USA)

Key Principles

1. Sediment trapping is achieved by both particle settlement within the settling pond formed by the dam (high flows), and by the filtration of minor flows passing through the porous outlet structure.
2. The critical design parameter for optimising particle settlement is the 'surface area' of the settling pond. The hydraulic properties of the rock embankment are critical in achieving the optimum settling pond conditions, which depends on the stage-discharge relationship of the embankment.
3. The critical design parameters for the filtration process are the design flow rate for water passing through the filter (which is related to the depth of water), and the surface area and flow resistance of the filter.
4. Geotextile filters provide superior filtration performance, especially within short-term installations; however, their maintenance can be tedious and time-consuming compared to aggregate filters.

Design Information

The design of a sediment trench is effectively the same as the design of a rock filter dam or excavated sediment trench. In effect, a sediment trench is just an excavated sediment trench placed transverse to the slope. A rock filter dam is often used as the outlet structure; however, the outlet may be replaced by a sediment weir, filter tube dam, modular units, or sediment fence.

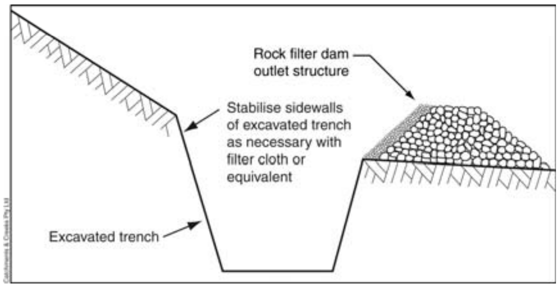

Figure 1 – Sediment trench with rock filter dam outlet structure

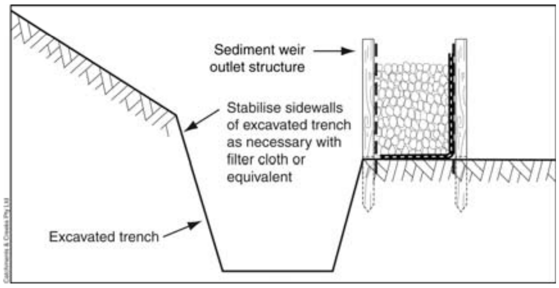

Figure 2 – Sediment trench with sediment weir outlet structure

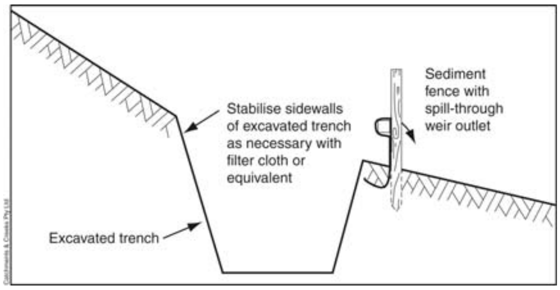

Figure 3 – Sediment trench with sediment fence outlet structure

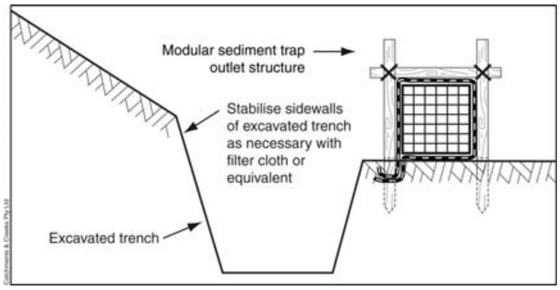

Figure 4 – Sediment trench with modular system outlet structure

A sediment trench, however, can also be used to collect and treat 'sheet' flows discharging down exposed slopes, in which case the design procedure follows that of an excavated sediment trap. If the trench needs to be formed down a slight slope, then rock check dams can be used to form individual sediment collection chambers within the trench (Figure 5).

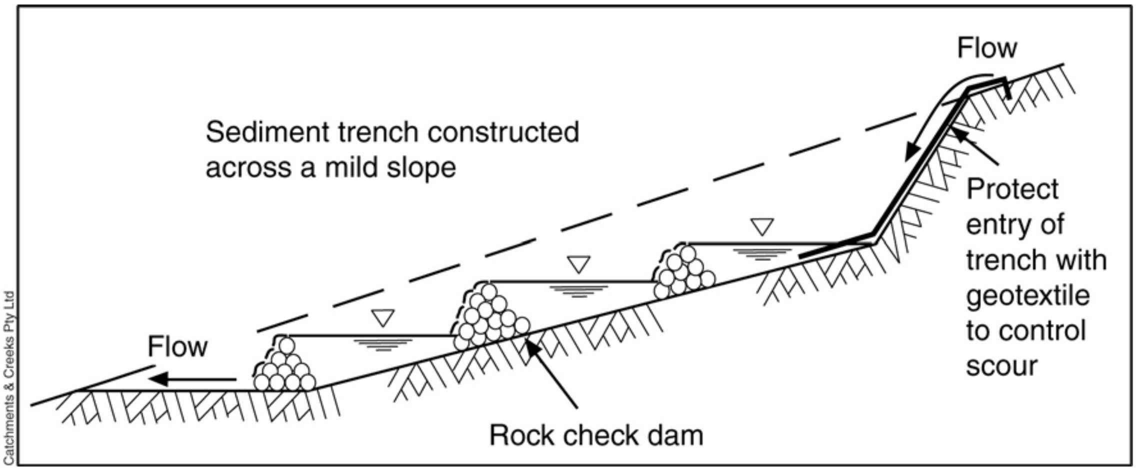

Figure 5 – Long-section of a sediment trench excavated diagonal to a slope

A rock filter dam outlet structure typically contains two different categories of rock, those being:

- The primary core rock, which makes up the bulk of the rock embankment.
- Filter layer aggregate, which is placed on the upstream face of the rock embankment.

The minimum core rock size of 225mm (nominal diameter for angular rock) for rock embankments in excess of 0.5m high.

Typical size of filter aggregate is 15 to 25mm nominal diameter.

The use of geotextile filters (minimum 'bidim' A34 or equivalent) is preferred in most construction site situations where the rock filter dam is likely to have an operational life of a few months.

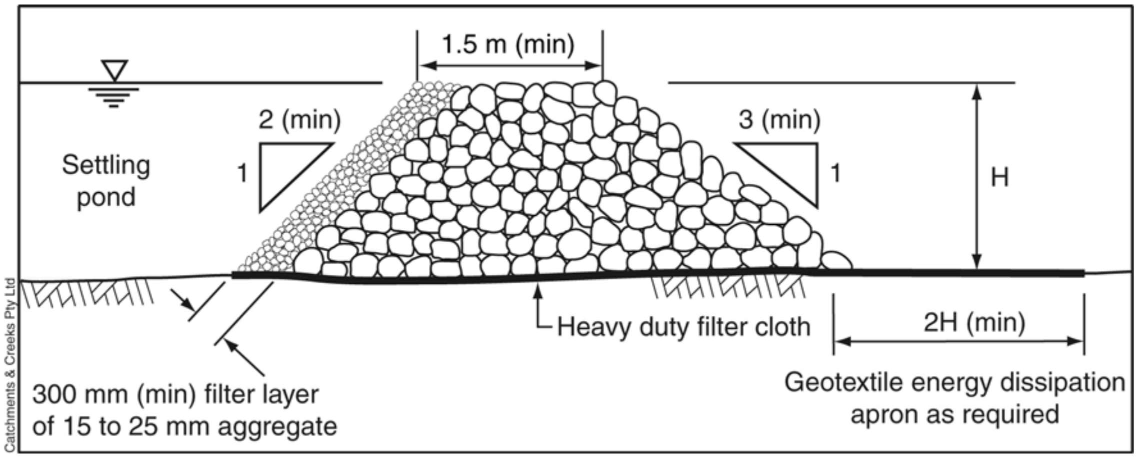

Figure 6 – Rock filter dam outlet system with aggregate filter

Rock filter dams with geotextile filters (Figure 7) usually require the use of an aggregate layer to achieve the desired stage-discharge flow conditions for the embankment for the purpose of achieving the optimum settling pond conditions.

The geotextile fabric wrapped around the rock filter dam also improves the stability of the structure allowing a reduced minimum top width.

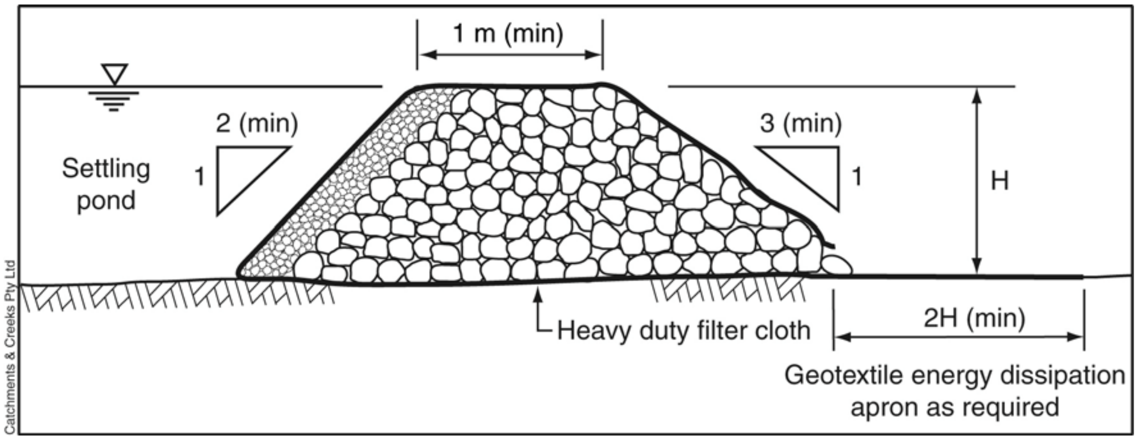

Figure 7 – Rock filter dam outlet system with aggregate and geotextile filter

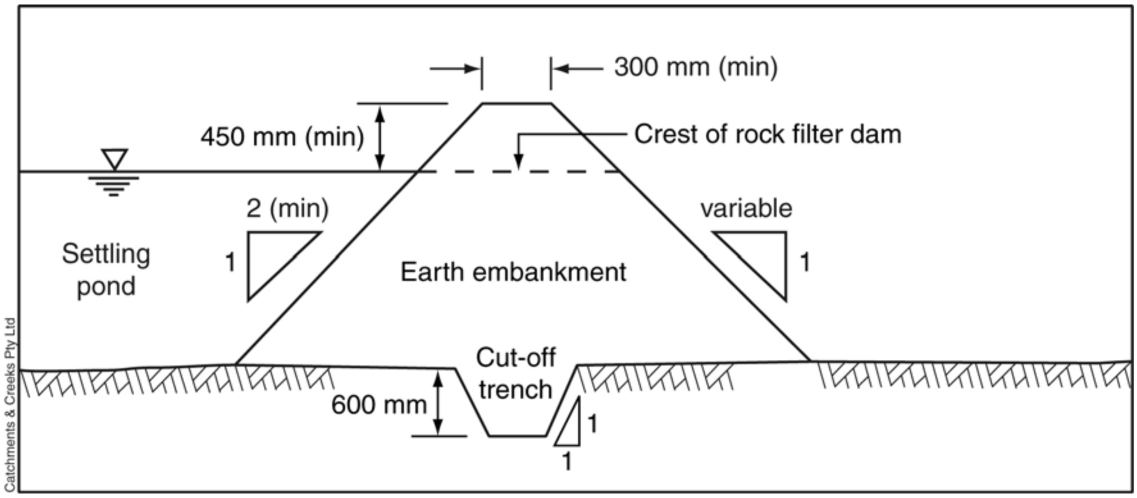

Figure 8 – Typical dimensional requirements for constructed fill abutments

Design Procedure

1. Determine the design flow rate (Q) for water passing through the outlet structure just prior to flows overtopping the spillway (Figure 9), as well as the design discharge (Q_{WEIR}) for overtopping flows.
2. Determine the desirable settling pond surface area (A_s) from Table 1 based on the design flow rate (Q). The available space of the settling pond is often limited by site conditions; however, wherever practical, choose a critical particle size of 0.05mm.
3. Determine the maximum allowable water level within the settling pond. This may be based on site constraints, or related to flooding and/or public safety issues.
4. Determine the effective width of the outlet structure (W). The width (perpendicular to the direction of flow) may be limited by site constraints, or controlled by the hydraulic management of overtopping flows. The hydraulic analysis of overtopping flows is normally based on broad-crested weir equations—refer to the separate fact sheet *'Chutes Part 1: General information'*.
5. Select the required crest elevation of the outlet structure to achieve the desired settling pond surface area. Ensure the spillway crest is sufficiently below the maximum allowable water elevation to allow for expected overtopping flows (this may be an iterative process).
6. Select the type of filtration system using Table 3 as a guide.
7. Determine the maximum allowable head loss (ΔH) through the outlet structure including filter medium. If flow conditions downstream of the outlet structure are such that there is little or no backwater effects during the design storm, then assume ΔH is equal to the height of the outlet structure (H).

   If flow depths downstream of the outlet structure are expected to be significant, then the maximum allowable head loss (ΔH) should be taken as the expected variation in water level across the dam during the design discharge.
8. Select a 'design' blockage factor (B.F.) using Table 4 as a guide.
9. Use the design information provided below to determine the make-up and thickness of the filter medium required to achieve the desired stage–discharge relationship.
10. If the available pond surface area is insufficient to settle the required particle size, then the efficiency of the sediment trap may be improved by placing filter cloth across the upstream face of the outlet structure (if not already used). In addition, *Filter Tubes* (refer to *Filter Tube Dams*) can be incorporated into the dam.
11. Determine the rock size required for the spillway (i.e. downstream face of the rock embankment).

(a) Settling pond:

Table 1 provides the required pond surface area per unit flow rate for various nominated 'critical' sediment particle sizes. The critical sediment particle size for a sediment trench may be assumed to be 0.05mm unless otherwise directed. The chosen critical sediment size should reflect the environmental values of the receiving water body and the expected weather conditions.

Table 1 – Minimum settling pond surface area per unit inflow rate ($m^2/m^3/s$)

Sediment trapping standard	Critical particle size (mm)	Pond water temperature [2]		
		10° C	15° C	20° C
Type 3	0.20	38	33	29
	0.15	67	58	51
Type 2	0.10	150	130	115
	0.05	600	525	460

[1] Pond area is based on a rectangular basin operating with uniform flow conditions across its width.

[2] Assume a pond temperature the same as the typical rainwater temperature during the time of year when the pond is likely to be operating at capacity.

It is noted that achieving the minimum pond surface area may not be practicable in all circumstances, in which case a greater focus should be placed on the design of the filter medium placed on the upstream face of the sediment trench.

Two design flow rates are used in the design of a sediment trench. The low flow rate (Q) is the flow rate required to pass through the filtration system just prior to flows overtopping the spillway (Figure 9). The maximum design flow condition (Q_{WEIR}) is when peak waters are achieved within the settling pond (Figure 10).

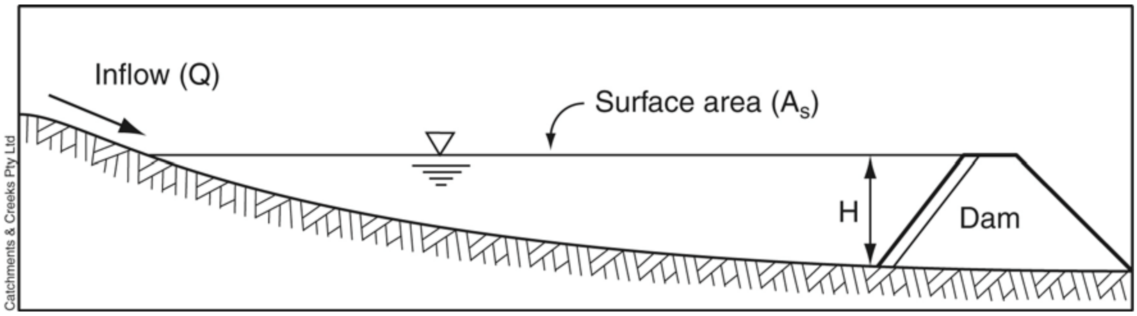

Figure 9 – Minimum design flow condition

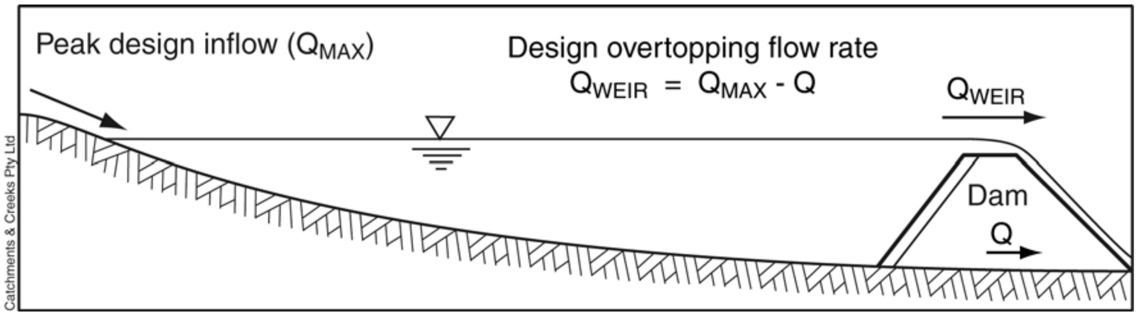

Figure 10 – Maximum design flow condition

(b) Earth abutments:

If the sediment trench outlet structure abuts into constructed earth embankments (Figures 3 & 6), then such embankments should be formed with stable bank slopes appropriate for the soil conditions. Typically bank slopes should not be steeper than 2:1 (H:V) if temporary, or 4:1 if the embankments are grassed and are required to be mown.

The crest of constructed earth embankments should ideally be 450mm; however, in many circumstances space is very limited, in which case the design should optimise the available site conditions.

In most circumstances, however, the entire embankment will consist of the outlet structure, thus maximising the potential flow rate through the filtration system.

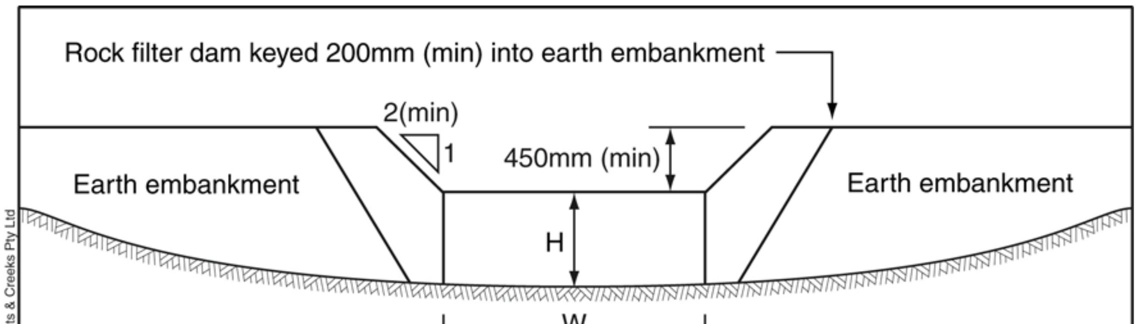

Figure 11 – Rock filter dam integrated into fill embankments

(c) Rock filter dam outlet structures:

Maximum height at centreline of the embankment is 1.5m. Otherwise the design should be assessed for stability by a suitably qualified person (e.g. geotechnical engineer).

Maximum side slopes of 2:1(H:V) on the up-slope face, and 3:1(H:V) on the down-slope face.

The core rock should be well graded, hard, erosion resistant stone. Minimum mean rock size (d_{50}) of 225mm if the embankment height exceeds 0.5m.

(d) Emergency spillway (embankments in excess of 0.5m high):

All formed embankments must be design to handle expected overtopping flows. Guidance on the hydraulic analysis of broad-crested weirs is provided in the separate fact sheet *'Chutes Part 1: General information'* located within the Drainage Structures sub-category.

The maximum design storm (Q_{MAX}) is typically the 1 in 2 year ARI (average recurrence interval) design storm, but may be 1 in 5 year, or 1 in 10 year ARI depending on the safety risks associated with hydraulic failure of the dam.

The design flow rate for the overtopping weir (Q_{WEIR}) is the difference between the maximum design storm flow rate (Q_{MAX}) and the design flow rate for the filter medium (Q).

Desirable longitudinal gradient of spillway no steeper than 3:1(H:V), absolute maximum of 2:1.

Spillway crest should be flat and perpendicular to the alignment of the spillway chute.

Typically for rock embankments greater than 0.5m high, the required mean armour rock size can be determined from either of the following:

- *'Chutes Part 5: Rock linings'* fact sheet, see the 'Drainage Structures' sub-category;
- *'Rock Linings'* fact sheet, see the 'Channel and Chute Linings' sub-category;
- Table 2, assuming angular rock with a specific gravity of 2.4, and safety factor of 1.2.

Table 2 – Flow depth [1], y (m) and mean rock size, d_{50} (m) for SF = 1.2

Safety factor, SF = 1.2			Specific gravity, s_r = 2.4			Size distribution, d_{50}/d_{90} = 0.5		
Unit flow rate (m^3/s/m)	Bed slope [2] = 5:1		Bed slope = 4:1		Bed slope = 3:1		Bed slope = 2:1	
	y (m)	d_{50}	y (m)	d_{50}	y (m)	d_{50}	y (m)	d_{50}
0.1	0.09	**0.10**	0.09	**0.10**	0.09	**0.20**	0.09	**0.20**
0.2	0.15	**0.20**	0.14	**0.20**	0.14	**0.20**	0.14	**0.30**
0.3	0.19	**0.20**	0.19	**0.20**	0.19	**0.30**	0.18	**0.30**
0.4	0.23	**0.30**	0.23	**0.30**	0.23	**0.30**	0.22	**0.40**
0.5	0.27	**0.30**	0.27	**0.30**	0.26	**0.40**	0.26	**0.40**
0.6	0.31	**0.30**	0.30	**0.40**	0.30	**0.40**	0.29	**0.50**
0.8	0.37	**0.40**	0.37	**0.40**	0.36	**0.50**	0.35	**0.60**
1.0	0.43	**0.40**	0.42	**0.50**	0.42	**0.60**	0.41	**0.70**
1.2	0.49	**0.50**	0.48	**0.50**	0.47	**0.60**	0.46	**0.70**
1.4	0.54	**0.50**	0.53	**0.60**	0.52	**0.70**	0.51	**0.80**
1.6	0.59	**0.60**	0.58	**0.70**	0.57	**0.70**	0.56	**0.90**
1.8	0.64	**0.60**	0.63	**0.70**	0.62	**0.80**	0.60	**1.00**
2.0	0.68	**0.70**	0.67	**0.70**	0.66	**0.90**	0.65	**1.00**

[1] Uniform flow depth down face of spillway is expected to be highly variable due to turbulence.

[2] Bed slope is the slope of the spillway (i.e. downstream face of the rock filter dam).

(e) Downstream channel protection:

Where appropriate, an appropriate scour control apron should extend downstream from the toe of the outlet structure a sufficient distance to prevent channel erosion, or a distance equal to the height of the outlet structure, whichever is the greater.

(f) Filter medium:

The entire upstream face of the rock structure should be covered with an appropriate filter media. The properties of the various filter media are presented in Table 3.

Table 3 – Properties of various filter media

Type	Material	Properties
Filter cloth	Heavy-duty filter cloth (minimum 'bidim' A34 or equivalent) one or more layers	Short-term sediment traps (< 12-months) Medium trapping efficiency Possible high maintenance requirements (the aim is for the operational life of the trap to be less than the time required for the fabric to block with sediment).
Aggregate	Minimum 300mm thick layer of 15 to 25mm aggregate	Short to medium-term traps (6 to 12-months) Initially poor filtering capacity until partial sediment blockage of the aggregate occurs, after which medium trapping efficiency Medium maintenance requirements
	Minimum 300mm thick layer of 25 to 75mm aggregate	Long-term sediment traps (> 12-months) Low trapping efficiency Low to medium maintenance requirements
Filter tube dam	Refer to specifications for *Filter Tubes*	Medium to long-term sediment traps Their use required significant spatial requirements that are often not available.

(g) Aggregate filter hydraulics:

The head loss (ΔH) of a rock-based outlet structures can be determined using Equation 1 which is based on the dimensions of an equivalent rectangular rock-filled medium.

$$\Delta H^{1.5} = \frac{1000.Q.T^{0.5}}{B.F.[15.2 - 0.0068(d)].W.d^{0.5}} \quad \text{(Eqn 1)}$$

Notes on Equation 1:

- It is assumed that the effective height of the rock structure (H) is equal to the head loss (ΔH) through the structure, i.e. it is assumed that there is no hydraulic back pressure on the downstream face of the rock filter.
- The equation was developed from research work presented by Jiang et al., within Fifield (2001).
- Given the complexity of many rock-based filtration systems, the equation may not be accurate in all circumstances, but is assumed to be satisfactory for design purposes.

If the core of the rock-based outlet structure contains rock larger than 100mm in diameter, then it may be assumed that this rock does not provide any measurable hydraulic resistance to the passage of water through the dam.

Alternatively, if the maximum allowable head loss (ΔH) is known, then the allowable flow rate (Q) can be determined using Equation 2.

$$Q = (B.F.)[15.2 - 0.0068(d)]\frac{W.\Delta H^{1.5}.d^{0.5}}{1000\ T^{0.5}} \quad \text{(Eqn 2)}$$

where:

Q = Flow rate (assuming no blockage) [m^3/s]

d = mean (d_{50}) size of the filter rock [mm]

W = width of rock filter dam across the direction of flow [m]

ΔH = head loss through rock filter [m]

T = thickness of rock filter in the direction of flow [m]

Table 4 – Blockage factors for filter mediums

Blockage factor (B.F.)	Appropriate usage
1.0	When assessing the 'As Constructed' maximum flow rate.
0.9	Sediment traps operating in coarse-grained soils where the runoff of fine silts and clays is expected to be only minor.
0.5	Default design value. Sediment traps likely to experience more than one storm event.

Ideally, rock filter dam should be able to fully discharge (de-water) the settling pond over **no less** than 8 hours to allow sufficient time for particle settlement. Settling ponds that can drain (from full) in less than 8 hours may not achieve optimum sediment capture. Settling ponds that drain (from full) over a period greater than 8 hours may indicated the need for maintenance of the filter medium.

(h) Filter cloth hydraulics:

The head loss through a layer of filter cloth can be determined from the permittivity (ψ) of the reported fabric in accordance with AS 3706-9.

$$\Delta H = \frac{Q}{(B.F.).A.\psi} \qquad \text{(Eqn. 3)}$$

where:

- ΔH = Hydraulic head loss through geotextile [m]
- Q = Total flow rate through the geotextile [m^3/s]
- A = Surface area of the geotextile [m^2]
- ψ = Permittivity of the geotextile (AS 3706-9) [s^{-1}]

Notes on Equation 3:

- Equation 3 assumes hydraulic pressure (i.e. water) exists on both sides of the fabric, i.e. the cloth is not 'damming' the water like most woven fabrics do.

The permittivity for various grades of 'bidim' filter cloth can be determined from Table 5.

Table 5: Flow rate per unit width for various grades of 'bidim' filter cloth (no blockage allowance)

bidim grade =	A12	A14	A24	A29	A34	A44	A64
Flow rate @ 100mm head [1] ($L/s/m^2$)	512	454	342	242	217	161	118
Permittivity (AS 3706-9) 'ψ' (s^{-1})	5.12	4.54	3.42	2.42	2.17	1.61	1.18

[1] Manufacturer's specified flow rate at a constant head of 100mm based on AS 3706-9.

Reference:

Fifield, J.S. 2001, *Designing for Effective Sediment and Erosion Control on Construction Sites.* Forester Communications, California. ISBN 0-9707687-0-2.

Description

A narrow excavated sediment trench usually placed transverse to the direction of surface runoff.

The design of a sediment trench is very similar to that used for a rock filter dam or excavated sediment trap.

Purpose

Typically used as a Type 2 sediment trap, but can be classified as a Type 3 sediment trap if the settling pond has insufficient surface area.

Most commonly used as a sediment trap at the base of fill embankments when space is very limited.

A sediment trench may be used to collect and treat sheet flows and/or concentrated flows discharging down exposed slopes.

Limitations

Limited ability to control turbidity levels or trap fine sediments, except during periods of low flow.

Advantages

These sediment traps make best use of limited available space at the base of a fill embankment.

Disadvantages

The filter medium may regularly block with sediment requiring their replacement.

Geotextile filters are very difficult to replace once covered in mud.

Fine sediments (e.g. clay particles) readily pass through most rock-based filtration systems.

Special Requirements

Suitable access must be provided for maintenance.

The sediment trench may consist of an excavated sediment collection trench formed immediately upstream of the rock filter dam, sediment weir or filter tube dam.

Location

Most commonly used in road construction projects.

Also used on building sites when sediment-laden flows discharge into adjacent properties.

Site Inspection

Check the choice and performance of the filter medium.

Check the dimensions of the settling pond.

Check for potential flows bypassing the filter medium.

Check that the bank slopes are 2:1 (H:V) or flatter.

Check if the trap requires maintenance or sediment removal.

Materials

- Embankment core rock: well graded, hard, angular, erosion resistant rock, with mean size as specified in the approved plan, but not less than 225mm if the embankment height exceeds 0.5m.
- Aggregate filter: 15 to 25mm clean aggregate.
- Geotextile filter fabric: heavy-duty non-woven, needle-punched filter fabric, minimum ‘bidim’ A34 or equivalent.

Installation

1. Refer to approved plans for location and construction details. If there are questions or problems with the location, or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Clear the foundation area of the outlet structure of woody vegetation and organic matter. Delay clearing the up-slope settling pond area until the outlet structure is formed.
3. Construct the associated earth abutment (if any). All cut and fill slopes should be 2:1(H:V) or flatter. The downstream face of earth abutments should be 3:1(H:V) or flatter. Earth abutments should be constructed of well-compacted, erosion resistant soil that is free of vegetation and roots.
4. If a rock filter dam outlet structure is used, then place the core rock for the outlet structure. Ensure the upstream face is 2:1(H:V) or flatter, and the downstream face is 3:1(H:V) or flatter.
5. If an alternative sediment weir outlet structure is specified, then refer to the relevant installation specifications.

6. If specified, construct the spillway section using the specified armour rock. The spillway should have a minimum profile depth of 300mm. The spillway weir crest must be level across its full width. The maximum longitudinal slope of the rock spillway should be 3:1(H:V).
7. Ensure the spillway outlet section extends downstream past the toe of the formed embankment until stable conditions are reached, or a distance equal to the height of the dam, whichever is the greater. The edges of the spillway should be left flush with the surrounding ground.
8. Install the specified filter system on the upstream face of the outlet structure.
9. If filter cloth is used, then extend the fabric over the crest of the outlet structure into the spillway chute.
10. Stabilise any associated earth embankments immediately after construction through appropriate compaction, vegetation and/or erosion control matting.
11. Establish all necessary up-slope drainage control measures to ensure that sediment-laden runoff is appropriately directed into the sediment trap.
12. Take all necessary measure to minimise the safety risk caused by the structure.

Maintenance

1. Check all sediment trenches after each runoff event and make repairs immediately.
2. Inspect all embankments for undercutting or undesirable seepage flows.
3. Ideally, sediment trenches should discharge (from full) over no less than 8 hours. If drainage is too rapid, then additional filter aggregate may be required to achieve optimum hydraulic performance.
4. If flow through the sediment trench is reduced to an unacceptable level, the upstream filter medium (aggregate or filter cloth) should be removed and replaced.
5. If a greater degree of water treatment (filtration) is required, extra geotextile filter fabric should be placed over the upstream face of the structure.
6. Check the structure and discharge area for damage from overtopping flows. Make repairs as necessary.
7. Immediately replace any rock displaced from the spillway.
8. Remove sediment and restore original sediment storage volume when collected sediment exceeds 10% of the specified storage volume.
9. Dispose of sediment and debris in a manner that will not create an erosion or pollution hazard.

Removal

1. When the up-slope drainage area has been stabilised, remove all materials included deposited sediment and dispose of in a suitable manner that will not cause an erosion or pollution hazard.
2. All water and sediment should be removed from the settling pond prior to the sediment trap's removal. Dispose of sediment and water in a manner that will not create an erosion or pollution hazard.
3. Bring the disturbed area to a proper grade, then smooth, compact and stabilise and/or revegetate as required to minimise the erosion hazard.