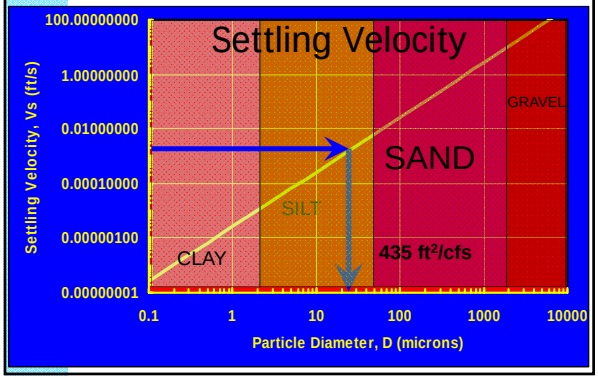
Sediment Basin Design Basics w/ Surface Dewatering Devices

Sediment Removal

- Gravity; Stokes Law $V_s = \frac{1}{18}\left[\frac{d^2 g}{\nu}(SG-1)\right]$
  - Particle diameter.
  - Liquid viscosity = f(temperature).
  - Particle density = 2.65 g/cc (165 #/ft³)
- Assumptions:
  - Water velocity = Zero (0); quiescent
  - Water temperature = 68°F
  - Laminar flow; Reynolds No. < 0.5



Impact of Control Features

- Washed aggregate. Helps a little (2%)
- Permanent pool. Helps 5 to 12%
- Dewatering control devices
  - Perforated risers. **Okay; not desired**
  - Skimmers. **Great Improvement; 10%**
  - Auxiliary spillways. **Better than no skimmer +6%**
- Basin lining. Reduces re-suspension, Good
- PAM to remove clays. Great

Impact of Control Features

- Geotextiles
  - To filter sediment. **Not very effective.**
  - As porous baffles. **Porous Jute/Coir w/ PAM & skimmer; Very Good**
- Dewatering time. Longer is better.
- Delaying the dewatering process. Very good.
- Infiltrating the captured water. Great if soils permit.

Structure Sizing

- Criteria:
  - Minimum Volume:
    - 2 yr, 24 hr storm for drainage area (EPA 2012 CGP) or
    - 3,600 ft^3/ac in drainage area (EPA)
- Criteria in Some States:
  - Minimum Volume Area
    - 1,800 ft^3/disturbed ac
  - Minimum Surface Area
    - 435 Q_{10} or Q_{25} (Rock or Perforated Riser)
    - 325 Q_{10} or Q_{25} (Surface Outlet or Flashboard Riser)

Sizing Example

- Determine the minimum volume and surface area for a Temporary Sediment Trap serving a 1.2-acre road construction site with a 2 acre watershed with a Q_{10} = 7 cfs.
- Solution:
  - Minimum Volume = 3600(2) = 7200 ft^3
  - Minimum Surface Area = 435(7) = 3045 ft^2

Controlling Discharge

- Rock outlet
- Perforated Riser
- Skimmer
- Flashboard riser

Rock Outlet

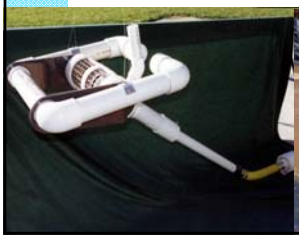
- When sediment laden water gets to the rock (porous) outlet, sediment remains in suspension.

Perforated Riser

- Will capture 80% of inflow fine sediment when water is held for 24 hours.

Skimmer

- Will capture 90% of fine (silts & clay) sediment when water is held for 24 hours.
- Surface Skimmer Alternate Skimmers



Orifice Equation (cfs)

$$Q = CA\sqrt{2gH}$$

- Perforated Riser & Skimmer are controlled by small orifices.
  - C = coefficient; 0.6
  - A = area of orifice, ft^2
  - g = 32.2 ft/sec^2 or 9.81 m/sec^2
  - H = driving head, ft
  - Q = flow rate, ft^3/sec, cfs

Orifice Equation (gpm)

- Alternate form (gpm):

$$Q = 12D^2\sqrt{H}$$

  - Where D = diameter, inches
  - H = head, ft
  - Last example: D = 0.75 in, H = 1.5 ft

$$Q = 12D^2\sqrt{H} = 12(0.75)^2\sqrt{1.5} = 8.1 gpm$$

Orifice Equation Example

- A skimmer has a 2-in orifice and a head of 0.25 ft. What is the skimmer's discharge rate?
- Solution: D = 2 in; H = 0.25 ft

$$Q = 12D^2\sqrt{H} = 12(2)^2\sqrt{0.25} = 24 gpm$$

Orifice Equation (ft^3/d)

- Alternate form (ft^3/d):

$$Q = 2310D^2\sqrt{H}$$

  - Where D = diameter, inches
  - H = head, ft
  - Last example: D = 2 in, H = 0.25 ft

$$Q = 2310D^2\sqrt{H} = 2310(2)^2\sqrt{0.25} = 4620\ ft^3/d$$

Surface Skimmer Sizing

- Determine the desired outflow rate, Q (ft^3/d) based on:
  - Volume of the basin, V in ft^3
  - Desired dewatering time, t_d in days.

$$Q = \frac{V}{t_d}$$

- Example: Dewater 21,000 ft^3 in 3 days.

$$Q = \frac{V}{t_d} = \frac{21000\ ft^3}{3 days} =$$

Select skimmer based on desired flow rate from Table 4-1

Skimmer Diameter (in)	Max. Outflow Rate (ft^3/d)	Driving Head (ft)
1.5	1,728	0.125
2.0	3,283	0.167
2.5	6,234	0.208
3.0	9,774	0.250
4.0	20,109	0.333
5.0	32,832	0.333
6.0	51,840	0.417
8.0	97,978	0.500

Table 4-1

Skimmer Orifice Sizing

- Apply the orifice equation to size the orifice diameter & radius
  - If we use a 3-inch skimmer (H = 0.250 ft), we can size the orifice as:

$$D = \sqrt{\frac{Q}{2310\sqrt{H}}} = \sqrt{\frac{7000}{2310\sqrt{0.250}}} = 2.5 inches$$

$$r = D/2 = 2.5/2 = 1.3 inches$$

Flashboard Riser

- Works like a skimmer but with more labor.

Dewatering Via Infiltration

- Can be effective into sandy soils.
- Compute the dewatering time knowing:
  - The soil's infiltration rate (permeability)
  - Depth of water in basin

$$T_d = \frac{water\_depth(inches)}{Infiltration\_rate(in/hr)} = \frac{D}{I}(hours)$$

Infiltration Rate

- Equals the soil's permeability
  - Given by NRCS in ranges; ex. 0.6 to 2.0 in/hr.
- Use permeability from slowest permeable soil horizon; usually B or C horizon.
- Use the lower value.
- That's the lowest value from slowest layer.

Dewatering Time

- Example: 10,000 ft^3 basin has a design depth of 1.5 feet. Soil has I = 0.6 in/hr.

$$T_d = \frac{D(in)}{I(in/hr)} = \frac{1.5\,ft}{0.6in/hr} x \frac{12in}{1\,ft} =$$

Emergency Spillway

Emergency Spillway

Drainage Area (acres)	Minimum Emergency Spillway Width or Broad Crested Weir Length (ft)
1	4.0
2	6.0
3	8.0
4	10.0
5	12.0

Weir Equation

- Flow from an emergency spillway or a flashboard riser is controlled by the weir equation.

$$Q = 2.5LH^{1.5}$$

- Where:
  - L = width of the weir, ft
  - H = the driving head (1 ft max), ft
  - Q = flow rate, cfs

Weir Equation Example

- How wide should an emergency spillway be to carry Q_{10} = 20 cfs with a maximum head of 0.5 ft.

Sediment Control BMPs

- Coir Fiber Baffles
- Rock Sediment Dams
- Skimmer Basin
- Tiered Skimmer Basin
- Riser Basin
- Infiltration Basin

Design Considerations

- Project phasing
- Scheduling of construction activities
- Cost-benefit issues
- Overall costs
- Equipment access
- Constructability
- Seasonality

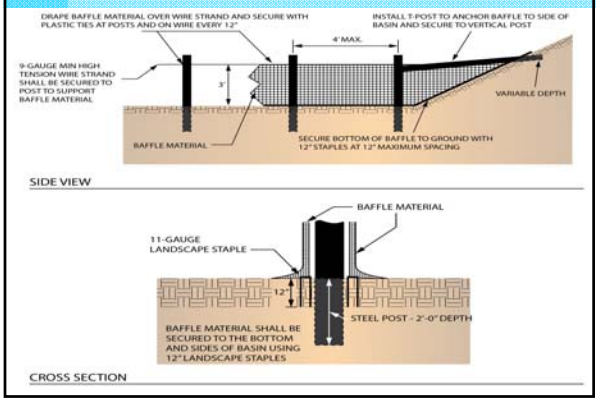
Stone Sizes

	Min. (inches)	Median (inches)	Max. (inches)
Sediment Control Stone (washed, no fines) No.5/No. 57	~3/8	½-3/4	1.5
Structure Stone--Class A	2	4	6
" " --Class B	5	8	12
" " --Class I	5	10	17
" " --Class II	9	14	23

Coir Fiber (Coconut) Baffles

- Purpose: Increase sediment trapping efficiency by spreading water out over width of basin
- Materials:
  - Coir Matting (6.5 ft width, 700 g/m^2)
  - Metal t-posts
  - 9 gauge wire (hi-tensile fencing wire)
  - UV coated plastic zip ties
  - 12 inch metal landscape staples

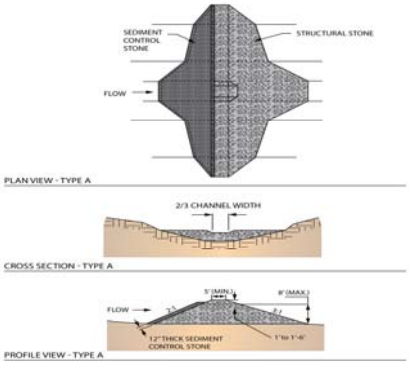
Coir Fiber (Coconut) Baffles



Temporary Rock Sediment Dam-Type A

- Large rock dam with weir outlet
- Location: site perimeter
- Drainage area < 10ac
- Surf. Area: $435Q_{10}$ or Q_{25}
- Volume: $3600ft^3/ac$
- Class I structure stone
- Sediment control stone on inlet face
- Earthen walls built above grade
- L:W ratio range 2:1-5:1

Temporary Rock Sediment Dam-Type A

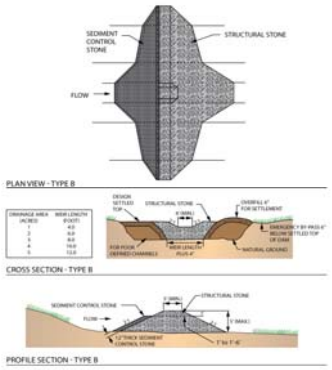


Temp. Rock Sediment Dam – Type B

- Small rock dam with weir outlet
- Location: site perimeter
- Drainage area < 5ac
- Surf. Area: $435Q_{10}$ or Q_{25}
- Volume: $3600ft^3/ac$

- Class B structure stone
- Sediment control stone face
- 3 coir baffles
- Earthen walls built above grade
- L:W ratio range 2:1-5:1

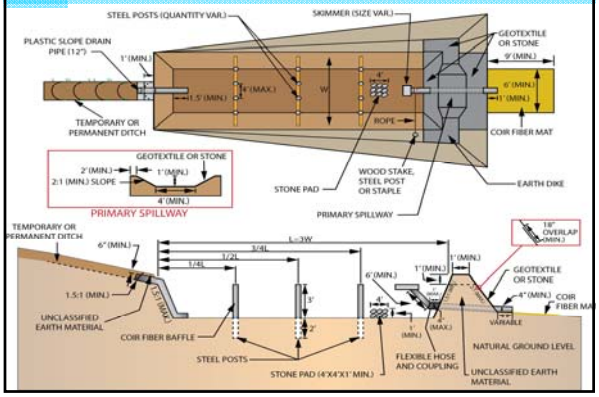
Temp. Rock Sediment Dam – Type B



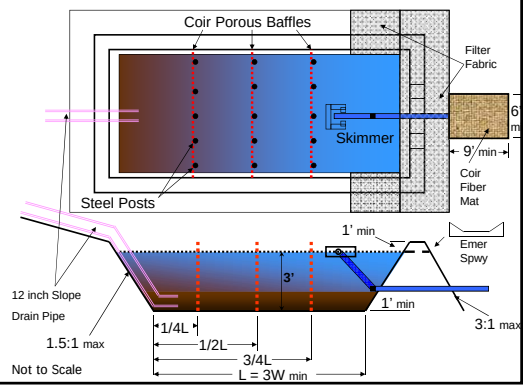
Skimmer Basin w/ Baffles

- Rectangular basin
- 3 coir baffles
- Location: site perimeter
- Drainage area < 10ac
- Surf. Area: $325Q_{10}$ or Q_{25}
- Volume: 1800 ft^3/ac
- Surface outlet devices
  - Surface Skimmer
  - Weir
- Earthen walls (above grade)
- L:W ratio range 3:1-5:1
- Drawdown in 2-3 days (top 2 ft only)
- Max depth to weir, 3 ft

Skimmer Basin w/ Baffles



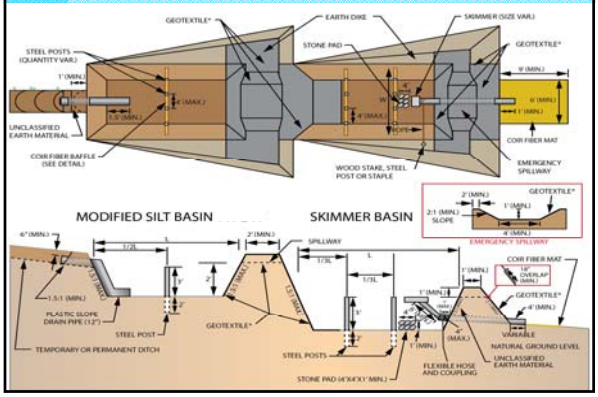
Skimmer Basin Detail



Tiered Skimmer Basin

- Rectangular basin
- 2 basins at diff. elev.
- 3 coir baffles
- Location: site perimeter
- Drainage area < 10ac
- Surf. Area: $325Q_{10}$ or Q_{25}
- Volume: 1800 ft^3/ac
- Surface outlet devices
  - Skimmer
  - Weir
- Earthen walls built above grade
- L:W ratio range 3:1-5:1

Tiered Skimmer Basin

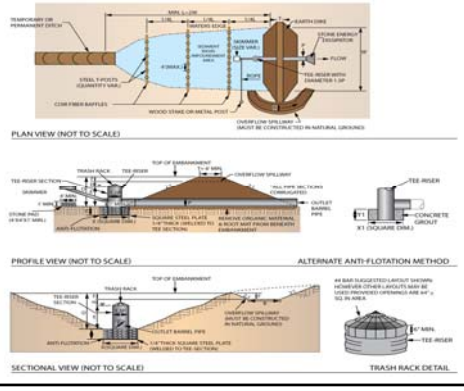


Riser Basin

- Rectangular basin
- Location: site perimeter
- Drainage area < 100ac
- Surf. Area: $435Q_{10}$ or Q_{25}
- Volume: 3600 ft^3/ac
- Earthen walls built above grade
- L:W ratio range 2:1-5:1

Outlet devices
- Perforated riser pipe w/ sed. control stone
- Overflow Spillway

Riser Basin

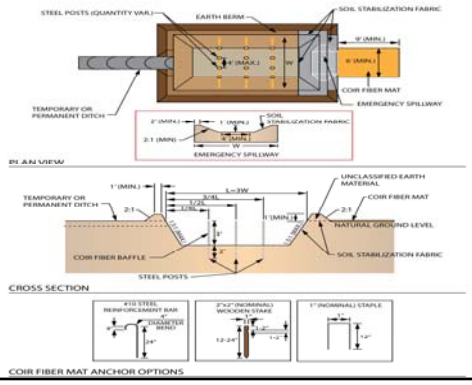


Infiltration Basin w/ Baffles

Infiltration Basin w/ Baffles

- Rectangular basin
- 3 coir baffles, equally spaced
- Location: site perimeter
- Requires highly porous soils--sand
- Drainage area < 10ac
- Surf. Area: $325Q_{10}$ or Q_{25}
- Volume: 1800 ft^3/ac
- Outlet devices
  - Infiltration
  - Weir (emergency spillway)
- Dug into ground
- L:W ratio range 3:1-5:1

Infiltration Basin w/ Baffles



Summary

Sediment Basin Type	Max. Drainage Area (acres)	Minimum Surface Area (ft^2 per cfs of Q_{10} peak inflow)	Minimum Volume (ft^3 per acre of drainage area)	Outlet Structure	Function
Riser Basin	100 (10 acre min.)	435	3,600	Non-perforated Riser w/ Skimmer	Removes Sand, Silt and Clay***
Skimmer Basin	10	325	3,600	Skimmer	Removes Sand, Silt and Clay***
Tiered Skimmer Basin	10	325	3,600	Skimmer	Removes Sand, Silt and Clay***
Rock Filter Dam	< 1	435	3,600	Riprap Dike	Removes Sand and Silt
Sed Basin Type II	< 3	325* (435**)	1,800* (3,600**)	N/A	Removes Sand and Silt

*- When used adjacent to drainage structures (e.g. inlets, catch basins, etc.)
**- When used in conjunction with stone devices (e.g. rock checks, stone inlet protection, etc.)
***- With flocculant incorporated on upgrade measures

Summary

Alternative Sediment Storage BMPs

Ditch Grade	0 – 2%	2-3%	>3%
Alternate BMP to Design Upgrade of Sediment Basin	Wattles with PAM	Wattles with PAM alternating with Rock Check Dams	Rock Check Dams with a section of erosion control blanket on upstream side with PAM applied to top of the blanket at weir

Questions