Sediment Basin Design, Construction and Maintenance
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1. Introduction

**Purpose of guidelines**

This document has been prepared to provide guidance on Brisbane City Council’s preferred method for the design, construction, operation and maintenance of sediment basins.

**Use of the guidelines**

The guidelines are recommended for use in all circumstances in which a sediment basin is operated within the Brisbane region.

These guidelines are not mandatory and designers should use their professional judgement on the suitability of the guidelines for particular site conditions.

Information contained within this document does not replace the need for site-specific evaluation, testing and design where it is judged necessary.

The document has been developed from the recommendations presented in the NSW Department of Housing “Managing Urban Stormwater - Soils and Construction” (1998). Modifications have been made to the NSW methodology in order to improve its relevance to Brisbane’s soil and weather conditions.

**Relationship between guidelines and Council’s ESC Standard**

Council’s Erosion and Sediment Control (ESC) Standard aims to:

- minimise or prevent environmental harm to the City’s waterways and associated ecosystems
- minimise localised flooding caused by sediment runoff
- minimise costs to ratepayers resulting from the desilting and dredging of the City’s waterways.

For many of the City’s soils, the construction and effective operation of a sediment basin is the only feasible means of controlling the discharge of turbid water and therefore the only feasible means of achieving the above aims.

**What is a sediment basin**

A sediment basin is a purpose built dam usually containing an inlet structure, a settling pond, a controlled or free-draining outlet structure, and an emergency spillway. The storage volume consists of two components, the settling zone and the sediment storage zone. Sediment basins are designed to trap and retain a wide range of sediment particle sizes, thereby reducing both the coarse sediment concentration and turbidity levels within the discharged fluid.
Types of sediment basins

There are basically two types of sediment basins; dry basins and wet basins.

A ‘dry’ basin is designed to commence draining the moment water enters the basin (i.e. free draining). As a result, a large percentage of the slow settling, clay-size particles can pass through this type of basin. These basins are referred to as Type C basins and are only suitable for coarse grained soils.

A ‘wet’ basin is designed to retain the water for long periods allowing extended time for the settlement of clay particles or for chemical flocculation. These basins are not drained until a suitable water quality is obtained within the retained water.

There are two forms of ‘wet’ basins: Type F basins are used for fine soils that do not require chemical flocculation; and Type D basins for dispersible soils that require flocculation.

Sediment basin flocculation

Soils usually contain a range of particle sizes from very fine clays to coarse sands. Fine soil particles, say less than 0.002 mm in diameter, generally pass through most sediment control structures including sediment fences, aggregate filters, and non flocculated sediment basins.

Most clay particles can contain a residual negative electro-magnetic charge. Due to the very small size of the clay particles, this negative charge can have a significant affect on its ability to settle under gravity. As a result, some clay particles take several hours to settle, while others may never settle unless the water is treated with a suitable flocculent.

The job of a flocculent is to effectively break down the dominance of these negative charges, allowing individual particles to be drawn together and settle under gravity.

The importance of sediment basins

Sediment basins generally perform two functions: firstly to readily settle the coarse sand and silt particles; and secondly to retain large volumes of contaminated runoff to allow time for gravitational settlement or chemical flocculation of the fine clay particles.

Because of their ability to reduce the turbidity of contaminated runoff, sediment basins perform an important function in minimising ecological harm in downstream waterways.

Sediment entering waterways in Brisbane can produce a range of adverse environmental impacts. For coarse sediment, these impacts include the smothering of benthic (bottom dwelling) plant communities and filling of deep pools in urban creeks. Such pools are important habitats to a variety of aquatic organisms (e.g. fish), particularly in periods of low flow and hot weather.

For fine sediment, increased turbidity can prevent light from penetrating the water column, leading to loss of vegetation and associated ecosystems. Perhaps the best example of the impact of fine sediment is in western Moreton Bay, where a loss of seagrass meadows has been shown to be linked to sustained periods of high turbidity.
Sediment Basin Design, Construction, Operation and Maintenance

TECHNICAL NOTE

The general health of a small creek system is usually dominated by the quality of the low flow water, rather than the quality of flood waters. Generally speaking, in a creek system, the lower the flow rate, the higher the required quality of water.

Therefore, while turbidity control is almost always a concern, this concern increases with decreasing flow rate and with increasing distance up a creek catchment.

To maintain the health of creek systems, it is important for turbid flood flows to be followed by several days of clean base flow. In a natural creek system, flood waters are often turbid due to natural erosion and creek meandering. However, after this turbid flood water has passed down the creek the many pools and riffles are cleaned out by days of clean base flow originating mainly from groundwater.

In an urban catchment, groundwater flows may be reduced by the introduction of impervious surfaces, but may also be increased by garden and lawn watering during dry weather. Therefore, the key to maintaining a healthy urban stream is to establish a catchment drainage system that produces several days of clean low flow water following storm events.

It is for this reason that sediment basins are designed to allow the discharge of relatively clean water into creeks following periods of rain.

In any event, contaminated runoff from a construction site should be directed through a sediment basin even if it is already full of turbid water. This is because the coarse sediment will continue to settle and thus be removed from the discharge.

Treatment train concept

Sediment basins, although an important part of any erosion and sediment control strategy, must be considered as only one carriage in the overall “Treatment Train”. The Institute of Engineer's publication “Soil Erosion and Sediment Control – Engineering Guidelines for Queensland Construction Sites” (1996) provides a number of other techniques suitable for the control of soil erosion and sediment runoff.

It is stressed that the basin or basins must be backed up by appropriate and effective on-site soil management practices. In most cases the sediment basin should not be relied upon as the only form of on-site sediment control.

The existence of an effective sediment basin does not remove the need for appropriate on-site drainage and erosion control.

When is a sediment basin required

Sediment basins are usually required when the disturbed area is greater than one (1) hectare, the disturbed soils are dispersible, and/or when there is a need to control runoff turbidity. As a general rule, the further upstream a development is within a catchment, the greater the need for turbidity control.
Introduction

This chapter presents a quick reference summary of the steps involved in the design of a sediment basin.

Step 1
(Chapter 1, p.3)

Assess the need for a sediment basin
Sediment basins are usually required when the disturbed area is greater than one (1) hectare, the disturbed soils are dispersible, and/or when there is a need to control runoff turbidity. As a general rule, the further upstream a development is within a catchment, the greater the need for turbidity control.

When space is limited and the ideal basin cannot be built, then the largest feasible basin should be built.

Step 2
(Chapter 3, p.9)

Select basin type
(i) Less than 33% of soil finer than 0.02 mm
   ➞ Type C basin

(ii) More than 33% of soil finer than 0.02 mm
    ➞ Type F basin

(iii) More than 10% of soil dispersible
     ➞ Type D basin

Formal soil testing will generally be required to determine particle size distribution, Emerson class and dispersion percentage.

Step 3
(Chapter 3, p.9)

Determine basin location
Locate basins to maximise the possible collection and treatment of contaminated runoff. Where possible, locate basins above the Q5 flood level.

Step 4
(Chapter 3, p.12)

Divert up-slope ‘clean’ water
Where possible, upslope ‘clean’ water should be diverted around the basin to decrease the required size of the basin and increase the efficiency of the basin. Flow diversion may need to be altered during the construction phase as new areas of land are first exposed, then rehabilitated.

Step 5
(Chapters 4 & 5)

Size basin
Type C basins:
Pond area at the base of the settling zone = 3400 (0.25 Q1)m²
Basin length should be at least three times the width, otherwise internal baffles may need to be used. Minimum basin depth is 0.6 metres.
Type F & D basins:
Settling volume \([m^3]\) = 400 \cdot C_v \cdot \text{Area [ha]} (Brisbane)
= 100 \cdot I_{1yr,24hr} \cdot C_v \cdot \text{Area (Elsewhere)}

where:
\(I_{1yr,24hr}\) = Average rainfall intensity for the 1 yr, 24 hr storm.
Volumetric runoff coefficient \((C_v)\):
\(C_v = 0.5\) (open soil) and
\(= 1.0\) (impervious surfaces).
Recommended length to width ratio of 2:1.

Step 6
Determine sediment storage depth
Type C basins: ➞ 100% of settling volume
Type F & D basins: ➞ 50% of settling volume

Assess need for baffles
Baffles are used to form an ‘inlet chamber’ if a high inflow velocity will result in uneven sediment flow through the basin.
Internal baffles are used to increase the effective length to width ratio of the basin.
An outlet baffle is used to keep settled sediment away from the primary outlet system, particularly riser pipes.

Design primary outlet system
Perforated riser outlets:
Anti-flotation mass = 1.1 times the displaced water mass. Trash rack placed on riser crest and consideration given to the placement of an anti-vortex plate. Anti-seep collars (Figure 4.1) must be placed on the buried outlet pipe.

Alternative outlet systems for Type C basins include: rock & aggregate filter dams, rock and geotextile filter dams (Figure 4.2), gabion walls (Figure 4.3) and sediment weirs.

Type F and D basins have pumped outlet systems that can discharge the entire basin in less than 24 hours.

Select internal and external bank gradients
Recommended bank gradients are 5:1 (H:V) for unfenced basins, and 2:1 to 4:1 for fenced basins typically 3:1 (H:V).
**Step 10 Design emergency spillway**

(i) Less than 3 months operation ➞ Q10  
(ii) 3-12 months operation ➞ Q20  
(iii) Greater than 12 months ➞ Q100  
(iv) If failure is expected to result in loss of life ➞ Probable Maximum Flood (PMF)

Spillway crest to be at least 300 mm above the primary outlet, 300 mm below a bank formed in virgin soil, and at least 750 mm below a fill embankment. The spillway can be curved upstream of the crest, but must be straight from the crest to the energy dissipater.

**Step 11 Determine overall dimensions of the basin**

If a sediment basin is constructed with 3:1 side slopes, then a typical basin would be 7 to 10 metres longer and wider than the length and width calculated in Step 5 above (given 0.6 m settling zone depth, 0.3 m spillway freeboard and 0.75 m freeboard for a fill embankment). It is clearly important to make sure the basin can fit into the designated area.

Compacted fill embankments should have a freeboard of 0.75 m above the design surcharge level. The minimum recommended embankment crest width is 2.5 metres.

**Step 12 Locate maintenance access ramp for desilting**

The basin width should allow for desilting works, otherwise equipment will need to access the basin for desilting. If trucks need to access the basin, then a maximum 10:1 access ramp will need to be constructed.

If the sediment is to be removed from the site, then a sediment drying area should exist, adjacent to the basin or somewhere on site within the basin’s catchment area.

**Step 13 Design the inlet system**

Protect any inlet chutes with rock or geotextile as appropriate to prevent scouring. Geotextile ‘inlet chambers’ should be installed on Type C basins if the expected inflow velocity exceeds 1 m/s.

**Step 14 Assess the need for safety fencing**

Safety fencing needs to be considered if settled sediment depths exceed 300 mm, and/or permanent water levels exceed 150 mm.
Step 15
(Chapters 4 & 5)

Define basin operation
An appropriately marked (painted) sediment desilting marker post shall be installed in the basin.

Type F and D basins should be flocculated if the trapped sediment laden water does not achieve a desirable standard, usually 50 mg/L total suspended solids (TSS).

See Chapter 5 for more detailed information on flocculation.

Step 16
(Chapter 3, p.13)

Define sediment disposal location/method
Trapped sediment can be mixed with on-site soils and buried, or removed from the site. If sediment is removed from the site, then it should be de-watered first. Removed sediment should be disposed of so as not to cause an erosion hazard.
<table>
<thead>
<tr>
<th>Basin type</th>
<th>Indicator tests</th>
<th>Soil characteristics</th>
<th>Basin design capacity = settling zone + sediment storage zone</th>
<th>Sediment storage zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type C</strong> Rapid settling of coarse sediments</td>
<td>Jar Settlement Test: settlement of clay particles in less than 1 hour. Aggregate Immersion or Field Emerson Aggregate Test: soil does not disperse, but may slake.</td>
<td>Less than 33% finer than 0.02 mm.</td>
<td>Surface area = 3,400 (Q) [m$^2$] (Brisbane) = 177.Area [ha] $Q = 0.25 Q \approx \frac{1}{2} \approx 5$ min</td>
<td>Equivalent to 100% of the settling volume. Decant time &gt; 24 hours. Alternatively, use the Revised Universal Soil Loss Equation (RUSLE) to estimate sediment runoff volume over the duration of the disturbance, or for the nominated period between clean-outs, typically 2-3 months. A marker peg should be installed to clearly identify the maximum sediment storage level.</td>
</tr>
<tr>
<td><strong>Type F</strong> Slow settling of fine sediments</td>
<td>Jar Settlement Test: clay particles settle in less than 5 days. Aggregate Immersion or Field Emerson Aggregate Test: soil is not dispersive.</td>
<td>Greater than 33% finer than 0.02 mm.</td>
<td>Capacity to contain runoff from a 40 mm, 5-day storm. Volume [m$^3$] = 400 . $C_v$ . Area [ha] (Brisbane) Volume [m$^3$] = 100 . $I_{1yr, 24hr}$ . $C_v$ . Area (Other locations) Typically, $C_v = 0.5$. Minimum depth = 0.6 metres. Minimum length to width ratio of 2:1.</td>
<td>Equivalent to 50% of the settling volume. Settlement time typically 36-48 hours. Alternatively, use RUSLE to estimate sediment runoff volume over the duration of the disturbance, or for the nominated period between clean-outs, typically 2-3 months. A marker peg should be installed to clearly identify the maximum sediment storage level and the minimum water level (where applicable).</td>
</tr>
<tr>
<td><strong>Type D</strong> Flocculated settlement of dispersible soils</td>
<td>Jar Settlement Test: clay particles do not settle in 5 days, or part of the water remains cloudy. Aggregate Immersion or Field Emerson Aggregate Test: soil is dispersive</td>
<td>Greater than 33% finer than 0.02 mm, and more than 10% dispersible material.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*(1) Basin selection and operation may need to be upgraded to a Type F or D basin if turbidity control is judged necessary, or if the approved basin fails to achieve the desired water quality objectives.*
3. Design Information

Selection of basin type

Basin selection should be based on the known soil conditions using the criteria provided in Table 3.1. The soil grain size should be determined from the soils that are likely to erode and flow into the basin. In most cases this means the exposed subsoils.

<table>
<thead>
<tr>
<th>BASIN TYPE</th>
<th>CATCHMENT SOIL CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type C</td>
<td>Less than 33% finer than 0.02 mm.</td>
</tr>
<tr>
<td>Type F</td>
<td>More than 33% finer than 0.02 mm.</td>
</tr>
<tr>
<td>Type D</td>
<td>More than 33% finer than 0.02 mm, and more than 10% dispersible materials. (^{[2]})</td>
</tr>
</tbody>
</table>

\(^{[1]}\) Basin selection and/or operation may need to be upgraded to a Type F or D basin if turbidity control is judged necessary, or if the approved basin fails to achieve the desired water quality objectives.

\(^{[2]}\) Soils that ‘disperse’ when immersed in water.

Dispersible soils

Soils that are considered dispersible have a combined percentage of clay (< 0.002 mm) plus half the percentage of silt (0.002–0.02 mm) expressed as a decimal fraction, multiplied by the dispersion percentage (Richie, 1963) equal to or greater than 10.

Formal soil testing will generally be required to determine whether a soil is dispersible or not. Informal indicator tests are discussed below.

Two simple tests exist to provide an indication of the existence of dispersible soils: the Field Emerson Aggregate Test, and the Aggregate Immersion Test (both described in Section 7).

The Jar Settlement Test is used to provide an indication of the suitability of a Type C, F or D sediment basin for a given soil type. This test is also described in Section 7.

Location

Wherever possible, sediment basins should be located above the estimated 5 year ARI flood level.
Length to width ratio

Restrictions are placed on the shape of the settling pond in order to reduce the risk of short circuiting. To ensure the optimum sediment trapping efficiency, the distance between the inlet and outlet of the basin should be the maximum that is practicable. These restrictions apply to both wet and dry basins.

Minimum length:width = 3:1 (single inflow point)

Minimum length:width = 2:1 (multiple inflow points with baffles)

The effective length of a basin can be increased with the use of baffles. If baffles are installed, then a check should be made on the potential scour velocity. Further discussion on the use of baffles is provided in Section 6.

Sediment scour velocities can be determined from Table 3.2.

<table>
<thead>
<tr>
<th>Critical particle diameter (mm)</th>
<th>Scour velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.16</td>
</tr>
<tr>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>0.02</td>
<td>0.07</td>
</tr>
</tbody>
</table>

The crest of these baffles should be set level with, or just below the spillway crest level. This is to prevent the resuspension of settled sediment during severe storms (i.e. flood water are meant to flow over the baffles, not around them).

Basin inlet

Basin inlet channels should be protected against erosion and scour. This may be achieved by using a rock or geotextile lined chute.

When sediment is allowed to enter a basin via the permanent stormwater pipe system, efforts should be made to prevent sediment settling within the stormwater pipes.

Inlet chambers

Inlet chambers are constructed to increase the efficiency of sediment basins by reducing the occurrence of dead water zones and short circuiting.
The chambers can be constructed from perforated sediment fence. The perforations are needed to allow sediment-laden water to flow evenly into both the full width and depth of the sediment basin. These perforations are also needed to prevent sediment blockage of the fabric.

Inlet chambers are important on Type C and F basins, and whenever a basin has a length to width ratio of less than 3:1.

TECHNICAL NOTE

To construct an inlet chamber, perforate a suitable length of woven sediment fabric with approximately 50 mm diameter holes at 300 mm spacing. These holes should not be placed within the area of fabric that will be located directly in front of a piped inlet.

Install the sediment fence across the full width of the basin approximately 1 to 2 metres from the inlet. The top of the fence should be level with the crest of the primary outlet spillway. The spacing between support posts should be 0.5 to 1.0 metres depending on the expected hydraulic force on the fence.

Examples of inlet chambers can be found in the discussion on baffles, Section 6.

Freeboard

For compacted earth basins, with catchments of less than fifteen (15) ha, a desirable freeboard allowance of at least 0.75 m should be provided between the design surcharge level in the basin and the top of the compacted embankment.

For compacted earth basins, with catchments larger than fifteen (15) ha and for environmentally sensitive sites, calculation of freeboard should include additional allowance for the following:
- surcharge;
- wave action;
- clearance; and
- embankment settlement.

Fencing

Sediment basins located within urban areas should be suitably fenced if:
- the settled sediment depths exceed 300 mm; and/or
- permanent water depths exceed 150 mm; and/or
- if public safety is at risk.
**Bypassing ‘clean’ water**

To reduce the size of the sediment basin and to increase the overall settling efficiency of the basin, all reasonable and practicable efforts should be taken to bypass ‘clean’ upslope water around the basin.

Clean water may consist of stormwater entering the site from external sources, or uncontaminated stormwater runoff from roofs, rehabilitated or vegetated areas of the work site.

**Internal batter gradients**

Internal batter gradients need to be consistent with the requirements of personal safety and generally within the following upper limits:

- Where water depth is less than 150 mm when surcharging, 2:1 to 4:1 (H:V) on earth structures; and gabion basket structures.
- Where water depth is between 150 mm and 1500 mm when unfenced and surcharging, a maximum slope of 5:1 (H:V).
- Where water depth is between 150 mm and 1500 mm when fenced and surcharging or greater than 1500 mm:
  - 2:1 to 4:1 (H:V) on earth structures;
  - 1.5:1 (H:V) on rock gibber structures;
  - 1:4 (H:V) on gabion basket structures; and
  - 1:4 (H:V) on stacked (rough squared) rock structures.

The actual bank gradient will depend on the ‘slipperiness’ of the saturated sediment, i.e. whether or not a person can achieve a firm footing and exit the basin. Slippery sediments should have less steep gradients, in the order of 8:1 (H:V) or even 10:1. Otherwise, the basin should be fenced.

**Embankment crest width**

The minimum embankment crest width should be 2.5 metres.

**Emergency spillway**

The recommended hydraulic capacity of the emergency spillway is presented in Table 3.3.

---

**TABLE 3.3 HYDRAULIC DESIGN CAPACITY**

<table>
<thead>
<tr>
<th>OUTLET SYSTEM</th>
<th>DESIGN ARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outlet:</td>
<td>1 year (@ 300 mm below emergency outlet)</td>
</tr>
<tr>
<td>Emergency spillway outlet:</td>
<td></td>
</tr>
<tr>
<td>• Less than 3 months operation</td>
<td>10 year</td>
</tr>
<tr>
<td>• 3-12 months operation</td>
<td>20 year</td>
</tr>
<tr>
<td>• Greater than 12 months</td>
<td>100 year</td>
</tr>
<tr>
<td>• If failure will result in loss of life</td>
<td>Probable Maximum Flood (PMF)</td>
</tr>
</tbody>
</table>

---
The crest of the emergency spillway should be at least:
- 300 mm above the primary outlet spillway;
- 300 mm below the crest of any bank constructed in virgin soil; and
- 750 mm below the crest of any fill embankment (desirable).

All reasonable and practicable efforts should be taken to construct the spillway in virgin soil, not in fill soil.

The spillway’s horizontal alignment can be curved upstream of the crest, but must be straight from the crest to the energy dissipater (Figure 4.1). Ensure that the approach section has a slope towards the impoundment area of not less than 2% and is flared at its entrance, gradually reducing to the design width at the spillway crest.

On large side channel spillways, the spillway crest should be level and straight and have at least a 6 metre weir crest length.

The downstream face of the spillway usually needs to be protected with rock or rock mattresses.

**Outlet protection**

Appropriate rock protection, or similar, should be placed at the end of the outlet pipe and spillway to dissipate energy and control undesirable soil erosion.

**Maintenance access**

The basin width should allow for desilting works, otherwise equipment will need to access the basin for desilting. If trucks need to access the basin, then a maximum 10:1 access ramp will need to be constructed.

If the sediment is to be removed from the site, then a sediment drying area should exist, adjacent to the basin or somewhere on site within the basin’s catchment area.

**Disposal of trapped sediment**

Trapped sediment can be mixed with on-site soils and buried, or removed from the site. If sediment is removed from the site, then it should be de-watered first. Removed sediment should be disposed of so as not to cause an erosion hazard.
4. Type C basins

Surface area (A)

The critical design parameter in the sizing of Type C basins is the pond surface area (A). Where possible, the ‘effective’ surface area of the basin should be maximised. Note: the effective surface area does not include ‘dead’ water areas that contain poor circulation. It is noted that several small basins will not have the same settling efficiency as a single basin of the same total surface area.

The pond surface area is measured at the base of the settling zone, not at the maximum pond level. The required surface area is given by equation (1)

\[ A = 3,400 \times (Q) \]  

(1)

where:

\( A \) = pond surface area [m²]

\( Q \) = design flow rate [m³/s] = 0.25Q \( t_{c, 1yr} \)

\( Q_{c, 1yr} \) = peak discharge from a 1 in 1 year (Q1) design storm for the critical time of duration (tc)

The design flow rate (Q) is assumed to be 0.25 times the critical duration, 1 in 1 year design storm peak discharge for the catchment flowing to the basin.

When determining the critical duration storm, consideration should be given to the time of concentration (tc) of the catchment at the time of installation of the permanent drainage system as this is often the shortest ‘tc’ during the construction phase. It is noted that the critical storm duration is determined at the basin’s inlet, not at the outlet (i.e. the basin is assumed to be full).

Typically:

\( t_c = 5 \) minutes;

\( i_{11} = 117 \) mm/hr for Brisbane

\( C_1 = 0.64 \) for vegetated and open soils areas

\( = 0.80 \) for impervious areas

where: \( C_1 \) = the 1 year coefficient of discharge

\( i_{11} = 5 \) minute, 1 in 1 year rainfall intensity

In most cases, runoff coefficients should be determined in accordance with the most impervious condition of the catchment during the construction phase.
Critical sediment size

The above design formula (Equation 1) is based on a ‘critical sediment size’ of 0.02 mm. In areas where the soil has a uniform, coarse-grain size, the critical sediment size maybe replaced by the D30 grain size (i.e. the grain size of which 30% by weight is smaller).

The critical sediment size is defined as the smallest grain size the basin is designed to trap. Hunt (1992) recommends a particle size for which at least 70% of particles are coarse, with a minimum particle size of 0.02 mm.

If a critical sediment size larger than 0.02 mm is chosen, then the pond size may be determined from Table 4.1.

<table>
<thead>
<tr>
<th>Particle size (mm)</th>
<th>Settling velocity (m/s)</th>
<th>Basin surface area (m²/m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.007</td>
<td>140</td>
</tr>
<tr>
<td>0.05</td>
<td>0.0019</td>
<td>530</td>
</tr>
<tr>
<td>0.02</td>
<td>0.00029</td>
<td>3400</td>
</tr>
</tbody>
</table>

Settling zone depth

The settling zone (Figure 4.1) should have sufficient depth to prevent the resuspension of settled sediment.

Minimum settling zone depth = 0.6 metres

For basins longer than 120 m, the minimum depth is L/200. Where L = basin length [m].

Sediment storage volume

The sediment storage volume (Figure 4.1) may be determined as 100% of the calculated settling zone volume.

Alternatively, the Revised Universal Soil Loss Equation (RUSLE) may be used to estimate sediment runoff volume over the duration of the disturbance, or for the nominated period between clean-outs, typically every 2-3 months. Further discussion is provided in Section 8.

Outlet system

The outlet for a Type C basin normally consists of two flow systems, the primary outlet and the emergency spillway. The primary outlet may consist of a Riser Pipe Outlet (Figure 4.1), a Rock Filter Dam (Figure 4.2), a Sediment Weir, or Gabion Wall (Figure 4.3).

The primary outlet on a riser pipe system normally contains a low-flow aggregate filter, and a medium-flow spillway located around the crest of the vertical riser pipe.
The required hydraulic capacity of each outlet component is listed in Table 4.2.

### Table 4.2 Hydraulic Design Capacity

<table>
<thead>
<tr>
<th>Outlet System</th>
<th>Design ARI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outlet:</td>
<td>1 year (@ 300 mm below emergency outlet)</td>
</tr>
<tr>
<td>Emergency spillway outlet:</td>
<td></td>
</tr>
<tr>
<td>• Less than 3 month operation</td>
<td>10 year</td>
</tr>
<tr>
<td>• 3-12 month operation</td>
<td>20 year</td>
</tr>
<tr>
<td>• Greater than 12 months</td>
<td>100 year</td>
</tr>
<tr>
<td>• If failure will result in loss of life</td>
<td>PMF</td>
</tr>
</tbody>
</table>

The dewatering facility should provide for the settling volume to be removed over an extended period (minimum 24 hours). This will ensure that basin efficiency is not adversely affected during smaller inflows, when less settling depth is available.

**Perforated riser design**

The design of any outlet pipe should include allowance for uplifting (buoyancy) forces on the structure in the form of a weighted concrete base (Figure 4.1). The weight of the anti-flotation mass should be greater than 1.1 times the weight of water displaced by the riser.

- **Inlet**
  - An outlet riser pipe can be surrounded with a ‘pyramid’ of aggregate, or a specially prepared wire basket filled with rock. The wire basket must be securely fastened to the riser pipe if it is to also act as an anti-flotation weight.

- **Hydraulic capacity**
  - It is recommended that the primary outlet be designed to discharge the peak flow from the relevant design storm when the pond water is level with the crest of the emergency spillway.
  - The open riser pipe can then be used as a siphon spillway during significant storms or when blockage of the riser’s perforations occurs. An enlarged trash and safety screen may need to be installed on top of the riser.

- **Freeboard and anti-vortex device**
  - The crest elevation of the primary outlet should be a minimum of 0.3 m below the elevation of the crest level of the emergency outlet. For risers less than 1.5 m high, fitting an anti-vortex type trash rack is advisable (Figure 4.1).

- **Minimum size and anti-seep collar**
  - The minimum size of the barrel for a pipe outlet should be 250 mm diameter. At least one anti-seep collar should be placed on the riser pipe to prevent seepage along the outer surface of the pipe.

- **Drainage holes**
  - Perforation holes in the riser pipe should exist within both the settling and sediment zones. Drainage holes within the settling zone can be easily sized by use of the orifice
discharge formula, integrated with respect to the depth or head of water above the hole. The resulting expression for the area of the orifice is as follows (Goldman et al. 1986):

\[ A_0 = \frac{A_s \sqrt{2gh}}{3600 \ T \ C_d \sqrt{g}} \]  

(2)

where:
- \( A_0 \) = surface area of orifice (m\(^2\))
- \( A_s \) = surface area of basin (m\(^2\))
- \( h \) = head of water above orifice (m)
- \( T \) = dewatering time (hrs)
- \( C_d \) = discharge coefficient (adopt \( C_d = 0.60 \))
- \( g \) = gravitational constant (9.806 m/s\(^2\))

When a single large hole is to be used for dewatering, it should be located at the base level of the settling zone.

To maximise sediment trapping efficiency, several holes of different sizes could be used within the settling zone, with the size of the holes graded vertically. That is, one hole is provided at the base level of the settling zone, with progressively larger holes provided higher up the riser.

When multiple holes are used throughout the settling zone, it becomes necessary to adjust the relative areas of each hole to provide a suitable overall dewatering period. This must take into account the variation in head over the dewatering time.

Dewatering holes in the settling zone should be covered with wire mesh (25 to 50 mm opening) or coarse gravel to prevent blocking by debris, but should not generally be covered by geotextiles or filter cloths.

Dewatering of the sediment storage zone should be considered so as to facilitate basin clean-out. Dewatering can be achieved by using filtered holes in the riser, ideally at the base of the sediment storage zone.

**Use of filter cloth**

It is generally not recommended for filter cloth to be placed around an outlet riser pipe. However, if filter cloth is to be used, it should not be placed in close contact with the riser. An air gap is essential between the perforated riser and any geotextile to allow free draining of the basin.

Wire mesh should be wrapped around and secured to the riser before attaching geotextile filter cloth, to increase the rate of water seepage into the riser. The fabric must be replaced after each storm event.
The embankment can be formed from earth, rock, gabions or suitable crushed concrete depending on the preferred drainage system.

Rock can be used to form a rock filter dam outlet system. In this system a structural rock wall is constructed as the primary outlet system of the basin. The upstream face of the rock dam is either lined with aggregate or a layer of needle-punched filter cloth. It is the aggregate or filter cloth that controls the decant rate and prevents most of the fine sediment from passing through the dam.

An upstream aggregate layer has the advantage that it can be placed by machinery and can be readily replaced with a backhoe if it becomes blocked with sediment. However, some guidelines do not recommend the use of aggregate filter layers because of reported maintenance difficulties.

Rock filter dam with aggregate

Needle-punched filter cloth has the advantage of being cheap, but its replacement can be messy and leaks may occur if the replaced filter cloth is not installed properly. The filter cloth is usually placed over a thin layer of aggregate.

Gabion walls should be lined on the inside with filter cloth, not aggregate. The filter cloth should not be placed between gabion baskets.

The design and operation of sediment weir outlet systems is similar to gabion walls. For further information, refer to the IEAust Guidelines (1996).

Whichever method is used, reverse flush or replace the filter cloth each time sediment is removed from the basin.

Given conditions:

The total site area is 2 ha. Of this 2 ha, 0.5 ha remains undisturbed and can be diverted around the basin.

The time of concentration for the catchment = 5 min.

The critical sediment particle size = 0.02 mm.

Step 1 – Calculate design flow rate (Q)

\[
Q = \frac{(CIA)}{360}
\]

Runoff coefficient (c) for the 10 year storm (C10) = 0.8 for the disturbed site.

Now; \( C_1 = 0.80 \times C_{10} = (0.80)(0.80) = 0.64 \)
Rainfall intensity (I) for a 5 min storm = 117 mm/hr
Effective catchment area, A = 1.5 ha

\[ Q_1 = \frac{(0.64)(117)(1.5)}{360} = 0.312 \text{ m}^3/\text{s} \]

Design flow rate:
\[ Q = 0.25(Q_1) = (0.25)(0.312) = 0.078 \text{ m}^3/\text{s} \]

Step 2 – Calculate basin surface area (As)
Surface area: \( A_S = 3400(Q) = (3400)(0.078) = 265 \text{ m}^2 \)

Step 3 – Determine settling zone length, width and depth
Let basin length (L) = 3 times basin width (W)
Therefore the surface area \( A_S = 3W^2 \)

Basin width: \( W = 9.4 \text{ m} \)
Basin length: \( L = (3)(9.4) = 28.2 \text{ m} \)
Nominate a settling zone depth of 0.6 m

Therefore the settling zone volume = 159 \text{ m}^3 (=106 \text{ m}^3/\text{ha})

Note: at this stage no allowance has been made of the effects of the sloping sides of the basin. Also, the above dimensions are assumed to exist at the base of the settling zone.

Step 4 – Nominate sediment storage zone volume

Nominate a sediment storage zone depth equal to the depth of the setting zone = 0.6 m.

Note: the consequence of nominating an inadequate sediment storage volume is an increase in the frequency of basin desilting. Also, it is always preferable to increase the surface area rather than increase the settling depth as this improved the basin’s efficiency. However, the depth should not be less than 0.6 m.

Alternatively, the sediment storage volume can be determined by estimating the sediment capture volume using the RUSLE. Example calculations on the use of RUSLE can be found in Section 8.
FIGURE 4.1 TYPE C (DRY) BASIN WITH RISER OUTLET

Inflow

Emergency spillway

Sediment storage zone

Length: width ratio 3:1 min.

Plan View

Inflow

Sediment settling zone

Sediment storage zone

600 mm min.

600 mm min.

750 mm min.

300 mm min.

Primary outlet

Riser pipe open at top, fitted with an anti-vortex device and/or trash rack

Spacers between mesh and pipe (50 mm min.)

Perforated riser

Example only

Wire mesh

Needle punched geofabric

Flow

Cut-off trench 600 mm min. depth backfilled with impermeable clay and compacted

Outlet protection

Outlet protection

Crest of emergency spillway

Anti-seep collar

Primary outlet

Weighted base

Flow

Example only

Trash rack/anti-vortex device

150 mm min.

350 mm min.

R1

1

R2

R3

 originated from NSW Department of Housing, 1998

Example only
FIGURE 4.2 TYPE C (DRY) BASIN WITH ROCK FILTER DAM OUTLET

Inflow
Sediment storage zone
Sediment settling zone
Sediment settling zone
Crest of spillway

Length: width ratio 3:1 min.

Crest
Centre spillway (second option)
Side spillway (first option)

Rock embankment
Needle punched geotextile

Graded rock
100 mm dia.
300 mm min.

Outlet protection
Needle punched geotextile

20 mm - 30 mm aggregate to hold geotextile in place

50 mm to 75 mm aggregate
100 mm dia. graded rock

Centre spillway option
500 mm min.

Needle punched geotextile
placed over rock wall

Originally sourced from NSW Department of Housing, 1998
FIGURE 4.3 TYPE C (DRY) BASIN WITH GABION OUTLET

Sediment Basin Design, Construction, Operation and Maintenance

Inflow

Sediment storage zone

Length:width ratio 3:1 min.

Plan View

Inflow

Sediment settling zone

Sediment storage zone

500 mm min.

600 mm min.

Crest of spillway

Outlet protection

Gabion embankment

Outlet protection

Needle punched geotextile

Secure geotextile to gabions with 20 mm to 30 mm aggregate or other means

Spillway 500 mm min.

Downstream elevation

Long section

Originally sourced from NSW Department of Housing, 1998
Settling zone volume

To control the turbidity of contaminated stormwater runoff it is usually not feasible to rely solely on gravitational settlement, especially if the soils are dispersive. Both Type F and Type D basins are designed to trap and treat a specified volume of stormwater runoff while allowing excess water to pass through the basin and over the spillway.

Thus the critical design parameter for Type F and D basins is the pond settling volume. Where possible, the ‘effective’ settling volume of the basin should be maximised, but at a minimum depth. Adopting a shallow depth reduces settlement time which is a critical component in the operation of these basins.

These basins operate on the principle of producing high quality effluent from the more frequent storm events, while removing only coarse sediment from the larger, less frequent storm events. Even when the basin is full, contaminated water should continue to be directed to the basin to allow settlement of the coarse sediments.

The same methodology is used to size both Type F and D basins. The only difference between the basins is the recommended methods of operation, and the use of flocculants in the Type D basin.

The settling zone volume is determined as the capacity necessary to contain all runoff expected from the ‘y’ percentile, 5-day rainfall event.

\[
\text{Settling volume} = 10 \times C_v \times A^* \times R_{y\% \text{, 5-day}} \tag{3}
\]

\(C_v = \text{the volumetric runoff coefficient [dimensionless]}
\)

\(A^* = \text{catchment area draining to the basin [ha]}
\)

\(R_{y\% \text{, 5-day}} = \text{the 5-day total rainfall depth that is not expected to be exceeded in } y\% \text{ of rainfall events} = 40 \text{ mm for Brisbane.}
\)

Therefore, the settling volume: \(V_s = 400 \times C_v \times A^* \text{ [m}^3\text{]} \quad \tag{4}
\)(Brisbane only)

Outside Brisbane, adopt the following formula; however note, that this formula is only preliminary, detailed analysis will be required of rainfall patterns in different locations to confirm the suitability of this formula.
Note that the following section of this guide is currently under review:

\[ V_S = 100 \cdot I_{1y,24h} \cdot C_v \cdot A^* \]

where: \( I_{1y,24h} \) = Average 1 yr, 24 hr rainfall intensity [mm/hr]

Note: the volumetric runoff coefficient (\( C_v \)) is not the same as the discharge runoff coefficient (\( C \)) that is used in the Rational Method for calculating peak storm discharge.

Recommended volumetric runoff coefficients are presented in Table 5.1. Higher values should be used on sites that have surface sealing soils or have a high level of soil compaction (e.g. wheel compaction).

<table>
<thead>
<tr>
<th>Land condition</th>
<th>Coefficient (( C_v ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation or open soil</td>
<td>0.5</td>
</tr>
<tr>
<td>Impervious surfaces</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Further details on the determination of an appropriate volumetric runoff coefficient may be obtained from NSW Department of Housing (1998).

**Sediment storage volume**

The sediment storage volume may be determined as 50% of the calculated settling volume.

Alternatively, the Revised Universal Soil Loss Equation (RUSLE) may be used to estimate the sediment runoff volume over the duration of the disturbance, or for the nominated period between clean-outs, typically every 2-3 months. Further discussion is provided in Section 8.

**Outlet system**

The embankment and outlet system on a Type F and D basin needs to be designed and constructed such that discharge from the basin's settling and storage volume can be prevented during the settling period. This can be achieved with the construction of a watertight basin and the use of portable decant pumps.

A standard outlet riser may be constructed to aid in the decanting of these basins, but a valve system must be installed to regulate discharge during the settling period.

**Basin operation**

Operation of the basin should ensure, where possible, that water has drained from the settling zone of the basin, and preferably from the sediment storage zone, prior to the next rainfall event that causes runoff.
Type F and D basins are usually decanted 36 to 48 hours after each storm event. Where possible, a floating inlet chamber should be used to minimise the re-suspension and discharge of fine sediment.

If a pump is used to decant the basin, then the decanting must cease prior to settled sediments being drawn into the intake pipe.

The intake pipe must not be allowed to rest on or near the settled sediment.

### TECHNICAL NOTE

One alternative may be to construct a portable intake chamber in which to house the foot valve of the decant pump. An intake chamber may be constructed from PVC pipe of suitable diameter and length (i.e. for the given foot valve diameter and pond depth).

The pipe is sealed at one end and a small hole may be placed in this end of the pipe to allow it to fill with water when first placed in the basin. Large holes are placed in the top (open) end of the pipe to allow water from the surface of the basin to readily flow into the pipe.

A water-tight drum or other suitable flotation system is then attached to the pipe to enable the top of the pipe to float near the water surface. This flotation device should aim to hold the open end of the pipe above the settled sediment when the basin is fully drained, thus preventing the inflow of sediment into the pipe.

A recovery or anchor rope is attached to the open end of the pipe and secured to the bank. The pump intake hose with foot valve (if attached) is placed into the PVC pipe and the pipe is then placed in the basin.

The aim of the intake chamber is to prevent settled sediment flowing into the decant pump and to allow water to be discharged only from the surface of the basin.

A marker peg should be installed in the basin to clearly identify both the maximum sediment storage level.

Sediment extracted from the basin shall be suitably disposed of in sediment dumps, or mixed with on-site soils in a manner that will not result in unnecessary soil erosion or sediment runoff from the site. Otherwise, the sediment shall be dried and removed from the site.

### Sediment flocculation

Many flocculating agents exist, including gypsum, alum, ferric chloride, ferric sulfate, polyelectrolytes (long-chain natural and synthetic organic polymers) and salt (sodium chloride). Gypsum and alum have traditionally been applied to captured stormwater
runoff. Gypsum (calcium sulfate) and alum (aluminium sulfate) are suitable chemicals for this purpose and are applied within 24 hours of the conclusion of each storm event as follows:

**Application**

(i) in larger ponds - mixed into a slurry with water and then sprayed over the pond surface; or

(ii) in smaller ponds and tanks - by simply broadcasting it over the surface by hand.

Whichever method is chosen, it is essential that the flocculating agent is spread evenly over the entire pond surface for proper treatment of water unless local experience or other criteria suggest differently.

Gypsum should be applied at a rate of about 32 kilograms per 100 cubic metres of stored water. Conversely, alum should be applied at 1.5 to 8 kilograms per 100 cubic metres of stored water (higher rates are more effective but can influence water pH more).

Care should be taken with the choice of an agent, its dosing rate and any special conditions to ensure that toxic situations are not created with consequent damage to the ecology.

In areas where repeated high intensity storms are likely, it is recommended that gypsum dosage rates be increased to 70 kilograms per 100 cubic metres. Depending on the clay mineralogy, this can achieve flocculation within 24 hours allowing discharge within two days from the conclusion of a storm.

**Effectiveness of agents**

When choosing a flocculating agent, note that:

(i) the trivalent positive aluminium (Al\(^{3+}\)) ion is 2,000 times more effective than the monovalent positive sodium (Na\(^{+}\)) ion; and

(ii) the bivalent positive calcium (Ca\(^{2+}\)) ion is only 50 times more effective than sodium (Barnes, 1981).

As such, alum produces a faster flocculation rate than gypsum, which has been shown for sediment basins in New South Wales (Goldrick, 1996). Table 5.2 below summarises some characteristics of common flocculating agents. Trials should be conducted on samples to determine the most appropriate dosing rate to reduce the likelihood of excessive dosing.

The use of alum as a flocculant is only recommended when it is used under controlled circumstances and by users that are aware of the potential downstream risks to the environment.

Details of the flocculation and decanting procedures should be provided in the Erosion and Sediment Control Program.
<table>
<thead>
<tr>
<th>AGENT</th>
<th>INDICATIVE DOSAGE</th>
<th>COMMENTS</th>
<th>PRECAUTIONS AND CONSTRAINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gypsum (calcium sulphate)</td>
<td>32 kg/100 m³</td>
<td>Little pH change, slight increase in salinity.</td>
<td>Needs to be spread evenly across pond, can cause scum deposits in equipment.</td>
</tr>
<tr>
<td>Alum (aluminium sulfate)</td>
<td>1.5-8 kg/100 m³</td>
<td>Produces stable sludge that binds pollutants, optimum pH 6 to 7.4. Do NOT overdose as pH will be lowered.</td>
<td>Likely toxic impacts on ecology at pH levels &lt; 5.5 due to release of dissolved aluminium. Must only be used in controlled conditions.[1]</td>
</tr>
<tr>
<td>Ferric chloride</td>
<td>1-3 kg/100 m³</td>
<td>pH greater than 5 is required or it might lower oxygen levels.</td>
<td>Is very corrosive, needs rubber or glass containment. Do not overdose.[1]</td>
</tr>
<tr>
<td>Ferric sulfate</td>
<td>1-2.5 kg/100 m³</td>
<td>pH greater than 5 is required.</td>
<td>Stored in wooden containers. Do not overdose.[2]</td>
</tr>
<tr>
<td>Polyelectrolytes (long chained polymers)</td>
<td>0.05-0.2 kg/100 m³</td>
<td>Careful preparation needed and adequate mixing with water body needed, little pH or salinity change, might be toxic.</td>
<td>A few are banned for use with potable water in some countries due to possible monomer impurities, do not overdose.</td>
</tr>
<tr>
<td>Salt (sodium chloride)</td>
<td>5.25 m³ seawater per 100 m³ of fresh water</td>
<td>Flocculation is complete for some clays with 2000 to 3000 mg/L, little extra benefit is gained when the salinity is above 10,000 mg/L.</td>
<td>Only used when the sediment basin discharges directly to sea water. Note: sea water contains approximately 35,000 mg/L salt.</td>
</tr>
</tbody>
</table>

Notes [1] The pH of the water in the basin must be in the range of 6.5-8.5 before release.

**Settlement time**

Normally, sufficient sediment will have flocculated and settled within about 36 to 72 hours in the case of gypsum.

**Expected water quality**

Following flocculation, a total suspended solid (TSS) content of less than about 50 milligrams per litre is typically achievable. A practical field test that approximates this level is to fill a clear plastic or glass 65 mm diameter soft drink bottle with the water and hold it up to the light. If seeing clearly through the sample is not possible, it is probably above about 50 milligrams per litre and needs further treating.
The pH of the flocculated water must be in the range 6.5 to 8.5 prior to discharge. If this is not achieved, pH adjustment may be necessary (e.g. dosing with lime to raise pH).

Site calibration

Despite the above comments, each pond should be calibrated after the first two storm events to assess the actual flocculent application rate and settling time required. Standard jar tests are the usual method (Barnes, 1981).

In some situations it might be necessary to test water samples in a laboratory before discharge to prove that the suspended solid content is, in fact, below recommended levels, e.g. where the receiving waters are particularly sensitive. In these cases, sampling details should be clearly set out on the site’s Erosion and Sediment Control Program.

The final application rate should be sufficiently high to permit sediment flocculation and pond discharge within two to four days from the conclusion of each storm event, whilst maintaining other required water quality criteria such as pH.

Water discharge

The water can be discharged from the basin once the suspended solid load has been lowered to an acceptable level. Achieve discharge with a system that:

(i) permits drainage of the pond in less than 24 hours; and

(ii) has a floating inlet to prevent flocculated sediments being removed as well - it is essential that materials from the sediment layer are not discharged in the pumping process.

Warnings

(a) With use of alum, accurate measurement of water pH must be undertaken to ensure that values remain in the range of 6.5 to 8.5. Values lower than pH 5.5 will result in environmentally toxic concentrations of soluble aluminium that can kill fish and other aquatic life. Further, treated waters should not be discharged if the pH is below 6.5 unless site-specific environmental risk assessment shows that it is safe to do so.

(b) Excessive dosing with polyelectrolytes can:

• result in the release of materials that can kill fish and other aquatic life; and
• reduce the effectiveness of the flocculent.

It is understood that the Polyelectrolyte Suppliers Group is producing a manual for polyelectrolyte use called Responsible Care® Guidelines for Use to advise on these and other matters.
Design example

Given site conditions:

Total catchment area draining to the basin = 1.2 ha. It has been judged that the basin will be at its design limit when 0.8 ha of the site is open earth and 0.4 ha is sealed surface. Soil tests indicate that site soils contain 20% clay (< 0.002 mm), 18% silt (0.002 mm), 18% silt (0.002–0.02 mm) and a dispersion index of 40%.

Step 1 – Determine the volumetric runoff coefficient
Given \( C_v = 0.5 \) for open soil
\[ C_v = 1.0 \text{ for sealed surfaces} \]
The effective \( C_v = \frac{(0.8)(0.5) + (0.4)(1.0)}{1.2} = 0.667 \)

Step 2 – Calculate settling volume
\[ V_s = 400.C_v.A \]
\[ V_s = (400)(0.667)(1.2) = 320 \text{ m}^3 (266 \text{ m}^3/\text{ha}) \]

Step 3 – Choose basin dimensions
Nominate a settling depth of 0.6 m
Surface area approximately equals 533 m² at the base of the setting zone.
Let \( L = 3W \)
Therefore, \( W = 13.3 \text{ m} \) and \( L = 40 \text{ m} \)

Step 4 – Determine the sediment storage volume
Select a sediment storage volume equal to half the settling volume = 160 \text{ m}^3

At a surface area of around 533 m² (not allowing of the effects of the sloping sides), the sediment storage depth will be slightly deeper than 0.3 m.

Step 5 – Determine whether the basin will be managed as a Type F or D
Soils that are considered dispersible have a combined percentage of clay (< 0.002 mm) plus half the percentage of silt (0.002–0.02 mm) expressed as a decimal fraction, multiplied by the dispersion percentage (Richie, 1963) equal to or greater than 10.

Given
\[
\begin{align*}
20\% \text{ Clay} \\
18\% \text{ Silt} \\
40\% \text{ Dispersion Index}
\end{align*}
\]

Therefore \((0.20 + 0.09) \times 40 = 11.6\%\),
Thus greater than 10% of soil is dispersible and a Type D basin is required.
Figure 5.1 Type F and D (Wet) Sediment Basin

**Plan view**

- Inflow
- Sediment storage zone
- Sediment settling zone
- Original ground level
- Water depth 1500 mm min.
- Crest of spillway
- Cut-off trench 600 mm min. depth backfilled with impermeable clay and compacted

**Long section**

- Length:width ratio 3:1 min.
- Length
- Width
- Earth embankment
- Spillway
- Crest
- Original ground level
- Sediment settling zone
- Sediment storage zone
- Water depth 1500 mm min.
- 750 mm min.
- 600 mm min.
- 2 min.
- 3 min.
- 1

Originally sourced from NSW Department of Housing, 1998
6. Use of baffles

Introduction

Baffles are used in sediment basins to improve the efficiency of the basin's settling characteristics and to keep coarse sediment away from the outlet system.

Baffles used to improve the inlet characteristics

If sediment-laden water is allowed to enter the basin at high velocity, then a submerged jet can be formed that propels the sediment towards the outlet end of the basin. In Type C basins, this jetting action can significantly reduce the efficiency of the basin.

An inlet chamber can be used to control jetting and allow sediment-laden water to enter evenly across the full width and depth of the basin. These chambers can be constructed using baffles as described in Section 3 of the guidelines.

Baffles used to alter the effective length to width ratio

The effective length of a basin can be increased with the use of baffles. If baffles are installed, then a check should be made on the potential scour velocity. Sediment scour velocities can be determined from Table 6.1.

<table>
<thead>
<tr>
<th>Critical particle diameter (mm)</th>
<th>Scour velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.16</td>
</tr>
<tr>
<td>0.05</td>
<td>0.11</td>
</tr>
<tr>
<td>0.02</td>
<td>0.07</td>
</tr>
</tbody>
</table>

The crest of these baffles should be set level with, or just below the spillway crest level. This is to prevent the resuspension of settled sediment during severe storms (i.e. flood waters are meant to flow over the baffles, not around them).

Baffles used to restrict sedimentation around the outlet structure

Maintenance of a sediment basin can be expensive if the outlet system of a basin becomes blocked with sediment or the outlet is damaged during the desilting procedure. A sediment fence baffle constructed around the outlet system limits the flow of coarse sediment around the outlet and may also improve the hydraulic efficiency of the basin.
Figure 6.1 Internal Flow Control Baffles

(a) If the outlet is located here, a baffle is required.

(b) If the outlet is placed here, no baffle is required.

(c) In this case, it is important to place the baffle so that $L_1 = L_2$.

(d) Sheets of 1200 mm x 400 mm x 13 mm marine plywood or sediment fence fabric.

Elevation of basin bottom: 1200 mm centres.

RL of primary outlet crest:
- Posts: minimum of 100 mm square or 130 mm round and set sufficiently deep to ensure stability in the design storm event.
FIGURE 6.2 INLET AND OUTLET CONTROL BAFFLES (PLAN VIEW)

Inlet chamber baffle

Flow

Primary outlet

Outlet baffle

Inlet

FIGURE 6.3 INLET AND OUTLET CONTROL BAFFLES (LONG SECTION)

Inlet chamber baffle

Settled sediment

Primary outlet

Emergency spillway

Anti-seep collars

Anti-flotation mass

Inlet
Sediment Basin Design, Construction, Operation and Maintenance

FIGURE 6.4 INLET CHAMBER BAFFLE

Inlet chamber baffle

Flow

0.05 m

0.3 m

0.5 - 1.0 m

Sediment fence
fabric not
filter cloth
7. Soil tests

**Jar Settlement Test**

The Jar Settlement Test provides an indication of the settling characteristics of a soil. This is simply an indicator test and cannot be used to justify a sediment basin design or operating procedure.

**Equipment:**
- clear jar with water tight lid (e.g. 250 ml glass jam jar);
- distilled or de-ionised water (available at service stations).

**Procedure:**
Place a small hand full of crushed soil into the jar (approximately 100 ml or 10 cm$^3$). Fill the jar with distilled or de-ionised water and shake the jar vigorously to disperse the soil into its sand, silt and clay particles.

Place the jar on a solid surface where it can remain undisturbed for at least 5 days.

**Results:**
The sand-size particles should settle within a minute followed by a wave of silt-size particles over the next few minutes.

If the clay particles settle within an hour, leaving clear or near-clear water above the settled soil, then the soil is likely to be suitable for treatment by a Type C sediment basin.

If the clay particles settle within 5 days, leaving clear or near-clear water above the settled soil, then the soil is likely to be suitable for treatment by a Type F sediment basin.

If the clay particles fail to settle, then it is likely that it is a Type D soil and chemical flocculation of the sediment basin will be required.

**Discussion:**
This should only be considered as an indicator test because in a real basin some non-dispersive soils may settle rapidly due to the fine clay particles remaining bound to other soil particles or held in small clumps. With such soil, their actual settling characteristics may depend on how much disturbance the clay particles experience in their travels from the disturbance area to the basin.
Aggregate Immersion Test

The Aggregate Immersion Test is similar to the Field Emerson Aggregate Test described below, except undisturbed samples of the soil are tested rather than a formed ‘bolus’.

Equipment:
• open dish or jar (e.g. white plastic breakfast bowl); and
• distilled or de-ionised water (available at service stations).

Procedure:
Fill the dish or jar with distilled water to a depth sufficient to cover the soil samples. Gently place several dry, hard clumps of soil (about 5 mm square) in the water – don’t put the soil in the dish before the water is added. Leave an hour, and do not disturb the water during the test.

The clumps of soil will completely collapse if the soil is slaking or dispersible. Highly dispersible or slaking soils will collapse in less than 10 minutes. A cloudy ring will be seen around the collapsed soil when it is dispersible.

Slaking soils must be distinguished from dispersive soils. Slaking soils readily break down in water, but they do not disperse (cloud the water).

In this test, some potentially dispersive soils may take more than 10 minutes to respond because the dispersive clay particles may be locked inside areas of non-dispersive soil. In the ‘Field Emerson Aggregate Test’ dispersive soils react faster because a reconstituted ‘bolus’ of soil is first formed.

Results:
Non-dispersive: Water remains clear though particles may slightly collapse. The boundary of clumps remains clearly defined.
Slightly dispersive: Discolouration surrounding particles or distinct cloudiness surrounding some. Boundary of clumps vaguely defined.
Dispersive: Dispersive and cloudiness surround most or all particles (extending vertically). Boundary of clumps not able to be defined.
Highly dispersive: Discolouration extending vertically throughout most or all water.
Slightly slaking: Water remains clear. Boundary of clumps vaguely defined.
Slaking: Water remains clear. Boundary of clumps not able to be defined. The clumps completely collapse and spread horizontally.
Field Emerson Aggregate Test

The Field Emerson Aggregate Test is based on the Emerson Aggregate Test (Emerson, 1967). This test is described in NSW Department of Housing (1998) and is detailed below.

Equipment:
• clear glass container; and
• distilled or de-ionised water (available at service stations).

Procedure:
In this test, a sample of soil material is taken from the likely sediment source and worked up as a bolus. Next, a 5 to 10 mm cube of the bolus material is placed gently, in a clear glass container previously filled with sufficient distilled water to cover the soil. It is left to stand undisturbed for about 3 minutes, with any change in condition noted.

Results:
One of two conditions is likely to occur:
• there will be no change; or
• the sample will slake and/or disperse.

If there is no change or the sample slakes, further laboratory testing should not be necessary. However, if any of the bolus disperses and goes into suspension (the water becomes milky), undertake laboratory testing to ascertain whether more than 10 percent of the soil materials are dispersive. Note that the more material that goes into suspension, the more dispersive is that sample.

Slaking soils must be distinguished from dispersive soils. Slaking soils readily break down in water, but they do not disperse (cloud the water).

How to form a bolus

To form a bolus, first ensure that your hands are clean – particularly, free of grease or oil – a sample of soil that can comfortably fit into the palm of the hand is then taken. Crush the soil structure with a pestle and mortar and pass it through a 2 mm sieve to remove any gravel or coarser materials.

Water is then added very slowly and the sample kneaded until all structure is broken down and the ball of soil just fails to stick to the fingers. More water or soil can be added to attain this condition called the sticky point, this approximates the field capacity for that soil.
Continue kneading and moistening until there is no further apparent change in the soil ball, usually about 2 or 3 minutes. The soil ball so formed is called a bolus.

Note; some soils:

(i) feel sticky as soon as water is added, but lose the condition as the bolus is formed - or at least until the sticky point is reached;

(ii) are far stickier than others; and

(iii) are very much harder to knead than others, e.g. heavy clays.
There are a number of models currently available to assist in the estimation of soil runoff rates. These include, the Universal Soil Loss Equation (USLE), the Revised Universal Soil Loss Equation (RUSLE), the Modified Universal Soil Loss Equation (MUSLE), CREAMS and the Australian SOILLOSS program.

In this document the RUSLE method is recommended for the prediction of soil loss rates. RUSLE is designed to predict the long term, average, annual soil loss from sheet and rill flow at a given location.

The main limitations of the RUSLE method are that it:

(i) only predicts soil erosion and cannot predict the actual amount of soil entering a given basin;

(ii) predicts annual sediment runoff, not that expected from a given storm or over a given period less than 12 months;

(iii) only considers soil runoff caused by sheet and rill erosion and does not account for erosion caused by concentrated flow; and

(iv) does not adequately account for soil dispersibility.

The RUSLE model calculates annual erosion rates using the following formula:

\[ A = R \cdot K \cdot LS \cdot P \cdot C \]  \hspace{1cm} (5)

where:

- \( A \) = annual soil loss due to erosion (tonnes/ha/yr)
- \( R \) = rainfall erosivity factor
- \( K \) = soil erodibility factor
- \( LS \) = topographic slope/length factor
- \( P \) = erosion control practice factor
- \( C \) = cover and management factor

The annual soil loss rate (A) needs to be multiplied by several factors before an estimate can be obtained of the volume of soil trapped by a basin.

\[ V_s = K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot A \]  \hspace{1cm} (6)
where:

\[ V_s = \text{Expected volume of captured sediment [m}^3\text{]} \]

\[ K_1 = \text{inverse of settled soil bulk density, typically 0.80 m}^3\text{/tonnes} \]

\[ K_2 = \text{area of exposed soil [ha]} \]

note: this may be less than the effective catchment area discharging to the basin because it does not include non erodible surfaces such as sealed surfaces and well-vegetated areas

\[ K_3 = \text{duration of exposure [years]} \]

note: if the exposure of a site is expected to change significantly over a long period, then soil loss estimates may be determined for periods of say 1 month over the duration of the disturbance

\[ K_4 = \text{expected capture percentage of soil particles} \]

= percentage of soil particles larger than the critical sediment size, usually 0.02 mm

**R-factor**

The R-factor is derived from probability statistics resulting from analysing rainfall records of individual storms. The R-factor may be determined from the following formula:

\[ R = 29.22 \left( \frac{6I_2}{1.89} \right) \]  

(7)

Where, \( \frac{6I_2}{1.89} \) is the 2 year ARI [mm/hr], 6 hour average storm intensity.

For Brisbane: \( \frac{6I_2}{1.89} = 13.33 \text{ mm/hr} \) \( R = 3900 \)

**K-factor**

For most construction sites, the K-factor should be determined for the exposed subsoils. Unfortunately, most K-factors in Queensland have been determined for topsoils – the soils most commonly exposed in farming practices.

The IEAust Soil Erosion and Sediment Control Guidelines (1996) provide K-factors for various soils in Queensland. Table 8.1 provides K-factors for some subsoils. K-factors for various topsoils may be found in the IEAust guidelines.
Generally the K-factors range from 0.005 (very low), to 0.040 (high) to 0.075 (extreme).

To account for soil dispersion, the K-factor should be increased by 20% for all dispersible soils.

In the absence of proper soil testing, K-factors may be determined from Table 8.2.

### TABLE 8.1 MEASURED K-FACTORS FOR QUEENSLAND SUBSOILS

<table>
<thead>
<tr>
<th>Subsoil Location</th>
<th>K-factor SI units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solodic B horizon Gatton-Esk Road</td>
<td>0.068</td>
</tr>
<tr>
<td>Solodic B horizon Plainlands</td>
<td>0.035</td>
</tr>
<tr>
<td>Solodic B horizon Hattonvale</td>
<td>0.049</td>
</tr>
</tbody>
</table>

### TABLE 8.2 APPROXIMATE K-FACTORS DERIVED FROM SOIL TEXTURE FOR USE IN RUSLE (SCS, 1993)

<table>
<thead>
<tr>
<th>SOIL TEXTURE</th>
<th>SYMBOL</th>
<th>K-FACTOR</th>
<th>SOIL TEXTURE</th>
<th>SYMBOL</th>
<th>K-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>S</td>
<td>0.015</td>
<td>Clay loam</td>
<td>CL</td>
<td>0.03</td>
</tr>
<tr>
<td>Clayey sand</td>
<td>CLS</td>
<td>0.025</td>
<td>Silty clay loam</td>
<td>SiCL</td>
<td>0.04</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>LS</td>
<td>0.02</td>
<td>Fine sandy clay loam</td>
<td>FSCL</td>
<td>0.025</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>SL</td>
<td>0.03</td>
<td>Sandy clay</td>
<td>SC</td>
<td>0.017</td>
</tr>
<tr>
<td>Fine sandy loam</td>
<td>FSL</td>
<td>0.035</td>
<td>Silty clay</td>
<td>SiC</td>
<td>0.025</td>
</tr>
<tr>
<td>Sandy clay loam</td>
<td>SCL</td>
<td>0.025</td>
<td>Light clay</td>
<td>LC</td>
<td>0.025</td>
</tr>
<tr>
<td>Loam</td>
<td>L</td>
<td>0.04</td>
<td>Light medium clay</td>
<td>LMC</td>
<td>0.018</td>
</tr>
<tr>
<td>Loam, fine sandy</td>
<td>Lfsy</td>
<td>0.05</td>
<td>Medium clay</td>
<td>MC</td>
<td>0.015</td>
</tr>
<tr>
<td>Silt loam</td>
<td>SIL</td>
<td>0.055</td>
<td>Heavy clay</td>
<td>HC</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Note: The suggested K-values are for the mid points of a texture class. Use average values for soils which lie between classes.
LS-factor
The LS-factor is a numerical representation of the length-slope combination. The LS-factor may be obtained from Table 8.3, (NSW Department of Housing, 1998).

P-factor
The P-factor measures the combined effect of all support practices and management variables. It also represents structural methods for controlling erosion.

The P-factor is reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill. At construction sites, it reflects the roughening or smoothing of the soil surface by machinery. The P-factor may be obtained from Table 8.4 (after NSW Department of Housing, 1998).

TABLE 8.3 LS-FACTORS ON CONSTRUCTION SITES FOR USE IN THE RUSLE

<table>
<thead>
<tr>
<th>SLOPE RATIO</th>
<th>SLOPE %</th>
<th>SLOPE LENGTH (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>100:1</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>50:1</td>
<td>2</td>
<td>0.14</td>
</tr>
<tr>
<td>33:1</td>
<td>3</td>
<td>0.17</td>
</tr>
<tr>
<td>25:1</td>
<td>4</td>
<td>0.21</td>
</tr>
<tr>
<td>20:1</td>
<td>5</td>
<td>0.24</td>
</tr>
<tr>
<td>16.6:1</td>
<td>6</td>
<td>0.28</td>
</tr>
<tr>
<td>12.5:1</td>
<td>8</td>
<td>0.34</td>
</tr>
<tr>
<td>10:1</td>
<td>10</td>
<td>0.42</td>
</tr>
<tr>
<td>8.3:1</td>
<td>12</td>
<td>0.52</td>
</tr>
<tr>
<td>7:1:1</td>
<td>14</td>
<td>0.62</td>
</tr>
<tr>
<td>6.3:1</td>
<td>16</td>
<td>0.71</td>
</tr>
<tr>
<td>5:1</td>
<td>18</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>5:1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>4:1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>3:1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2.5:1</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>2:1</td>
<td>50</td>
</tr>
</tbody>
</table>
C-factor

The C-factor measures the combined effect of all the interrelated cover and management variables. It also represents non-structural methods for controlling erosion.

C-factors may be obtained from Table 8.5 (after NSW Department of Housing, 1998).

### TABLE 8.4 P-FACTORS FOR CONSTRUCTION SITES

<table>
<thead>
<tr>
<th>SURFACE CONDITION</th>
<th>P-FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compacted and smooth</td>
<td>1.3</td>
</tr>
<tr>
<td>Track-walked along the contour</td>
<td>1.2</td>
</tr>
<tr>
<td>Track-walked up and down the slope</td>
<td>0.9</td>
</tr>
<tr>
<td>Punched straw [1]</td>
<td>0.9</td>
</tr>
<tr>
<td>Loose to 0.3 metres depth</td>
<td>0.8</td>
</tr>
</tbody>
</table>

[1] Straw mulch punched into loose ground with a disc harrow.

Sediment Basin Design, Construction, Operation and Maintenance
<table>
<thead>
<tr>
<th>TYPE OF COVER</th>
<th>C - FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mulching or seeding, no plant roots</td>
<td>1.00</td>
</tr>
<tr>
<td>Little or no aboveground plant material but roots still intact and undisturbed</td>
<td>0.45</td>
</tr>
<tr>
<td>Open - weave jute mesh (&lt;40% coverage of soil - this is not jute mat)</td>
<td>0.40</td>
</tr>
<tr>
<td>Straw anchored to soil:</td>
<td></td>
</tr>
<tr>
<td>(i) 2.2 tonnes/ha and</td>
<td></td>
</tr>
<tr>
<td>(a) 6 - 10% slope, up to 30 m long</td>
<td>0.20</td>
</tr>
<tr>
<td>(b) ≤ 5% slope, up to 60 m long</td>
<td>0.20</td>
</tr>
<tr>
<td>(ii) 4.5 tonnes/ha and</td>
<td></td>
</tr>
<tr>
<td>(a) 34 - 50% slope, up to 10 m long</td>
<td>0.20</td>
</tr>
<tr>
<td>(b) 26 - 33% slope, up to 15 m long</td>
<td>0.17</td>
</tr>
<tr>
<td>(c) 21 - 25% slope, up to 22 m long</td>
<td>0.14</td>
</tr>
<tr>
<td>(d) 16 - 20% slope, up to 30 m long</td>
<td>0.11</td>
</tr>
<tr>
<td>(e) 11 - 15% slope, up to 45 m long</td>
<td>0.07</td>
</tr>
<tr>
<td>(f) 6 - 10% slope, up to 60 m long</td>
<td>0.06</td>
</tr>
<tr>
<td>(g) &lt; 5% slope, up to 120 m long</td>
<td>0.06</td>
</tr>
<tr>
<td>Woodchip applied at:</td>
<td></td>
</tr>
<tr>
<td>(i) 16 tonnes/ha and</td>
<td></td>
</tr>
<tr>
<td>(a) 16 - 20% slope, up to 15 m long</td>
<td>0.08</td>
</tr>
<tr>
<td>(b) ≤ 15% slope, up to 22.5 m long</td>
<td>0.08</td>
</tr>
<tr>
<td>(ii) 27 tonnes/ha and</td>
<td></td>
</tr>
<tr>
<td>(a) 21 - 33% slope, up to 22.5 m long</td>
<td>0.05</td>
</tr>
<tr>
<td>(b) 16 - 20% slope, up to 30 m long</td>
<td>0.05</td>
</tr>
<tr>
<td>(c) ≤15% slope, up to 45 m long</td>
<td>0.05</td>
</tr>
<tr>
<td>(iii) 56 tonnes/ha and</td>
<td></td>
</tr>
<tr>
<td>(a) 34 - 50% slope, up to 22.5 m long</td>
<td>0.02</td>
</tr>
<tr>
<td>(b) 21 - 33% slope, up to 30 m long</td>
<td>0.02</td>
</tr>
<tr>
<td>(c) 16 - 20% slope, up to 45 m long</td>
<td>0.02</td>
</tr>
<tr>
<td>(e) ≤ 15% slope, up to 60 m long</td>
<td>0.02</td>
</tr>
<tr>
<td>Woven straw blanket</td>
<td>0.08</td>
</tr>
<tr>
<td>Seeded grasses after 60 days (average conditions using perennial rye or millet)</td>
<td>0.05</td>
</tr>
<tr>
<td>Bitumen emulsion (12,000 L/ha)</td>
<td>0.02</td>
</tr>
<tr>
<td>Jute fine mat (100% coverage of soil)</td>
<td>0.01</td>
</tr>
<tr>
<td>Turf (100% coverage of soil)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Undisturbed native vegetation or well established grass (100% coverage)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Example

Given:

- \( R = 3900 \) (Brisbane)
- \( K = 0.04 \) Assumed soil type
- \( LS = 2.05 \) Average 80 metres at 8% slope
- \( P = 1.3 \) Typical rubber tyre compacted soil
- \( C = 1.0 \) Worst case - before mulching

Soil bulk density (\( K_1 \)) = 0.8 m³/tonne (1.25 tonnes/m³)
Disturbed construction area (\( K_2 \)) = 2 ha
Construction period = 8 months (i.e. \( K_3 = 8/12 \))
80% of soil particles larger than 0.02 mm (i.e. \( K_4 = 0.8 \))

Calculation:

\[
A = R \times K \times LS \times P \times C \\
= (3900)(0.04)(2.05)(1.3)(1.0) \\
= 416 \text{ tonnes/ha/year}
\]

\[
V_s = K_1 \times K_2 \times K_3 \times K_4 \times A \\
= (0.8)(2)(8/12)(0.8)(416) \\
= 355 \text{ m}^3
\]

On a real site, these calculations would be broken down into approximately two-week or one-monthly periods and the various factors calculated separately for the expected site condition during each of these periods. This would allow for the effects of progressive disturbance of the site as well as progressive stabilisation.
 Specifications and Construction Details

The following is the recommended construction specifications for sediment basins.

Construction

1. Refer to approved plans for location, extent, and details. If there are questions or problems with the location, extent, or methods of installation, contact the engineer or responsible on-site personnel for assistance.

Site preparation:

2. Before starting any clearing or construction, have all the necessary materials and components on the site to avoid delays in completing the pond once work begins.

3. Clear, grub and strip topsoil from areas under the proposed embankment. Delay clearing the basin area until the dam is complete.

4. Stockpile all topsoil for use on the embankment.

5. Place temporary sediment control measures below the basin as required.

Cutoff trench:

6. Excavate a cutoff trench along the centerline of the earth fill embankment. Cut the trench to stable soil material, but in no case make it less than 600 mm deep. The cutoff trench must extend into both abutments to at least the elevation of the riser pipe crest. Make the minimum bottom width wide enough to permit operation of excavation and compaction equipment, but in no case less than 600 mm. Make the side slopes of the trench no steeper than 1:1.

7. Any water that accumulates in the trench must be removed. The trench must be backfilled with soil of the same quality as that to be used in the dam. Compaction requirements are the same as those for the embankment.

Embankment:

8. Take fill material from the approved areas shown on the plans. It should be clean soil, free of roots, woody vegetation, rocks and other unsuitable material. Scarify areas on which fill is to be placed before placing the fill.
9. The fill material must contain sufficient moisture so it can be formed by hand into a ball without crumbling. If water can be squeezed out of the ball, it is too wet for proper compaction. Place fill material in 150 to 250 mm continuous layers over the entire length of the fill area and then compact it.

10. Unless otherwise specified on the approved plans, compact the soil at about 1-2% wet of optimum and to 95% modified or 100% standard compaction.

11. Construct the embankment to an elevation 10% higher than the design height to allow for settling.

12. Do not use the embankment as a dump for debris from building the settling pool.

Conduit outlet:

13. Drill dewatering holes in the riser as specified on the plan.

14. Securely attach the riser to the conduit or conduit stub to make a watertight structural connection. Secure all connections between conduit sections by approved watertight assemblies. Attach the anti-seep collars to the conduit as shown on the approved plan. Place the conduit and riser on a firm, smooth foundation of impervious soil. Do not use pervious material such as sand, gravel, or crushed rock as backfill around the conduit or anti-seep collars.

15. Place fill material around the conduit in 100 mm layers and compact it under and around the pipe to at least the same density as the adjacent embankment. Care must be taken not to raise the pipe from firm contact with its foundation when compacting under the pipe haunches.

16. Place a minimum depth of 600 mm of lightly compacted backfill over the conduit before crossing it with construction equipment. Anchor the riser in place by concrete or other satisfactory means to prevent flotation. In no case should the conduit be installed by cutting a trench through the dam after the embankment is completed.

17. Attach anti-floatation weights, anti-vortex device and trash guard to riser and as required – refer to specifications shown on the approved plan.

Emergency spillway:

18. Install the emergency spillway in undisturbed soil whenever possible. The achievement of planned elevations, grades, design width, and entrance and exit channel slopes are critical to the successful operation of the emergency spillway.
Sediment Basin Design, Construction, Operation and Maintenance

Basin inflow:

19. Discharge water into the basin in a manner that will not cause soil erosion. Use diversions with outlet protection to divert sediment-laden water to the upper end of the pool area to improve basin trapping efficiency.

Sediment settling pool area:

20. Place a post or stake to indicate clearly the depth at which accumulated sediment must be removed. The top of the stake must indicate the elevation of the top of the sediment storage volume. Use at least a 100 mm post firmly set in the basin floor. Refer to the plan for the top elevation of the post.

Erosion control:

21. The sediment basin should be constructed in a way that minimises the total disturbed area. Divert surface water away from bare areas. Complete the embankment before the area is cleared. Stabilise the emergency spillway, embankment and all other disturbed areas above the crest of the emergency spillway immediately after construction.

Safety aspects:

22. Sediment basins may attract children and can be dangerous. Avoid steep, smooth internal slopes. Appropriately fence basins and post warning signs if unsupervised public access is likely and public safety is at risk.

23. If public safety is a concern, and if the basin banks are steeper than 3(h):1(v), then at least one bank should be turfed a width of at least two (2) metres from top of bank to the toe of bank to allow ease of exit during wet weather.

Maintenance

1. Inspect the sediment basin during the following periods:

(i) **during construction**: to determine whether machinery, falling trees, or construction activity has damaged any components of the sediment basin. If damage has occurred, repair it.

(ii) **after each runoff event**: to ensure that runoff into the basin has caused damage or sediment has accumulated to a level where it must be removed. If damage has occurred, make the necessary repairs. If necessary, remove the accumulated sediment and restore the original storage volume.

2. Clean out accumulated sediment when it reaches the top of the indicator post. Place sediment in a disposal area or, if appropriate, mix with dry soil on the site.

3. Do not dispose of sediment in a manner that will create an erosion hazard.

4. Check all pipe connections for leaks, and repair as necessary.
5. Check fill material in the dam for excessive settlement, slumping of the slopes or piping between the conduit and the embankment; make all necessary repairs.

6. Remove all trash and other debris from the basin and riser.

**Removal**

1. When grading and construction in the drainage area above the sediment basin is completed and the disturbed areas are adequately stabilised, the sediment basin must be removed or otherwise converted to a permanent pond, wetland, stormwater detention or treatment structure. In either case sediment should be cleared and properly disposed of and the basin area stabilised.

2. Once the area that formed the basin is stabilised to the point where erosion is restrained, the embankment and outlet structures can be removed and properly disposed.
10. References


