In-channel coarse sediment trap
Best Management Practice

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Complexity	Environmental Value	Cost
Low – Moderate – High	Low – Moderate – High	Low – Moderate – High

Definition

Coarse sediment traps are excavations in the bed of a watercourse designed to limit the downstream movement of sand and gravel from upstream sediment sources. Depending on trap design and stream characteristics, lesser amounts of fine sediments (the fine sand, silts and clays that move in the flow rather than along the bed) can be trapped. A coarse sediment trap is required as the upstream component of a constructed wetland system. The trap is for sedimentation of solids down to coarse and medium silt; and the wetland removes the fine sediment, and dissolved and finely dispersed contaminants.

Purpose

1) Instream sediment traps are used in conjunction with other sediment control measures to reduce excessive sediment in watercourses: For upland sediment sources, the most desirable strategy is to implement land management practices that reduce erosion and transport of sediment and associated contaminants (e.g. conservation tillage; critical area planting). The second strategy is to retain sediments on the land before they get to the drainage network (e.g. filter strips, sediment retention ponds). For channel sources, streamflow should be retarded to protect the channel (e.g. vegetated banks); eroding banks should be repaired (e.g. contour and vegetate); and livestock that cause erosion should be removed from the channel and banks. If these measures are not undertaken, then continuous in-channel sediment problems will occur. In some cases, the in-channel sediment trap is the first line of defence (e.g. multiple, uncontrollable sediment sources).
2) Excessive sediment deposition is common, destabilises channels, and reduces instream habitat quality and quantity: Excessive sediment reduces channel capacity and causes drainage and flooding problems. Aggrading channels tend to have bank erosion. Pools are infilled and finer material accumulates in the gravel bed reducing habitat quality and quantity. Trout populations (and presumably other species that require clean gravel bed channel) are significantly reduced with sand deposition in a gravel stream.
3) Sediment traps confine sediment deposition to a small reach of channel and reduce excavation costs: Sediment traps are relatively wide, short and deep excavations in the bed. Trapped sediment does not progress downstream where deposition would reduce channel capacity. The trap itself has to be episodically excavated (after major storms) rather than a much greater length of the stream. Further monitoring is required, but preliminary indications are that in appropriate situations maintenance costs are reduced to about half or less of regular downstream channel excavation. Widespread use internationally indicates the economic and environmental benefits of sediment traps.
4) Environmental benefits result from limiting downstream disturbance: Excavating channels causes modification or loss of habitat; re-suspension of sediment and sediment associated contaminants; and removes invertebrates, fish, eels and crayfish from the channel. This may have long-term impacts.
5) Trapping excessive sediment improves physical habitat: Habitat for fish and food production are damaged by excessive sediment. Stopping excessive inputs of sediment into channels and trapping sediment improves habitat. However, erosion of the channel may occur if the natural sediment supply is cut off, or if the bed at the trap is unstable.

6) Establishing and maintaining good bank vegetation is a priority: Appropriate vegetation provides bank protection, shade and nutrients, with improvements in channel stability and habitat quality.
7) It may take years before channel changes are apparent: The damage from excessive sediment inputs can take years to work there way downstream. Recovery by trapping sediment is rapid immediately below the sediment trap, but it takes time for a wave of sediment to move through the system (or to be trapped in other places downstream) and for conditions to improve.
8) A plume of sediment will be released from the channel during excavation of the sediment trap and with re-excavation of the trap: Sediment Control measures must be used to minimise sediment washing into the channel from tracks and stockpiles of spoil. During excavation a plume of sediment will be released from the channel, but this usually results in a short duration discolouration of water without biological impact.
9) Channel diversions may be an effective means of reducing sediment plumes during excavations: In particularly sensitive areas where large quantities of fine sediment are trapped, it might be prudent to divert flow around the sediment trap during excavation. However, these diversions may also introduce a sediment plume.
10) A vegetated by-pass channel may be an effective means of reducing sediment plumes during excavations: A permanent low flow bypass channel could be constructed and stabilised with vegetation prior to excavation of the in-channel sediment trap. The bypass channel could be temporarily re-activated when the sediment trap is to be re-excavated (e.g. block the main channel with straw bales to divert the flow into the grassed waterway bypass channel). (See the Grassed Waterways BMP).

Location

1) A long relatively straight channel reach with good access, room to operate an excavator, room to stockpile or dispose of sediment, and suitable ground conditions are required.
2) Sediment traps should not cause channel instability and endanger infrastructure, and public health and safety.
3) Sediment traps to enhance fisheries should be constructed where the potential for downstream recovery from excessive sediment exists (e.g. gravel bed channels with excessive sand deposition).

Work Window

1) Establish which fish and birds use the channel and channel margins.
2) Establish which times and places are sensitive to disturbance by consulting the "Work Windows" management practice.
3) Avoid in-channel works during sensitive times (e.g. trout spawning and incubation in gravel bed streams).

Performance Indicators

1) Design objectives are stated and followed in the construction and maintenance of the sediment trap. As-built surveys will be undertaken.
2) Sediment control management measures are followed in the construction and maintenance of the sediment trap, which includes delineation and protection of sensitive places on the channel banks and berms.
3) Construction and maintenance costs are documented.
4) Design trapping efficiencies are achieved.
5) After a period of adjustment, channel conditions approach reference reach conditions, and the channel should be in dynamic equilibrium.

6) After a period of adjustment, biological conditions approach reference reach conditions.

7) The sediment trap does not endanger infrastructure, such as bridges and water intakes.

8) The banks of the sediment trap are vegetated with species that promote bank stability, trap sediment and provide habitat.

9) Sensitive times and places of fish and wildlife (e.g. trout spawning in riffles; bird nesting) are avoided during construction and maintenance.

10) Sediment traps should not endanger infrastructure or public safety. Sediment traps should be well signposted and secured from inadvertent access (e.g. the access track to the trap is gated).

Procedures

These procedures are not a substitute for expert advice on the particular conditions prevailing at the site. Get expert advice on the design requirements (e.g. the river engineers at the Regional Council).

Planning

1) Consult with experts at the regional or district council regarding the location and design of in-channel sediment traps, paying particular attention to channel stability and public health and safety.

2) Develop a construction, operational and maintenance plan, and obtain the necessary resources consents and access agreements. This plan will include Sediment Control measures. As part of this plan consult with Fish and Game, Department of Conservation and the Work Windows guidelines to avoid sensitive times and places for construction and maintenance. Flag or signpost sensitive areas and make operators aware of the need to avoid these areas. Consult to see if fish salvage is required.

3) Assess if a diversion channel or vegetated bypass channel will provide significant benefit in the construction and on-going maintenance of the sediment trap.

4) Assess if grade control structures are required.

5) Plan and undertake construction activities following the Sediment Control guidelines. The sediment control plan will avoid and/or control discharge of sediment to the channel and other sensitive areas (e.g. wetlands). The plan must emphasise minimising soil disturbance and source control of sediment.

Construction

6) All embankments and structures must be constructed in accordance with accepted engineering practice, and with appropriate materials.

7) Determine the design flow for the channel where the sediment trap is to be located and establish the viability of creating a trap (see location).

8) Determine the target size of material to be trapped, and the trapping efficiency required. Fine sand (i.e. sediment ≥0.125 mm) and 90% trapping are often used.

9) Determine the surface area of the sediment trap from Equation 1 or Figure 1. For example, for a design flow (Q) of 1 m^3/s, fine sand (w = 0.10 m/s), and an efficiency (E) of 90%; the required surface area (A) is 222 m^2.

$$A = -\frac{\ln(1-E)}{w}Q \qquad (1)$$

10) Use a rule of thumb for the initial trap size estimate: 1.5 times wider than the channel; length to width ratio of 4:1 to 10:1; and a depth 1.5 m below the average bed level. For a 5 m wide channel, the trap width is 7.5 m, and the trap length 30 m to 75 m long.

11) Check the depth required to prevent re-suspension of the trapped sediment (the cross section average velocity is used). From Figure 2, for a design flow of 1 m^3/s a cross sectional area (CSA) of 5.6 m^2 is required to stop fine sand re-suspension (a velocity of 0.18 m/s – Table 1). For a 7.5 m wide trap, the minimum depth to prevent re-suspension is 0.75 m (i.e. the trap is effectively full when sediment is 0.75 from the design water surface). A 1.5 m deep excavation provides more than 0.75 m of effective storage because the depth of flowing water, which is determined by the outlet control, provides additional settling capacity. This additional depth can be used as a factor of safety.

12) Trap length:width ratios are normally 4:1 to 10:1. The trap should gradually widen downstream. Trap size is determined by the input of bedload and the desired frequency of cleaning. An estimate can be made from historic channel cleaning records. At 4:1 the gross storage is ~340 m^3; and the effective storage is ~170 m^3. At 10:1 the gross storage is ~840 m^3 and the effective storage is ~420 m^3.

13) Excavation would preferably be undertaken with a dragline or hydraulic excavator operating from the bank. The cross section of the trap should be uniform, to limit flow separation, and gradually expand in the downstream direction.

14) Channel side slopes should be 1 vertical: 3 horizontal, or more gentle if possible.

15) Suitable vegetation should be planted to stabilise the banks and berms, and provide food and habitat for fish and wildlife. Locally sourced native species are preferred, and these may be inter-planted with exotic vegetation to promote rapid re-vegetation and channel stabilisation.

16) Construct grade control structures if required.

Maintenance

17) Work within the planning guidelines developed for this particular site (e.g. the Sediment Control plan for the site).

18) Regular inspections should be carried out as part of an overall system maintenance programme, and after floods. The inspections will determine when the trap should be re-excavated; and to detect potential problems (e.g. scour; bank failure).

19) Vegetation should be maintained in good condition (See the Sediment Control guidelines).

Sediment Removal and Stockpiles

20) The design depth of the sediment trap should be marked in the sediment trap (e.g. a stage gauge board). Once the effective capacity of the sediment trap is reached, the trap effectiveness declines, and the sediment trap should be re-excavated.

21) If a diversion channel or grassed waterway has been installed, divert flow into the by-pass before excavating the sediment trap.

22) It is preferable to undertake re-excavation of the sediment trap operating from the bank rather than from in the channel. This will be determined by the sediment trap dimensions, and size and type of excavator.

23) Stockpiles must not be left in the channel where they impede flow or are likely to be eroded by flowing water. Overburden, vegetation or other debris should not be deposited into a watercourse or left in a position where that material could fall into or be washed away. This material may be removed from the site, buried or levelled.

24) Excavated materials should not be placed in wetlands with significant habitat value. Grading should not occur in significant wetlands.

25) Clean spoil can be used to build an embankment along the channel. Embankments may be used as access lanes for future maintenance. Embankments should not confine or direct overbank flows to cause instability of the channel or other structures (e.g. roads, bridges, and culverts).

26) Direct water accumulating on or behind spoil areas or embankments to protected outlets (See Grassed Waterways).

Decommissioning

27) In many cases a sediment trap can be de-commissioned merely by not removing sediment deposits. The bed will build up, and the edges will infill as vegetation encroaches and traps sediment. The channel will eventually be indistinguishable from the adjacent channel.

28) Once stockpiles have been removed, the site should be levelled and re-vegetated. Unless agreements have been made to retain access tracks, tracks should be covered in soil and re-vegetated. These requirements should be explicitly stated in the plans for the site.

Related BMPs

Channel Diversions (Hudson, 2001); Grassed Waterways (Hudson, 2001).

Channel Stability Assessment (recommended guideline); Constructed riffle (recommended BMP);

Rock weir (recommended BMP); Vegetative bank protection (recommended BMP)

Bibliography

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Design Guides

Table 1. Average fall velocities for naturally worn quartz grains in 20^{0}C water (based on relations in Raudkivi, 1993); and scouring velocities (from VSC, 1999).

Size Class	Nominal Diameter (mm)	Settling Velocity (m/s)	Scouring Velocity (m/s)
Very coarse sand	2.00	0.193	0.72
Coarse sand	1.00	0.121	0.51
Medium sand	0.50	0.064	0.36
Fine sand	0.250	0.029	0.25
Very fine sand	0.125	0.010	0.18
Coarse silt	0.062	0.0026	0.13
Medium silt	0.031	0.00064	0.09
Fine silt	0.016	0.00016	0.06
Very fine silt	0.008	0.00004	
Clay	0.004	0.00001	

The upper end of each size class is listed (e.g. very coarse sand is 1-2 mm; coarse sand 0.5-1 mm)

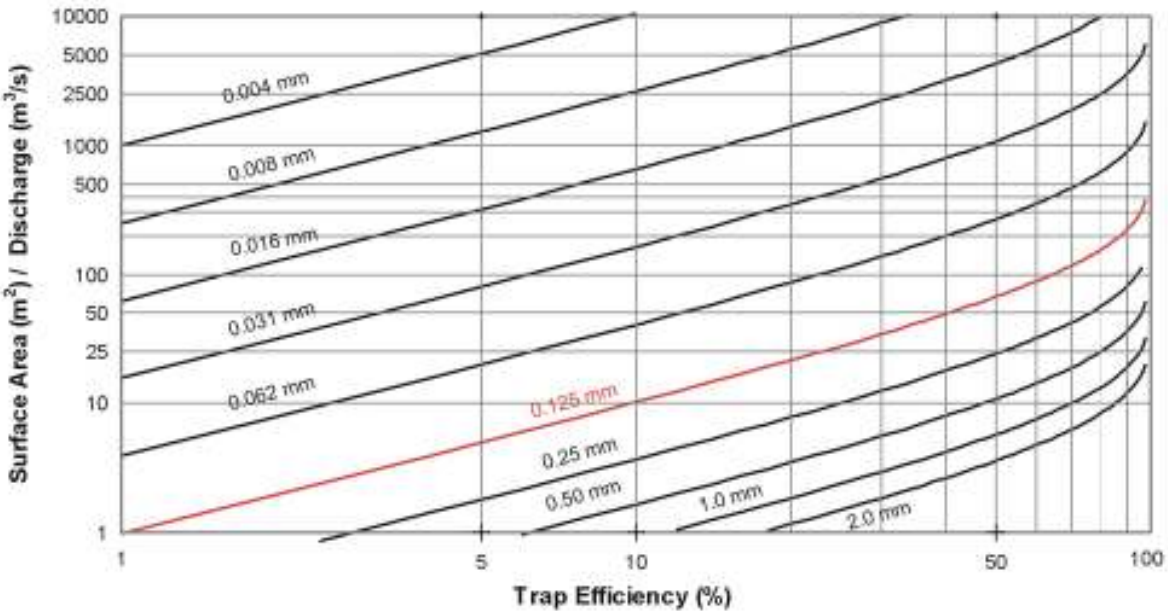

Figure 1. Percent of sediment retained for different sediment trap areas, sediment sizes and discharges.

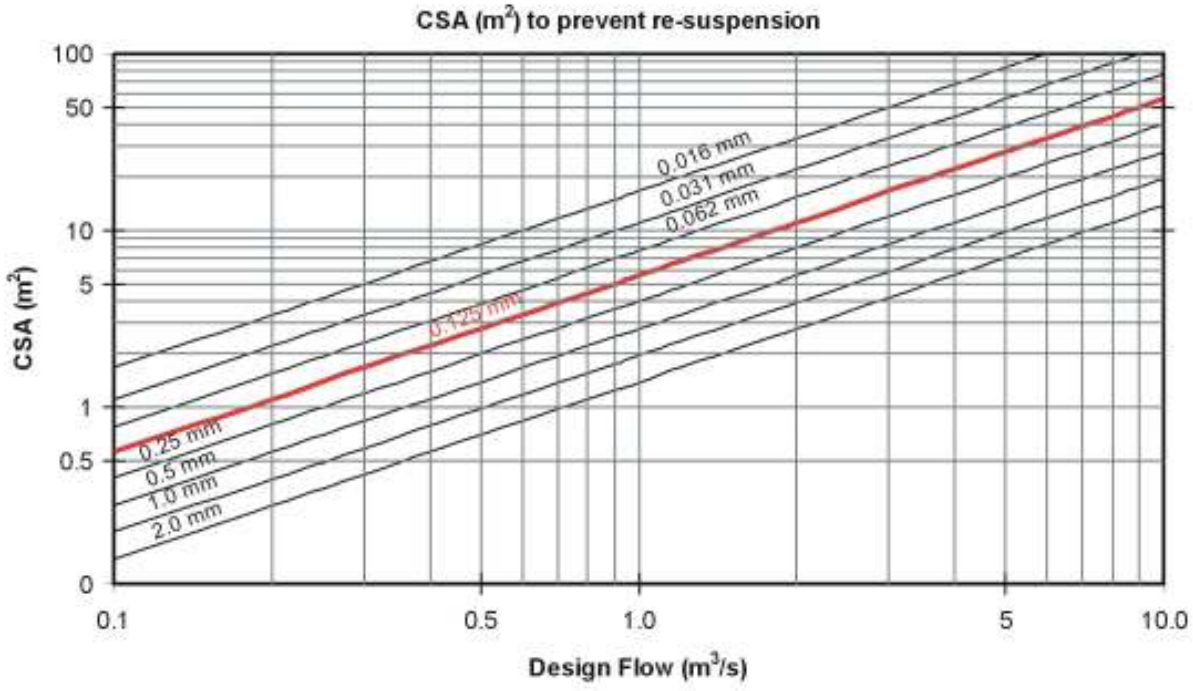

Figure 2. Cross sectional areas required for preventing re-suspension for different sediment sizes and discharges.