Sediment Basin Sizing and Channel Design

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Sediment Basins

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Purpose

- Collect sediment-laden stormwater runoff and retain pollutants
- Probably the most effective of all sediment control devices due to their large water and sediment storage capacity
- Generally used on larger (>2,500m^2 construction sites)
- Types C and F (non-dispersive) and D (dispersive)

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Permanent Basins

- Designed by experienced professionals, having regard to the volumes of runoff, quantity and types of sediment expected
- Size includes a sediment settling and a sediment storage zone, mark with pegs
- Prioritise public safety
- Provide length/width ratio > 3:1 – use baffles if necessary
- Ensure inlet/outlet structures are stabilised against erosion

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Wet Basins

- Watertight structures that store water for sufficient time to allow settling of fine and dispersed suspended solids
- Complete storm capture devices (typical)
- Often flocculated to enhance performance if sediments are dispersive (colloidal)
- Pump water out once settling has occurred

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Example – Wet basin

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Dry Basins

- Only effective for coarse sediments where shorter settling times are required
- May be employed for 'pre-treatment'
- Can be built of earth, rock or gabions
- Drain naturally through a geotextile-lined permeable wall or slotted riser

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Example – Dry Basin

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Temporary Basins

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Temporary Basins

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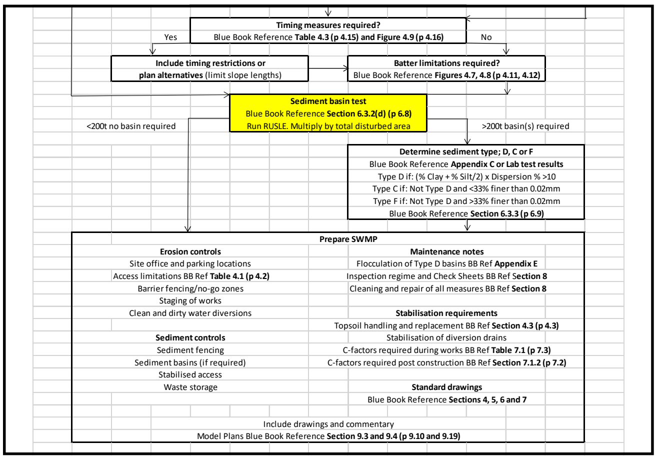

Sediment basin test

- Blue Book Reference Section 6.3.2(d) p6-8
- Some small and flat sites may not warrant construction of a sediment basin
- Run RUSLE to check the annual soil loss from the 'total disturbed area'
- If annual soil loss <150m^3 (150m^3 = 200 tonnes) a sediment basin may not be required
- If so, employ alternative measures

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Sediment Basin Test - exercise

Is a sediment basin required for the following activity at Moolarben?

- 4.5ha works area, of which 3.8ha will be disturbed
- Subsoil excavation (K = 0.04), with identified dispersion (+20%)
- Site gradient (slope) is 5%, default slope length (80m)
- Ground is compacted and smooth (P=1.3)
- Bare ground (C = 1.0)

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RUSLE solution

- Sediment Basin Test – Moolarben site
- Equation: A = R x K x LS x P x C

A = 1,300 x 0.048 x 1.19 x 1.3 x 1.0
A = 96.53 tonnes/ha/year

- Result = 96.53 t/ha/yr x 3.8ha = 366.8 tonnes (~282.2m^3 per year)

Sediment basin will be required

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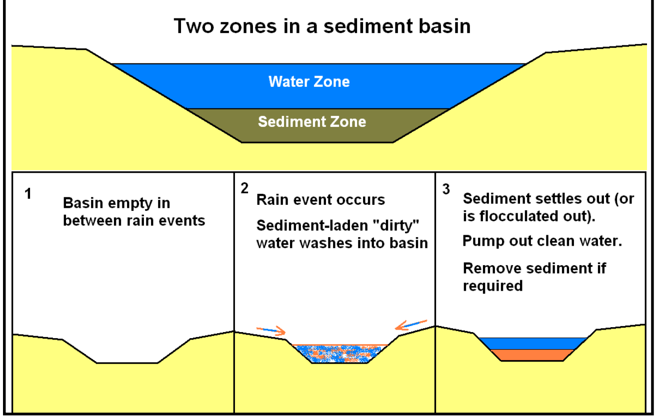

Sediment Basin Design Criteria

- Settling zone (Type D/F) = 10 x Cv x A x R, where:
  - Cv = (Volumetric runoff coefficient) (proportion of rainfall expected to runoff as stormwater)
  - A = catchment area of basin (ha)
  - R = design rainfall depth (mm)
- Storage (soil) zone design = 50% of settling volume or 2 months soil loss (RUSLE)

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Settling Zone capacity

Blue Book Reference Section 6.3.4 (page 6-15) and Appendix J (worksheets)

- 5 day, 75th percentile is default design parameter
- 80th percentile for highly sensitive receiving waters where rehabilitation to take less than 6 months
- 85th percentile (or higher) if receiving waters are highly sensitive AND/OR rehabilitation to take longer than 6 months

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Settling Zone capacity

- BB Vol 2E Table 6.1 specifies:
  - 80th / 85th percentile for highly sensitive receiving waters and projects up to 3 years in duration
  - 90th / 95th percentile for project durations greater than 3 years (typical)
- Consider better erosion controls rather than just making basins bigger

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Settling Zone capacity

- If required to change the design criteria (e.g. from 75th to 90th percentile rainfall depth) for a sensitive receiving location (e.g. wetland area)
  - What implication will this have for basin sizing?
  - How else might we be able to address this constraint?
- In what circumstances might 2-day or 20-day rainfall figures be used?
  - What implications does this have for maintenance?

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Storage Zone capacity

- Storage zone sized for:
  - 2 months soil loss (RUSLE) or
  - 50% of settling (water) zone on low erosion hazard sites

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Basin Overflow

- BB Vol 2E Table 6.2 estimates 'average' overflow (spill) frequency for sediment basins designed using the 5-day storm duration procedure:
  - 75th percentile = 8-11 spills per year
  - 80th percentile = 6-8 spills per year
  - 85th percentile = 4-6 spills per year
  - 90th percentile = 2-4 spills per year
  - 95th percentile = 1-2 spills per year
- Higher design value = greater confidence

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Basin Sizing Tools

Blue Book Design Spreadsheet (Appendix J)

- Site details
- Catchment and disturbed catchment areas
- Soil analysis
- Rainfall data
- RUSLE Factors
- Sediment basin design criteria
- Calculations and Sediment basin volumes

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Required Calculations

- Soil loss (t/ha/yr) RUSLE
- Soil Loss Class
- Soil loss (m^3/ha/yr)
- Sediment basin storage (soil) volume (m^3)
- Sediment basin settling (water) volume (m^3)
- Sediment basin total volume (m^3)

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Site Problem

- We are to design a sediment basin to capture dirty water from a new works area at MCO
- The area will be opened up in stages, with control measures staying in place for 2-3 years
- We will also design the conveyance drainage (channels) from work areas to the basin

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Site Problem

- Total Catchment Area = 4.5ha
- Disturbance Area = 3.8ha
  - Stage 1 = 1.3ha
  - Stage 2 = 1.7ha
  - Stage 3 = 0.8ha
- R (1,300) K (0.048) P (1.3) C (1.0)
- Average annual soil loss (A) = 96.53 t/ha/year
- Average slope = 5% (20:1) 80m length
- Sediment type = 'D' (dispersible)
- Hydrologic group = C (structured fine clay)

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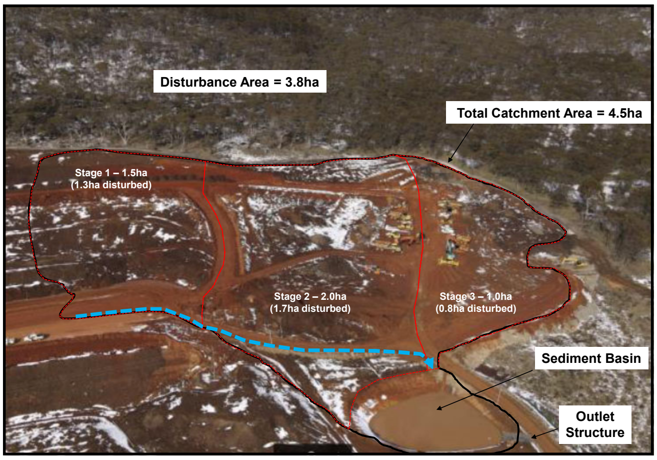

Design Rainfall

BB Vol 2E Table 6.1 specifies:

- 80th / 85th percentile for highly sensitive receiving waters and projects up to 3 years in duration
- 90th / 95th percentile for project durations greater than 3 years (typical)

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Design Rainfall depth

Table 6.3a 75th, 80th, 85th, 90th and 95th-percentile 2 and 5-day rainfall depths for 59 sites in New South Wales

Location	2-day rainfall depths (mm)					5-day rainfall depths (mm)				
	75th %ile	80th %ile	85th %ile	90th %ile	95th %ile	75th %ile	80th %ile	85th %ile	90th %ile	95th %ile
Northern Tablelands and Northwestern Slopes										
Armidale	12.4	15.2	19.3	25.0	35.3	19.8	24.1	29.2	37.4	52.9
Gunnedah	14.2	17.3	21.3	27.7	39.2	20.0	24.1	30.2	38.4	53.0
Tamworth	15.2	18.3	22.2	27.7	39.6	21.6	25.2	30.8	39.2	54.2
Tenterfield	18.8	22.3	26.7	33.8	46.0	26.7	31.4	38.1	47.4	63.3
Central Tablelands and Central Western Slopes										
Bathurst	10.7	13.2	16.5	21.4	30.4	16.8	20.6	24.9	31.4	43.7
Cowra	12.0	14.7	18.0	22.9	32.8	18.1	21.6	26.1	32.5	44.9
Dubbo	12.7	16.0	20.2	26.1	36.0	18.8	22.8	28.4	35.6	50.7

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Coefficient of Runoff

- "C" is a calibration term
- Each term only suitable on catchment of similar characteristics to those from which it was derived
  - Cv = Volumetric Runoff coefficient
  - C_{10} = 'Peak' Flow Runoff coefficient
- Based on 'soil hydrologic group' and 'design rainfall' Blue Book Reference Appendix F
- BB Vol 2E Section 6.1 specifies:
  - Cv should be assumed **0.9** for any impervious areas within basin catchment on mine and quarry sites

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Coefficient of Runoff

Table F2. Runoff coefficients (Cv) for volumetric data in disturbed catchments (adapted from USDA, 1996)

Soil Hydrologic Group	Design Rainfall depth (mm)							Runoff potential
	<20	21-25	26–30	31–40	41-50	51-60	61-80	
A	0.01	0.05	0.08	0.15	0.22	0.28	0.37	very low
B	0.10	0.19	0.25	0.34	0.42	0.48	0.57	low to moderate
C	0.25	0.35	0.42	0.51	0.58	0.63	0.70	moderate to high
D	0.39	0.50	0.56	0.64	0.69	0.74	0.79	high

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Site Problem – solution

- Design Criteria:
  - Design rainfall depth = 5-day, 85th percentile (Dubbo) = 28.4mm
  - R-factor = 1,300 (estimated)
  - Volumetric runoff (Cv) = 0.42 (mod-high)
- Design Solution:
  - Settling zone (Type D) = 10 x Cv x A x R
    = 10 x 0.42 x 4.5 x 28.4 = 536.8m^3
  - Storage Zone = 268.4m^3 (or 47m^3 ??)

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EPL 12932

- Assumes disturbance period will always be >3 years
- Assumes 5-day 'design' rainfall duration
- Assumes design rainfall depth of 44mm
- Assumes Cv = 0.64 (64% runoff)
- Assumes storage zone based on 50% settling volume

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Channel Design

- Drainage channels (catch drains, table drains, down (slope) drains, diversion banks etc.) are an important tool for managing both clean and dirty water in and around construction sites
- Critical design characteristic for channel design is 'design discharge' or "Q"
- Q = m^3/second

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Channel Design Standards

- All 'waterways, drains, spillways and their outlets' should be constructed to be stable
- BB Vol 2E Table 6.1 specifies:

- Temporary drainage structures
  - 1 in 10-year ARI design storm event (<3 year duration)
  - 1 in 20-year ARI design storm event (>3 year duration)
- Embankments and spillways
  - 1 in 50-year ARI design storm event (<3 year duration)
  - 1 in 100-year ARI design storm event (>3 year duration)

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Design Discharge "Q"

- The estimated 'peak' discharge (m^3/sec) for a given storm ARI (Y)
- ARI – Average Recurrence Interval
- For example, Q_{10} is the peak discharge from a 1 in 10 year design storm event
- "Q" can be estimated many ways

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Design Methods

- Complex numerical models:
  - DRAINS
  - RORB/RAFTS
  - TUFLOW
- The 'Rational Method' – simple empirical formula, 50-200% of real values, but tends to overestimate.
- OK for temporary structures

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Rational Method

- Uses key hydraulic parameters to estimate peak discharge Q=CIA/360

Where:

- Catchment Area – (A) (ha)
- Design Rainfall Intensity – (I) (mm/hr)
- Coefficient of Discharge – (C_{10})
- Critical Storm duration – (t_c) (mins)

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Catchment Area (A)

- "A" is the effective catchment area upstream of the point of interest (i.e. discharge point)
- Should be calculated for each sub-catchment area feeding to individual structures
- Remember to divert all unnecessary water

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Design Rainfall Intensity (I)

- "I" is compound function for a given storm duration (t_c) and storm frequency (Y)
- Typically selected from Intensity-Frequency-Duration (IFD) charts developed for specific locations
- Design storm selection is task specific

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Time of Concentration (t_c)

- "t_c" is the theoretical time required for runoff to flow from the furthest part of the sub-catchment to the point of interest (where discharge is being calculated)
- Determines the shortest storm duration that will contribute flow from the whole sub-catchment at one time
- Can determine from tables/graphs

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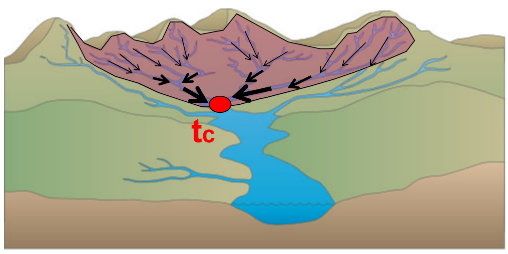
"Time of Concentration"



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Time of Concentration

- Can be calculated by formula:

  t_c (hrs) = 0.76 x (A x 100)$^{0.38}$
- For Urban Areas, either reduce rural t_c values by 50% or undertake detailed calculations:
  - Sheet flow estimate
  - Kerb flow estimate
  - Pipe flow estimate
  - Channel flow estimate

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Design Application

- We are to design a catch drain to collect and transfer 'dirty water' from Stage 1 works (1.5ha) to the sediment basin
- The sub-catchment is disturbed (~86%)
- Assume the drain will be used throughout the 3-year activity period

What is the appropriate Design Standard?

What is the Design Storm Event (Y)?

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Design Standard

- "Y" is a fictitious, isolated storm event of varying frequency and duration
- Selection based on the expected design life of the structure, typically:

Drainage Structure	Design Life (months)		
	<12	12-24	>24
Catch drains, flow diversion berms etc.	1 in 5 year	1 in 10 year	1 in 10 year

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Design Application

- The sub-catchment is highly disturbed, with slopes between 4-5% and the distance from the furthest point to the discharge location is >150m

What is the Time of Concentration (t_c)?

- ~5 minutes (for disturbed)

What is the average rainfall intensity for the design storm duration?

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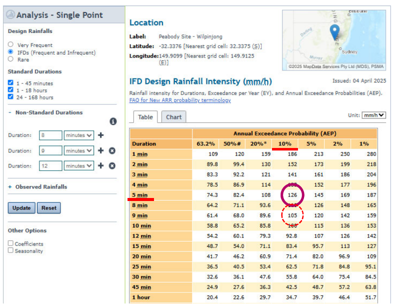
Design Storm Duration/Intensity


Analysis - Single Point

Design Rainfalls
- Very Frequent
- IFDs (Frequent and Infrequent)
- Rare

Standard Durations
- 1 - 45 minutes
- 1 - 18 hours
- 24 - 168 hours

- Non-Standard Durations

Duration: 8 minutes

Duration: 9 minutes

Duration: 12 minutes

+ Observed Rainfalls

Update Reset

Other Options
- Coefficients
- Seasonality

Location

Label: Peabody Site - Wilpinjong

Latitude: -32.3376 [Nearest grid cell: 32.3375 (S)]

Longitude: 149.9099 [Nearest grid cell: 149.9125 (E)]

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IFD Design Rainfall Intensity (mm/h)

Issued: 04 April 2025

Rainfall intensity for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).

FAQ for New ARR probability terminology

Table Chart Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	63.2%	50%#	20%*	10%	5%	2%	1%
1 min	109	120	159	186	213	250	280
2 min	89.8	99.4	130	152	173	199	218
3 min	83.3	92.2	121	141	161	186	204
4 min	78.5	86.9	114	[illegible]	152	177	196
5 min	74.3	82.4	108	126	145	169	187
8 min	64.2	71.1	93.6	[illegible]	126	148	165
9 min	61.4	68.0	89.6	105	120	142	159
10 min	58.8	65.2	85.8	[illegible]	115	136	153
12 min	54.2	60.1	79.3	92.8	107	126	142
15 min	48.7	54.0	71.1	83.4	95.7	113	127
20 min	41.7	46.2	60.9	71.4	82.0	96.9	109
25 min	36.5	40.5	53.4	62.5	71.8	84.8	95.1
30 min	32.6	36.1	47.6	55.8	64.0	75.4	84.5
45 min	24.9	27.6	36.3	42.5	48.7	57.2	63.8
1 hour	20.4	22.6	29.7	34.7	39.7	46.4	51.7

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Coefficient of Discharge

Table F3 Runoff coefficients (C10) for peak flow data in disturbed catchments

Soil Hydrologic Group	Rainfall intensity (mm) in the design storm						Runoff potential
	<20	21-40	41-60	61-80	81-100	>100	
A	0.20	0.37	0.55	0.64	0.68	0.75	very low
B	0.46	0.58	0.70	0.75	0.78	0.82	low to moderate
C	0.69	0.76	0.83	0.85	0.86	0.88	moderate to high
D	0.80	0.86	0.89	0.90	0.90	0.90	high

- Enter this value into the BB design spreadsheet (Flow Calculations – Tab 3)

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Design Solution

- Now we can solve for the peak discharge in the 1 in 10 year (Q_{10}) event, remembering:
- Q = C.I.A / 360 (m^3/sec)
- Q = (0.88) x (126) x (1.5) / 360
- Q = 0.462 m^3 per second or (462 L/sec)

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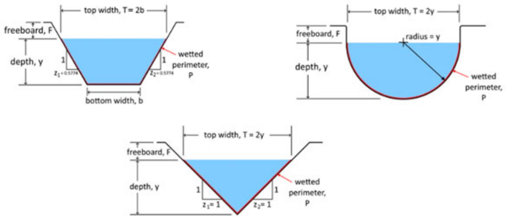
Channel Geometry

- Multiple channel forms common, trapezoidal most efficient



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Open Channel Flow

- In simple form velocity (V) can be calculated as:
  V (m/sec) = Q (m^3/sec ÷ cross-sectional flow area)
- Flow velocity (V) in a constructed channel can be calculated using Manning's equation:
  $$V \text{ (m/sec)} = 1/n \times R^{2/3} \times s^{1/2}$$
- Where:
  - n = Manning's roughness coefficient
  - R = channel hydraulic radius
  - S = channel slope (%)

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Basin Alternatives

- Situations where traditional basin installation not achievable / warranted:
  - Insufficient available area
  - Pre-existing development restrictions (e.g. hardstand or other built structures)
  - Construction difficulties (machinery access limits)
  - Small disturbance areas
  - Short project durations or lead times

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Dewatering Bag

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Settling Tanks

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Settling Tanks

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Lamella Clarifiers

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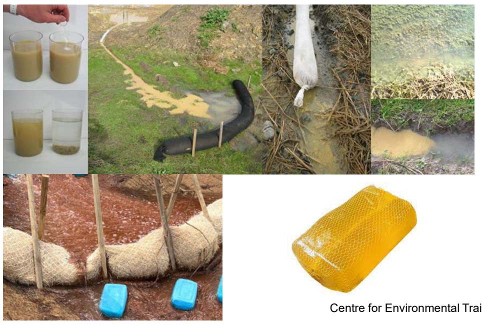
Basin Pre-treatment



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Rainfall Activated Flocculant Dosing

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