Filter Tube Barriers (Instream)

INSTREAM PRACTICES

Flow Control		No Channel Flow	✓	Dry Channels	
Erosion Control		Low Channel Flows	✓	Shallow Water	✓
Sediment Control	✓	High Channel Flows		Deep Water	

Symbol

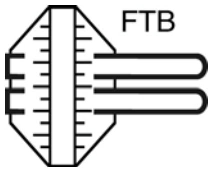

Photo 1 – Filter tube barrier

Photo 2 – Filter tube barrier

Key Principles

1. Most filtration systems have only a limited ability to capture and retain clay-sized particles; therefore, operators should not expect a significant change in the colour or clarity of water passing through the filter tubes, especially when working in clayey soils.
2. Sediment trapping is achieved by both particle settlement within the settling pond formed by the embankment, and by the filtration of water passing through the filter tubes (and possibly the embankment).
3. Critical design parameters are the 'filtration' capacity of the filter tubes (governed by the pore size and mass per unit area), and the allowable flow rate through the filtration system.
4. The allowable flow rate through the filtration system is governed by the maximum allowable hydraulic head, the allowable flow rate per filter tube, and the number of filter tubes.
5. Critical operational issues include:
   - the prevention of blockage of the filter tubes by bulk coarse sediment—achieved by either raising the inlet to the filter tubes; and
   - controlling sediment 'crusting' that can form on the surface of the filter tubes reducing their discharge—usually achieved by regularly brushing the surface of the filter tubes with a stiff-bristle broom.
6. Gravity-induced 'sedimentation' upstream of the filter tube barrier can be improved by raising the invert of the filter tubes above ground level (minimum 300mm is ideal), however, this is not always practical.
7. Filter tubes can be incorporated into a number of traditional sediment traps such as *Modular Sediment Barriers, Rock Filter Dams* and *Sediment Weirs*.

Design Procedure

1. Determine the primary design discharge (Q) for water passing through the filter tube barrier just prior to flows overtopping the spillway (Figure 1). This is normally set equal to the expected dry weather flow rate of the stream.
2. Determine the weir design discharge (Q_{WEIR}) for overtopping flows (Figure 2). The appropriate design event may be set by the licence conditions (set by State or local authority), otherwise choose a stream flood frequency of at least 10 times the expected operational life of the structure, but at least a 1 in 1 year channel flow.
3. Determine the desirable settling pond surface area (A_s) from Table 1 based on the design discharge (Q). Where practical, a critical particle size of 0.05mm should be chosen.
4. 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.
5. Determine the required width of the embankment (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 weir equations—refer to the separate fact sheet *'Chutes Part 1: General Information'*.
6. Select the required crest elevation of the embankment 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 (possibly an iterative design step).
7. Operators should **avoid** circumstances where the instream settling pond needs to be excavated (expanded) to achieve the required surface area as this can cause undesirable channel damage.
8. Select the type of embankment. Table 2 can be used as a guide.
9. Determine the maximum allowable head loss (ΔH) through the filter tube barrier. If flow conditions downstream of the embankment are such that there is little or no backwater effects during the design discharge (Q), then assume ΔH is equal to the height of the embankment (H).
10. If flow depths downstream of the filter tube barrier are expected to be significant, then the maximum allowable head loss (ΔH) should be taken as the expected variation in water level across the embankment during the design discharge.
11. Select a 'design' blockage factor (B.F.) using Table 3 as a guide.
12. Use the design information provided below to determine the make-up and thickness of the combined embankment and filter system that is required to achieve the desired stage–discharge relationship.
13. 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 embankment (if not already used), and/or increasing the number of filter tubes. Note the filter tube intake pipes need to be set at an elevation above the expected settled sediment depth.
14. Determine design of the splash pad/scour control downstream of the embankment.

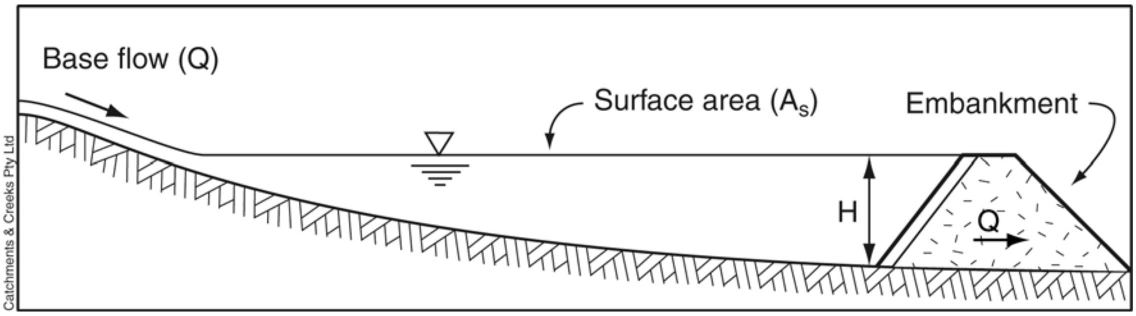

Figure 1 – Minimum design flow condition

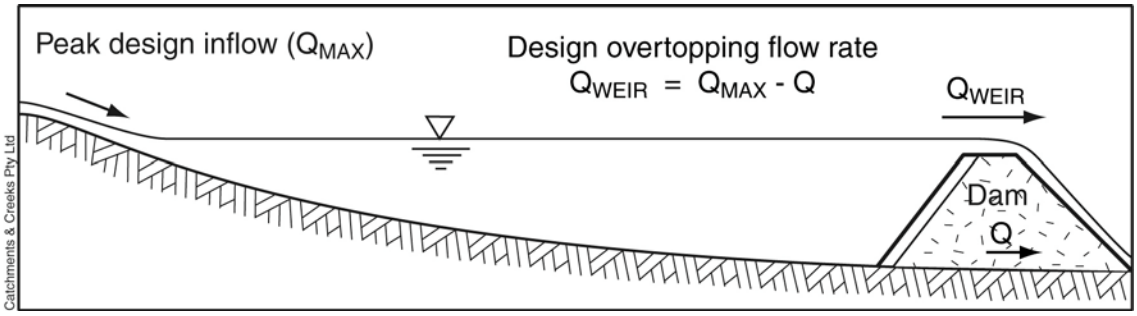

Figure 2 – Maximum design flow condition

(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 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.

Ideally, the settling pond should have a length (in the main direction of flow) at least three times its average width. If the pond length is less than three times its average width, then the pond area should be increase by 20% from the values presented in Table 1.

It is noted that achieving the minimum pond surface area may not be practical in all circumstances, in which case a greater focus should be placed on the design of the filter medium and/or the incorporation of filter tubes.

Table 1 – Minimum settling pond surface area per unit inflow rate

Design standard	Critical sediment size (mm)	Surface area of settling pond per unit discharge ($m^2/m^3/s$) [1]			Allowable through-velocity (m/s)
		10° C [2]	15° C [2]	20° C [2]	
Type 3 sediment trap	0.50	6	5.2	4.6	0.3
	0.20	38	33	29	0.3
	0.15	67	60	52	0.3
Type 2 sediment trap	0.10	150	130	115	0.2
	0.05	600	525	460	0.2
Type 1 sediment trap	0.04	940	820	720	0.2
	0.02	3700	3230	2860	0.2

[1] Pond area is based on a rectangular pond operating with uniform inflow 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.

(b) Filter tubes

One or more parallel filter tubes may need to be used depending on the required total flow rate.

The design flow rates for filter tubes can vary significantly depending on the length of the tubes and type of geotextile used in its manufacture. Product-specific pressure/head vs discharge relationships should be obtained from the relevant manufacturer or distributor.

If the manufacturer’s head–discharge relationship is not available, then an approximate relationship can be estimated from the specified permittivity of the geotextile. The following guidelines can be used to ‘estimate’ a head–discharge relationship:

- Allowable flow rate is the lesser of:
  - (i) the assessed flow rate based on the effective hydraulic head;
  - (ii) the hydraulic capacity of the filter tube’s inlet (usually governed by inlet control conditions—refer to *Filter Tube Dams* fact sheet in the Sediment Control section).
- Assume fully sediment blockage of the underlying surface area of the filter tube; thus include only the top surface area of the filter tube.

- Assume 10 to 50% blockage of the upper surface area of the bag (depending on intended duration of use and frequency of maintenance).
- When determining the hydraulic head (ΔH), assume zero flow occurs at a water depth of 50mm; therefore, the available hydraulic head is equal to the upstream water level (relative to the under-surface of the filter tubes) minus 50mm.

$$Q = B.F. \times \Delta H \times A \times \psi$$

where:

Q	=	Total flow rate through the filter tube [m^3/s]
B.F.	=	Blockage factor, assume 0.9 to 0.5 depending on expected usage
ΔH	=	Hydraulic head loss through the filter tube [m]
A	=	Upper surface area of the filter tube [m^2]
ψ	=	Permittivity of the geotextile (AS 3706-9) [s^{-1}]

Warning: *It is noted that significant errors can result from the above equation, especially if applied to 'woven' fabrics, thus preference must always be given to head–discharge relationships determined from prototype testing rather than estimations based on standard permittivity testing of the fabric. Note; standard permittivity testing is based on flow rates achieved at a hydraulic head of 100mm.*

(c) Embankment

Filter tubes can be integrated into various types of temporary embankments formed across a channel. The choice of embankment materials affects not only the filtration of low flows, but also the potential risks to the stream during the installation and removal of the temporary embankment.

Table 2 provides discussion on the attributes of various embankment forms.

Table 2 – Attributes of various temporary embankments

Embankment type	Attributes
Earth embankment	• High potential for sediment to be released into flowing streams during the installation and removal of the earth embankment. • Best used in dry channel beds, or when stream flows can be diverted during installation and removal.
Rock embankment (uniform rock size)	• Low risk of sediment releases during installation and removal. • Large rock sizes (say > 25mm) reduce the potential for particle settlement within the upstream settling pond. • The geotextile fabric wrap must be of material at least equivalent to the filter tube fabric (typically 'bidim' A64 or equivalent).
Rock embankment with aggregate filter	• As above for uniform rock size, plus the following: • The aggregate filter can be used to improve the hydraulic properties of the embankment.
Sediment weir	• Reduced disturbance to the bed and banks during installation and removal compared to earth and rock embankments. • Best used in natural streams with significant bed and bank vegetation.
Modular sediment barrier	• Similar attributes to *Sediment Weirs* above. • Best used in concrete lined drainage channels.
Sandbags	• Low flow leakages between the sandbags can be a problem, which is why the embankment should ideally be wrapped in filter cloth. • Best used in concrete lined drainage channels.

Earth embankments (Figure 3) should have a minimum height of 500mm, with 200mm clearance over the pipe obvert, and maximum 2:1(H:V) side slopes. Minimum grade of filter cloth wrap is ‘bidim’ A34 or the equivalent.

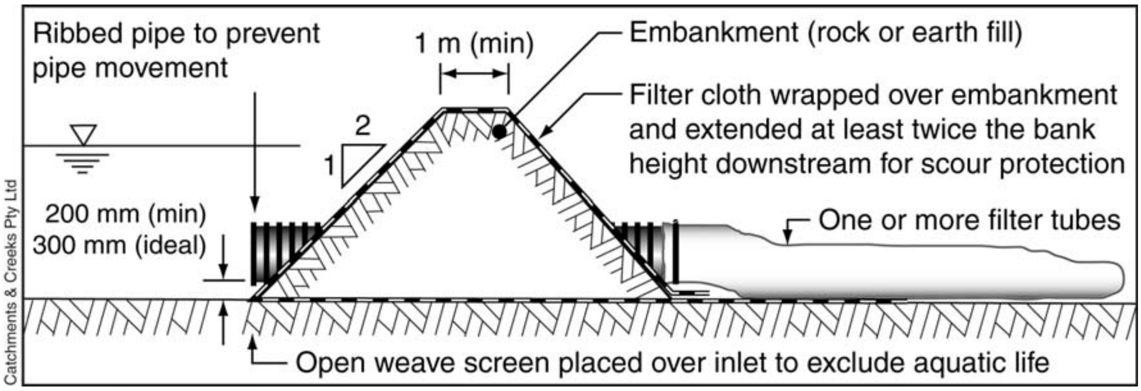

Figure 3 – Typical arrangement of a filter tube dam

Minimum grade of filter cloth used to wrap rock embankments (Figure 4) should be equivalent to the filter tube fabric, typically ‘bidim’ A64 or the equivalent.

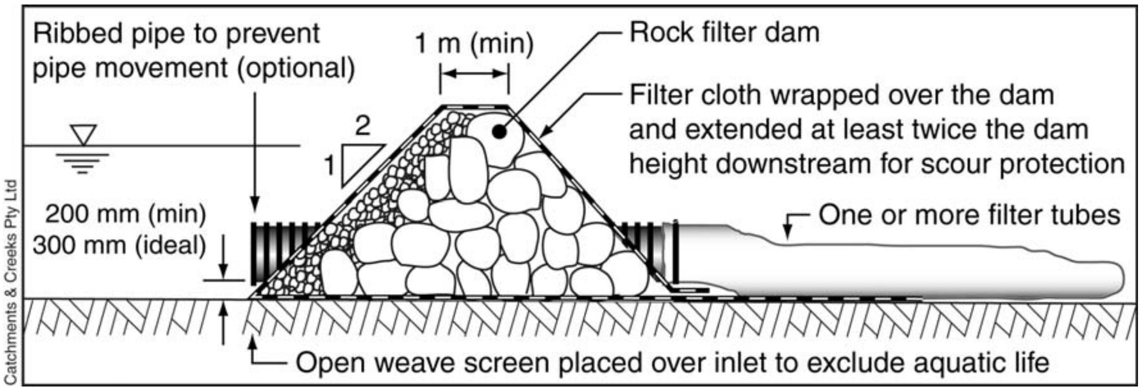

Figure 4 – Filter tube dam incorporated into a rock filter dam

Incorporating filter tubes into modular system (Figure 5) requires the modification of some of the modular units to house the connection pipes; however, once modified, these units can be reused on similar installations.

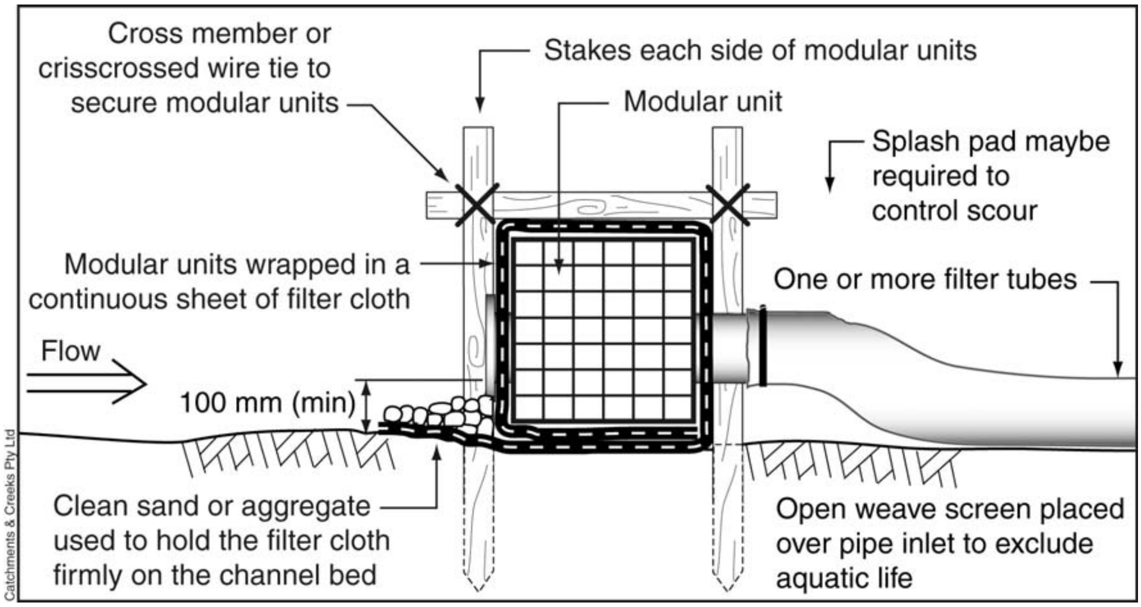

Figure 5 – Typical arrangement of filter tubes incorporated into modular units

Incorporating filter tubes into a *Sediment Weir* (Figure 6) can increase the working life of the sediment weir, allowing the sediment trap to continue to function successfully even if the sediment weir and/or the filter cloth incorporated into the weir becomes blocked with sediment.

Where necessary, the stage-discharge characteristics of the combined filter tube barrier can be regulated by either attaching an adjustable orifice plate to the entrance of each filter tube, or incorporating woven fabric into the sediment weir to reduce the through-velocity.

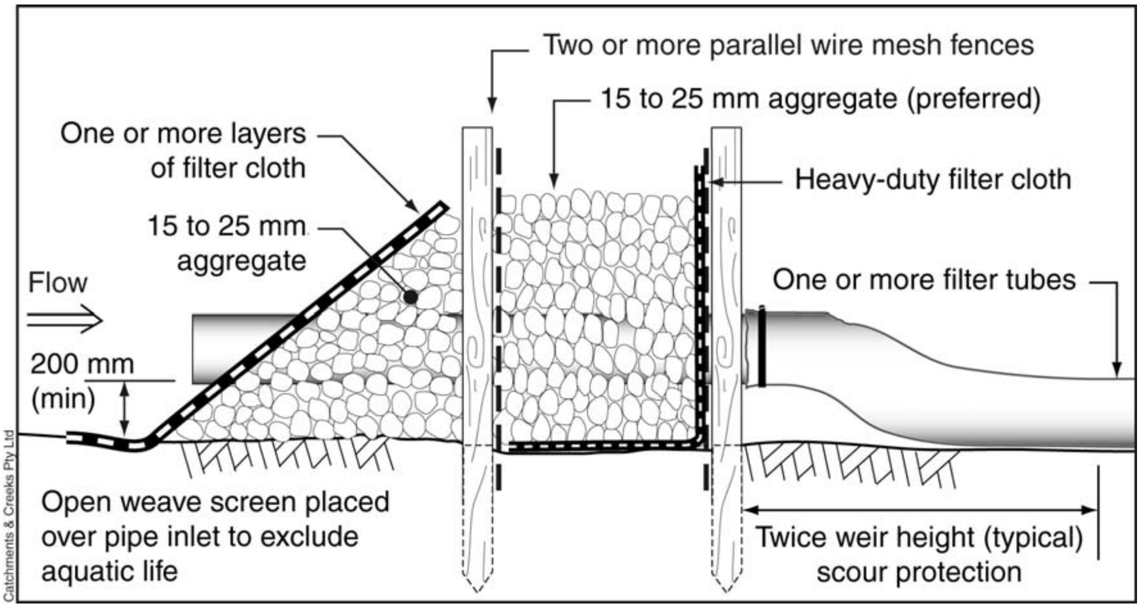

Figure 6 – Typical arrangement of filter tubes incorporated into a sediment weir

Both sandbag embankments (Figure 7) and modular units can be used in concrete-lined drains.

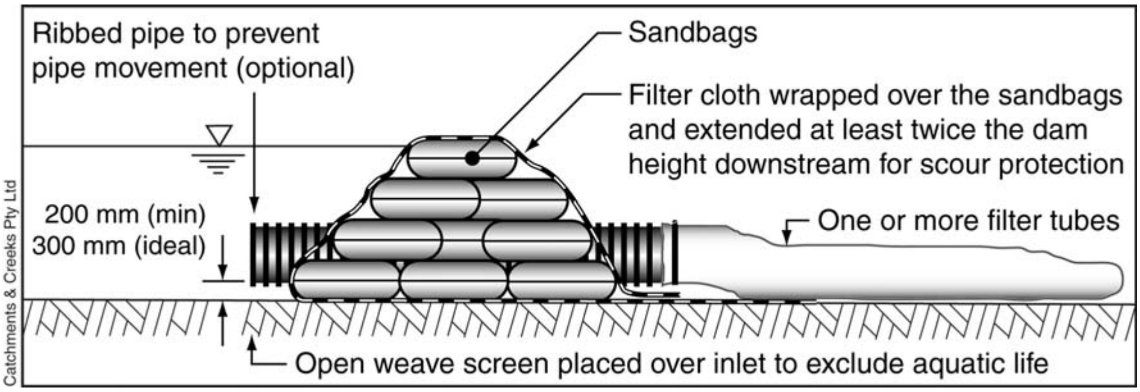

Figure 7 – Typical arrangement of filter tubes incorporated into a sandbag embankment

Table 3 – 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.

Photo 3 – Open weave fabric (e.g. shade cloth or wire mesh) placed over the pipe inlet to exclude aquatic wildlife

Photo 4 – Ribbed pipe used to anchor pipe within the earth embankment

Photo 5 – Filter tube looking downstream

Photo 6 – Filter tube

Description

One or more parallel geotextile filter tubes incorporated into a porous or non-porous embankment placed across the streambed. Sediment-laden low-flows are directed into the open end of the pipe(s) and then allowed to filter through the filter tubes.

Porous embankments allow the filtration of water passing through both the embankment and filter tubes.

Filter tubes are significantly longer than the more traditional *Filter Socks*.

Purpose

Filtration of contaminated water discharged from instream work activities.

Filter tubes are primarily used to treat base flows when the water is expected to contain a large percentage of fines.

Also used to increase the design flow rate of other sediment traps such as *Modular Sediment Barrier, Rock Filter Dams*, and *Sediment Weirs*.

Limitations

Limited ability to trap fine, clay-sized particles; however, usually a higher level of treatment is achieved compared to other instream sediment traps.

Typically used on low discharge streams; however, several parallel filter tube can be used to increase the allowable flow rate.

No treatment of dissolved pollutants.

Advantages

Commercially available product.

One of the most effective forms of instream sediment control.

Generally cheep to install and operate.

Filter tubes are light and easy to handle (when empty).

Disadvantages

When full, the filter tubes can be very heavy and usually require mechanical assistance to remove from the stream channel.

Common Problems

Fine sediment blockages can occur within the fabric after a few days well before the tubes are full of sediment. This can often be fixed by brushing the fabric surface with a stiff bristle brush.

Special Requirements

Filter tubes need to be manufactured from heavy-duty non-woven filter cloth.

Minimum grade of the filter cloth wrap for porous embankments should be equivalent to the filter tube fabric, typically 'bidim' A64 or the equivalent.

A coarse, open weave fabric (e.g. shade cloth or wire mesh) should be placed over the pipe inlets to prevent the entrance of aquatic wildlife.

Location

Best used down-slope of a Type 3 sediment trap or suitable settling pond to reduce the risk of sediment blockage of the entrance to the filter tubes.

Site inspection

Check for flow bypassing around the filter tubes.

Check for excessive sedimentation around the entrance to the filter tubes.

Check for sediment crusting on the surface of the filter tubes.

Check for uncontrolled leaks from the embankment.

Materials

- Filter tube: manufactured from a non-woven geotextile reinforced with a UV-stabilised, woven fabric or poly-propylene mesh. The geotextile fabric should be either polyester or polypropylene. Properties (AS3706) minimum wide strip tensile strength of 20kN/m in both directions; pore size EOS less than 160microns, O_{95} less than 90microns; minimum mass of 300gsm (minimum 'bidim' A44 or equivalent).
- Ribbed pipe (used with earth banks): ribbed, PVC or similar pipe.
- Earth embankment: non-dispersive (Emerson's Aggregate Class 6, 7 or 8) clean earth fill, free of organic debris and with sufficient clay content to prevent the through-flow of water.
- Aggregate: 15 to 25mm crushed rock.
- Geotextile fabric: heavy-duty, needle-punched, non-woven filter cloth. Minimum 'bidim' A34 or equivalent if used on non-porous embankments, or equivalent to the filter tube fabric if used on porous embankments (minimum 'bidim' A44 or equivalent).

Installation

1. Prior to commencing any works, obtain all necessary approvals and permits required to conduct the necessary works including permits for the disturbance of riparian and aquatic vegetation, and the construction of all permanent or temporary instream barriers and instream sediment control measures.
2. Refer to approved plans for location and construction details. If there are questions or problems with the location, extent, or method of installation contact the engineer or responsible on-site officer for assistance.
3. If there is flow within the watercourse or drainage channel at the time of construction of the embankment, then install appropriate downstream sediment control devices and/or flow diversion systems prior to construction of the embankment. Such measures should only be installed if considered appropriate for the local conditions, and only if their installation is judged to provide a net overall environmental benefit.
4. To the maximum degree practical, construction activities and equipment must not operate within open flowing waters.
5. Where practicable, divert all surface water runoff from the adjacent construction site into stable, undisturbed, vegetated areas adjoining the watercourse so as to minimise the direct discharge of sediment-laden water into flowing channel waters.
6. Ensure clearing and excavation of access paths and the banks and bed of the watercourse are limited to the minimum practicable.
7. If flow diversion systems cannot be installed, then conduct bank excavations by pulling the soil away from the channel.

8. If dispersible, highly unstable, or highly erosive soils are exposed, then priority must be given to the prompt stabilisation of all such areas.
9. Clear the location for the filter tube's support embankment; clearing only what is needed to provide access and to install the embankment.
10. Remove any cleared organic matter and debris from the disturbance area and dispose of it properly. Do not use organic matter or debris to build the embankment.
11. To assist in the eventual removal of all materials used in the construction of the embankment, a protective layer of geotextile fabric (preferably in the form of a single sheet) should be placed over the channel prior to installation of the embankment. If more than one sheet of fabric is required, overlap the fabric by at least 600mm. The fabric should extend upstream a sufficient distant to allow this material to eventually be wrapped over the finished embankment, thus fully enclosing the embankment.
12. Construct the embankment out of the material specified within the approved plans or as directed. Earth embankments shall be suitably compacted during their placement. Install and anchor the specified number of ribbed pipe sections through the embankment as appropriate during installation of the embankment.
13. If the embankment is to be construct with compacted fill, the sides of the embankment must be no steeper than a 2:1 (H:V) slope. Firmly hand-stamp (compact) the soil around the ribbed pipe.
14. Cover the upstream end of the ribbed pipe/s with a suitable coarse mesh such as shade cloth or wire mesh, <u>not</u> sediment fence fabric or filter cloth.
15. Lay the filter tube/s length-wise down the channel and securely attach the tubes to the ribbed pipe/s.
16. After completion of the embankment, stretch the upstream section of the filter cloth up over the crest of the embankment and secure (pin) to form a spillway.
17. Where necessary, place rock over the filter cloth to provide additional protection to protect the embankment from overtopping flood flows.

Maintenance

1. Inspect the embankment and filter tubes prior to forecast rainfall, after significant runoff producing rainfall, or otherwise on a daily basis.
2. Ensure that embankment is stable and undamaged.
3. In some circumstances, flow through the filter tubes may be temporarily improved by brushing the tubes with a stiff-bristle broom on a daily basis.
4. Dispose of any excessive accumulations of sediment or debris in a manner that will not create an erosion or pollution hazard.
5. Repair any places in the embankment that have weakened or that have been subjected to damage from inflows or overtopping water.

Removal

1. The embankment and filter tubes are to be removed as soon as possible after they are no longer needed.
2. If excessive sediment or debris has collected upstream of the embankment remove it before the embankment is removed and dispose of such material properly.
3. If there is flow within the watercourse or drainage channel at the time of removal of the filter tubes and embankment, then install appropriate instream sediment control devices and/or flow diversion systems prior to removal of the device. Such measures should only be installed if considered appropriate for the local conditions, and only if their installation is judged to provide a net overall environmental benefit.
4. Remove all materials used to form the embankment including the geotextile fabric and dispose of in a manner that will not create an erosion or pollution hazard.
5. Restore the watercourse channel to its original cross-section, and smooth and appropriately stabilise and/or re-vegetate all disturbed areas.