POST- EXHIBITION REVISION

St Marys *Freight Hub*—

Stormwater Mangement Report



FOR / Civil Engineering Services

CLIENT / Pacific National

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1 INTRODUCTION

1.1 Background

Pacific National (PN) plan to develop the St Marys site in Western Sydney (Lots 2 and 3 DP 876781). The development involves the construction of a Freight Hub Facility on a staged basis to accommodate a new dedicated port shuttle service from Port Botany to St Marys.

The Facility is to be developed to accommodate a maximum operating capacity of 300,000 TEU (Twenty-foot Equivalent Unit) throughput annually. It is proposed to operate the site 24 hours per day, 7 days per week.

The proposed development will form an important port link to move containers to and from Port Botany to greater western Sydney. This will result in increased freight movement via rail and thus relieving the demand on the regional and local road network from container freight related traffic.

The initial Development Application for the proposed Freight Hub facility at St Marys was submitted to the Department of Planning, Industry & Environment in May 2019. This report has been updated in response to comments received from the Department of Planning Industry and Environment, Penrith City Council (PCC) and other agencies on the exhibited proposal.

1.2 Site Location and Description

The site is known as Lots 2 and 3 DP 876781 with a frontage to Forrester Road, St Marys, NSW owned by Pacific National. It is located within a largely industrial area of St Marys, 8 km east of Penrith, NSW. The site is bounded by Forrester Road and industrial development to the east, the Great Western Railway Line to the south, and Little Creek to the North. Refer to the locality plan shown in Figure 1.

The area to be developed comprises approximately 10 hectares within a 40 hectares land area. The existing terrain can be described as being generally flat, with a slight fall toward the north with the elevation varying from approximately RL 24 - 30m AHD.

Douglas Partners carried out a review of historical aerial photography of the site with their findings summarised in the *Preliminary Site Contamination Investigation (March 2019).* The investigation found that the site has historically been predominantly vacant, containing limited structures and access paths. Between 1994 and 2005 the site appears to have been filled and levelled with additional material stockpiled on site. A sediment basin to the north of the site was also constructed during this time.

1.3 Scope and Objectives

BG&E Pty Ltd (BG&E) has been engaged by Pacific National to prepare a Stormwater Management Plan and Report. This Stormwater Management Report aims to outline the existing drainage conditions, as well as provide an overall philosophy for the collection, treatment and disposal of stormwater from the development site and in doing so demonstrate compliance with the requirements as set out in the Revised Planning Secretary's Environmental Assessment Requirements (SEARs).

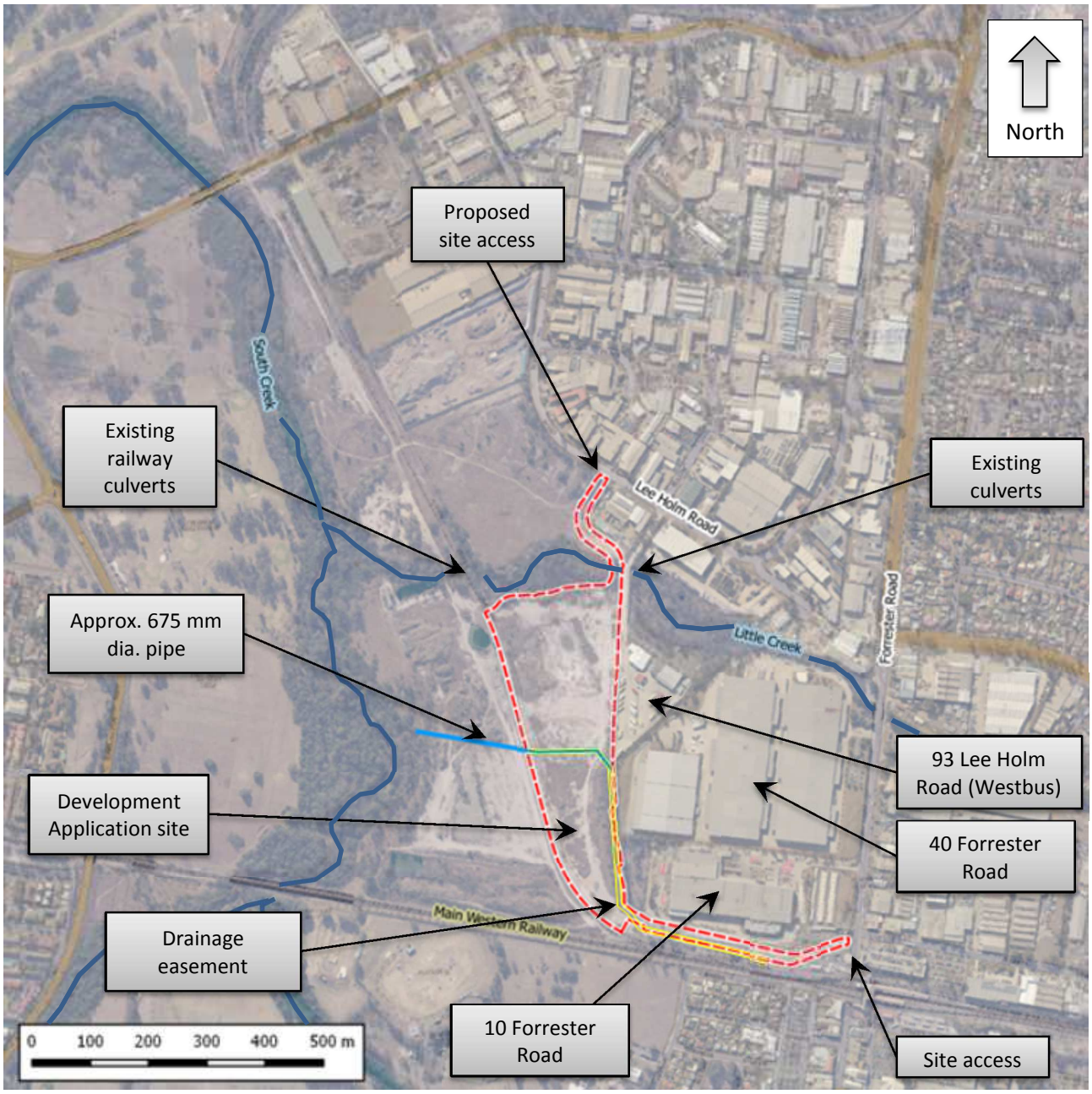


Figure 1 - Locality Plan

2 EXISTING DRAINAGE

2.1 Existing Site Drainage

The existing site is believed to have been filled and levelled somewhere between 1994 and 2005. Based on this and site observations, the site is assumed to be 100% pervious. It falls in a northerly direction at approximately 1% towards Little Creek.

An existing basin is present on the northern portion of the proposed development site, to which the majority of the site drains. Refer to Figure 2 below. The previous usage or purpose of this basin is unknown, however, it is assumed to be a sediment basin. It is assumed that the basin does not provide any attenuation.



Figure 2 - Existing Sediment Basin

Site runoff is directed to the basin via two existing 300 mm diameter culverts and cut off drains. The basin in turn discharges to Little Creek, a tributary of South Creek. Little Creek is a 2nd order classified stream, and South Creek is a classified 3rd order stream.

External catchment flows are conveyed through the site via a vegetated channel running along the southern side of the existing access road from Forrester Road. A 300 mm diameter culvert conveys flows under the existing access road to a vegetated channel running along the sites eastern boundary. This vegetated channel

follows the alignment of a drainage easement (average width 3.0m) shown on site survey to a low point on the sites eastern boundary near the boundary between 40-88 Forester Road and 93 Lee Holm Road.

Current survey does not pick up any culverts draining from this low point, however site inspections identified that the low point was drained via an existing pit and an approximately 675 mm diameter pipe. It is assumed that this pipe follows the alignment of the easement in a westerly direction towards South Creek. Title searches show the easement being for the benefit of drainage from the railway corridor. Flow that cannot be conveyed by this pipe spills from the low point and flows overland toward the existing basin and Little Creek.

Two large box culverts are present on the site. An existing 2.4 m x 1.8 m box culvert (approximate) is located under the access road from Lee Holm Road to the property at 93 Lee Holm Road, while an existing 2.5 m x 1.8 m (approximate) culvert exists beneath the rail sidings. These culverts convey Little Creek through the site and are discussed in further detail in *St Marys Freight Hub Desktop Flood Study and Flood Impact Assessment, Rev E (BG&E, Sept 2019).*

Key features of the existing drainage layout are shown on the Existing Drainage Sketch in Appendix A. Further survey is required during detailed design to confirm existing pipe sizes and pit locations.

2.1.1 Upstream and Adjoining Site Drainage

There are external catchments to the site. The following outlines our understanding of these catchments for the purpose of the Development Application. Confirmation of these catchments and the exact discharge locations will be further developed during detailed design.

2.1.1.1 Main Western Line Rail Corridor

Based on LIDAR, aerial photography and Council drainage records, it is believed that approximately 2.1 ha of rail corridor catchment flows are conveyed through the subject site, discharging via an existing headwall adjacent to the south-eastern corner of the site and flowing overland toward the existing access road from Forrester Road.

2.1.1.2 Lot 100 DP1136503 for (93 Lee Holm Road)

Drainage plans for Lot 100 DP1136503 for (93 Lee Holm Road) were provided to BG&E by the site owner. These plans for the Westbus Site show all runoff for storm events up to and including the 1% AEP will discharge toward Little Creek to the north and will not enter the St Marys Freight Hub site. Copies of the plans obtained can be found in Appendix B.

2.1.1.3 Lot 221 DP1025100 (40 Forrester Road)

Drainage plans for Lot 221 DP1025100 (40 Forrester Road) were provided to BG&E by Council. The drainage plan provided by Penrith City Council for 40 Forrester Road also included the area of 10 Forrester Road. The plan does not correspond with the current development on Number 10, however the three warehouses shown on Number 40 do appear to correspond to the current site conditions. The plan provided indicates the presence of a pipe network discharging flows to the north to Little Creek. Copies of the plans obtained can be found in Appendix B.

2.1.1.4 Lot 220 DP1172926 (10 Forrester Road)

Information on the existing drainage within this site was unable to be obtained as neither Council nor the current owners of the site had access to drainage plans. Based on LiDAR and Council's Little Creek flood model, it is believed the property at 10 Forrester Road discharges to the development site near to the existing drainage easement and swale.

The following assumptions have been made based on the drainage plans obtained and review of LiDAR data and aerial photography:

- The intention of the drainage layout on 40 Forrester Road is to discharge stormwater collected in the piped drainage system towards Little Creek to the north.
- For warehouses 1 and 2 (central and eastern), overland flows would also flow to Little Creek the north.
- LiDAR and aerial imagery also show a low lying vegetated area between the Westbus site at 93 Lee Holm Road and the property at 40 Forrester Road. This area appears to drain toward the development site.
- Stormwater runoff that exceeds the pipes network from around warehouse 3 would discharge to a low lying area between 93 Lee Holm Road and 40 Forrester Road and subsequently drain towards the proposed development site.
- It is assumed that the site piped drainage was designed in accordance with Penrith City Council's Stormwater Drainage Policy ES002 which requires internal and piped drainage systems to be designed for the 5% AEP event with an overland flow path provided to the 1% AEP event.

The existing catchments are shown on the Existing Drainage Sketch in Appendix A. Further survey and confirmation of these catchment assumptions are required during detailed design.

3 PROPOSED DRAINAGE

3.1 Basis of Design

The proposed development is subject to the Planning Secretary's Environmental Assessment Requirements (SEARS), application number 7308. The following sections outline the adopted design objectives for the development.

3.1.1 IFD Data

The flood modelling adopted by Council used Australian Rainfall and Runoff 1987 (ARR1987) methods. For consistency, the drainage design has been carried out using Australian Rainfall and Runoff 1987 (ARR1987) methods and IFD data.

IFD data has been obtained from Appendix E of the *Stormwater Drainage Specification for Building Developments ES002* (Penrith City Council, 2016).

3.1.2 Drainage Network

3.1.2.1 Design Annual Exceedance Probabilities

As required by the *Stormwater Drainage Guidelines for Building Developments ES002* (Penrith City Council, 2016), the site pit and pipe drainage system shall be designed to accommodate runoff from a 5% AEP rainfall event for the minor event, while the overland flow system will be designed to cater for the 1% AEP event.

The cross drainage pipe network for the upstream catchments will be designed to cater for the 1% AEP event.

3.1.2.2 Design Criteria

A desirable flow width of 25 m has been adopted for the hardstand area for the minor event. This provides a maximum flow depth of approximately 100 mm based on the current grading. The intent of this is to minimise flow paths encroaching on the container storage areas.

Flow widths for the internal access roads to Forrester Road and Lee Holm Road shall be limited to a 1.0 m encroachment into trafficable lanes for the minor event.

All other design criteria are to be generally in accordance with Penrith City Council design Standards.

3.1.3 Water Sensitive Urban Design

A water quality treatment train will be implemented to limit the amount of gross pollutants, sediments, nutrients and hydrocarbons discharging to downstream waterways. Attenuation of smaller events will also be incorporated into the treatment train to assist in protecting the geomorphic values of the receiving waterways. The objectives to be achieved are outlined in Section 3.4.1.

3.2 Drainage Strategy

3.2.1 Proposed Drainage Network

The design intent is to ensure that stormwater run-off generated from the subject site is segregated from the external catchment flows conveyed through the site.

To manage site runoff, it is proposed to provide a pit and pipe network within the proposed roads and hardstand areas to collect and convey runoff from the minor storm events away from roads and hardstand

areas as well as proposed structures. This network is proposed to discharge to Little Creek to the north of the proposed hardstand area, via a proposed sediment and bio-retention basin.

Runoff from the proposed buildings will be collected by gutters and discharged to proposed rainwater collection tanks. These tanks will overflow to the stormwater network outlined above.

In the major storm event (1% AEP) the hardstand areas will direct flows in a northerly direction toward Little Creek. The piped network draining the trapped low point in the Forrest Road access road has been designed to cater for the major event.

The overland flow path through the site for the external catchments is proposed to be retained / reinstated from the south east corner of the site, continuing to pick up flows discharging from the upstream rail corridor catchment. It will continue along the southern side of the proposed access road and eastern boundary along the approximate alignment of the existing easement until it meets the start of the existing 675 mm diameter pipe. At this location the overland flow path will be replaced with a proposed pipe along the eastern boundary that will discharge flows to Little Creek. The 675 pipe will be retained, with the intention to mimic the pre-development flow regime as closely as possible for a range of storm durations. It is expected, based on preliminary modelling that post development flows through the existing pipe will approximately match pre development levels.

Extension of the drainage culverts on the site has been assessed as part of the flood modelling. Refer to *St Marys Freight Hub Desktop Flood Study and Flood Impact Assessment, Rev E (BG&E, Sept 2019)* for proposed modifications.

3.2.2 Drainage Modelling

The drainage system has been designed and analysed using the 12d and DRAINS software packages. Both the pre-development and post-development scenarios were assessed. Refer to Appendix C for result outputs from the post development drains model for both the 5% and 1% AEP. Models can be provided upon request.

3.3 On Site Stormwater Detention (OSD)

Given the proximity of the proposed development to the outfall of Little Creek an assessment of the need for OSD has been undertaken. Typical of developments located at waterway outlets, providing OSD can cause detrimental impacts as the attenuated water that is held back can coincide with the main waterway's peak flow, resulting in 'peak on peak'. This in effect increases the peak flow of the waterway. Hence an analysis of the Little Creek hydrology has been undertaken considering the site developed and undeveloped to determine the impact of OSD. Through this assessment it was determined that it is considered beneficial in **not** providing OSD, as it can be demonstrated that there may be less impact to Little Creek by omitting OSD.

Whilst it is acknowledged that the development will increase peak flow discharge from the site, the overall peak flow in Little Creek will not increase. Noting that the overall peak flow is the flow that causes the most flooding and inundation. The overall peak flow does not increase due to the site's immediate proximity to Little Creek's outfall, resulting in the peak flow from the site passing prior to the occurrence of the overall peak flows within Little Creek.

As outlined in *St Marys Freight Hub Flood Impact Assessment, Rev E (BG&E, Sept 2019)*, the critical storm duration for the Little Creek catchment is a 2 hour storm event. The hydrographs for the 1% AEP, 2 hour storm for both Little Creek and the outlet of the proposed site drainage are shown in Figure 3 below. As shown the site drainage discharge peaks at approximately 3.2 m^3/s at approximately 40 minutes, and then subsiding prior to Little Creek peaking at 30.5 m^3/s after 105 minutes as it passes through and around the site.

Provision of OSD to attenuate site flows would result in flows being discharged from the site during the slower falling limb of the Little Creek hydrograph, and thus potentially increase the duration of flooding at this location. Therefore there is benefit in discharging peak flows from the site prior to the significant rising limb of the Little Creek hydrograph to minimise increased flows entering the Little Creek waterway during flooding.

To further illustrate the minimal impact an increase in site flow will have on Little Creek, a flood volume of 215 mega litres is predicted to pass along Little Creek within a 4 hour period. In comparison, a total volume of 7.4 mega litres (approx. 3.4% of the total volume) is expected from the site over the same 4 hour period.

This approach meets the objective of development Control C.2.d.iii. (Part C3, Section 3.6 PDCP 2014) which requires that is should be demonstrated that the development will not overload the trunk drains during peak storm events or cause localised flooding.

Penrith City Council OSD Control C.1.d. requires that OSD must be located at a level above the 1 in 5 year ARI (20% AEP) flood level. The 20% AEP flood level is 23.38 m AHD from PCC's Little Creek Flood Study model. Proposed fill levels near to the creek corridor are below 24 m AHD for a distance of about 30 m from the creek which gives less than 600 mm depth to include OSD storage plus required cover to surface level. Given these site level constraints, it is not possible to provide OSD above the 20% AEP flood level, and below the proposed surface level unless significant further fill is placed on site, and the entire site is raise to maintain the grade towards the channel. In doing this additional impacts to South Creek flooding may occur, which affects a wider area than then Little Creek flooding.

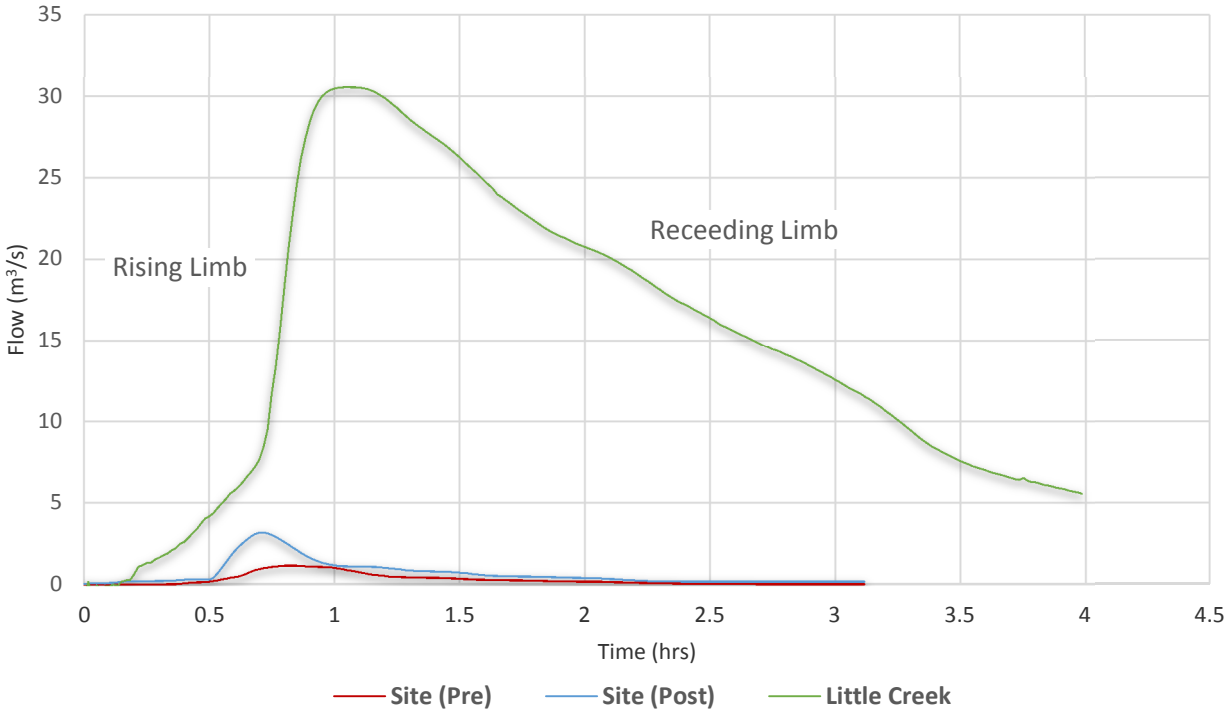


Figure 3 - 1% AEP 2 Hour Storm Hydrograph

It is therefore determined that OSD is not provided, as it will do little to enhance the receiving waterway.

Furthermore, there are significant hydraulic constraints that would render a proposed OSD system highly ineffective, due to high tailwater levels.

Whilst OSD is not considered feasible or necessary the basin design has resulted in provision of 1000m^3 of attenuation volume. This is as a result of the basin design and system grading. As OSD is not proposed, this volume can still be used to moderate and control frequent site discharge (1 in 3 month or 97% AEP) to aid in stream bank stability. Refer to Section 3.4.4.2 of this document for a Stream Erosion Index (SEI) assessment..

3.4 Stormwater Quality

3.4.1 Water Sensitive Urban Design (WSUD) Objectives

As part of the SEARS approval process, WSUD requirements from the following agencies are required to be addressed:

- Penrith City Council;
- NSW Environmental Protection Agency (EPA); and
- Department of Planning, Industry & Environment.

3.4.1.1 Penrith City Council

Penrith City Council's Water Sensitive Urban Design requirements are set out in Part C3 Water Management of the Development Control Plan, 2014, Penrith City Council (The DCP) and the WSUD Technical Guidelines, Version 3, June 2015, Penrith City Council. Commercial and Industrial developments greater than 2,500 m^2 in area are required to consider both Stormwater Quality and Water Quantity Flow.

The stormwater quality targets outlined in the WSUD Policy Section 3.2 are as follows:

i) 90% reduction in the post development mean annual load total gross pollutant (greater than 5mm);
ii) 85% reduction in the post development mean annual load of Total Suspended Solids (TSS);
iii) 60% reduction in the post development mean annual load of Total Phosphorus (TP);
iv) 45% reduction in the post development mean annual load of Total Nitrogen (TN); and
v) 90% Free Oils and Grease with no visible discharge.

Water quantity flow targets outlined in the WSUD Policy Section 3.3 are as follows:

> *The post development duration of stream forming flows shall be no greater than 3.5 times the pre developed duration of stream forming flows. The comparison of post development and pre development stream flows is commonly referred to as the Stream Erosion Index (SEI).*

3.4.1.2 NSW EPA and the Department of Planning, Industry & Environment

The EPA require the development to consider the NSW Water Quality and River Flow Objectives (WQO) to ensure the water management system for the site is appropriately designed to contribute to waterway outcomes.

WQOs are yet to be formulated and established for the Hawkesbury – Nepean Catchment, within which this development site occurs. As such an assessment of the eleven water quality objectives and twelve river flow objectives applied in other Sydney catchments and their relevance to this site has been undertaken. The assessment has found the following objectives to be relevant to this site:

- **Water Quality Objectives**
  - Aquatic ecosystems;
  - Visual amenity;
  - Secondary contact recreation; and
  - Primary contact recreation.

- **River Flow Objectives**
  - Maintain natural flow variability.

The specific requirements of these objectives are outlined in Section 3.4.4.2.

3.4.2 Proposed Treatment Train

To achieve the WSUD objectives outlined in Section 3.4.1 the following industry best practice treatment train is proposed for the site:

- **Rainwater Tanks with Reuse**
  - The proposed office building drains to a 25kL rainwater tank. Water will be reused for toilet flushing. The office building is assumed to be two storey, resulting in a floor area of approximately 1000 m^2. Based on workplace regulations it is estimated this building will have 7 toilets and 2 urinals. The Penrith City Council WSUD Technical Guidelines (June 2015) outline reuse rates for toilet flushing, resulting in a reuse rate of 0.9kL/day. These figures are to be confirmed by the project hydraulic engineer during detailed design;
  - The proposed Transport and Container Repair workshops drain to a 100kL tank. Water will be reused in the proposed Wash Bay. The estimated reuse rate for this facility is 5kL/day. These figures are to be confirmed by the project hydraulic engineer during detailed design;
- **Bio-Retention and Sediment Pre-treatment**
  - The sites hardstand areas will drain to a combined sediment, bio-retention and attenuation basin. The sediment portion of the basin will have a permanent pool of approximately 560 m^3 and will capture primarily coarse sediments before overtopping to the bio retention section with a plan area of 1000 m^2. Here further suspended solids as well as phosphorous and nitrogen will be removed. Storms that exceed the treatable flow rate of the bio retention basin will be attenuated within the basin by an outlet orifice within the overflow pit in the bio retention section of the basin. The basin has approximately 1000 m^3 of attenuation storage in additional to the proposed sediment portion of the basin and bio retention ponding. As discussed in Section 3.3 this will moderate and control frequent rainfall events; and
- **Gross Pollutant Traps**
  - Ocean Protect gross pollutant inlet inserts (Enviropods) are pollutant catching baskets that will be used to capture pollutants in pits on the Lee Holm Road access road as the levels of this part of the site do not allow connection to the proposed Gross Pollutant Traps.

3.4.3 MUSIC Modelling

MUSIC modelling has been undertaken to assess the effectiveness of the proposed treatment train in meeting the objectives set out in Section 3.4.1, and determine the Stream Erosion Index for the development.

The modelling was carried out in accordance with the recommendations contained in the *Draft MUSIC Modelling Guidelines for NSW* (Catchment Management Authority, 2010) and the *WSUD Technical Guidelines* (Penrith City Council, June 2015).

Rainfall for the site model was obtained from the eWater Pluviograph Rainfall Data Tool. Six minute data for Penrith Lakes AWS Station 067113 was used for the period of 1/1/1999 – 1/1/2008. Evapotranspiration values have been used as per Penrith City Council guidelines. Further information regarding the modelling and inputs can be provided on request.

The MUSIC model used to assess the pollution reduction and concentrations can be seen in Figure 4 below.

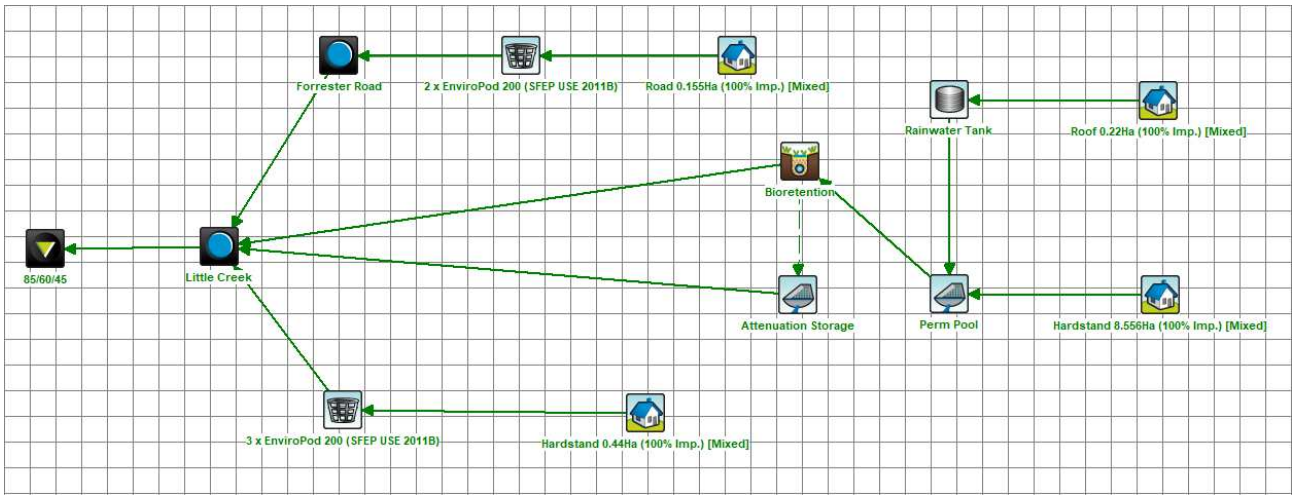


Figure 4 - MUSIC Treatment Train Model Layout

Two additional models were run to determine the Stream Erosion Index for the site runoff. Figure 5 below shows the layout for the existing model with the flow conversion node included as per Council guidelines. The proposed model is shown in Figure 6.

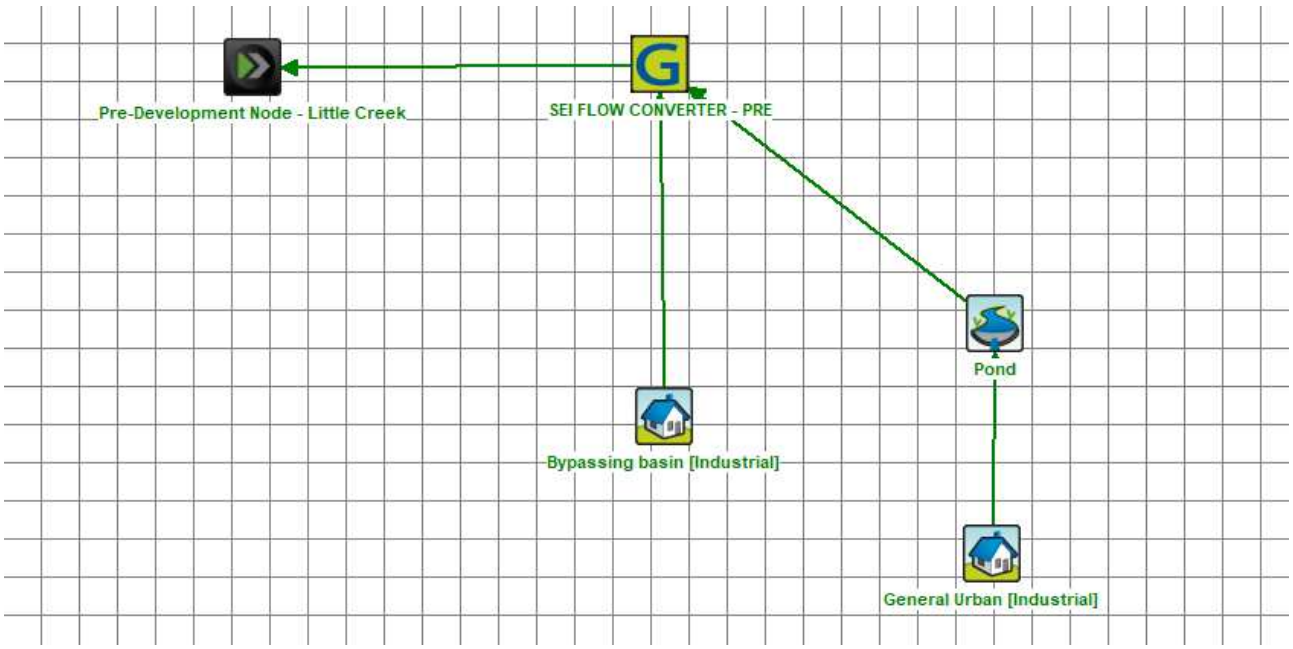


Figure 5 - MUSIC Existing Model Layout (SEI)

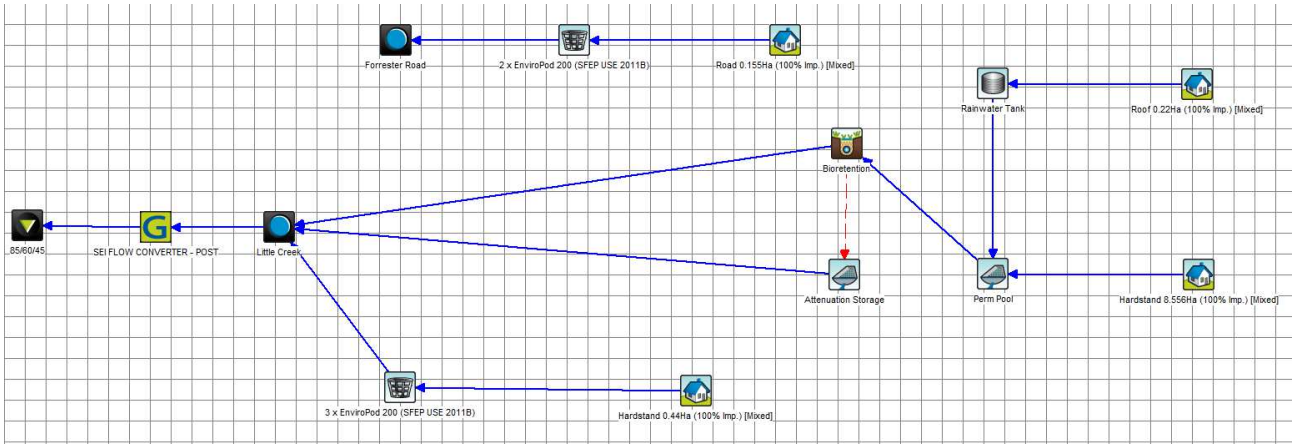


Figure 6 - MUSIC Proposed Model Layout (SEI)

3.4.4 Compliance with WSUD Objectives

3.4.4.1 Penrith City Council

The results of the model at the receiving node in Figure 4 are shown in Table 1. As can be seen the proposed treatment train sufficiently improves runoff quality to meet the required Council standards.

Table 1 - Pollution Reduction Results

Pollutant	Reduction Target Required (%)	Pollutant Reduction Achieved (%)	Compliance
Gross Pollutants (GP)	90	99.9	Achieves Target
Total Suspended Solids (TSS)	85	95.6	Achieves Target
Total Phosphorus (TP)	60	81.1	Achieves Target
Total Nitrogen (TN)	45	54	Achieves Target
Free Oils and Grease with no visible discharge	90	NA	MUSIC does not report on oils and grease. Oil and grease typically binds to TSS particles and is expected to be captured to the required levels.

As required within Council's WSUD Policy the development must achieve a maximum Stream Erosion Index (SEI) of 3.5 times the pre developed duration of stream forming flows to ensure downstream waterway stability. In order to calculate the SEI for the site runoff, BG&E have followed the method outlined in WSUD Technical Guidelines, Version 3 (June 2015, Penrith City Council). Calculations are included in Appendix C. These calculations have been based on the site catchment draining to Little Creek only. External catchments

and site catchments draining to either South Creek or Forrester Road have been excluded as these do not form part of the development.

The assessment provides a site SEI value of **3.34**, thus achieving Council requirements.

3.4.4.2 NSW EPA and the Department of Planning, Industry & Environment

The specific requirements and the method through which this development has demonstrated compliance with the NSW Water Quality and River Flow objectives are outlined in the following sections.

Aquatic Ecosystems

This objective requires the development to assist in maintaining or improving the ecological condition of waterbodies and their riparian zones over the long term.

Whilst this objective lists a number of trigger values for various effluents, it is important to note that the ANZECC guidelines from which these values have been obtained states the following:

> *The Guidelines have not been designed for direct application in activities such as discharge consents, recycled water quality or stormwater quality, nor should they be used in this way" (page 2-17, Section 2.2.1.9).*

As such it is not the intent, nor is it reasonable for these guidelines to be applied as concentration limits for flows discharging from any one particular site. Rather they are intended to be assessed on ambient water conditions in the water body as a whole.

Table 2 below summarises the numerical requirements of this objective and demonstrates the measures taken to address these requirements in the sites WSUD design.

Table 2 - Aquatic Ecosystems

Indicator	Numerical Criteria (Trigger Values)	Compliance Strategy
Total Phosphorus	25 µg/L for rivers flowing to the coast	Implementation of an industry best practice treatment train including a 1000m^2 bio retention basin. The proposed treatment train provides a flow-weighted daily mean of 54.3 µg/L. Settings within MUSIC do not allow concentrations to be reported that meet the required trigger values. Sensitivity assessments carried out on the MUSIC model for a bio-retention basin of 2000 m^2 reports a flow-weighted daily mean of 55.2 µg/L. Thus it can be concluded that an increase in bioretention area would have a negligible impact on the further reduction to the total phosphorus concentration.
Total Nitrogen	350 µg/L for rivers flowing to the coast	Implementation of an industry best practice treatment train including a 1000m^2 bio retention basin. The proposed treatment train provides a flow-weighted daily mean of 491 µg/L. Settings within MUSIC do not allow concentrations to be reported that meet the trigger values.

Indicator	Numerical Criteria (Trigger Values)	Compliance Strategy
		Sensitivity assessments carried out on the MUSIC model for a bio-retention basin of 2000 m^2 reports a flow-weighted daily mean of 481 µg/L. Thus it can be concluded that an increase in bio-retention area would have a negligible impact on the further reduction to the total nitrogen concentration.
Chlorophyll-a	5 µg/L	Nutrients entering Little creek will be controlled through the implementation of an industry best practice treatment train which will help limit the growth of algae.
Turbidity	6–50 NTU	Implementation of an industry best practice treatment train including a 1000m^2 sediment pond and 1000m^2 bio retention basin. This provides a flow-weighted daily mean of 4.23 mg/L.
Salinity (electrical conductivity)	125–2200 µS/cm	No activities on site will impact on the salinity of the runoff and as such this indicator is not relevant.
Dissolved oxygen	85–110%	No activities on site will impact on the dissolved oxygen content of the runoff and as such this indicator is not relevant.
pH	6.5–8.5	No activities on site will impact on pH of the runoff and as such this indicator is not relevant.
Temperature	See ANZECC 2000 Guidelines, table 3.3.1.	No activities on site will impact on temperature of the runoff and as such this indicator is not relevant.
Chemical contaminants or toxicants	See ANZECC 2000 Guidelines, chapter 3.4 and table 3.4.1.	No chemicals or toxicants are proposed to be used on site. Wash-down areas will treat and recycle water / drain to the sewerage system.
Biological assessment indicators	This form of assessment directly evaluates whether management goals for ecosystem protection are being achieved (e.g. maintenance of a certain level of species diversity, control of nuisance algae below a certain level, protection of key species, etc). Many potential indicators exist and these may relate to single species, multiple species or whole communities. Recognised protocols using diatoms and algae, macrophytes, macroinvertebrates, and fish populations and/or communities may be used in NSW and interstate (e.g. AusRivAS). **Compliance -** No biological contaminants will be directed to the stormwater system and as such this indicator is not relevant to the site.	

3.4.4.2.1 Visual Amenity

Table 3 below summarises the numerical requirements of this objective and demonstrates the measures taken to address these requirements in the sites WSUD strategy.

Table 3 - Visual Amenity

Indicator	Numerical Criteria (Trigger Values)	Compliance Strategy
Visual clarity and colour	Natural visual clarity should not be reduced by more than 20%. Natural hue of the water should not be changed by more than 10 points on the Munsell Scale. The natural reflectance of the water should not be changed by more than 50%	Water clarity and colour are adversely impacted by suspended solids and algae. The implementation of an industry best practice treatment train will minimise the amount of suspended solids as well as minimise nutrients which will limit any potential increases in algae growth.
Surface films and debris	Oils and petrochemicals should not be noticeable as a visible film on the water, nor should they be detectable by odour. Waters should be free from floating debris and litter.	Oil and grease are visible at an approximate rate of 5mg/l. Regular roads and carparks have a pollutant loading of approximately 6mg/l. Hydrocarbons are absorbed by sediments and will be removed along with these sediments by the proposed treatment train to a rate below the visible 5mg/l approximate threshold.
Nuisance organisms	Macrophytes, phytoplankton scums, filamentous algal mats, blue-green algae, sewage fungus and leeches should not be present in unsightly amounts.	Nutrient concentrations which encourage the growth of macrophytes, scums and algae will be limited through the implementation of the stormwater runoff treatment train.

3.4.4.2.2 Primary and Secondary Contact Recreation

Table 4 below summarises the numerical requirements of these objectives and demonstrates the measures taken to address these requirements in the sites WSUD strategy.

Table 4 - Primary and Secondary Contact Recreation

Indicator	Numerical Criteria (Trigger Values)	Compliance Strategy
Turbidity	A 200 mm diameter black disc should be able to be sighted horizontally from a distance of more than 1.6 m (approximately 6 NTU).	Implementation of an industry best practice treatment train including a 1000m^2 sediment pond and 1000m^2 bio retention basin. This provides a flow-weighted daily mean of 4.23 mg/L.
Faecal coliforms	Median over bathing season of < 150 faecal coliforms per 100 mL, with 4 out of 5 samples < 600/100 mL (minimum of 5 samples taken at regular intervals not exceeding one month).	Relevant effluents will be directed to the sewerage system.
Enterococci	Median over bathing season of < 35 enterococci per 100 mL (maximum number in any one sample: 60-100 organisms/100 mL).	Relevant effluents will be directed to the sewerage system.
Protozoans	Pathogenic free-living protozoans should be absent from bodies of fresh water. (Note, it is not necessary to analyse water for these pathogens unless temperature is greater than 24 degrees Celsius).	No activities on site will impact on the level of Protozoans in the runoff and as such this indicator is not relevant.
Algae & blue-green algae	< 15 000 cells/mL	An industry best practice treatment train will be implemented to minimise the concentration of nutrients entering Little Creek, which in turn will limit the promotion of algae.
Nuisance organisms	Use visual amenity guidelines. Large numbers of midges and aquatic worms are undesirable.	These organisms are dominant in oxygen depleted and nutrient rich water bodies. Site activities will not have an adverse impact on oxygen levels within Little Creek. The proposed treatment train will assist in minimising nutrients entering the waterway.
pH	5.0-9.0	No activities on site will impact on pH of the runoff and as such this indicator is not relevant.

Indicator	Numerical Criteria (Trigger Values)	Compliance Strategy
Temperature	15°-35°C for prolonged exposure.	No activities on site will impact on temperature of the runoff and as such this indicator is not relevant.
Chemical contaminants	Waters containing chemicals that are either toxic or irritating to the skin or mucus membranes are unsuitable for recreation. Toxic substances should not exceed the concentrations provided in tables 5.2.3 and 5.2.4 of the ANZECC 2000 Guidelines 2000.	No chemicals or toxicants are proposed to be used on site. Wash-down areas will treat and recycle water / drain to the sewerage system
Visual clarity and colour	Use visual amenity guidelines	Water clarity and colour are adversely impacted by suspended solids and algae. The implementation of an industry best practice treatment train will minimise the amount of suspended solids as well as minimise nutrients which will limit any potential increases in algae growth.
Surface films	Use visual amenity guidelines	Oil and grease are visible at an approximate rate of 5mg/l. Regular roads and carparks have a pollutant loading of approximately 6mg/l. Hydrocarbons are absorbed by sediments and will be removed also with these sediments by the proposed treatment train to a rate below the visible 5mg/l approximate threshold.

3.4.4.2.3 Maintain Natural Flow Variability

This objective requires the development to take action to limit the impact on flow regime that amongst other things can lead to streambank stability issues. The required objective is to take action to mimic natural variability.

The compliance with this objective is demonstrated through meeting the Stream Erosion Index target required by Penrith City Council (refer to Section 3.4.4.1). As outlined above, the SEI is a simplified measure

to assess the change to stream forming flows that affect the geomorphic and ecologic conditions of the receiving water way.

3.4.5 Maintenance

The proposed treatment train requires ongoing maintenance if the modelled performance is to be obtained.

- **Catch Pit Inserts** – information regarding inspection and maintenance of the Stormwater 360 Enviropods can be found in Appendix D.
- **Rainwater Reuse Tank** – regular maintenance is required to ensure an acceptable level of water quality is maintained within the tank and pumps are able to function as required. As such the following maintenance regime is proposed:
  - Service pumps as per supplier recommendations.
  - Every 3 months – Clean and check first flush devices and filters.
  - Every 6 months – Check tank for defects and repair as necessary.
  - Every 2 years – Remove accumulated sediment and clean out as required.
- **Sediment / Bio-retention basin** – the proposed maintenance regime should include the following:
  - Vegetation within the basin should be maintained as per landscape specifications.
  - Every 6 months or after heavy rainfall events, gross pollutants and sedimentation build-up should be removed from the basin to ensure designated ponding depths are retained.
  - Every 6 months or after heavy rainfall, grates, pits, trash racks and orifices should be checked that they are in good working order and that they are clear of any blockages. All gross pollutants, sedimentation or otherwise should be removed.

4 SEDIMENT AND EROSION CONTROL

4.1 Objectives

The objective of the Construction Phase Management Plan is to ensure compliance with Landcom's "Blue Book" requirements. The purpose of the management plan is to prevent the discharge of polluted stormwater off the site and to ensure that the environmental values of receiving waters are maintained or enhanced. Pollutants typically generated during the Construction Phase are outlined in Table 5.

Table 5 - Typical Construction Phase Pollutants

Pollutant	Sources
Litter	Paper, construction packaging, food packaging, cement bags, off-cut
Sediment	Unprotected exposed soils and stockpiles during earthworks and building
Hydrocarbons	Fuel and oil spills, leaks from construction equipment
Toxic Material	Cement slurry, asphalt prime, solvents, cleaning agents, wash waters (e.g. from tile works)
pH altering substances	Acid sulphate soils, cement slurry and wash waters

4.2 Management of Sedimentation and Erosion

The existing sediment basin is to be retained at the downstream end of the site with temporary cut off drains catching runoff from the entire development site. It is expected that this sediment basin will eliminate almost all risk of sediment being washed off the site. Accidental spills of soil or any other material shall be removed immediately if rainfall is likely to occur or at least upon completion of the days work depending upon the material.

Entry and exit from the site will be restricted to a single stabilised location to minimise the risk of tracking sediment over the site. It is expected that a layer of crushed rock will provide the necessary stabilisation for the access route. A specific area on the site shall be designated for washing down construction plant. The washdown area will be contained by earth bunds. There will be no waste water discharged from the site during construction.

4.3 Management of Contaminated Soils

The site is not known to contain acid sulfate soils. However in the event that Acid Sulfate Soils or Contaminated Land is found on site, a management plan is to be implemented and maintained by a suitably qualified professional.

4.4 Management of Imported Material

Any material imported onto the site (including construction materials) will be stockpiled in a location where it cannot contaminate stormwater runoff. It should be stored clear of flow paths and be surrounded by silt fences on the downstream side.

4.5 Monitoring and Maintenance

Silt traps, sediment fences and structural measures should be checked daily during construction by the Construction Manager. Inspections will ensure the integrity of control structures and other structural measures. Additional inspections will be required immediately following periods of heavy rain. Sediment build-up is to be removed from behind the silt fences and other barriers immediately after each major rainfall event. All noted stormwater treatment devices within this report are to be inspected, maintained, rectified and reported on.

4.6 Pre-Construction Phase

Before construction activities commence, the following measures are to be implemented to ensure minimal disturbance and adverse water quality impacts. These measures may be adopted in a staged approach, and may be implemented prior to construction beginning in any one section of the project. These elements are further discussed within the CEMP, prepared by the Contractor.

- Designation of area for plant, storage of raw material, construction equipment, vehicle parking and wash down pads;
- Diversion of upstream stormwater runoff around disturbed areas of the development as required;
- Immediate stabilization of disturbed areas, where required for highly erodible soils. This can be assessed and confirmed once site soil analysis results are available;
- Monitoring of stormwater quality discharging from the site and the implementation of additional measures if quality of discharge exceeds the requirements;
- Designation and marking of transport routes across the site to minimise dust disturbance;
- Erosion management techniques and measures to be installed during construction. This is further discussed within the following sections of this report;
- Sediment control measures to be installed during construction. This is further discussed within the following sections of this report; and
- Education of site personnel for the implementation and management of sediment and erosion control measures.

4.7 Construction Phase

The following outlines the proposed erosion and sediment control measures to be adopted for construction.

4.7.1 Bulk Earthworks

Bulk earthworks are to be minimised to where necessary and to be carried out in accordance with the civil design package.

Dust will be generated during this phase of construction, as such, water trucks or other methods are to be employed in time to provide effective dust suppression. Refer to Appendix D for general practice on "*Dust Control*".

For details regarding extent of earthworks, and cut and fill areas, refer to the Bulk earthworks design package.

4.7.2 Erosion Control

Erosion matter is triggered by the unintended energy mismanaged by the movement of surface runoff. The following engineering features are expected to be provided as part of the civil works package to ensure that the erosion by surface runoff is minimised:

- Inlet & Outlet Protection:
  Culvert inlet and outlet protection has been implemented as part of the drainage works, to prevent soil erosion caused by the flow acceleration into culverts and concentrated flow exiting culverts;

- Gravel Mesh Filter:
  These have been used within shallow open drains to limit flow energy and trap sediment. This is primarily about the hardstand area. Where deeper open drainage is provided, rock check dams have been adopted; and

- Geotextile:
  This has been designed and implemented, where deemed necessary, to manage the impact caused by the kinetic energy carried with the runoff, as well as in (assisting) providing efficient drainage solution where it is applicable such as acting as a separation layer between rock mattress and underlying soil.

For details refer to the erosion and sediment control plans.

4.7.3 Sediment Control

The following measures have been proposed for the project to form a holistic sediment control during the construction phase of the civil works

- Stabilised Entry/Exit:
  This is to be implemented at the entry location of all working area to ensure that the sediments do not continue to be carried in or out of the site onto the road network. Refer to Appendix D for general practice guide on "*Construction Exits – Rock Pads*".

- Sediment/Silt Fencing:
  This is to be implemented at the entry location of all working area to ensure that the sediments do not continue to be carried in or out of the site onto the road network. Refer to Appendix D for general practice guide on "*Construction Exits – Rock Pads*".

- Wash Down Area:
  A specific area on the site shall be designated for washing down construction plant. The wash down area will be contained by earth bunds. There will be no waste water discharged from the site during construction.

- Sediment Basin:
  A sediment basin is an effective end of line sediment control measure designed to settle out particles within runoff and prevent them from continuing downstream. A Type D sediment basin, in accordance with the NSW Landcom Bluebook, has been proposed. The existing dam about the south-western corner of the site is proposed to be reused as a sediment basin. Note that the existing dam will required to be dewatered before construction commences. The following Table 6 provides sediment basin sizes to suit a range of runoff events.

Table 6: Type D Sediment Basin Sizing

Catchment Area (ha)	Rainfall Period	Sediment Settling Volume Required (m^3)	Sediment Storage Volume Required (m^3)	1 in 20 year Spillway Requirements
7.90	5 days	67	1709 @ 600mm deep	9m wide @ 300mm deep

Note that the above sizes do not account for any external catchment as they are to be diverted around the disturbed areas via catch drains.

Refer to Appendix E for sizing details of the sediment basin.

It is noted that chemical flocculation is required for Type D sediment basin, together with pump outlet to allow for de-watering and flow outlet. For details of establishing and maintaining the Type D sediment basin refer to Appendix F.

4.8 Operational Phase

The proposed operational drainage scheme for the terminal can be found within Appendix E. The scheme provides a combination of open channels and piped drainage.

The following aspects of the works have been considered:

4.8.1 Erosion Control

The following erosion control measures are provided as part of the ESCP to minimise erosion by surface runoff:

- Vegetation/Ground Cover:
  The primary erosion control measure across the site is established ground cover, which will largely remove the potential for erosion. Note that no immediate vegetation other than landscaping is proposed. The remainder of the site will be covered by hardstand or pavement, which eliminates erosion potential.

- Shallow Grade Open Drainage:
  Shallow open drainage has been adopted wherever possible to allow for low flow velocities, largely mitigating the need for additional scour protection above and beyond ground cover.

- Inlet & Outlet protection:
  Culvert inlet and outlet protection has been implemented as part of the drainage works, to prevent soil erosion caused by the flow acceleration into culverts and concentrated flow exiting culverts.

- Geotextile:
  This has been designed and implemented, where deemed necessary, to manage the impact caused by the kinetic energy carried with the runoff, as well as in (assisting) providing efficient drainage solution where it is applicable such as acting as a separation layer between rock mattress and underlying soil.

4.8.2 Sediment Control

The following measures have been proposed for the project to form a holistic sediment control during the operational phase of borrow pit:

- Vegetation/Ground Cover:
  Aside from providing erosion protection during rainfall events, vegetation also acts to trap sediment within shallow slow moving water. This allows soils to be retained on site, should they erode. Erosion within open drainage is not expected to occur due to the low flow velocities and rock protection provided. The remainder of the site will be covered by hardstand or pavement.

- Sediment Basin:
  A sediment basin is an effective sediment control measure designed to settle out particles within runoff and prevent them from continuing downstream. The section basin outlined within 4.3.3 and Table 1 is proposed to be retained for operational use. Noting that the basin is currently sized for construction sediment loss. Once the site is established with ground cover there is expected to be minimal sediment loading into the basin.

Refer to Appendix E for sizing details of the sediment basin.

It is noted that chemical flocculation is required for Type D sediment basin, together with pump outlet to allow for de-watering and flow outlet. For details of establishing and maintaining the Type D sediment basin refer to Appendix F.

5 QUALITY MANAGEMENT PLAN

With the ESC measures proposed, it is essential that a quality management plan is to be set up and implemented prior to the commencement of works to ensure that the proposed measures can be implemented as the works progress. The following Table 7 outlines the intended management plan.

Table 7: Management Plan

	Stormwater Quality Management – Construction Phase
Purpose:	To provide a set of Best Practice site management procedures to control the severity and extent of soil erosion and pollutant transport during the earthworks and construction phase.
Performance Criteria:	Water discharged from the site is to comply with State Planning Policy to ensure that no detrimental impacts on water quality and the environment occur during the construction phase. The quality of discharge from the site to satisfy the following Water Quality Objectives (WQOs): ***Release Criteria:*** • Water pH released from a controlled sediment basin outflow must be within the range 6.5 to 8.5. • Suspended Solids released from controlled sediment basin outflows must be no greater than 50mg/L. • Oils and Grease – no visible films or odour. • Litter – no visible litter washed or blown from the site.
Responsibility:	The Principal Contractor is responsible for the implementation of the Water Quality Monitoring Program (WQMP) during the course of all construction activities. The Principal Contractor is responsible for the implementation of the Stormwater Management Plan (SWMP) during the course of all construction activities.
Implementation Strategy:	Permanent and long-term drains and bund walls to be topsoiled and vegetated with suitable vegetation as soon as possible. Clean-up of general site litter on a weekly basis, prior to anticipated heavy rainfall and after significant rainfall events (>25mm/24hours). Landscaping activities and revegetation to occur as soon as practical after completion of earthworks and construction activities within the immediate area and must achieve a minimum 70% coverage of all erodible surfaces. Only appropriate herbicides and fertilisers to be used. The storage and handling of flammable and combustible liquids is managed in accordance with AS1940–1993.
Monitoring:	Erosion and sediment control (ESC) measures to be inspected daily by the site manager (or nominated representative) during periods of runoff-producing rainfall, and de-silted, repaired and amended as appropriate to maintain the WQOs. (a) **Daily site inspections**, during periods of runoff-producing rainfall must include: • all drainage, erosion and sediment control measures; • occurrences of excessive sediment deposition (whether on-site or off-site); • all site discharge points. (b) **Weekly site inspections** must include: • all drainage, erosion and sediment control measures; • occurrences of excessive sediment deposition (whether on-site or off-site); • occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements; • litter and waste receptors; • oil, fuel and chemical storage facilities. (c) Site inspections immediately **prior to anticipated runoff-producing rainfall** must include:

	Stormwater Quality Management – Construction Phase
	• all drainage, erosion and sediment control measures; • all temporary (e.g. over-night) flow diversion and drainage works. (d) Site inspections immediately **following runoff-producing rainfall** must include: • treatment and de-watering requirements of sediment basins; • sediment deposition within sediment basins and the need for its removal; • all drainage, erosion and sediment control measures; • occurrences of excessive sediment deposition (whether on-site or off-site); • occurrences of construction materials, litter or sediment placed, deposited, washed or blown from the site, including deposition by vehicular movements; • occurrences of excessive erosion, sedimentation, or mud generation around the site office, car park and material storage areas. (e) In addition to the above, **monthly site inspections** must include: • surface coverage of finished surfaces (both area and percentage cover); • health of recently established vegetation; • proposed staging of future site clearing, earthworks and site/soil stabilisation. Water quality monitoring must be carried out on any controlled discharge of water from a sediment basin, including water pH and suspended solids. • Water quality monitoring at the nominated monitoring stations must be carried out monthly and following significant rainfall (>25mm in 72hrs). The parameters to be tested for waters collected at monitoring stations must include: temperature, dissolved oxygen, pH, specific conductance, salinity, turbidity, suspended solids, and litter. Note that additional water quality monitoring maybe required if the WQOs are not being met.
Auditing:	ESCP reviews are to be carried out on a monthly basis to assess the implementation strategy. A checklist is to be completed which assesses the strategies listed above.
Identification of Incident or Failure:	Non-compliance with agreed performance criteria will be identified by: 1. Visual inspections identifying: • build-up of sediment off the site; • excessive sediment build-up on the site; • excessive erosion on the site; • release of construction material from the site; • poor vegetation establishment; • poorly maintained, damaged or failed ESC devices. 2. Deteriorated water quality identified by the Environmental Consultant as being attributable to the construction activities.
Corrective Action:	After any identification of incident or failure, the source/cause is to be immediately located and the following measures implemented: • Build-up of sediment off the site – the material must be collected and disposed of in a manner that will not cause ongoing environmental nuisance or harm; then on-site ESC measures amended, where appropriate, to reduce the risk of further sedimentation. • Excessive sediment build-up on the site – collect and dispose of material, then amend up-slope drainage and/or erosion control measures as appropriate to reduce further occurrence. • Severe or excessive rill erosion – investigate cause, control up-slope water movement, re-profile surface, cover dispersive soils with a minimum 100mm layer

	Stormwater Quality Management – Construction Phase
	of non-dispersive soil, and stabilise with erosion control blankets and vegetation as necessary. • Off-stream erosion – fill rills, vegetate and install velocity control measures. • In-stream erosion – consult appropriate hydraulic/waterway consultant for advice. • Release of construction material from the site – collected and disposed of in a manner that will not cause ongoing environmental nuisance or harm; then inspect litter and waste receptors. • Poor vegetation growth or soil coverage – plant new vegetation and/or mulch as required. Newly planted and previously planted areas may require supplementary watering and replanting. • Sediment fence failure – replace and monitor more frequently. Regular failures may mean that the sediment fence location, alignment or installation may need to be amended. If the release of excessive sediment and/or other materials off the site occurs, or water quality monitoring indicates levels are not within the WQOs, clean up deposition, and inspect all control measures. If the release of excessive sediment and/or other materials off the site is identified during two consecutive site inspections, or water quality monitoring indicates levels not within the WQOs on two consecutive monthly tests, then review and revise the ESCP, or otherwise reduce the rate, extent and/or duration of soil exposure. If monitored levels within any sediment basin does not conform to the release criteria for: • suspended solids – flocculate and retest; • pH – add acid if pH is too high, or add hydrated lime if pH is too low, and retest.
Reporting:	Reports will be submitted monthly during the construction at each stage. The reporting will include: • Construction Contractor site manager's report; and • Environmental Consultant's water quality monitoring report. Reporting will conform to all relevant standards guidelines of DILGP and identify performance of the implementation strategy, monitoring, identification of incidents and failure, and necessary/adopted corrective action. Reports will be submitted to the appointed representative monthly for submission to DILGP.

5.1 Responsibility & Reporting

Performance monitoring of all drainage control measures along with erosion and sediment control devices will remain the responsibility of the contractor. Site inspections shall be carried out and documented according to the Construction Management Plan.

The contractor should erect signage at the entrance to the site with contact information (including after-hours contact information). The contractor shall be responsible for the appropriate handling of all complaints.

Refer to Appendix G for template of supporting documents a Non-Conformance Report.

APPENDIX A

Existing Drainage Layout

N

LEE HOLM ROAD

FORRESTER ROAD

SOUTH CREEK

EXISTING 2.4m x 1.8m RCBC

EXISTING 2.5m x 1.8m RCBC

EXISTING SEDIMENT BASIN

FLOWS GREATER THAN 5% AEP ONLY TOWARD THE SITE

0.21 Ha

2.01 Ha

3.01 Ha

5.90 Ha

0.05 Ha

1.63 Ha

2.69 Ha

0.47 Ha

0.91 Ha

3.51 Ha

1.25 Ha

e104-1 e104-2 e103-2 e103-1 e102-2 e101-1 e101-2 e101-3 e101-4 e101-5 e100-2 e100-1

Ø300 Ø375 Ø675

LEGEND

- PROJECT SITE BOUNDARY
- EXISTING GRASSED SWALE
- EXISTING DRAINAGE CATCHMENT BOUNDARY
- 3.51 Ha — EXISTING DRAINAGE CATCHMENT AREA
- OVERLAND FLOW PATH
- e101-3 — EXISTING STORMWATER PIPE AND PIT AND IDENTIFIER
- EXISTING EASEMENTS
- SW — EXISTING STORMWATER PIPE
- S — EXISTING SEWER MAIN
- W — EXISTING WATER MAIN
- OPTIC — EXISTING OPTIC FIBRE
- HV — EXISTING ELECTRICAL HV
- OH — EXISTING ELECTRICAL OH

SKETCH ONLY

0 20 40 60 80 100 120m
SCALE 1:2000 AT A1 SIZE

BG&E

DATE 30/01/2019	PROJECT ST MARY'S			
SCALE 1:2000	TITLE EXISTING DRAINAGE			
GRID				
PREPARED CB				
SHEET 1 OF 1	PROJECT No. B18028	SKETCH No. SK-C-0038	REV A	

APPENDIX B

Upstream Drainage Catchment Plans

CONCEPT STORMWATER DRAINAGE CALCULATIONS:

CATCHMENT AREA A (DRAINAGE LINE A)

SITE STORAGE REQUIREMENT:	340.2m³
PERMISSABLE SITE DISCHARGE:	0.146m³/sec.
PROVIDED SITE STORAGE:	630m³
PROVIDED SITE DISCHARGE:	0.139m³/sec.

CATCHMENT AREA B (DRAINAGE LINE B)

SITE STORAGE REQUIREMENT:	44.5m³
PERMISSABLE SITE DISCHARGE:	0.019m³/sec.
PROVIDED SITE STORAGE:	100m³
PROVIDED SITE DISCHARGE:	0.018m³/sec.

CATCHMENT AREA C (DRAINAGE LINE C)

SITE STORAGE REQUIREMENT:	116.3m³
PERMISSABLE SITE DISCHARGE:	0.050m³/sec.
PROVIDED SITE STORAGE:	235m³
PROVIDED SITE DISCHARGE:	0.048m³/sec.

NOTE:

1. SITE STORAGE REQUIREMENT BASED ON VALUE OF 28m³ PER 1000m².
2. PERMISSABLE SITE DISCHARGE BASED ON VALUE OF 12l/sec. PER 1000m².
3. PROVIDED STORAGE VOLUMES BASED ON MAX. PONDING DEPTH OF 200mm.

EXISTING CULVERT NOTE:

DIMENSIONS :	2.4m(W) x 1.8m(H)
CATCHMENT AREA :	120ha
CRITICAL STORM FLOW :	30.3m³/sec.
(100YR ARI, 1hr DURATION,	66.2mm/hr)
DEPTH OF FLOW:	1.048m

STORMWATER TREATEMENT MEASURES:

STORMWATER TREATMENT MEASURES TO CONSIST OF THE FOLLOWING:

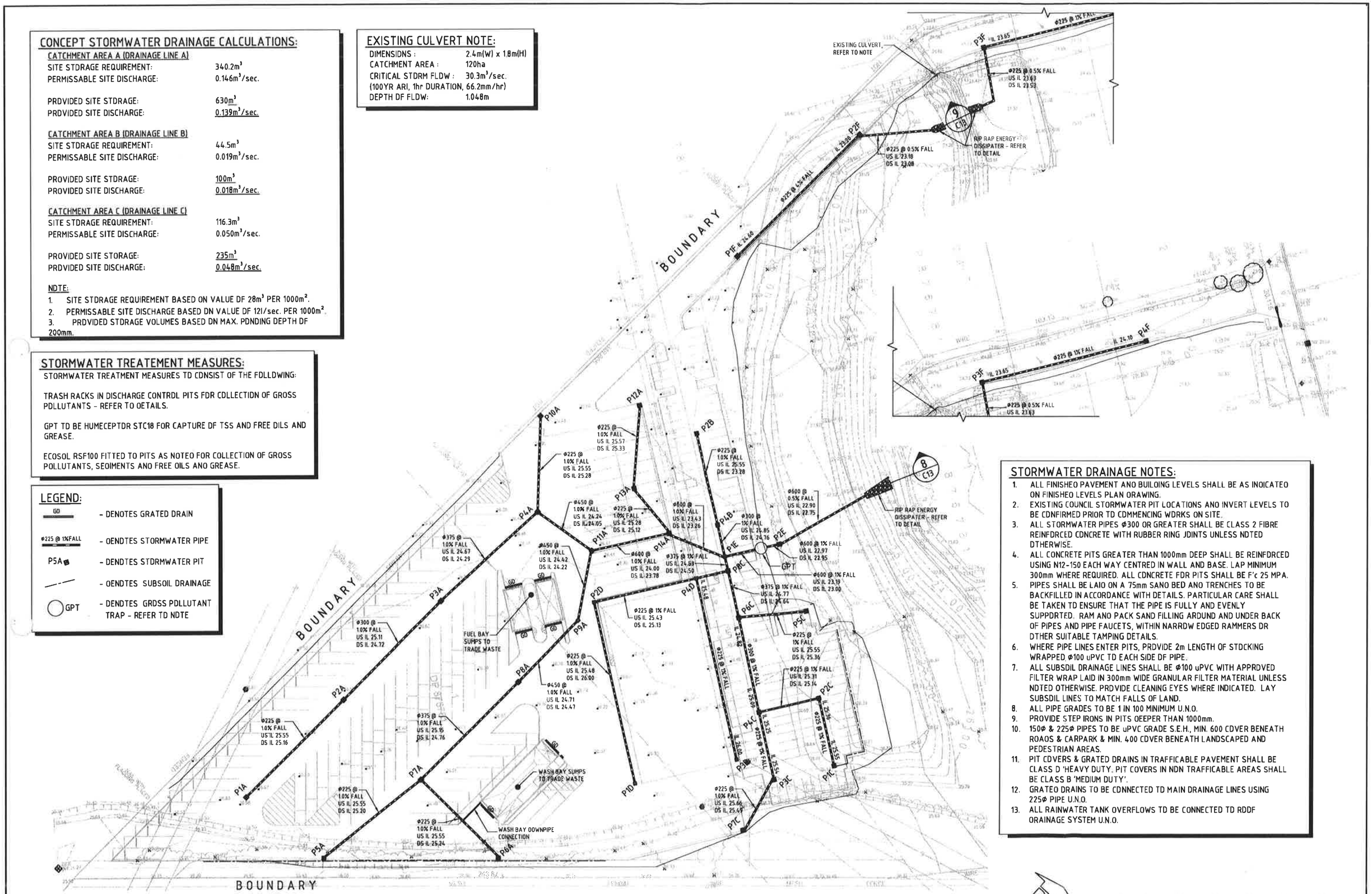
TRASH RACKS IN DISCHARGE CONTROL PITS FOR COLLECTION OF GROSS POLLUTANTS - REFER TO DETAILS.

GPT TO BE HUMECEPTOR STC18 FOR CAPTURE OF TSS AND FREE OILS AND GREASE.

ECOSOL RSF100 FITTED TO PITS AS NOTED FOR COLLECTION OF GROSS POLLUTANTS, SEDIMENTS AND FREE OILS AND GREASE.

LEGEND:

- GO — DENOTES GRATED DRAIN
- Ø225 @ 1%FALL — DENOTES STORMWATER PIPE
- P5A — DENOTES STORMWATER PIT
- DENOTES SUBSOIL DRAINAGE
- GPT — DENOTES GROSS POLLUTANT TRAP - REFER TO NOTE



STORMWATER DRAINAGE NOTES:

1. ALL FINISHED PAVEMENT AND BUILDING LEVELS SHALL BE AS INDICATED ON FINISHED LEVELS PLAN DRAWING.
2. EXISTING COUNCIL STORMWATER PIT LOCATIONS AND INVERT LEVELS TO BE CONFIRMED PRIOR TO COMMENCING WORKS ON SITE.
3. ALL STORMWATER PIPES Ø300 OR GREATER SHALL BE CLASS 2 FIBRE REINFORCED CONCRETE WITH RUBBER RING JOINTS UNLESS NOTED OTHERWISE.
4. ALL CONCRETE PITS GREATER THAN 1000mm DEEP SHALL BE REINFORCED USING N12-150 EACH WAY CENTRED IN WALL AND BASE. LAP MINIMUM 300mm WHERE REQUIRED. ALL CONCRETE FOR PITS SHALL BE F'c 25 MPA.
5. PIPES SHALL BE LAID ON A 75mm SAND BED AND TRENCHES TO BE BACKFILLED IN ACCORDANCE WITH DETAILS. PARTICULAR CARE SHALL BE TAKEN TO ENSURE THAT THE PIPE IS FULLY AND EVENLY SUPPORTED. RAM AND PACK SAND FILLING AROUND AND UNDER BACK OF PIPES AND PIPE FAUCETS, WITHIN NARROW EDGED RAMMERS OR OTHER SUITABLE TAMPING DETAILS.
6. WHERE PIPE LINES ENTER PITS, PROVIDE 2m LENGTH OF STOCKING WRAPPED Ø100 uPVC TO EACH SIDE OF PIPE.
7. ALL SUBSOIL DRAINAGE LINES SHALL BE Ø100 uPVC WITH APPROVED FILTER WRAP LAID IN 300mm WIDE GRANULAR FILTER MATERIAL UNLESS NOTED OTHERWISE. PROVIDE CLEANING EYES WHERE INDICATED. LAY SUBSOIL LINES TO MATCH FALLS OF LAND.
8. ALL PIPE GRADES TO BE 1 IN 100 MINIMUM U.N.O.
9. PROVIDE STEP IRONS IN PITS DEEPER THAN 1000mm.
10. 150Ø & 225Ø PIPES TO BE uPVC GRADE S.E.H., MIN. 600 COVER BENEATH ROADS & CARPARK & MIN. 400 COVER BENEATH LANDSCAPED AND PEDESTRIAN AREAS.
11. PIT COVERS & GRATED DRAINS IN TRAFFICABLE PAVEMENT SHALL BE CLASS D 'HEAVY DUTY'. PIT COVERS IN NON TRAFFICABLE AREAS SHALL BE CLASS B 'MEDIUM DUTY'.
12. GRATED DRAINS TO BE CONNECTED TO MAIN DRAINAGE LINES USING 225Ø PIPE U.N.O.
13. ALL RAINWATER TANK OVERFLOWS TO BE CONNECTED TO ROOF DRAINAGE SYSTEM U.N.O.

FOR CONSTRUCTION

CONCEPT STORMWATER DRAINAGE PLAN
1:500 SCALE

5m 0 10 20 30 40 50m
1:500 SCALE AT A1 SIZE PLOT

ISSUED	DATE	ISSUE
ISSUED FOR CONSTRUCTION	05.01.09	D
ISSUED FOR INFORMATION	17.11.08	D
ISSUED FOR TENDER	11.10.08	C
ISSUED FOR TENDER	08.10.08	B
ISSUED FOR INFORMATION	02.10.08	A
AMENDMENTS	DATE	ISSUE

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NSW, 2000, Australia
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PROJECT
WESTBUS FACILITY
LEE HOLM ROAD, ST MARYS

DESIGNED	DRAWN	DATE	CHECKED	SIZE	SCALE	CAD REF:
MW	MW	25.06.08		A1	AS SHOWN	9765 00- C11

Costin Roe Consulting Pty Ltd.
Consulting Engineers
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Costin Roe Consulting
Value In Engineering and Management

DRAWING TITLE
STORMWATER DRAINAGE PLAN

DRAWING No C09765.00-C11
ISSUE 0

RECEIVED
D/MGT
14 JUN 2011
PENRITH CITY COUNCIL

EXISTING FACTORY

DOWNPIPE FROM NEW WORKSHOP TO BE CONNECTED INTO EXISTING FACTORY DOWNPIPE

EXISTING DOWNPIPE (TYP)

DOWNPIPE FROM NEW WORKSHOP TO BE CONNECTED INTO EXISTING FACTORY DOWNPIPE

A

EXISTING DOWNPIPE

FH

EXIST S.W. PIT

EXISTING DOWNPIPE

NEW MAINTENANCE WORKSHOP

NOM 10045

D.P.

BOX GUTTER

D.P.

9500 | 6995 | 6995 | 6995

1 2 3 4 5

This plan was approved with Development Application
No 100811
THE

PLAN LAYOUT

EXIST S.W. PIT

ISSUE	DETAILS OF ALTERATIONS	APP BY	DRN	DATE
A	FIRST ISSUE	R.P.	R.P.	05.05.08

ARC
THE AUSTRALIAN REINFORCING COMPANY

ARC
PROPOSED MAINTENENCE WORKSHOP
ST MARYS FACTORY PROJECT
STORMWATER PLAN

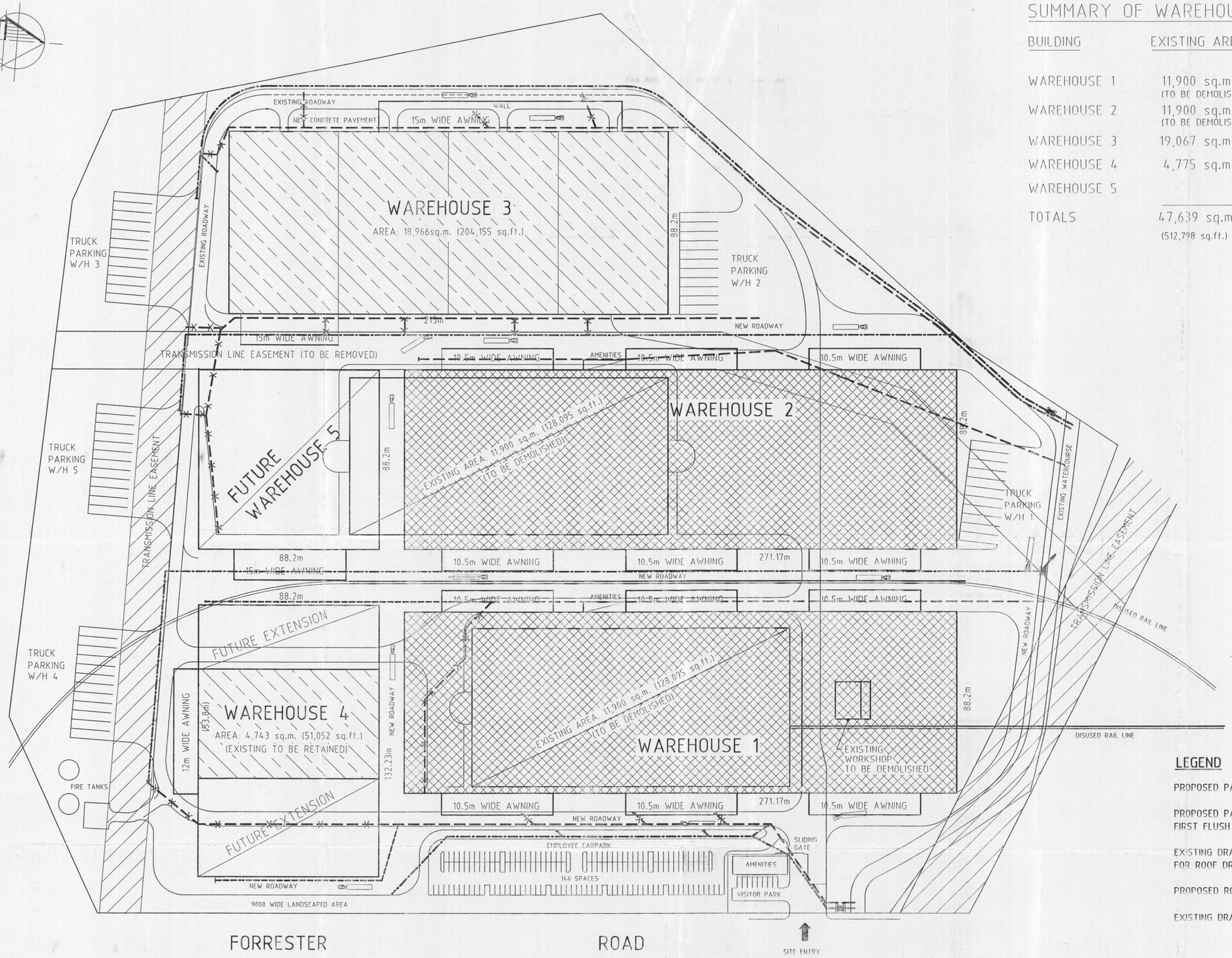
1:100	A3	ARC-WS-101	A

SUMMARY OF WAREHOUSE AREAS

BUILDING	EXISTING AREA	PROPOSED NEW CONSTRUCTION	DEVELOPED AREAS
WAREHOUSE 1	11,900 sq.m. (TO BE DEMOLISHED)	23,917 sq.m.	23,917 sq.m.
WAREHOUSE 2	11,900 sq.m. (TO BE DEMOLISHED)	23,917 sq.m.	23,917 sq.m.
WAREHOUSE 3	19,067 sq.m:	NIL	19,067 sq.m.
WAREHOUSE 4	4,775 sq.m.	6,953 sq.m.	11,728 sq.m.
WAREHOUSE 5		7,779 sq.m.	7,779sq.m.
TOTALS	47,639 sq.m. (512,798 sq.ft.)	62,566 sq.m. (673,477 sq.ft.)	86,408 sq.m. (930,118 sq.ft.)

EXISTING WAREHOUSING

PROPOSED NEW WAREHOUSING



NOTE
EXISTING DRAIN LINES SHOWN BASED ON CURRENT SURVEY INFORMATION.
DETAIL SURVEY CONFIRMATION WILL BE OBTAINED AT DETAIL DESIGN PHASE TO CONFIRM LEVELS, SIZES AND GRADES.
UPGRADING, IF REQUIRED, WILL BE INCORPORATED IN THE DESIGN.

LEGEND

PROPOSED PAVEMENT DRAINS

PROPOSED PAVEMENT DRAIN FIRST FLUSH INTERCEPTOR PITS

EXISTING DRAINS TO BE UTILISED FOR ROOF DRAINAGE ONLY

PROPOSED ROOF DRAINAGE ONLY DRAINS

EXISTING DRAINS TO BE DISCONTINUED

This is the plan referred to in Penrith City Council's consent:
No. DA 98159 Dated 16/4/98
for Environmental Planning Manager
(Council does not warrant or attest to the accuracy of the detail in this plan.)

20000 0 20000 40000 60000 80000 100000
DIMENSIONS ARE IN MILLIMETRES
1:1000 (AT A1 SHEET SIZE)

No.	Date	Amendment	By
		Revision	

Date	Amount	To	Date	Amount	To
Issue			Issue		

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ACN 050 214 894

Quality System Australian Standards ISO 9001/AS 3902 Victoria Quality Endorsed Company

FINEMORES
LEADERS IN TRANSPORT

R.A.DONNAN CONSULTING
BUILDING, TRANSPORT & WAREHOUSE PLANNING & DESIGN.
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Job Title: PROPOSED WAREHOUSE FACILITY LOT 2 FORRESTER RD. ST.MARYS

Drawing Title: PROPOSED STORMWATER SYSTEM

Date: MARCH 1998
Drawn: MTJ
Checked:
Scale: 1 : 1000
Rev:

Job Number: 84043

Drawing Number: CSK-1

CSK-1 1:56 P.M. 16/3/1998

A1

APPENDIX C

Supporting Calculations

C.1 20 YEAR ARI & 100 YEAR ARI RESULTS

St Mary's Freight Hub

Drainage Calculation Tables

LOCATION				TIME		SUB-CATCHMENT RUNOFF						INLET DESIGN								DRAIN DESIGN												HEADLOSSES									PART FULL PIPE			DESIGN LEVELS				
				tc	I	C	C10	C10	A	C*A	Q	Qa					Qi	Qb		tv	I	A	Q			Qp	L				Vf			Ku	Kw			Hw	Sf	Hf	V2/2g	D	Vp					
DESIGN EVENT (AEP)	STRUCTURE NAME	DRAIN SECTION	SUB-CATCHMENTS CONTRIBUTING	SUB-CATCHMENT TIME OF CONC.	RAINFALL INTENSITY (mm/hr)	CO-EFFICIENT OF RUNOFF	10yr RUNOFF CO-EFFICIENT (IMPERVIOUS AREA)	10yr RUNOFF CO-EFFICIENT (PERVIOUS AREA)	SUB-CATCHMENT AREA	EQUIVALENT AREA	SUB-CATCHMENT DISCHARGE	FLOW IN K&C (INC. BYPASS)	ROAD GRADE AT INLET	MINOR FLOW ROAD CAPACITY	INLET TYPE	INLET DESCRIPTION	FLOW INTO INLET	BYPASS FLOW	BYPASS STRUCTURE NAME	CRITICAL TIME OF CONC.	CRITICAL RAINFALL INTENSITY	CRITICAL EFFECTIVE AREA	MAJOR TOTAL FLOW	MAJOR SURFACE FLOW CAPACITY	MAJOR SURFACE FLOW	PIPE FLOW	REACH LENGTH	PIPE GRADE	PIPE/BOX DIMENSIONS	PIPE TYPE (CLASS)	FLOW VELOCITY FULL (PIPE GRADE CAPACITY)	STRUCTURE Ku CHART	STRUCTURE Ku METHOD	STRUCTURE Ku	STRUCTURE Kw	STRUCTURE SUBMERGENCE RATIO	STRUCTURE GRATE FLOW RATIO	STRUCTURE W.S.E LOSS	PIPE FRICTION SLOPE	PIPE FRICTION HEADLOSS (L x Sf)	PIPE VELOCITY HEAD	PART FULL FLOW DEPTH	PART FULL FLOW VELOCITY	PIPE UPSTREAM HGL	PIPE DOWNSTREAM HGL	UPSTREAM STRUCTURE HGL	STRUCTURE SETOUT LEVEL	STRUCTURE NAME
				(mins)	(mm/hr)				(ha)	(ha)	(m^3/s)	(m^3/s)	(%)	(m^3/s)			(m^3/s)	(m^3/s)		(mins)	(mm/hr)	(ha)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m)	(%)			(m/s)							(m)	(%)	(m)	(m/s)	(m)	(m/s)	(m AHD)	(m AHD)	(m AHD)	(m AHD)	
20.0%	1-1	1-1 to 1-2		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.047	0.043	0.020	0.020	2.583	0.543	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.010	0.010	3-1	5.000	165.924	0.043		0.543	0.036	0.010	8.506	2.000	0.375	RCP RRJ2	0.089	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.010	1.000	0.004	1.544	0.149	0.000	0.049	1.155	30.524	30.393	30.528	31.700	1-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.047	0.047	0.036	0.036		0.543			0.028	0.007	3-1	5.000	269.934	0.047				0.028					0.258	G2		9.700	9.700	1.088	1.000	0.033	1.273	0.138	0.003	0.082	1.582	30.575	30.467	30.608		
20.0%	1-2	1-2 to 1-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.047	0.042	0.019	0.019	2.725	0.543	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.017	0.002	1-3	5.071	165.164	0.085		0.543	0.035	0.027	68.982	2.000	0.375	RCP RRJ2	0.245	G1/T9/T10	Ku,Kw>0 - Missouri/Hare Charts	3.625	3.63(3.88)	1.032	0.639	0.012	1.929	1.357	0.003	0.080	1.559	30.382	29.051	30.394	31.690	1-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.047	0.047	0.035	0.035		0.543			0.028	0.007	1-3	5.071	268.790	0.094				0.056					0.508	T9/T10		2.325	2.32(2.68)	1.094	0.496	0.035	1.802	1.292	0.013	0.116	1.923	30.436	29.193	30.471		
20.0%	1-3	1-3 to 1-4	3-1 1-1 1-2	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.037	0.033	0.015	0.017	2.344	0.384	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.015	0.002	1-4	5.575	160.066	0.150		0.384	0.035	0.052	69.264	1.200	0.375	RCP RRJ2	0.475	T3/T6	Ku,Kw>0 - Missouri/Hare Charts	1.814	1.81(2.33)	1.072	0.281	0.027	1.117	0.807	0.012	0.128	1.570	29.030	28.257	29.057	30.052	1-3
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.037	0.037	0.028	0.035		0.384			0.028	0.007	1-4	5.646	260.070	0.167				0.107					0.969	T3/T6		1.825	1.83(2.33)	1.297	0.248	0.111	0.461	0.376	0.048	0.191	1.897	29.105	28.786	29.217		
20.0%	1-4	1-4 to 1-5	4-1 3-1 1-1 1-2 1-3	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.037	0.033	0.015	0.017	1.458	0.311	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.017	0.000	1-5	6.152	154.790	0.216		0.311	0.034	0.093	17.602	0.500	0.450	RCP RRJ2	0.584	T3/T6	Ku,Kw>0 - Missouri/Hare Charts	1.847	1.85(2.31)	1.089	0.175	0.040	0.537	0.088	0.017	0.205	1.318	28.225	28.130	28.265	29.029	1-4
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.037	0.037	0.028	0.034		0.311			0.028	0.007	1-5	6.152	253.114	0.240				0.155					0.974	T1/T3		1.560	1.56(1.85)	1.748	0.170	0.090	0.251	0.044	0.048	0.280	1.490	28.710	28.666	28.800		
20.0%	1-5	1-5 to 1-6	5-1 4-1 3-1 1-1 1-2 1-3 1-4	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.016	0.015	0.007	0.007	0.497	0.018	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet	0.007	0.000		6.299	153.533	0.246		0.018	0.022	0.105	10.439	0.500	0.600	RCP RRJ2	0.370	T1/T3	Ku,Kw>0 - Missouri/Hare Charts	0.790	0.79(0.90)	1.010	0.063	0.006	0.633	0.050	0.007	0.192	1.339	27.999	27.933	28.005	28.937	1-5
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.016	0.016	0.012	0.022		0.009			0.022	0.000		6.299	251.209	0.273				0.199					0.702	T1/T3		1.254	1.25(1.48)	1.465	0.107	0.037	0.089	0.009	0.025	0.272	1.593	28.634	28.625	28.671		
20.0%	1-6	1-6 to 1-7	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.012	0.011	0.005	0.006	1.071	0.225	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.006	0.000	1-5	6.386	152.802	0.290		0.225	0.012	0.124	20.184	0.500	0.600	RCP RRJ2	0.439	T1/T3	Ku,Kw>0 - Missouri/Hare Charts	1.129	1.13(1.34)	1.022	0.047	0.013	0.574	0.099	0.010	0.210	1.404	27.849	27.733	27.862	28.965	1-6
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.012	0.012	0.009	0.012		0.225			0.010	0.002	1-5	6.386	250.101	0.322				0.228					0.805	T1/T3		0.940	0.94(1.08)	1.677	0.043	0.036	0.117	0.024	0.033	0.294	1.650	28.594	28.570	28.630		
20.0%	1-7	1-7 to 1-8	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.025	0.022	0.010	0.010	1.571	0.396	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.009	0.001	1-6	6.050	155.685	0.304		0.396	0.019	0.131	36.456	0.682	0.600	RCP RRJ2	0.465	T3/T6	Ku,Kw>0 - Missouri/Hare Charts	1.876	1.88(2.27)	1.042	0.069	0.025	0.384	0.194	0.011	0.200	1.595	27.232	27.092	27.257	29.191	1-7
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.025	0.025	0.019	0.019		0.396			0.015	0.004	1-6	6.554	248.002	0.347				0.239					0.846	T3/T6		1.456	1.46(1.63)	2.627	0.061	0.060	0.129	0.047	0.037	0.277	1.875	28.517	28.470	28.576		
20.0%	1-9	1-9 to 1-10	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.552	0.497	0.229	0.229	1.200	0.227	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.196	0.033	1-10	6.555	151.408	0.781		0.227	0.414	0.296	98.996	0.500	0.600	RCP RRJ2	1.046	G1/T1/T3	Ku,Kw>0 - Missouri/Hare Charts	2.306	2.31(2.34)	2.041	0.603	0.131	0.198	0.196	0.056	0.345	1.758	26.921	26.726	27.052	28.863	1-9
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.552	0.552	0.414	0.414		0.227			0.268	0.146	1-10	6.555	247.987	0.868				0.452					1.599	G1/T1/T3		1.327	1.33(1.35)	4.101	0.532	0.176	0.461	0.457	0.130	0.472	1.895	28.112	27.655	28.288		
20.0%	1-10	1-10 to 1-11	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-9	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.824	0.742	0.342	0.375	1.200	0.195	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.306	0.068	1-11	5.825	157.712	1.430		0.195	0.764	0.558	99.101	0.500	0.600	RCP RRJ2	1.973	G1/T1	Ku,Kw>0 - Missouri/Hare Charts	1.592	1.590	2.355	0.509	0.316	0.703	0.697	0.199	0.600	1.973	26.409	25.713	26.726	27.664	1-10
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.824	0.824	0.618	0.764		0.195			0.269	0.495	1-11	5.825	257.537	1.589				0.642					2.269	T1		1.049	1.050	3.905	0.373	0.276	0.929	0.921	0.263	0.600	2.269	27.380	26.458	27.655		
20.0%	1-11	1-11 to 1-12	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-9 1-10	5.0	165.924	0.900	0.900,1.000	0.750,0.750	1.219	1.097	0.505	0.574	1.200	0.195	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.447	0.127	1-12	6.651	150.638	2.526		0.195	1.409	0.930	63.184	1.200	0.750	RCP RRJ2	2.106	T1	Ku,Kw>0 - Missouri/Hare Charts	1.592	1.590	1.480	0.445	0.360	1.026	0.722	0.226	0.464	3.240	25.353	24.704	25.713	26.464	1-11
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	1.219	1.219	0.914	1.409		0.195			0.505	0.904	1-12	6.651	246.818	2.807				1.021					2.311	T1		1.155	1.160	2.270	0.440	0.315	0.716	0.452	0.273	0.495	3.301	26.144	25.691	26.458		
20.0%	1-12	1-12 to 1-13	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-9 1-10 1-11	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.927	0.834	0.384	0.511	1.200	0.195	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.404	0.108	1-13	6.352	153.081	3.227		0.195	1.598	1.265	64.624	1.200	0.900	RCP RRJ2	1.988	T1	Ku,Kw>0 - Missouri/Hare Charts	1.065	1.060	1.238	0.303	0.215	1.178	0.775	0.202	0.497	3.514	24.490	23.728	24.704	25.695	1-12
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.927	0.927	0.695	1.598		0.195			0.682	0.916	1-13	7.177	240.686	3.734				1.580					2.484	T1		1.163	1.160	2.075	0.401	0.366	0.649	0.419	0.315	0.574	3.692	25.325	24.906	25.691		
20.0%	1-13	1-13 to 1-14	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-9 1-10 1-11 1-12	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.968	0.871	0.401	0.509	1.200	0.195	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.402	0.107	1-14	6.891	148.756	4.098		0.195	1.642	1.587	54.729	1.032	1.050	RCP RRJ2	1.832	T1	Ku,Kw>0 - Missouri/Hare Charts	0.859	0.860	1.140	0.241	0.147	0.721	0.507	0.171	0.542	3.518	23.581	23.186	23.728	24.908	1-13
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.968	0.968	0.726	1.642		0.195			0.689	0.952	1-14	6.891	243.961	4.553				2.133					2.464	T1		0.933	0.930	1.945	0.304	0.289	0.520	0.284	0.310	0.653	3.767	24.617	24.333	24.906		
20.0%	1-14	1-14 to 1-15	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-9 1-10 1-11 1-12 1-13	5.0	165.924	0.900	0.900,1.000	0.750,0.750	1.035	0.932	0.429	0.536	1.033	0.178	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.421	0.115	1-15	7.347	145.369	5.029		0.178	1.729	1.916	53.851	0.902	1.200	RCP RRJ2	1.694	T1	Ku,Kw>0 - Missouri/Hare Charts	0.780	0.780	1.095	0.210	0.114	0.097	0.105	0.146	0.584	3.506	23.072	23.020	23.186	24.334	1-14
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	1.035	1.035	0.776	1.729		0.178			0.765	0.964	1-15	7.347	238.811	5.588				2.743					2.426	T1		0.882	0.880	1.851	0.264	0.265	0.422	0.227	0.300	0.729	3.818	24.068	23.841	24.333		
20.0%	1-15	1-15 to 1-16	6-1 5-1 4-1 3-1 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-9 1-10 1-11 1-12 1-13 1-14	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.999	0.899	0.414	0.530	0.900	0.237	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.416	0.113	10-2	7.796	142.251	5.928		0.237	1.713	2.229	12.133	1.000	1.200	RCP RRJ2	1.971	T3/T6	Ku,Kw>0 - Missouri/Hare Charts	1.952	1.95(2.42)	1.400	0.179	0.480	-0.046	0.030	0.198	0.620	3.785	22.633	22.638	23.113	23.841	1-15
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.999	0.999	0.749	1.713		0.237			-0.547	2.260	10-2	7.796	234.063	6.587				2.023					1.788	T3/T6		1.905	1.91(2.08)	1.862	0.000	0.340	0.229	0.028	0.163	0.585	3.694	23.500	23.473	23.840		
20.0%	2-1	2-1 to 2-2		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.041	0.037	0.017	0.017	1.426	0.546	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.017	0.000	LOST	5.000	165.924	0.037		0.546	0.031	0.017	8.510	0.500	0.375	RCP RRJ2	0.155	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.032	1.000	0.012	0.083	0.027	0.001	0.090	0.834	31.685	31.678	31.697	32.893	2-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.041	0.041	0.031	0.031		0.546			0.025	0.006	LOST	5.000	269.934	0.041				0.025					0.224	G2		9.700	9.700	1.066	1.000	0.025	-0.026	0.014	0.003	0.109	0.927	31.719	31.722	31.744		
20.0%	2-2	2-2 to 2-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.044	0.039	0.018	0.018	1.417	0.384	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.018	0.000	LOST	5.071	165.164	0.076		0.384	0.033	0.035	8.918	1.451	0.375	RCP RRJ2	0.317	G1/T9/T10	Ku,Kw>0 - Missouri/Hare Charts	2.727	2.73(2.91)	1.040	0.514	0.015	1.845	0.099	0.005	0.099	1.498	31.664	31.500	31.679	32.887	2-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.044	0.044	0.033	0.033		0.384			0.026	0.007	LOST	5.071	268.789	0.085				0.051					0.458	G1/T9/T10		2.727	2.73(2.91)	1.083	0.514	0.031	1.932	0.093	0.011	0.120	1.664	31.692	31.520	31.724		
20.0%	3-1	3-1 to 10-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.036	0.033	0.015	0.025	2.348	0.384	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.012	0.012	4-1	5.000	165.924	0.033		0.384	0.034	0.012	8.500	2.000	0.375	RCP RRJ2	0.113	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.017	1.000	0.006	-0.003	0.000	0.001	0.055	1.240	29.051	29.051	29.057	30.052	3-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.036	0.036	0.027	0.034		0.384			0.028	0.007	4-1	5.000	269.934	0.036				0.028					0.249	G2		9.700	9.700	1.263	1.000	0.031	0.021	0.002	0.003	0.081	1.567	29.194	29.193	29.225		
20.0%	4-1	4-1 to 10-4		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.037	0.033	0.015	0.028	1.458	0.311	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.028	0.000	5-1	5.000	165.924	0.033		0.311	0.034	0.028	8.500	2.000	0.300	RCP RRJ2	0.392	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.253	1.000	0.076	0.898	0.112	0.008	0.088	1.605	28.333	28.257	28.409	29.029	4-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.037	0.037	0.027	0.034		0.311			0.028	0.007	5-1	5.000	269.934	0.037				0.027					0.389	G2		6.500	6.500	2.119	1.000	0.050	0.069	0.006	0.008	0.088	1.602	28.791	28.786	28.842		
20.0%	5-1	5-1 to 10-5		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.017	0.015	0.007	0.007	0.498	0.020	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet	0.007	0.000		5.000	165.924	0.015		0.020	0.025	0.007	8.500	2.000	0.375	RCP RRJ2	0.063	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.005	1.000	0.002	1.057	0.108	0.000	0.042	1.040	28.094	28.004	28.096	28.937	5-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.017	0.017	0.013	0.025		0.010			0.025	0.000		5.000	269.934	0.017				0.025					0.227	G2		8.386	8.390	1.743	1.000	0.022	0.017	0.001	0.003	0.077	1.525	28.667	28.666	28.689		
20.0%	6-1	6-1 to 10-6		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.038	0.034	0.016	0.016	1.062	0.225	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	0.016	0.000	5-1	5.000	165.924	0.034		0.225	0.028	0.016	8.501	2.000	0.300	RCP RRJ2	0.222	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.081	1.000	0.024	2.338	0.138	0.003	0.066	1.363	28.238	28.039	28.262	28.966	6-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.038	0.038	0.028	0.028		0.225			0.023	0.006	5-1	5.000	269.934	0.038				0.023					0.321	G2		8.267	8.270	1.765	1.000	0.044	0.047	0.004	0.005	0.079	1.517	28.629	28.625	28.672		
20.0%	7-1	7-1 to BYPASS-1		5.0	165.924	0.900	0.900,1.000	0.750,0.750	2.563	2.307	1.063	1.063	1.423		H.W.IN	HEADWALL	1.063	0.000		5.000	165.924	2.307			1.922	1.063	29.958	1.000	0.600	RCBC	1.477		Direct	2.000	2.000			0.191	1.394	0.218	0.095	0.291	3.040	28.309	27.892	28.500	27.900	7-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	2.563	2.563	1.922	1.922					1.922	0.000		5.000	269.934	2.563				1.922					2.670			2.000	2.000			0.191	1.394	0.218	0.095	0.291	5.495	28.309	27.892	28.500		
20.0%	8-2	8-2 to 8-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.053	0.047	0.022	0.022			R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.022	0.000		5.000	165.924	0.047			0.039	2.094	99.203	0.500	1.200	RCP RRJ2	1.852	T1/T3	Ku,Kw>0 - Missouri/Hare Charts	0.339	0.34(0.36)	1.053	0.010	0.063	0.485	0.496	0.175	0.741	2.858	24.157	23.675	24.220	26.380	8-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.053	0.053	0.039	0.039					0.039	0.000		5.000	269.934	0.053				4.540					4.014	T1/T3		0.294	0.29(0.31)	2.517	0.009	0.146	0.673	0.668	0.479	1.200	4.014	26.234	25.566	26.380		
20.0%	8-3	8-3 to 8-4		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.047	0.042	0.019	0.019		2.879	R.S.I.P. 900x1800	Grated Surface Inlet Pit	0.000	0.019	8-4	5.827	157.696	0.089		2.879	0.035	2.092	98.824	0.593	1.200	RCP RRJ2	1.850	T1	Ku,Kw>0 - Missouri/Hare Charts	0.200	0.200	1.029	0.000	0.035	0.404	0.524	0.175	0.700	3.054	23.640	23.241	23.675	25.566	8-3
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.047	0.047	0.035	0.035		2.879			-0.114	0.149	8-4	5.827	257.513	0.099				4.423					3.911	T1		0.200	0.200	2.268	0.000	0.156	1.096	1.083	0.780	1.200	3.911	25.410	24.327	25.566		
20.0%	8-4	8-4 to 8-5	8-2 8-3	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.043	0.039	0.018	0.037	1.240	0.093	R.S.I.P. 1800x1800	Grated Surface Inlet Pit	0.000	0.037	LOST	6.650	150.643	0.128		0.093	0.181	2.089	53.243	0.500	1.200	RCP RRJ2	1.847	T6/T9	Ku,Kw>0 - Missouri/Hare Charts	2.216	2.22(2.52)	1.366	0.000	0.439	0.139	0.116	0.174	0.739	2.857	22.855	22.781	23.294	24.327	8-4
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.043	0.043	0.032	0.181		0.093			-0.648	0.829	LOST	6.650	246.825	0.143				3.769					3.332	T6/T9		1.901	1.90(2.13)	2.068	0.000	1.207	0.924	0.400	0.567	1.200	3.332	23.120	22.628	24.327		
20.0%	9-1	9-1 to 9-2		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.017	0.015	0.007	0.007	1.198	0.136	3.0 EKI	Grated Gully Pit with 3.0m Extended Kerb Inlet Lintel	0.006	0.001	11-1	5.000	165.924	0.015		0.136	0.013	0.006	24.769	0.500	0.375	RCP RRJ2	0.058	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.004	1.000	0.002	0.287	0.088	0.000	0.056	0.625	23.343	23.272	23.344	24.437	9-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.017	0.017	0.013	0.013		0.136			0.010	0.003	11-1	5.000	269.934	0.017				0.010					0.093	G2		9.700	9.700	1.171	1.000	0.004	0.003	0.001	0.000	0.070	0.719	23.721	23.721	23.726		
20.0%	9-2	9-2 to 9-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.060	0.054	0.025	0.025	1.214	0.242	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	0.025	0.000	9-3	5.000	165.924	0.069		0.242	0.045	0.031	28.374	0.500	0.450	RCP RRJ2	0.195	G1/T1/T3	Ku,Kw>0 - Missouri/Hare Charts	4.881	4.88(4.93)	1.021	0.795	0.010	0.448	0.139	0.002	0.114	0.972	23.262	23.135	23.272	24.651	9-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.060	0.060	0.045	0.045		0.121			0.045	0.000	9-3	5.000	269.934	0.076				0.055					0.344	G1/T1/T3		5.072	5.07(5.12)	1.285	0.813	0.031	0.031	0.009	0.006	0.153	1.142	23.690	23.681	23.721		
20.0%	9-4	9-4 to 10-16	9-1 9-2	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.265	0.238	0.110	0.110	1.000		2.4 EKI	Grated Gully Pit with 2.4m Extended Kerb Inlet Lintel	0.088	0.021	10-2	5.000	165.924	0.299			0.198	0.116	42.759	0.500	0.450	RCP RRJ2	0.729	G1/T1	Ku,Kw>0 - Missouri/Hare Charts	4.455	4.460	1.268	0.744	0.121	0.510	0.214	0.027	0.233	1.394	23.016	22.798	23.137	24.244	9-4
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.265	0.265	0.198	0.198					0.094	0.104	10-2	5.000	269.934	0.333				0.142					0.896	G1/T1		2.573	2.570	1.978	0.636	0.106	0.213	0.091	0.041	0.265	1.463	23.564	23.473	23.669		
20.0%	10-1	10-1 to 10-2		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.321	0.289	0.133	0.133	0.242	0.292	3.6 EKI	Grated Gully Pit with 3.6m Extended Kerb Inlet Lintel	0.133	0.000	10-2	5.000	165.924	0.289		0.292	0.241	0.133	19.246	2.000	0.450	RCP RRJ2	0.837	G1	Ku,Kw>0 - Missouri/Hare Charts	3.712	3.710	2.532	1.000	0.133	0.185	0.036	0.036	0.170	2.411	23.358	23.323	23.491	23.841	10-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.321	0.321	0.241	0.241		0.292			0.117	0.124	10-2	5.000	269.934	0.321				0.117					0.735	G1		3.141	3.140	3.013	1.000	0.086	0.143	0.027	0.027	0.159	2.326	23.621	23.594	23.708		
20.0%	10-2	10-2 to 10-16		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.498	0.448	0.206	0.341	1.194	0.000	3.6 EKI SAG	Grated Gully (Sag) Pit with 3.6m Extended Kerb Inlet Lintel	0.341	0.000		5.160	164.221	0.737		0.000	2.861	0.471	8.490	0.500	0.525	RCP RRJ2	2.174	G1/T3/T6	Ku,Kw>0 - Missouri/Hare Charts	2.479	2.48(2.55)	2.655	0.719	0.616	1.020	0.087	0.241	0.525	2.174	22.725	22.638	23.341	23.634	10-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.498	0.498	0.373	2.861		0.000			2.861	0.000		5.160	267.368	0.819				2.972					13.731	G1/T3/T6		2.938	2.94(2.94)	3.137	0.961	0.108	0.155	0.013	0.037	0.525	13.731	23.486	23.473	23.594		
20.0%	11-1	11-1 to 11-2		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.024	0.021	0.010	0.011	1.169	0.110	2.4 EKI	Grated Gully Pit with 2.4m Extended Kerb Inlet Lintel	0.011	0.000	12-2	5.000	165.924	0.021		0.110	0.020	0.011	4.527	2.000	0.375	RCP RRJ2	0.095	G2	Ku,Kw>0 - Missouri/Hare Charts	9.700	9.700	1.012	1.000	0.004	-0.007	0.000	0.000	0.051	1.179	22.789	22.790	22.794	23.554	11-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.024	0.024	0.018	0.020		0.110			0.016	0.004	12-2	5.000	269.934	0.024				0.016					0.147	G2		9.700	9.700	1.029	1.000	0.011	-0.008	0.000	0.001	0.063	1.341	22.724	22.724	22.734		

St Mary's Freight Hub

Drainage Calculation Tables

LOCATION				TIME		SUB-CATCHMENT RUNOFF						INLET DESIGN							DRAIN DESIGN											HEADLOSSES							PART FULL PIPE			DESIGN LEVELS				
				tc	I	C	C10	C10	A	C*A	Q	Qa					Qi	Qb		tv	I	A	Q			Qp	L				Vf				Ku	Kw			Hw	Sf	Hf	V2/2g	D	Vp					
DESIGN EVENT (AEP)	STRUCTURE NAME	DRAIN SECTION	SUB-CATCHMENTS CONTRIBUTING	SUB-CATCHMENT TIME OF CONC.	RAINFALL INTENSITY (mm/hr)	CO-EFFICIENT OF RUNOFF	10yr RUNOFF CO-EFFICIENT (IMPERVIOUS AREA)	10yr RUNOFF CO-EFFICIENT (PERVIOUS AREA)	SUB-CATCHMENT AREA	EQUIVALENT AREA	SUB-CATCHMENT DISCHARGE	FLOW IN K&C (INC. BYPASS)	ROAD GRADE AT INLET	MINOR FLOW ROAD CAPACITY	INLET TYPE	INLET DESCRIPTION	FLOW INTO INLET	BYPASS FLOW	BYPASS STRUCTURE NAME	CRITICAL TIME OF CONC.	CRITICAL RAINFALL INTENSITY	CRITICAL EFFECTIVE AREA	MAJOR TOTAL FLOW	MAJOR SURFACE FLOW CAPACITY	MAJOR SURFACE FLOW	PIPE FLOW	REACH LENGTH	PIPE GRADE	PIPE/RCK DIMENSIONS	PIPE TYPE (CLASS)	FLOW VELOCITY FULL (PIPE GRADE CAPACITY)	STRUCTURE Ku CHART	STRUCTURE Ku METHOD	STRUCTURE Ku	STRUCTURE Kw	STRUCTURE SUBMERGENCE RATIO	STRUCTURE GRATE FLOW RATIO	STRUCTURE W.S.E LOSS	PIPE FRICTION SLOPE	PIPE FRICTION HEADLOSS (L x Sf)	PIPE VELOCITY HEAD	PART FULL FLOW DEPTH	PART FULL FLOW VELOCITY	PIPE UPSTREAM HGL	PIPE DOWNSTREAM HGL	UPSTREAM STRUCTURE HGL	STRUCTURE SETOUT LEVEL	STRUCTURE NAME
				(mins)	(mm/hr)				(ha)	(ha)	(m^3/s)	(m^3/s)	(%)	(m^3/s)			(m^3/s)	(m^3/s)		(mins)	(mm/hr)	(ha)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m)	(%)			(m/s)								(m)	(%)	(m)	(m/s)	(m)	(m/s)	(m AHD)	(m AHD)	(m AHD)	(m AHD)	
20.0%	11-2	11-2 to 11-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.124	0.112	0.051	0.051	1.228	0.117	2.4 EKI	Grated Gully Pit with 2.4m Extended Kerb Inlet Lintel	0.051	0.000	12-3	5.000	165.924	0.133		0.117	0.093	0.062	12.331	0.500	0.375	RCP RRJ2	0.558	G2/T1/T3	Ku,Kw=0 - Missouri/Hare Charts	7.051	7.05(7.13)	1.302	0.829	0.113	0.078	0.012	0.016	0.178	1.190	22.678	22.668	22.791	23.558	11-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.124	0.124	0.093	0.093		0.117			0.064	0.029	12-3	5.000	269.934	0.148				0.080					0.722	G2/T1/T3			6.541	6.54(6.64)	1.471	0.797	0.176	0.512	0.062	0.027	0.208	1.268	22.550	22.487	22.727		
20.0%	12-1	12-1 to 12-2		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.048	0.043	0.020	0.020		0.000	G.S.I.P. 900x900	Grated Surface Inlet Pit	0.000	0.020	12-2	5.000	165.924	0.043	0.000	0.036	0.000	2.764	3.000	0.450	RCP RRJ2	0.000		Direct	0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	22.671	22.671	22.671	23.387	12-1
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.048	0.048	0.036	0.036		0.000			0.000	0.036	12-2	5.000	269.934	0.048				0.000					0.000				0.000	0.000			0.000	0.000	0.000	0.000	0.000	0.000	23.111	23.111	23.111		
20.0%	12-2	12-2 to 12-3		5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.204	0.183	0.085	0.104	0.535	0.639	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	0.104	0.000	12-3	5.000	165.924	0.226		0.639	0.193	0.104	4.500	0.500	0.450	RCP RRJ2	0.656	G2	Ku,Kw=0 - Missouri/Hare Charts	9.700	9.700	1.473	1.000	0.213	0.046	0.006	0.022	0.219	1.357	22.458	22.456	22.671	23.202	12-2
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.204	0.204	0.153	0.193		0.319			0.193	0.000	12-3	5.000	269.934	0.251				0.193					1.211	G2			6.141	6.140	2.205	1.000	0.459	0.388	0.017	0.075	0.328	1.550	22.652	22.634	23.111		
20.0%	12-3	12-3 to 12-4	12-1 12-2	5.0	165.924	0.900	0.900,1.000	0.750,0.750	0.049	0.044	0.020	0.021	0.526	0.149	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	0.021	0.000	LOST	5.038	165.521	0.270		0.149	0.066	0.125	15.568	0.822	0.450	RCP RRJ2	0.784	T1/T3	Ku,Kw=0 - Missouri/Hare Charts	1.371	1.37(1.61)	1.112	0.166	0.050	0.052	0.024	0.031	0.210	1.709	22.413	22.405	22.463	23.202	12-3
1.0%				5.0	269.934	1.000	0.900,1.000	0.750,0.750	0.049	0.049	0.037	0.066		0.074			0.066	0.000	LOST	5.038	269.327	0.301				0.258					1.624	T1/T3			1.534	1.53(1.78)	1.533	0.256	0.240	0.926	0.126	0.135	0.341	1.998	22.428	22.284	22.668		
20.0%	e101-3	e101-3 to e101-4	e102-1 e103-1 7-1	10.0	129.365	0.855	0.900,1.000	0.750,0.750	0.759	0.649	0.260	0.260		0.000	R.S.I.P. 1200x1200	Grated Surface Inlet Pit	-1.813	2.073	8-1	7.389	145.067	7.599	0.000	0.462	0.990	35.840	1.011	0.675	RCP RRJ2	2.765	T10	Ku,Kw=0 - Missouri/Hare Charts	1.637	1.64(1.98)	3.417	0.000	0.772	1.180	0.423	0.390	0.675	2.765	26.365	25.942	27.137	26.155	e101-3
1.0%				10.0	214.355	0.925	0.900,1.000	0.750,0.750	0.759	0.702	0.462	0.462		0.000			-4.038	4.501	8-1	7.389	238.351	8.333				1.016					2.840	T10			1.637	1.64(1.98)	3.417	0.000	0.814	1.245	0.446	0.412	0.675	2.840	26.323	25.877	27.137		
20.0%	e102-1	e102-1 to e101-1		10.0	129.365	0.855	0.900,1.000	0.750,0.750	0.207	0.177	0.071	0.071		1.310	R.S.I.P. 1200x1200	Grated Surface Inlet Pit	0.071	0.000		5.000	165.924	0.154		1.310	0.126	0.071	27.432	0.500	0.300	RCP RRJ2	1.001	G1	Ku,Kw=0 - Missouri/Hare Charts	1.800	1.800	7.103	1.000	0.092	0.456	0.125	0.051	0.235	1.193	27.280	27.155	27.372	26.000	e102-1
1.0%				10.0	214.355	0.925	0.900,1.000	0.750,0.750	0.207	0.191	0.126	0.126		0.655			0.126	0.000		5.000	269.934	0.168				0.126					1.782	G1			1.800	1.800	8.673	1.000	0.292	1.445	0.396	0.162	0.300	1.782	27.551	27.155	27.843		
20.0%	e103-1	e103-1 to BYPASS-2		10.0	129.365	0.855	0.900,1.000	0.750,0.750	5.850	5.002	2.002	2.002		0.981	R.S.I.P. 900x900	Grated Surface Inlet Pit	2.002	0.000		5.000	165.924	4.344		0.981	3.564	2.002	6.560	2.000	1.050	RCP RRJ2	2.312	G1	Ku,Kw=0 - Missouri/Hare Charts	4.465	4.460	2.160	1.000	1.218	6.486	0.000	0.273	0.512	4.778	27.950	27.525	29.168	28.694	e103-1
1.0%				10.0	214.355	0.925	0.900,1.000	0.750,0.750	5.850	5.411	3.564	3.564		0.491			3.564	0.000		5.000	269.934	4.753				3.564					4.116	G1			4.360	4.360	2.210	1.000	1.270	6.529	0.000	0.291	0.745	5.425	27.963	27.535	29.233		

C.3 STREAM EROSION CALCULATION

PENRITH CITY COUNCIL STREAM EROSION INDEX CALCULATION

PROJECT NAME: ST MARYS

PROJECT NUMBER: B18028

DESIGNER: NK

STEP 1 - ESTIMATE CRITICAL FLOW FOR THE RECEIVING WATERWAY

SITE AREA	8.223	(Ha)	only included site flows draining directly to little creek
T_c	17.64722	(MINUTES)	
I_2	58.07	(mm/hr)	
C_2	0.444		C10 x FF2
Q_2	0.588929		
$Q_{critical}$	0.147232		25% ASSUMPTION

STEP 4 - CALCULATE SEI

Q_{POST}	2.61
Q_{PRE}	0.781
SEI	3.341869

APPENDIX D

WSUD Maintenance Requirements

Vortechs®

Operations and Maintenance Guide



Stormwater360
AUSTRALIA

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Appendix B – Example Monitoring & Maintenance Form (LOG)

1. INTRODUCTION

The following report details the recommended methods for cleaning and maintaining the Vortechs Stormwater Treatment System. The aspects associated with cleaning included in this manual are methods for cover removal, unit inspection, and minor and major maintenance activities. This plan should be used in conjunction with the appropriate traffic management plans and site safety plans produced for each project. Other Stormwater360 (SW360) documents which SW360 staff should use in conjunction with this report include the SW360 Employee Health and Safety Manual. It is recommended that contractors develop their own health and safety plans for activities to ensure that the workers are placed in a safe work environment.



Vortechs System in service

Maintenance is an essential component of stormwater management enabling ongoing at source control of stormwater pollution. Maintenance will also prevent failures such as structural failure (e.g. prevents blocked outlets) or aesthetic failure (e.g. debris accumulation). All stormwater treatment devices require maintenance to ensure the ongoing performance of the system.

Stormwater360 is a specialised stormwater consultancy with trained and experienced staff. The company has a comprehensive database with detailed information on every Vortechs filter sold and serviced by SW360, collecting site-specific data that can be easily accessed and analysed as required.

This document consists primarily of the processes and tasks associated with the hand maintenance and inductor maintenance procedures. It does not include detail of the traffic management requirements or occupational health and safety requirements. Contractors or SW360 staff should utilise their own Employee Health and Safety Manual, which details the policies and procedures for safe work.

2. VORTECHS HEALTH AND SAFETY

The following section details some of the considerations which may be required for a contactor to comply with relevant health and safety regulations regarding the manual handing activities, hazards associated with the waste material and issues associated with working on roads.

Cleaning of Vortechs is a specialist activity. Material collected can be harmful if not handled correctly. Sediments may contain heavy metals and carcinogenic substances as well as harmful objects such as broken glass and syringes. As all of the Vortechs units are located on roads particular care must be taken due to the potential buildup of hydrocarbon based products and other vehicle based contaminants which may be carcinogenic or toxic. It is essential that Occupational Safety and Health guidelines are followed at all times, and that the following steps are carried out to ensure safe and successful maintenance operations.

In additional to the hazards associated with the cleaning & handling of material, there also hazards associated with traffic at the work site, the removal of the grate, pedestrians and other non-worker personnel, and general work place hazards associated with working outdoors.

This section is not intended to address all the safety issues associated with Vortechs maintenance, providing only information and suggestions on safety aspects associated with the maintenance procedures.

The procedures indicated in the Operations section of this manual are recommend as the safest and most efficient manner in conducting the maintenance of Vortechs Units (Section 3), however contractors and cleaning staff may vary the procedure in response to the site conditions, varying work practices or general preferences in the cleaning techniques. Please note that procedures outlined in this manual are not exhaustive, and that any changes should still comply with general safe work practices.

2.1 Personnel Health and Safety

All contractors and staff shall comply with all current Health and Safety Legislation and take all practicable steps to:

- Comply with all applicable laws, regulations and standards.
- Ensure that all employees, contractors and visitors are informed of and understand their obligations in respect of current Health and Safety Legislation.
- Ensure that employees understand and accept their responsibility to practice and promote a safe and healthy work environment.

All relevant precautions must be taken to prevent contact with sediment and litter when maintaining filters. The following personal protective equipment (PPE) safety equipment should be worn:

- Puncture resistant gloves.
- Steel capped safety boots.
- Fluorescent safety vest.
- Overalls or similar skin protection.
- Eye protection. (if necessary)*

*Higher personal safety conditions may be required when maintaining units that may contain more hazardous material, for example pits where syringes have be observed or pits/systems located in areas associated with such activities.

2.2 Confined Spaces

Confined space poses a serious safety hazard for all personnel; however during the normal maintenance procedures there should be no reason to enter a confined space. All maintenance procedures for the Vortechs system are able to be conducted from the surface.

Confined space entry procedures are not included as part of this manual, for SW360 employees confined space entry procedures are included as part of the SW360 Safety Manual. It is recommend that all contractors evaluate their own needs for confined space entry and compliance with Occupation Health and Safety regulations.

When repairs or maintenance activities cannot be conducted from the surface, the contractor/cleaner should evaluate the need to enter the confined space, considering all alternative options. Where there is a need to proceed in a confined space, only staff with current confined space training shall operate in a confined space. Appropriate measures and controls shall be put in place to meet confined space entry requirements. Safety equipment must be worn where deemed necessary and where gas or oxygen hazard occurs; staff trained in its use will only use BA gear. **Non-trained staff must not go into confined spaces**.

3. OPERATIONS

This section details the specific activities required to clean the Vortechs units. Please note it has been written for use by someone who has never encountered a stormwater pit or a Vortechs unit, providing a step by step process for each of the cleaning stages.

3.1 Maintenance & Monitoring of Vortechs Filters

The maintenance frequency is dependant on several variables, such as catchment area, surrounding land use, vegetation type, traffic loading and rainfall patterns. Inspection is the key to effective maintenance and is easily performed. Stormwater360 recommends ongoing quarterly inspections of the accumulated sediment.

Attached in Appendix A is an example of a Vortechs Service Receipt and Maintenance & Performance Monitoring Form which is to be completed by the Cleaning Contractor when servicing any system. Relevant information is recorded and forwarded to the client and/or Council (depending upon regulations) when immediately following each maintenance/inspection clean. The frequency of each procedure is set-out below in Table2.

Table 2: FREQUENCY OF MAINTENANCE ACTIVITY

ITEM	PERIOD	RESPONSIBILITY	MAINTENANCE PROCEDURE
Inspection - Inspect & Record Data	3-Monthly or after Major Storms	Maintenance Contractor and/or Owner	Follow procedure set out on page 9 of the Vortechs Operations Manual
Minor Maintenance; • Remove Floatables	3-Monthly or after Major Storms	Maintenance Contractor	Follow procedure set out on page 9 of the Vortechs Operations Manual
Major Maintenance; • Evacuation of Chamber	12 month (typ) or as required	Maintenance Contractor	Follow procedure set out on page 8 of the Vortechs Operations Manual
Emergency Maintenance	After Major Storms or Spills	Maintenance Contractor	Follow procedure set out on page 8 of the Vortechs Operations Manual

3.2 Stormwater Pit Cover Removal

There are several different types of stormwater pit covers used throughout Australia. These grates/lids are constructed of three main materials, cast iron, galvanised steel and concrete. Stormwater pits covers on all Vortechs units will cast iron type simply placed on a recessed frame (lockable) to prevent the grate being easily knocked open by passing traffic. A GATIC type lifter (long handle only) and socket set with 1/2in driver will be required to unlock and open the cover.

The following steps indicate a safe and efficient method to clean the Vortechs using an Inductor:

1. Ensure all PPE is worn.
2. Locate locking nut and remove with appropriate sized 1/2in driver and socket.
3. Place GATIC lifter in recess and lever cover open.
4. Slide cover across frame and onto surrounding ground/pavement. Never attempt to lift the cover.
5. Repeat steps 4 & 2 when inspection/maintenance is complete

3.3 Cleaning Methods

One of the following methods of maintenance should be used for the servicing of the Vortechs system:

- Major Maintenance (Cleaning using Inductor Truck).
- Minor Maintenance (Using grapple or net to remove floatables).
- Inspection

3.3.1 Major/Emergency Maintenance (Cleaning using Inductor Truck)

The following steps indicate a safe and efficient method to clean the Vortechs using an Inductor truck. Please complete in conjunction with the form in Appendix A & B as part of this procedure.

1. Open gully pit. (See Section 3.2)
2. Place the inductor hose from the suction truck over the material collected in the sump and switch on the inductor.
3. Using the inductor hose suck all of the sediment, organic leaf material, litter etc, collected in the sump
4. If material has built up around the overflows, use the inductor hose to clear the accumulated material.
5. Check the Vortechs unit. (See Section 3.4)
6. Remove the Suction hose.
7. Spray the inside of the Vortechs system with a high pressure water blaster to remove any accumulated grit. Do not use any chemicals.
8. Replace gully pit cover.



Plate 1 Cleaning a Vortechs using the inductor method

3.3.2 Minor Maintenance

The following steps indicate a safe and efficient method to clean the Vortechs manually by hand. Please complete in conjunction with the form in Appendix A & B as part of this procedure.

1. Open cover. (See Section 3.2)
2. Visually inspect the floating debris from surface and performance composition assessment of material.
3. Measure depth floating debris & record.
4. Measure depth to sediment pile & record.
5. Remove the accumulated floating debris by a net or grapple from the surface of the pit.
6. Complete paperwork.
7. Reinstate pit lids (See Section 3.2).

3.4 Unit Inspection

Pollutant deposition and transport may vary from year to year and quarterly inspections will help insure the system is cleaned out at the appropriate time. Inspections should be performed every 3 month or after major storm events. It is very useful to keep a record of each inspection. A Monitoring & Maintenance form (Attached in Appendix B) for doing so is provided.

The Vortechs should be cleaned when the sediment depth has accumulated to a depth of three feet in the treatment sump. Take two measurements with a stadia rod or similar measuring device; one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the distance measured is less than the distance given in the following table, the Vortechs should be maintained to ensure effective treatment.

Vortechs Model	Design Treatment Capacity cfs (l/s)	Sediment Storage yd^3 (m^3)
1000	0 - 1.6 (0 - 45)	0.7 (0.54)
2000	1.6 - 2.8 (45-80)	1.2 (0.91)
3000	2.8 - 4.5 (80-125)	1.8 (1.38)
4000	4.5 - 6.0 (125-175)	2.4 (1.84)
5000	6.0 - 8.5 (175-240)	3.2 (2.45)
7000	8.5 - 11.0 (240-315)	4.0 (3.06)
9000	11.0 - 14.0 (315-400)	4.8 (3.67)
11000	14.0 - 17.5 (400-495)	5.6 (4.28)
16000	17.5 - 25.0 (495-710)	7.1 (5.43)

Table 1. Vortechs Maintenance Indicators

3.5 Disposal of Material

All Vortechs wastes from the site are to be taken off site and disposed of at a transfer station or similar approved disposal site/facility. No waste material shall be dewatered on-site in case of accidental spills. Dewatering must only be performed at the waste facility. Stormwater Sediments can contain Lead, Copper, Zinc, Mercury, hydrocarbons and PCBs, which are harmful to both humans and the receiving environment. Appropriate sampling and laboratory analysis may be required to classify the material as suitable for reuse, or disposal under appropriate local guidelines.

4 EMERGENCY PROCEDURES

4.1 Spill Procedures

In the event of a spill discharging into any gully pit all sediment is to be extracted and removed from site. Normal operation procedures apply to additional cleaning as a result of spills.

Appendix A

Service Receipt Example

Vortechs Service Receipt

Site:
Contractor:
Location:
Year:

Job Number:
Receipt Number:
Week Serviced:

Service Frequency:
Vortechs s on Site:

Vortechs s Cleaned:
Bags Checked:
Overflows Checked
Tonnage:

If Damaged, Action:
If Blocked, Cleaned:

Comments

This service has been performed in accordance with Vortechs Operations Management Plan (EMP) for above site. Please file this receipt with EMP and keep on site for compliance inspections.

Signature:

Position:

Appendix B
Monitoring & Maintenance Form (log) Example

Vortechs Maintenance & Performance Monitoring Log

Location: _____
_____
Device Model: _____
Owner of Site: _____
Person Responsible for
Maintenance and Contract #:_____
_____

Date	Water Surface to Sediment Distance[1]	Floatable Layer Thickness[2] and Composition	Maintenance Performed[3]	Maintenance Personnel	Estimated Volume of Sediment[4]	Estimated Volume of Floatables	Wet Mass Removed[6]	Comments

1 The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. When the difference between the two measurements is less than the value from the table below, maintenance should be performed.

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of a spill, the system should be cleaned immediately. For composition purposes estimate the percentage organics & litter e.g. 60% Litter, 40% Organics.

3. Maintenance Activities Performed are;
   A) Inspection
   B) Minor – Deploying oil absorbents and/or removal floatables by grapple or net.
   C) Major – Evacuation of entire chamber including grit and floatables

4. To estimate the volume the sediment in the chamber, = 2.05m *subtract* (1) Water Surface to Sediment Distance *multiply by* 1.14 (m^3).

5. To estimate the volume of floatables in the chamber, = (2) Floatable Layer Thickness *multiply by* 1.14 (m^3).

6. Obtain the wet mass of the tipped pollutants by weighing the debris at the tip facility or by scales (Minor Maintenance).

Stormwater360
AUSTRALIA

Operations and Maintenance

Enviropod

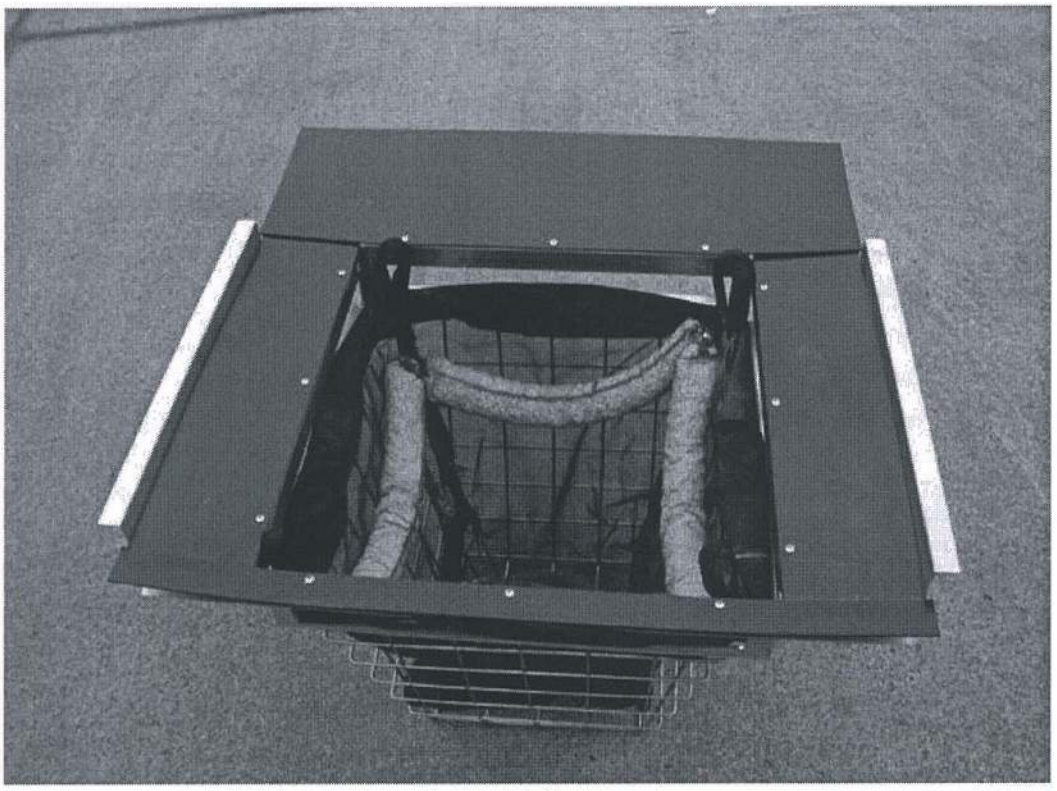


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APPENDIX B – EXAMPLE MAINTENANCE FORM

1 INTRODUCTION

The following report details the recommended methods for cleaning and maintaining the Enviropod Stormwater Gully Pit Insert. The aspects associated with cleaning included in this manual are methods for grate removal, filter bag cleaning, unit inspection, filter bag rejuvenation and the re-installation of the filter bags. This plan should be used in conjunction with the appropriate traffic management plans and site safety plans produced for each project. Other Stormwater360 (IES) documents which IES staff should use in conjunction with this report include the IES Employee Health and Safety Manual. It is recommended that contractors develop their own health and safety plans for activities to ensure that the workers are placed in a safe work environment.



Enviropod filter in service.

Each stormwater treatment device must be inspected and maintained regularly to ensure it is working properly throughout the estimated design life. The Enviropod filters require servicing every 1 - 6 months depending on site characteristics; however the maintenance requirements are less labour intensive than alternate traditional treatments. During each inspection and clean, details of the mass, volume and type of material observed should be record to provide ongoing data for future management plan revisions and the optimisation of the maintenance frequency. It is essential that maintenance (including inspections, recording and reporting) be carried out in a systematic manner and is carried out by qualified and experienced personnel. It is also advisable that the treatment device owner has a nominated person responsible for overseeing the management process.

Maintenance is an essential component of stormwater management enabling ongoing at source control of stormwater pollution. Maintenance will also prevent failures such as structural failure (e.g. prevents blocked outlets) or aesthetic failure (e.g. debris accumulation). All stormwater treatment devices require maintenance to ensure the ongoing performance of the system.

Stormwater360 (IES) is a specialised stormwater consultancy with trained and experienced staff. The company has a comprehensive database with detailed information on every Enviropod filter

sold and serviced by IES (formerly Enviropod), collecting site-specific data that can be easily accessed and analysed as required.

This document consists primarily of the processes and tasks associated with the hand maintenance and inductor maintenance procedures. It does not include detail of the traffic management requirements or occupational health and safety requirements. Contractors or IES staff should utilise their own Employee Health and Safety Manual, which details the policies and procedures for safe work.

2 Enviropod Health and Safety

The following section details some of the considerations which may be required for a contactor to comply with relevant health and safety regulations regarding the manual handing activities, hazards associated with the waste material and issues associated with working on roads.

Cleaning of Enviropod filters is a specialist activity. Material collected can be harmful if not handled correctly. Sediments may contain heavy metals and carcinogenic substances as well as harmful objects such as broken glass and syringes. As all of the Enviropod units are located on roads particular care must be taken due to the potential build-up of hydrocarbon based products and other vehicle based contaminants which may be carcinogenic or toxic. It is essential that Occupational Safety and Health guidelines are followed at all times, and that the following steps are carried out to ensure safe and successful maintenance operations.

In additional to the hazards associated with the cleaning handling of material in the filter bags, there also hazards associated with traffic at the work site, the removal of the grate, pedestrians and other non-worker personnel, and general work place hazards associated with working outdoors.

This section is not intended to address all the safety issues associated with Enviropod maintenance, providing only information and suggestions on safety aspects associated with the maintenance procedures. A separate safety plan should be prepared for each project address the specific requirements of the project.

The procedures indicated in the Operations section of this manual are recommend as the safest and most efficient manner in conducting the maintenance of Enviropod Units (Section 3), however contractors and cleaning staff may vary the procedure in response to the site conditions, varying work practices or general preferences in the cleaning techniques. Please note that procedures outlined in this manual are not exhaustive, and that any changes should still comply with general safe work practices.

2.1 Personnel Health and Safety

All contractors and staff shall comply with all current Health and Safety Legislation and take all practicable steps to:

- Comply with all applicable laws, regulations and standards.
- Ensure that all employees, contractors and visitors are informed of and understand their obligations in respect of current Health and Safety Legislation.
- Ensure that employees understand and accept their responsibility to practice and promote a safe and healthy work environment.

All relevant precautions must be taken to prevent contact with sediment and litter when maintaining filters. The following personal protective equipment (PPE) safety equipment should be worn:

- Puncture resistant gloves.
- Steel capped safety boots.
- Fluorescent safety vest.
- Overalls or similar skin protection.
- Safety apron. (if necessary)*
- Eye protection. (if necessary)*

*Higher personal safety conditions may be required when maintaining units that may contain more hazardous material, for example pits where syringes have be observed or pits located in areas associated with such activities.

2.2 Traffic Control

All stormwater collection pits are typically situated either in/on roads and car parks or adjacent to roads in the footpath or swales. Traffic control requirements at each of these locations is typically the same, with most of the state and local road authorities requiring the same controls implemented whether the work is to be conducted on the road or on the road reserve.

As traffic requirements vary based on the road usage and the specific road configuration, traffic control plans should be prepared for each site. Given that maintenance is typically a quick process, the contractor should liaise with the relevant road authority to determine the specific road safety requirements for each location to ensure that on site workers can conduct the cleaning operations safely and efficiently, while complying with all laws and regulations.

NSW RTA working on roads safety manual indicates the signage requirements, placement of barricades or witches hats and the positioning of traffic control personnel. In addition to standard safety requirements IES recommends that the maintenance vehicle be used to increase safety, through shielding the work area from oncoming traffic.

Plate 1 indicates the vehicle placed to shield the work area with cones placed around the vehicle. Plate 2 indicates at head on view, note the vehicle is positioned to allow access to the drive, whilst still blocking the pit from on-coming traffic. The vehicle has a flashing light on the roof and the hazard lights switched on.



Plate 1 Vehicle positioned near pit, preventing traffic from passing close to the pit.



Plate 1 Head-on view, indicating the placement of the vehicle near the pit.

2.3 Confined Spaces

Confined spaces poses a serious safety hazard for all personnel, however during the normal maintenance procedures there should be no reason to enter a confined space. All maintenance procedures are able to be conducted from the surface. Confined space entry procedures are not included as part of this manual, for IES employees confined space entry procedures are included as part of the IES Safety Manual. It is recommend that all contractors evaluate their own needs for confined space entry and compliance with Occupation Health and Safety regulations.

When repairs or maintenance activities cannot be conducted from the surface, the contractor/cleaner should evaluate the need to enter the confined space, considering all alternative options. Where there is a need to proceed in a confined space, only staff with current confined space training shall operate in a confined space. Appropriate measures and controls shall be put in place to meet confined space entry requirements. Safety equipment must be worn where deemed necessary and where gas or oxygen hazard occurs, staff trained in its use will only use BA gear. **Non-trained staff must not go into confined spaces.**

3 Operations

This section details the specific activities required to clean the Enviropod units. Please note it has been written for use by someone who has never encountered a stormwater pit or an Enviropod unit, providing a step by step process for each of the cleaning stages.

3.1 Maintenance & Monitoring of Enviropod filters

The maintenance frequency is dependent on several variables, such as catchment area, surrounding land use, vegetation type, traffic loading and rainfall patterns. IES recommends that during the first year of operation the units should be monitored monthly, with maintenance as required.

The ensure that the unit performs optimally, the material collected by the filter bag should be emptied when the level of material is no more than approximately **half to two thirds** of the total bag depth or when there is evidence of material overflow. Although the bag has greater storage area, it is recommended that it is not left to fill completely prior to empting, for the following reasons; the bags are capable of retaining a heavy mass of material (in excess of 50kg); material near the top of the bag can be resuspended during high to extreme rainfall events; and blockage of the overflow sections can occur, when material is allowed to build up above the filter bag.

Maintenance frequency should be adjusted to accommodate variable rainfall patterns. Regions east of the Great Dividing Range typically are dominated by greater rainfall during summer and Autumn Months, as such more maintenance is typically required during these periods. It is recommended that biannual inspections be carried out in November and April, while quarterly inspections should be conducted in February, April, July and November.

It is also recommended that additional monitoring should be conducted following moderate to extreme rainfall events, in particular, when preceding months have had little to no rainfall. This monitoring is considered necessary to accommodate for higher volumes of runoff generated during major rainfall events, an anticipated greater accumulation of surface contamination during low rainfall periods and to ensure that the units have not been damaged due to high pipe velocities.

Attached in Appendix A & B is an example of an Enviropod Service Receipt and Generic Monitoring Form which is to be completed by the Cleaning Contractor when servicing any Filters. Relevant information is recorded and forwarded to the client following each maintenance clean.

Table 1: FREQUENCY OF MAINTENANCE ACTIVITY

	INSPECTION/MINOR MAINTENANCE (TIMES/YEAR)	MAJOR MAINTENANCE (TIMES/YEAR)
Enviropod	12 (and after major storms)	2-6 (except in case of a spill)

3.2 Stormwater Pit Cover Removal

There are several different types of stormwater pit covers used throughout Australia. These grates/lids are constructed of three main materials, cast iron, galvanised steel and concrete. Stormwater pits covers will either be hinged (lockable) or simply placed on a recessed frame, with cover which are not hinged are typically heavy, to prevent the grate being easily knocked open by passing traffic. Each different pit cover requires different techniques to safely remove the cover to gain access to the Enviropod Unit.

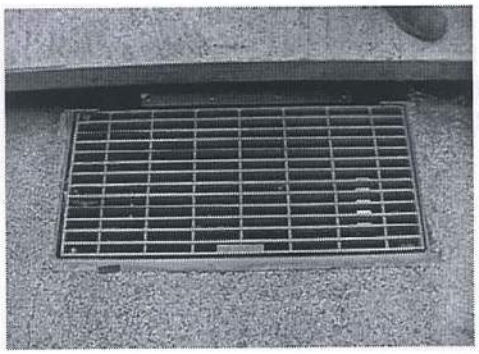


Plate 2 Hinged galvanised steel pit grate



Plate 3 Heavy duty hinged galvanised steel pit grate

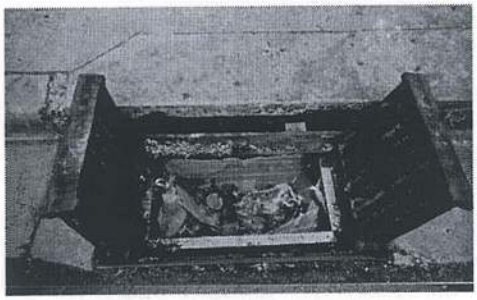


Plate 4 Hinged cast iron grate

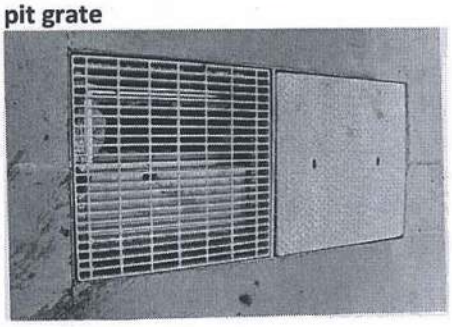


Plate 5 Non-hinged heavy duty galvanised steel pit grate



Plate 6 Non-hinged cast iron grate

3.2.1 Hinged Pit Grates

Hinged pit grates are typically either light duty galvanised steel, heavy duty galvanised steel or two-piece cast iron. Generally hinged pit grates can be opened by one person, however heavy duty galvanised lids and cast iron lids may require two people. If you are unclear about the type of grate, always use two people.

To open a hinged pit grate follow the following steps:

1. Insert the lifting hooks beneath the grate. (Position indicated in Plate 7)
2. Check hinge point is not damaged and debris is not caught in the hinge area.
3. Note many cast iron hinges are not hinged securely (to enable the removal of the grate). This may result in the pit grate not being able to sit in an open position. Additionally the hinge pins may also be damaged or corroded, which may allow for the pit grate to fall into pit. Such pit grates can be removed using the method indicated below for non-hinged grates.
4. Fully open pit grate, ensuring that the grate will stay in the open position without any external forces applied. Grates which do not remain open without being held should be removed or secured during cleaning or maintenance activities. Plate 8 and Plate 9 indicate the grate being opened and grate resting freely in the open position, respectively.



Plate 7 Lifting the grate

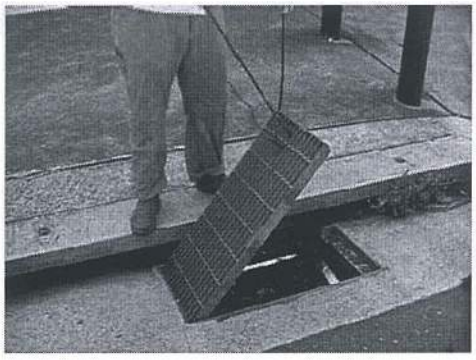


Plate 8 Opening Grate

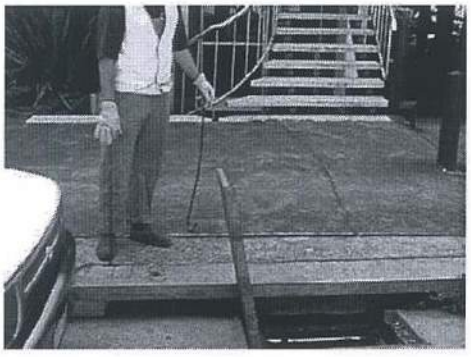


Plate 9 Fully open grate



Plate 10 Lowing grate

To close an open hinged grate

1. Place lifting hooks through grate. (same position to remove grate)
2. Gently lower grate into position. (Plate 10)
3. Note some grates have offset hinges points that prevent the grate from falling over, such pits require the hinged side of the grate to be lifted while the grate is lowered into position. (insert picture)

3.2.2 Non-Hinged Pit Grates

Non hinged pits are typically constructed of cast iron, concrete or heavy duty galvanised steel. As such the pit grates are generally heavy and difficult to remove, generally requiring two people to safely remove the lids.

To remove a non-hinged pit grate:

1. Place lifting hooks beneath grate, where possible in the four corners of the grate (Plate 11). Concrete lids may have Gatic lifting points, a key arrangement or holes in the lid, as such special equipment, such as Gatic lifters may be required.
2. Position each person either side of the grate. (Plate 12)
3. Lift the grate, ensuring that good heavy lifting posture is used at all times.
4. Place the grate on an angle on the gutter, to allow for the lifting hooks to be removed. (Plate 13)
5. For extremely heavy one piece grates and concrete Gatic covers, insert the lifters in place and slide the lids back. Note some lids may still require two people. (Picture required)

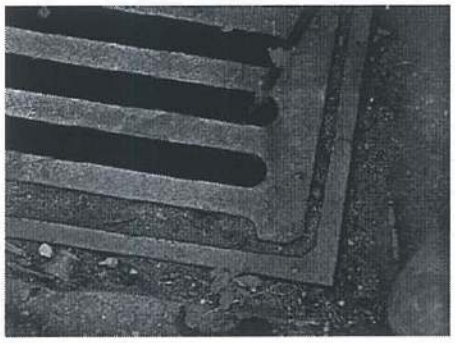


Plate 11 Insert hook near edge of grate



Plate 12 Position each lifter either side of the grate



Plate 13 Lift grate and move grate to one side



Plate 14 Lift grate above the support frame



Plate 15 Reinstated non hinged grate

To reinstate a non-hinged pit grate

1. Place lifting hooks though the grate. Note do not place hooks at the very edge of the grate, as this will make it difficult to place grate on the support.
2. Lift the grate into position and lower onto the supporting frame (Plate 14), ensuring that the grate sits level with the finished surface. If the grate does not sit securely remove the pit cover and check for debris in the pit cover frame, then try to lower grate again.
3. Check final position of the cover, ensuring that the cover sits flush with the surface and does not create a trip or traffic hazard. (Plate 15)

Note all grates should be reinstated to the original condition.

Care should be taken with old or damaged pit covers and grates. Grates or covers observed to be in poor condition should be first inspected to determine whether further damage will occur if an attempt to remove the grate is made. Pits grates which appear to be severely damaged or appear as though they would break while being removed should not be removed. Contact the client (and pit owner if not the client) and IES (IES Sydney office number is 02 9907 1401) to discuss an appropriate action. Pit grates and covers damaged by the contractor will be repaired at the cost of the contractor, or as part of an arrangement with the pit owner.

3.2.3 Pits unable to be opened

Pits may be unable to be opened for several reasons, including through corrosion, new road surfaces covering the pit lid, and foreign material jammed in the lid. The following steps may assist in opening the pits:

- Chip away new road coverings or concrete/bitumen spills using a pinch bar or similar device. **Care must be taken not to damage road surfaces**.
- Corroded or jammed pits may be loosened from the grate frame by using a lubricant such as RP7 and tapping the grate frame and grate. **Note if the grate or grate frame appears severely corroded, the grate should not be opened and IES and the client should be contacted to discuss options.**
- Pits which cannot be opened may require a hydraulic lifting arm to fully remove the lid.

3.3 Cleaning Methods

One of the following methods of maintenance should be used for the servicing of these Enviropod Filters:

- Cleaning using Inductor Truck.
- Hand Maintenance.

One of the advantages of the Enviropod units is that it doesn't require specialised equipment for maintenance. In certain situations it may be more feasible to maintain the units using the inductor truck method, while for other projects hand maintenance may be the preferred option. The cleaning method for the Enviropod units should be evaluated specifically for each project.

3.3.1 Cleaning using Inductor Truck

The following steps indicate a safe and efficient method to clean the Enviropod using an Inductor:

1. Open gully pit. (See Section 3.2)
2. Place the inductor hose over the material collected in the filter bag and switch on the inductor.
3. Using the inductor hose suck all of the sediment, organic leaf material, litter etc., collected in the filter bag
4. Allow the filter bag to be sucked up into the inductor hose for a few seconds to allow for the filter mesh pores to be cleaned. Care is to be taken by the operator not to damage the filter, i.e. ensure that there are no sharp edges on the inductor hose.
5. If material has built up around the overflows, use the inductor hose to clear the accumulated material.
6. Remove filter bag from the pit.
7. Sediment retained in the gully pit grate is to be removed.

8. Back opening channels are to be cleared of any debris to ensure flow is not hindered. Debris can be collected using the inductor truck.
9. All gully pit waste is to be removed from the pit.
10. Check the Enviropod unit. (See Section 3.4)
11. Check filter bag. (See Section 3.5)
12. Reinstate filter bag and gully pit lids.

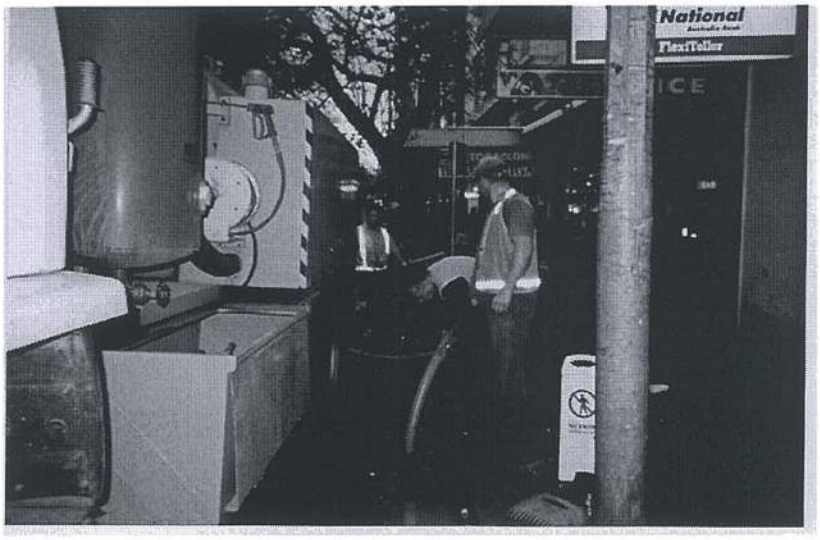


Plate 16 Cleaning an Enviropod using the inductor method

Gully pit sediments under no circumstances are to be backwashed into the gully pit.

3.3.2 Hand Maintenance

Two people are generally preferred to maintain the units by hand. However for shallow units and units which contain mainly leaf material (low overall accumulated weight), may be cleaned by one person. Note additional personnel may be required for traffic management purposes or for general safety.

The following steps indicate a safe and efficient method to clean the Enviropod manually by hand:

1. Open gully pit. (See Section 3.2)
2. Place the lifting hooks in the lifting loops of the filter bag. (See Plate 17)
3. For extremely heavy and overfilled bags either use a hydraulic lifting arm to lift the bag, or remove excess material using a shovel or similar piece of equipment. IES prefers the use of a post hole shovel, due to the reduced strain on the back when digging and the ability of the shovel to grab material vertically. (Insert Picture)
4. Lift the bag vertically off the supporting frame, ensuring that no undue pressure is placed on the filter bag. (See Plate 18)
5. Lift the bag clear of the stormwater pit. (See Plate 19)
6. Position the bag over the truck or other collection vehicle, taking hold of the loops at the base of the bag. (See Plate 20 and Plate 21)
7. Lift and empty the filter bag by holding the bottom lifting loops only. (See Plate 22)
8. Completely empty the filter bag. (See Plate 23)
9. Brush the filter bag with a stiff brush to remove bound sediment from the filter pores. (See Plate 24)

10. Check the filter bag. (See Section 3.5)
11. Check the Enviropod unit. (See Section 3.4)
12. Reinstate filter bag, ensuring bag is installed the correct way. (See Plate 25 and Plate 26)
13. Reinstate gully pit lids. (See Plate 27 and Plate 28)



Plate 17 Place the lifting hooks through the bag loops



Plate 18 Lift the bag from the cage and support frame



Plate 19 Lift the bag from the stormwater pit



Plate 20 Lift the bag onto the collection vehicle

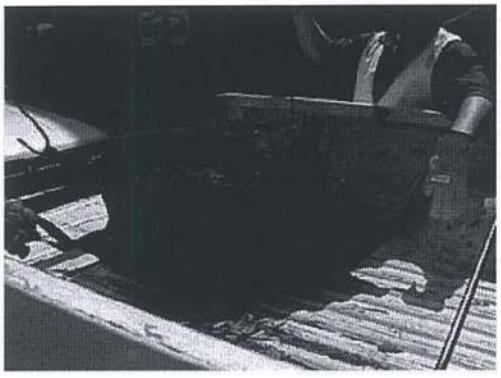


Plate 21 Grab the bottom lifting loops



Plate 22 Lifting the bottom bag loops empty the filter bag



Plate 23 Completely empty the contents of the filter bag



Plate 24 Brush the pores filter bag with a stiff brush



Plate 25 Reinstall filter bag



Plate 26 Ensure that the unit is positioned correctly, with the lifting loops on the inside

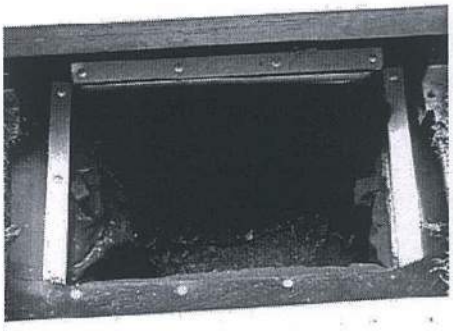


Plate 27 Correctly installed filter bag

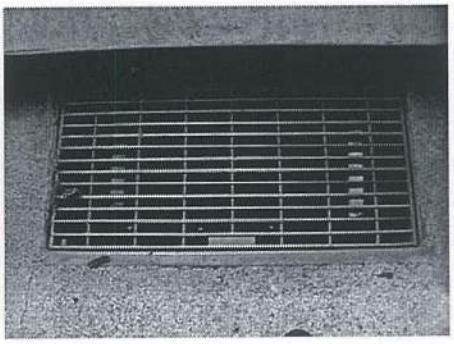


Plate 28 Installed filter bag and sealed pit

3.4 Unit Inspection

After the Enviropod filter bag is removed, emptied and cleaned, the following should be checked to ensure that the unit has not been damaged:

- All connections and joints should be checked and broken rivets replaced (See Plate 29);
- The plastic pit seals should be inspected for unit movement or damage (See Plate 30); and

- The cage should be inspected for damage or movement (See Plate 31).

The overflow diversion channels, and the area between the Enviropod cage and pit wall should also be inspected for the accumulation of debris. Any observed debris should be removed and disposed of off-site. Accumulated material within the outlet pipe may need to be flushed.

Note: If the units are not cleaned regularly the mobilisation of material collected in the Enviropod unit may occur, as such cleaning of the units in accordance with this management plan is required. As this plan is based on observations and data collected during the monitoring period, ongoing adjustment of the cleaning frequency is generally required to improve the overall efficiency in the removal of collected material and prevent material overflow.



Plate 29 Check seals are pushed against the pit walls

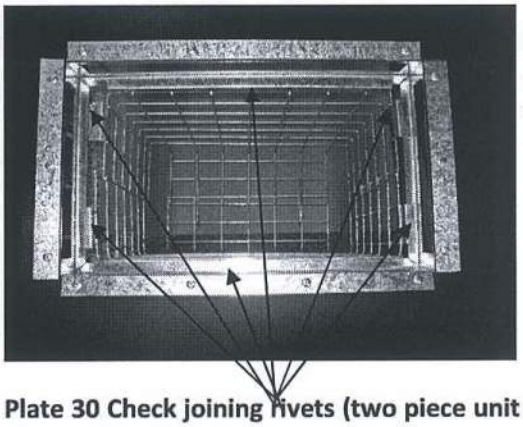


Plate 30 Check joining rivets (two piece unit shown above)

3.5 Filter Bag Inspection and Rejuvenation

Following the emptying and cleaning of the filter bags, the filter bag should be inspected to evaluate the bag condition. Given the nature of stormwater the filter bag from some Enviropod units can become considerably clogged with fine sediment. Filters can also be damaged by various objects in stormwater as well as fauna. Sharp objects such as sticks combined with high velocity water and a large mass in the filter bag can cause small tears in the filter material. Animals such as rats have also been known to chew through fine mesh filter bags located in gully pits near takeaway food outlets.

3.5.1 Clogged Filters

Clogged filter bags can be clean using several different methods. If the bag cleaning techniques described in the general maintenance sections above are not able to clean the filter bags the following options should be considered:

- Using a stiff brush and a bucket of soapy water scrub the filter bag surface.
- Remove filter bags from the pit and wash the bags using a high pressure water spray. Care has to be taken to not transfer the contamination elsewhere. Waste water from the process should be collected of and disposed of correctly.
- Remove the filter bags from the pits and the support rings and wash the bags in an industrial washing machine.

The final option presented above typically results in the bags appearing like new, with no visible stain or pore clogging within the filter mesh.



Plate 31 Slightly clogged filter bag, indicated by the brown stain on in the centre of the bag



Plate 32 A clean used filter bag

3.5.2 Damaged Filters

Damaged filters can often be repaired, provided the damage is small. Small tears in the fabric may occur do to several reasons, however the overall strength & structure of the nylon fabric typically prevents small tears becoming much large. Although the bag is unlikely to tear further care must be used when clean torn bags as not to spill the collected material into the pit.

Small tears may repaired by either sewing the tear back together, with additional fabric to increase the strength of the stitching, or by sewing a patch of the filter material onto the filter bag. The filter bags may need to be replaced if large tears are present, as the filter bag is no longer able to function as intended.

IES is able to repair bags or replace bags which have been damaged during maintenance. Please contact IES Sydney office on 02 9907 1401 for details or a quote.

3.6 Disposal of Material

All gully pit wastes from the site are to be taken off site and disposed of at a transfer station or similar approved disposal site. Stormwater Sediments can contain Lead, Copper, Zinc, Mercury, hydrocarbons and PCBs, which are harmful to both humans and the receiving environment. Appropriate sampling and laboratory analysis may be required to classify the material as suitable for reuse, or disposal under appropriate local guidelines.

4 Emergency Procedures

4.1 Spill Procedures

In the event of a spill discharging into any gully pit all sediment is to be extracted and the filter bags are to be removed and replaced with rejuvenated filter bags. Normal operation procedures apply to additional cleaning as a result of spills.

4.2 Blockages

In the unlikely event of surface flooding around a gully pit fitted with an Enviropod the following steps should be carried out:

Check Enviropod over flow bypass. The Enviropod filter has been designed with an overflow mechanism built into the filter box. If surface flooding still exists check the overflow slots underneath the rubber seal. If debris is lodged in the overflow slots these can be easily cleared by hand or steel rod.

If overflow is clear and surface flooding still exists remove Enviropod and check outlet pipe for blockages.

Removal of the Enviropod may be difficult if the filter is clogged and the Enviropod is holding water. If the filter is clogged, brush the side walls of the filter with a yard broom or similar. This will dislodge particles trapped at the interface allowing contained water to flow through the filter.

If the outlet pipe is blocked, it is likely that a gully sucker truck will be required to unblock it. Debris should be removed from the Enviropod with the gully sucker truck before removal of the Enviropod filter.

If a gully sucker truck is not available and the Enviropod needs to be removed by hand, follow the steps below:

- Remove excess debris by hand or brush the side of the filter.
- Lift and place filter ring through the filter box and into cage.
- Remove Filter box.
- Lift cage containing filter bag and ring out of the pit.
- Unblock outlet pipe.

Appendix A
Service Receipt Example

Enviropod Service Receipt

Site:
Contractor:
Location:
Year:

Job Number:
Receipt Number:
Week Serviced:

Service Frequency:
Enviropods on Site:

Enviropods Cleaned:
Bags Checked:
Frames and Seals Checked:
Overflows Checked
Tonnage:

If Damaged, Action:
If Damaged, Action:
If Blocked, Cleaned:

Comments

This service has been performed in accordance with Enviropod Management Plan (EMP) for above site. Please file this receipt with EMP and keep on site for compliance inspections.

Signature:

Position:

Appendix B
Maintenance Form Example

Enviropod Maintenance Form

Client: **Bag:** **NOTE:** **See maps for detailed location.**

Project: **Date:**

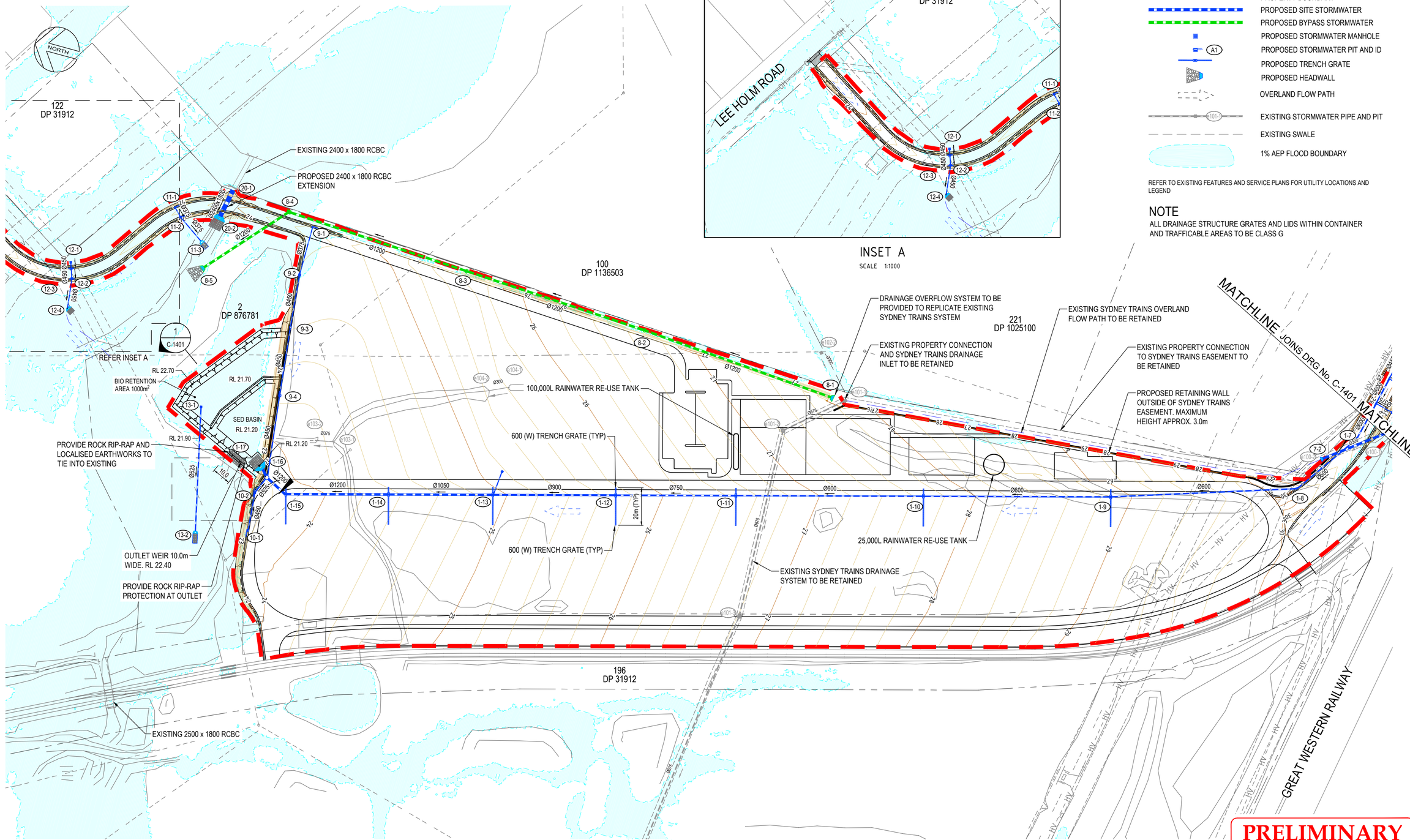
ENVIROPOD Sites

Pit No.	Map No.	Location	Bag Size	Date	% Organics	% Litter	% Sediment	Fullness - F, 1/2, 1/4 or 0	Notes	Grate
1										
2										
3										
4										
5										
6										
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APPENDIX E

Proposed Drainage Scheme

DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE



INSET A
SCALE 1:1000

LEGEND

- PROJECT LIMIT OF WORKS
- PROPERTY BOUNDARY
- PROPOSED SITE STORMWATER
- PROPOSED BYPASS STORMWATER
- PROPOSED STORMWATER MANHOLE
- A1 — PROPOSED STORMWATER PIT AND ID
- PROPOSED TRENCH GRATE
- PROPOSED HEADWALL
- OVERLAND FLOW PATH
- 101-1 — EXISTING STORMWATER PIPE AND PIT
- EXISTING SWALE
- 1% AEP FLOOD BOUNDARY

REFER TO EXISTING FEATURES AND SERVICE PLANS FOR UTILITY LOCATIONS AND LEGEND

NOTE

ALL DRAINAGE STRUCTURE GRATES AND LIDS WITHIN CONTAINER AND TRAFFICABLE AREAS TO BE CLASS G

PRELIMINARY

P:\BGE\BNE\B18028\01 DRAWINGS\102 Civil\AutoCAD\B18028-DRG-C-1400 To C-1401

09/9/2019 6:19 PM

Used on / Next higher assembly:

0 10 20 30 40 50 60m
SCALE 1:1000 AT A1 SIZE

Filename: B18028-DRG-C-1400 to C-1401.dwg

Alternate DMS number:

Rev	Date	Revision Description	Designed	Checked	Ind. Rev.	Approved	Accepted
K	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
J	27.08.19	ISSUED FOR APPROVAL	AK	SW			

Designing Company: Sydney Office — BG&E DOC No: B18028
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Designed N.Kelly
Checked S.West
Ind.Rev. Company | Ind.Rev. Name
Ind.Review Signature

pacific national

Approved By | Accepted By
Signed: | Signed:
Approval Date | Acceptance Date

BG&E

J K

C-1400

Sheet No. 1 of 2
Scale: 1:1000
SHEET SIZE A1

ST MARYS FREIGHT HUB
PHASE 1 - STORMWATER LAYOUT
SHEET 1

DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE

NORTH

221
DP 1025100

2220
DP 1172926

PROPOSED RETAINING WALL OUTSIDE OF SYDNEY TRAINS EASEMENT. MAXIMUM HEIGHT APPROX 3.0m

EXISTING SYDNEY TRAINS OVERLAND FLOW PATH TO BE RETAINED

EXISTING CULVERT CROSSING TO BE UPGRADED TO SUIT ACCESS ROAD. PROPOSED 1200x600 RCBC.

MATCHLINE No. C-1400

MATCHLINE JOINS DRG No. C-1400

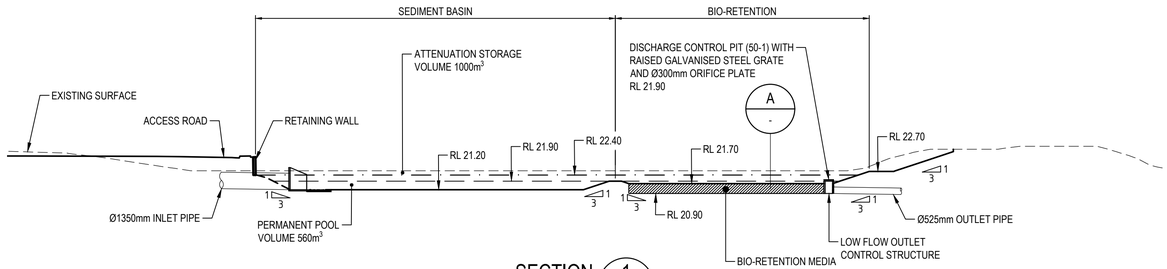
GREAT WESTERN RAILWAY

EXISTING SYDNEY TRAINS OVERLAND FLOW PATH TO BE RETAINED

EXISTING DISCHARGE PIPE FROM RAIL CORRIDOR TO BE RETAINED

CONNECT PROPOSED DRAINAGE TO EXISTING PIPE AND MAKE GOOD

FORRESTER ROAD

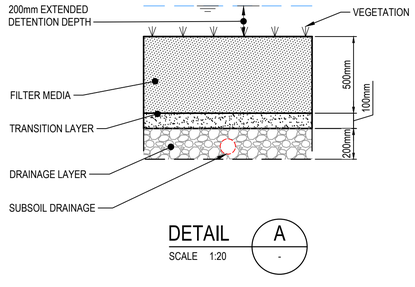


SECTION 1 — SCALE 1:250 — C-1400

LEGEND

- PROJECT LIMIT OF WORKS
- PROPERTY BOUNDARY
- PROPOSED SITE STORMWATER
- PROPOSED BYPASS STORMWATER
- PROPOSED STORMWATER MANHOLE
- PROPOSED STORMWATER PIT AND ID (A1)
- PROPOSED TRENCH GRATE
- PROPOSED HEADWALL
- OVERLAND FLOW PATH
- EXISTING STORMWATER PIPE AND PIT (≤101)
- EXISTING SWALE
- 1% AEP FLOOD BOUNDARY

REFER TO EXISTING FEATURES AND SERVICE PLANS FOR UTILITY LOCATIONS AND LEGEND



DETAIL A — SCALE 1:20

BIOFILTER MEDIA DETAIL

PRELIMINARY

SCALE 1:20 AT A1 SIZE | SCALE 1:250 AT A1 SIZE | SCALE 1:1000 AT A1 SIZE

Used on / Next higher assembly:

Filename: B18028-DRG-C-1400 to C-1401.dwg

Alternate DMS number:

Rev	Date	Revision Description	Designed	Checked	Ind. Rev.	Approved	Accepted
K	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
J	27.08.19	ISSUED FOR APPROVAL	AK	SW			

Designing Company: Sydney Office — Lvl 3, 8 Windmill St, Sydney NSW 2000 P / +61 2 9770 3300 E / info@bgeeng.com bgeeng.com

BG&E DOC No: B18028

Designed N.Kelly

Checked S.West

Ind.Rev. Company | Ind.Rev. Name

Ind.Review Signature

Approved By | Accepted By

Signed: | Signed:

Approval Date | Acceptance Date

pacific national

BG&E

J K

C-1401

Sheet No. 2 of 2

Scale: 1:1000

SHEET SIZE A1

ST MARYS FREIGHT HUB
PHASE 1 - STORMWATER LAYOUT
SHEET 2

P:\BGE\BNE\B18028\100_DRA\MSS1\02 Civil\Acad\CAD\B18028-DRG-C-1400 To C-1401

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DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE

LEGEND

- CATCHMENT BOUNDARY
- PROPOSED STORMWATER
- CATCHMENT AREA (e.g. 16-1 0.3208ha)
- PROPOSED STORMWATER MANHOLE
- PROPOSED STORMWATER PIT AND ID
- PROPOSED HEADWALL

NORTH

122 DP 31912

11-1 0.0236ha
12-1 0.2037ha
12-2 0.0478ha
12-3 0.0492ha
11-2 0.1240ha
9-1 0.0172ha
9-2 0.1240ha
9-3 0.0598ha
9-4 0.2647ha
8-4 0.0433ha
8-3 0.0468ha
8-2 0.0525ha
e102-1 0.2068ha
e101-3 0.7585ha
1-7 0.0248ha
1-6 0.0117ha
6-1 0.0379ha
1-15 0.9988ha
1-14 1.0351ha
1-13 0.9679ha
1-12 0.9267ha
1-11 1.2185ha
1-10 0.8244ha
1-9 0.5519ha
10-2 0.8502ha
10-1 0.3208ha

REFER INSET A

2 DP 876781

100 DP 1136503

221 DP 1025100

196 DP 31912

LEE HOLM ROAD

INSET A
SCALE 1:1000

FLOWS GREATER THAN 5% AEP ONLY TOWARD THE SITE

MATCHLINE JOINS DRG No. C-1411 MATCHLINE

GREAT WESTERN RAILWAY

PRELIMINARY

P:\BGE\BNE\B18028\100 Drawings\102 Civil\AutoCAD\B18028_DRG-C-1410 To C-1411

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Used on / Next higher assembly:

SCALE 1:1000 AT A1 SIZE (0 10 20 30 40 50 60m)

Filename: B18028-DRG-C-1410 to C-1411.dwg

Alternate DMS number:

Rev	Date	Revision Description	Designed	Checked	Ind. Rev.	Approved	Accepted
E	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
D	15.04.19	ISSUED FOR APPROVAL	AK	SW			
C	12.04.19	ISSUED FOR APPROVAL	AK	SW			
B	07.03.19	ISSUED FOR APPROVAL	NK	SW			
A	05.02.19	ISSUED FOR REVIEW	NK	SW			

Designing Company: Sydney Office — L2, 8 Windmill St, Sydney NSW 2000 P / +61 2 9370 3300 E / info@bgeng.com bgeng.com

BG&E DOC No: B18028

Designed N.Kelly

Checked S.West

Ind.Rev. Company | Ind.Rev. Name

Ind.Review Signature

pacificnational

Approved By | Accepted By

Signed: | Signed:

Approval Date | Acceptance Date

BG&E

A B C D E

C-1410

Sheet No. 1 of 2

Scale: 1:1000

SHEET SIZE A1

ST MARYS FREIGHT HUB
PHASE 1 - STORMWATER CATCHMENT PLAN
SHEET 1

DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE

NORTH

221
DP 1025100

2220
DP 1172926

GREAT WESTERN RAILWAY

MATCHLINE

JOINS DRG No. C-1410

MATCHLINE

FORRESTER ROAD

REFER INSET A

LEGEND

- CATCHMENT BOUNDARY
- PROPOSED STORMWATER
- CATCHMENT AREA
- PROPOSED STORMWATER MANHOLE
- PROPOSED STORMWATER PIT AND ID
- PROPOSED HEADWALL

16-1
0.3208ha

e103-1
5.8500ha

1-5
0.0162ha

1-4
0.0367ha

1-3
0.0367ha

1-2
0.0467ha

1-1
0.0475ha

2-1
0.0412ha

2-2
0.0436ha

4-1
0.0367ha

3-1
0.0364ha

5-1
0.0167ha

7-1
2.5632ha

7-1
2.5632ha

INSET A

SCALE 1:1000

PRELIMINARY

Rev	Date	Revision Description	Designed	Checked	Ind. Rev.	Approved	Accepted
E	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
D	15.04.19	ISSUED FOR APPROVAL	AK	SW			
C	12.04.19	ISSUED FOR APPROVAL	AK	SW			
B	07.03.19	ISSUED FOR APPROVAL	NK	SW			
A	05.02.19	ISSUED FOR REVIEW	NK	SW			

Used on / Next higher assembly:

0 10 20 30 40 50 60m
SCALE 1:1000 A1 A1 SIZE

Filename: B18028-DRG-C-1410 to C-1411.dwg

Alternate DMS number:

Designing Company: Sydney Office
L2, 8 Windmill St, Sydney NSW 2000
P / +61 2 9770 3300
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bgeng.com

BG&E DOC No: B18028

Designed N.Kelly

Checked S.West

Ind.Rev. Company | Ind.Rev. Name

Ind.Review Signature

pacific national

Approved By | Accepted By

Signed: | Signed:

Approval Date | Acceptance Date

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C-1411

Sheet No. 2 of 2

Scale: 1:1000

SHEET SIZE A1

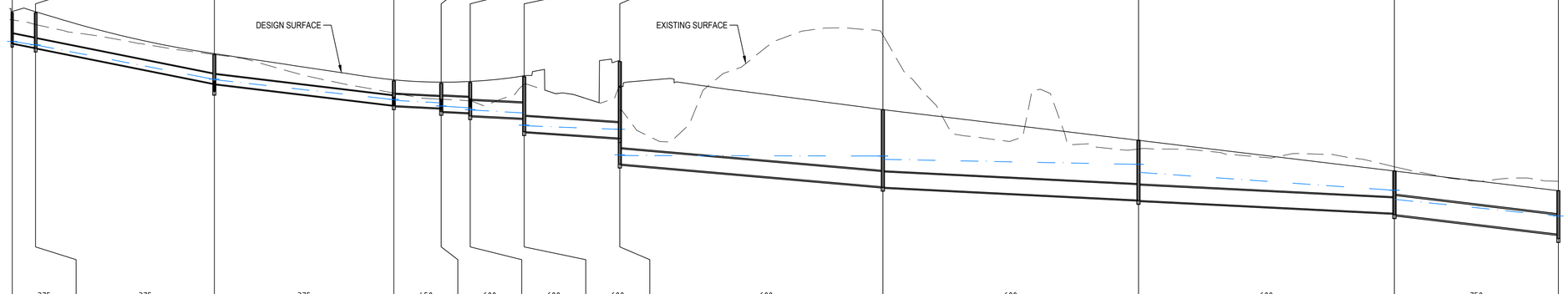
ST MARYS FREIGHT HUB
PHASE 1 - STORMWATER CATCHMENT PLAN
SHEET 2

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DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE

STRUCTURE NAME	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-10	1-11	1-12
STRUCTURE DESCRIPTION	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	R.S.I.P. 900x1800	Grated Surface Inlet Pit	R.S.I.P. 900x1800	Grated Surface Inlet Pit	R.S.I.P. 900x1800	Grated Surface Inlet Pit



PIPE SIZE (mm)		375	375	375	450	600	600	600	600	600	600	750
PIPE CLASS		(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)
PIPE GRADE (%)		2%	2%	1.2%	0.5%	0.5%	0.5%	0.68%	0.87%	0.5%	0.5%	1.2%
PIPE GRADE (1 in)		1 in 50	1 in 50	1 in 83.3	1 in 200	1 in 200	1 in 200	1 in 146.7	1 in 115.3	1 in 200	1 in 200	1 in 83.3
MAX FLOW PIPE VELOCITY (m/s)		Vmax=0.09	Vmax=0.25	Vmax=0.47	Vmax=0.58	Vmax=0.37	Vmax=0.44	Vmax=0.46	Vmax=0.46	Vmax=1.05	Vmax=1.97	Vmax=2.11
VELOCITY HEAD (m)		0.000m	0.003m	0.012m	0.017m	0.007m	0.010m	0.011m	0.011m	0.056m	0.199m	0.226m
DATUM (m)		12.5							13.5			
H.G.L. IN PIPE	30.528	30.394	29.057	28.265	28.005	27.862	27.257	27.096	27.052	26.726	25.713	24.704
DESIGN PIPE FLOW (m3/s - 5% AEP)		0.010	0.027	0.052	0.093	0.105	0.124	0.131	0.129	0.296	0.558	0.930
FLOW CAPACITY RATIO		4%	10%	25%	42%	22%	26%	24%	21%	63%	119%	70%
DEPTH TO INVERT	1.205	1.366	1.386	1.127 1.436	1.147	0.955	0.975	0.971	1.104	1.185	1.302	1.628	2.151	2.990	3.010	3.015	3.035	2.331	2.351	1.647	1.707	1.697
INVERT LEVEL	30.454	30.284	30.264	28.884 28.561	28.864	28.033	28.013	27.925	27.792	27.740	27.623	27.523	27.000	26.751	26.731	25.847	25.827	25.332	25.312	24.817	24.756	23.998
DESIGN SETOUT LEVEL	31.700	31.690	30.052	29.029	28.937	28.965	29.191	29.781	28.863	27.664	26.464	25.695
SETOUT COORDINATES	E 293745.665 N 6262065.819	E 293747.492 N 6262074.800	E 293679.575 N 6262091.255	E 293611.384 N 6262107.776	E 293593.403 N 6262112.132	E 293582.382 N 6262114.802	E 293561.914 N 6262119.859	E 293528.783 N 6262137.079	E 293496.160 N 6262234.523	E 293470.087 N 6262330.956	E 293443.986 N 6262427.491	E 293427.260 N 6262489.354
STRUCTURE CHAINAGE	0.000											
PIPE LENGTH		8.506	9.106	68.982	78.988	69.264	149.152	17.602	167.653	10.439	178.992	20.184	200.077	36.456	237.433	101.933	340.265	98.996	440.161	99.101	540.162	63.184	604.247
LINE		1										

PRELIMINARY

0 10 20 30 40 50 60m SCALE 1:1000 AT A1 SIZE

0 1 2 3 4 5 6m SCALE 1:100 AT A1 SIZE

Used on / Next higher assembly:

Filename: B18028-DRG-C-1450 to C-1457.dwg

Alternate DMS number:

Rev	Date	Revision Description	Designed	Checked	Ind. Rev.	Approved	Accepted
E	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
D	15.04.19	ISSUED FOR APPROVAL	AK	SW			
C	12.04.19	ISSUED FOR APPROVAL	AK	SW			
B	07.03.19	ISSUED FOR APPROVAL	NK	SW			
A	05.02.19	ISSUED FOR REVIEW	NK	SW			

Designing Company: Sydney Office — L2, 8 Windmill St, Sydney NSW 2000 P / +61 2 9770 3300 E / info@bgeeng.com bgeeng.com

BG&E DOC No: B18028

Designed N.Kelly | Checked S.West | Ind.Rev. Company | Ind.Rev. Name | Ind.Review Signature

Approved By | Accepted By | Signed: | Signed: | Approval Date | Acceptance Date

BG&E | C-1450 | Sheet No. 1 of 4 | Scale: AS SHOWN | SHEET SIZE A1

ST MARYS FREIGHT HUB

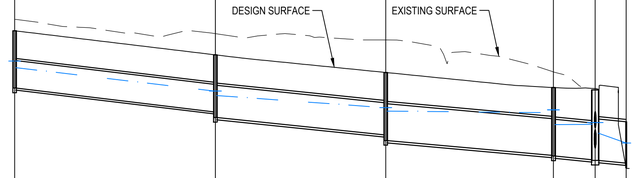
PHASE 1 - STORMWATER LONGITUDINAL SECTION SHEET 1

P:\BGE\DWG\B18028\100 DRG\MINOS\102 Civil\Auto\CAD\B18028-DRGC-1450 To C-1457

10/9/2019 5:48 PM

DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE

STRUCTURE NAME	1-12	1-13	1-14	1-15	1-16	1-17	2-1	2-2	2-3	3-1	1-3	4-1	1-4	5-1	1-5	6-1	1-6	7-1	7-2
STRUCTURE DESCRIPTION	R.S.I.P. 900x1800	Grated Surface Inlet Pit	R.S.I.P. 900x1800	Grated Surface Inlet Pit	R.S.I.P. 900x1800	Grated Surface Inlet Pit	JUNCTION PIT	Lidded Junction Pit	JUNCTION PIT	Lidded Junction Pit	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	CONNECTION	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	2.4 EKI SAG	1.8 EKI	Grated Gully Pit with 1.8m Extended Kerb Inlet Lintel	1.8 EKI	HEADWALL INLET	HEADWALL OUTLET





PIPE SIZE (mm)		900	1050	1200	1200	1350	375	375		375		375		375		375		1200x600	
PIPE CLASS		(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)		(RCP RRJ2)		(RCP RRJ2)		(RCP RRJ2)		(RCP RRJ2)		(RCBC)	
PIPE GRADE (%)		1.2%	1.03%	0.9%	1%	1%	0.5%	1.45%		2%		2%		2%		2%		1%	
PIPE GRADE (1 in)		1 in 83.3	1 in 96.9	1 in 110.9	1 in 100	1 in 100	1 in 200	1 in 68.9		1 in 50		1 in 50		1 in 50		1 in 50		1 in 100	
MAX FLOW PIPE VELOCITY (m/s)		Vmax=1.99	Vmax=1.83	Vmax=1.69	Vmax=1.97	Vmax=1.92	Vmax=0.15	Vmax=0.32		Vmax=0.11		Vmax=0.39		Vmax=0.06		Vmax=0.22		Vmax=1.48	
VELOCITY HEAD (m)		0.202m	0.171m	0.146m	0.198m	0.188m	0.001m	0.005m		0.001m		0.008m		0.000m		0.003m		0.095m	
DATUM (m)		9.5					18.5			15.5		14.5		14.5		14.5		14.5	
H.G.L. IN PIPE	24.704	23.728	23.186	23.113	22.698	22.030	31.697	31.679	31.500	29.057		28.499		28.096		28.262		28.500	
DESIGN PIPE FLOW (m3/s - 5% AEP)		1.265	1.587	1.916	2.229	2.749	0.017	0.035		0.012		0.028		0.007		0.016		1.063	
FLOW CAPACITY RATIO		59%	53%	48%	53%	47%	13%	15%		5%		19%		3%		11%		40%	
DEPTH TO INVERT	1.697	1.871 1.861	2.045 2.035	2.222 2.214	2.234 2.280	2.300 1.350	1.261	1.297	1.317 1.350	1.261	1.430 1.147	0.783	0.953 0.975	0.861	1.031 1.104	0.783	0.952 1.302	0.600	0.980 1.000
INVERT LEVEL	23.998	23.823 23.048	22.863 22.298	22.112 21.626	21.606 21.485	21.465 21.374	31.592	31.550	31.530 31.400	28.751	28.581 28.581 28.864	28.206	28.036 28.013	28.036	27.866 27.792	28.143	27.973 27.623	27.900	27.600 27.580
DESIGN SETOUT LEVEL	25.695	24.908	24.334	23.841	23.808	21.200	32.893	32.887	32.750	30.052		29.029		28.937		28.966		27.900	
SETOUT COORDINATES	E 2934.271.260 N 6262.489.354	E 2934.10.158 N 6262552.607	E 293395.639 N 6262606.308	E 293381.349 N 6262659.161	E 293387.269 N 6262671.374	E 293392.157 N 6262680.163	E 293917.108 N 6262078.953	E 293915.446 N 6262087.909	E 293923.650 N 6262092.400	E 293677.480 N 6262082.399		E 293609.265 N 6262098.926		E 293591.260 N 6262103.288		E 293580.110 N 6262105.989		E 293565.194 N 6262106.842	
STRUCTURE CHAINAGE	604.247						0.000			0.000		0.000		0.000		0.000		0.000	
PIPE LENGTH		64.624	54.729	53.851	12.133	9.057	8.510	9.110	8.918	8.500	78.988	8.500	149.152	8.500	167.653	8.501	178.992	29.958	0.000
LINE		1					2			3		4		5		6		7	

PRELIMINARY

SCALE 1:1000 AT A1 SIZE (0 10 20 30 40 50 60m)

SCALE 1:100 AT A1 SIZE (0 1 2 3 4 5 6m)

Used on / Next higher assembly:

Filename: B18028-DRG-C-1450 to C-1457.dwg

Alternate DMS number:

Rev	Date	Revision Description	Designed	Checked	Ind. Rev.	Approved	Accepted
E	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
D	15.04.19	ISSUED FOR APPROVAL	AK	SW			
C	12.04.19	ISSUED FOR APPROVAL	AK	SW			
B	07.03.19	ISSUED FOR APPROVAL	NK	SW			
A	05.02.19	ISSUED FOR REVIEW	NK	SW			

Designing Company: Sydney Office — L2, 8 Windmill St, Sydney NSW 2000 P / +61 2 9770 3300 E / info@bgeeng.com bgeeng.com

BG&E DOC No: B18028

Designed N.Kelly | Checked S.West | Ind.Rev. Company | Ind.Rev. Name | Ind.Review Signature

Approved By | Accepted By | Signed: | Signed: | Approval Date | Acceptance Date

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BG&E

C-1451

Sheet No. 2 of 4

Scale: AS SHOWN

SHEET SIZE A1

ST MARYS FREIGHT HUB

PHASE 1 - STORMWATER LONGITUDINAL SECTION

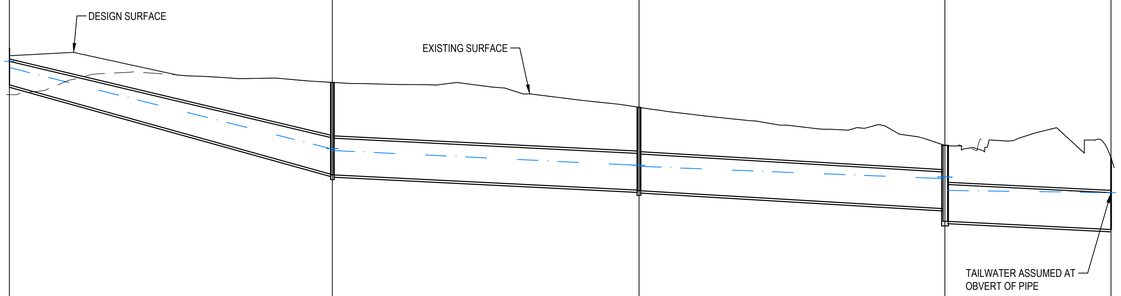
SHEET 2

P:\BGE\ONE DRIVE\18 JOBS\18028 WINGS 102 Civil\AutoCAD\18028-DRG-C-1450 To C-1457

10/9/2019 5:48 PM

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STRUCTURE NAME	8-1	8-2	8-3	8-4	8-5	9-1	9-2	9-3	9-4	1-16	10-1	10-2	1-16	11-1	11-2
STRUCTURE DESCRIPTION	HEADWALL INLET	R.S.I.P. 900x1800 Grated Surface Inlet Pit	R.S.I.P. 900x1800 Grated Surface Inlet Pit	R.S.I.P. 1800x1800 Grated Surface Inlet Pit	HEADWALL OUTLET	3.0 EKI Grated Gully Pit with 3.0m Extended Kerb Inlet Lintel	2.4 EKI SAG Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	3.6 EKI Grated Gully Pit with 3.6m Extended Kerb Inlet Lintel	2.4 EKI Grated Gully Pit with 2.4m Extended Kerb Inlet Lintel	JUNCTION PIT	3.6 EKI Grated Gully Pit with 3.6m Extended Kerb Inlet Lintel	3.6 EKI SAG Grated Gully (Sag) Pit with 3.6m Extended Kerb Inlet Lintel	JUNCTION PIT	2.4 EKI Grated Gully Pit with 2.4m Extended Kerb Inlet Lintel	2.4 EKI
PIPE SIZE (mm)		1200	1200	1200	1200	375	450	450	450		450	525		375	
PIPE CLASS		(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)		(RCP RRJ2)	(RCP RRJ2)		(RCP RRJ2)	
PIPE GRADE (%)		2.78%	0.5%	0.59%	0.5%	0.5%	0.5%	0.5%	0.5%		2%	0.5%		2%	
PIPE GRADE (1 in)		1 in 36	1 in 200	1 in 168.7	1 in 200	1 in 200	1 in 200	1 in 200	1 in 200		1 in 50	1 in 200		1 in 50	
MAX FLOW PIPE VELOCITY (m/s)		Vmax=2.71	Vmax=1.85	Vmax=1.85	Vmax=1.85	Vmax=0.06	Vmax=0.19	Vmax=0.19	Vmax=0.73		Vmax=0.84	Vmax=2.17		Vmax=0.10	
VELOCITY HEAD (m)		0.102m	0.175m	0.175m	0.174m	0.000m	0.002m	0.002m	0.027m		0.036m	0.241m		0.000m	
DATUM (m)		10.5				9.5					8.5			9.5	
H.G.L. IN PIPE	27.069	24.220	23.675	23.294	22.781	23.344	23.272	23.135	23.137		23.491	23.341		22.794	22.791
DESIGN PIPE FLOW (m3/s - 5% AEP)		2.073	2.094	2.092	2.089	0.006	0.031	0.030	0.116		0.133	0.471		0.011	
FLOW CAPACITY RATIO		40%	70%	64%	70%	5%	14%	14%	53%		30%	143%		4%	
DEPTH TO INVERT	1.200	3.000	3.020	2.702	2.722	2.069	2.482	2.338	1.111	1.448	1.468	1.576	1.596	1.405	1.425	1.200	2.300	1.356	1.627	1.647	1.861	2.300	1.061	1.156
INVERT LEVEL	26.300	23.380	23.360	22.864	22.844	22.258	21.845	21.579	21.579	23.287	23.163	23.143	23.001	22.981	22.799	22.779	22.565	21.465	22.352	21.967	21.947	21.905	21.465	22.453	22.362
DESIGN SETOUT LEVEL	26.300	26.380	25.566	24.327	23.917	24.437	24.651	24.617	24.244		23.841	23.634		23.554	23.558
SETOUT COORDINATES	E 293507.967 N 6262392.494	E 293516.085 N 6262491.641	E 293521.483 N 6262597.598	E 293526.868 N 6262697.327	E 293486.540 N 6262733.090	E 293522.118 N 6262683.004	E 293496.602 N 6262682.832	E 293468.378 N 6262679.912	E 293431.272 N 6262676.072		E 293357.377 N 6262673.451	E 293377.737 N 6262675.571		E 293512.956 N 6262756.025	E 293509.236 N 6262752.501
STRUCTURE CHAINAGE	0.000	105.460	205.563	305.437	359.680	0.000	24.769	25.519	28.374	54.794	36.404	92.098	42.759	793.783	0.000	19.246	20.596	8.490	793.783	0.000	4.527	5.127
PIPE LENGTH		105.008	99.203	98.824	53.243										
LINE		8				9					10			11	



PRELIMINARY

0 10 20 30 40 50 60m SCALE 1:1000 AT A1 SIZE

0 1 2 3 4 5 6m SCALE 1:100 AT A1 SIZE

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E	10.09.19	ISSUED FOR APPROVAL	MWE	SW			
D	15.04.19	ISSUED FOR APPROVAL	AK	SW			
C	12.04.19	ISSUED FOR APPROVAL	AK	SW			
B	07.03.19	ISSUED FOR APPROVAL	NK	SW			
A	05.02.19	ISSUED FOR REVIEW	NK	SW			

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BG&E DOC No: B18028

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Approved By | Signed: | Approval Date

Accepted By | Signed: | Acceptance Date

BG&E C-1452

Sheet No. 3 of 4 | Scale: AS SHOWN | SHEET SIZE A1

ST MARYS FREIGHT HUB

PHASE 1 - STORMWATER LONGITUDINAL SECTION

SHEET 3

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DRAWN TO AS1100 | DO NOT SCALE | ALL DIMENSIONS IN MM UNLESS STATED OTHERWISE

STRUCTURE NAME	11-2	11-3	12-1	12-2	12-3	12-4	13-1	13-2
STRUCTURE DESCRIPTION	2.4 EKI	Grated Gully Pit with 2.4m Extended Kerb Inlet Lintel	G.S.I.P. 900x900	Grated Surface Inlet Pit	2.4 EKI SAG	Grated Gully (Sag) Pit with 2.4m Extended Kerb Inlet Lintel	R.S.I.P. 900x900	Grated Surface Inlet Pit
		HEDAWALL OUTLET		2.4 EKI SAG		HEADWALL OUTLET		JUNCTION PIT
								Lidded Junction Pit
PIPE SIZE (mm)		375		450	450	450		300
PIPE CLASS		(RCP RRJ2)		(RCP RRJ2)	(RCP RRJ2)	(RCP RRJ2)		(RCP RRJ2)
PIPE GRADE (%)		0.5%		3%	0.5%	0.82%		0.5%
PIPE GRADE (1 in)		1 in 200		1 in 33.3	1 in 200	1 in 121.7		1 in 200
MAX FLOW PIPE VELOCITY (m/s)		Vmax=0.56		Vmax=0.00	Vmax=0.66	Vmax=0.78		Vmax=0.00
VELOCITY HEAD (m)		0.016m		0.000m	0.022m	0.031m		0.000m
DATUM (m)		9.5		8.5				8.5
H.G.L. IN PIPE	22.791		22.671		22.671	22.463	22.405	20.900
		22.668						20.576
DESIGN PIPE FLOW (m3/s - 5% AEP)		0.062		0.000	0.104	0.125		0.000
FLOW CAPACITY RATIO		46%		0%	48%	44%		0%
DEPTH TO INVERT	1.156	1.176	1.035	0.893	1.043	1.066	1.091	0.800
		0.375					0.450	0.518
INVERT LEVEL	22.362	22.342	22.352	22.269	22.119	22.096	22.071	20.900
	22.281	22.281				21.943	21.943	20.576
DESIGN SETOUT LEVEL	23.558		23.387	23.202		23.202	21.943	21.700
		22.281						21.095
SETOUT COORDINATES	E 293509.236	N 6262752.501	E 2934.70.277	N 6262802.410	E 2934466.957	N 6262801.258	E 2934462.125	N 6262799.627
	E 2935501.675	N 6262742.394	E 2934466.386	N 6262797.638				E 2934.10.975
								N 6262720.050
								E 293368.869
								N 6262700.257
STRUCTURE CHAINAGE	5.127		0.000				0.000	
PIPE LENGTH		12.331		2.764	3.514	4.500	8.614	15.568
		17.761					24.484	64.732
								65.184
LINE		11		12				13

EXISTING SURFACE

DESIGN SURFACE

TAILWATER ASSUMED AT OBVERT OF PIPE

TAILWATER ASSUMED AT OBVERT OF PIPE

PRELIMINARY

0 10 20 30 40 50 60m SCALE 1:1000 AT A1 SIZE

0 1 2 3 4 5 6m SCALE 1:100 AT A1 SIZE

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Designed N.Kelly

Checked S.West

Ind.Rev. Company | Ind.Rev. Name

Ind.Review Signature

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Signed: | Signed:

Approval Date | Acceptance Date

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A B C D E

C-1453

Sheet No. 4 of 4

Scale: AS SHOWN

SHEET SIZE A1

ST MARYS FREIGHT HUB

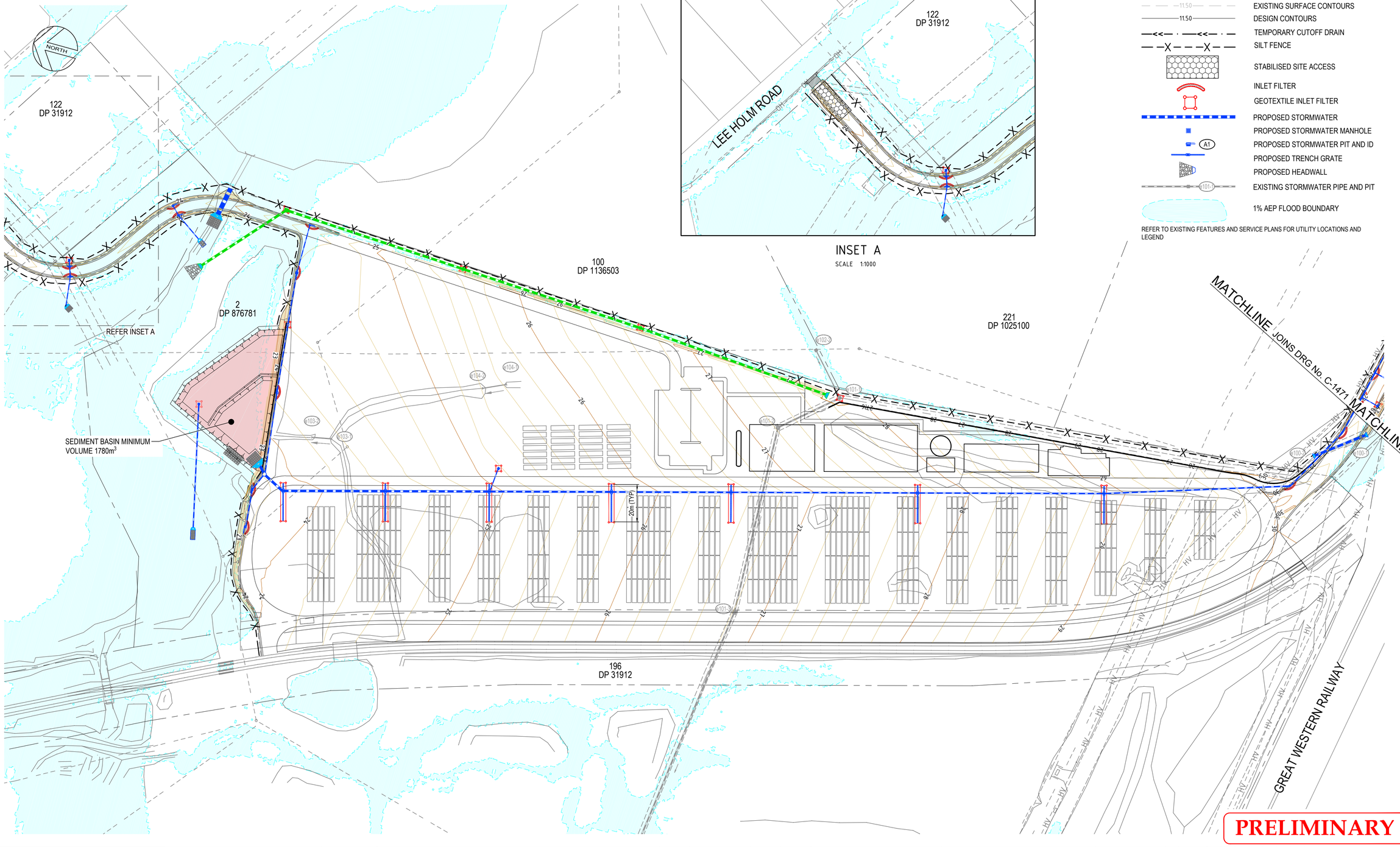
PHASE 1 - STORMWATER LONGITUDINAL SECTION

SHEET 4

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LEGEND

- PROJECT LIMIT OF WORKS
- PROPERTY BOUNDARY
- EXISTING SURFACE CONTOURS (11.50)
- DESIGN CONTOURS (11.50)
- TEMPORARY CUTOFF DRAIN
- SILT FENCE
- STABILISED SITE ACCESS
- INLET FILTER
- GEOTEXTILE INLET FILTER
- PROPOSED STORMWATER
- PROPOSED STORMWATER MANHOLE
- PROPOSED STORMWATER PIT AND ID (A1)
- PROPOSED TRENCH GRATE
- PROPOSED HEADWALL
- EXISTING STORMWATER PIPE AND PIT (101-1)
- 1% AEP FLOOD BOUNDARY

REFER TO EXISTING FEATURES AND SERVICE PLANS FOR UTILITY LOCATIONS AND LEGEND

PRELIMINARY

Used on / Next higher assembly:

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SCALE 1:1000 AT A1 SIZE

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BG&E DOC No: B18028

Designed N.Kelly

Checked S.West

Ind.Rev. Company | Ind.Rev. Name

Ind.Review Signature

pacific national

Approved By | Accepted By

Signed: | Signed:

Approval Date | Acceptance Date

BG&E

A

C-1470

Sheet No. 1 of 2

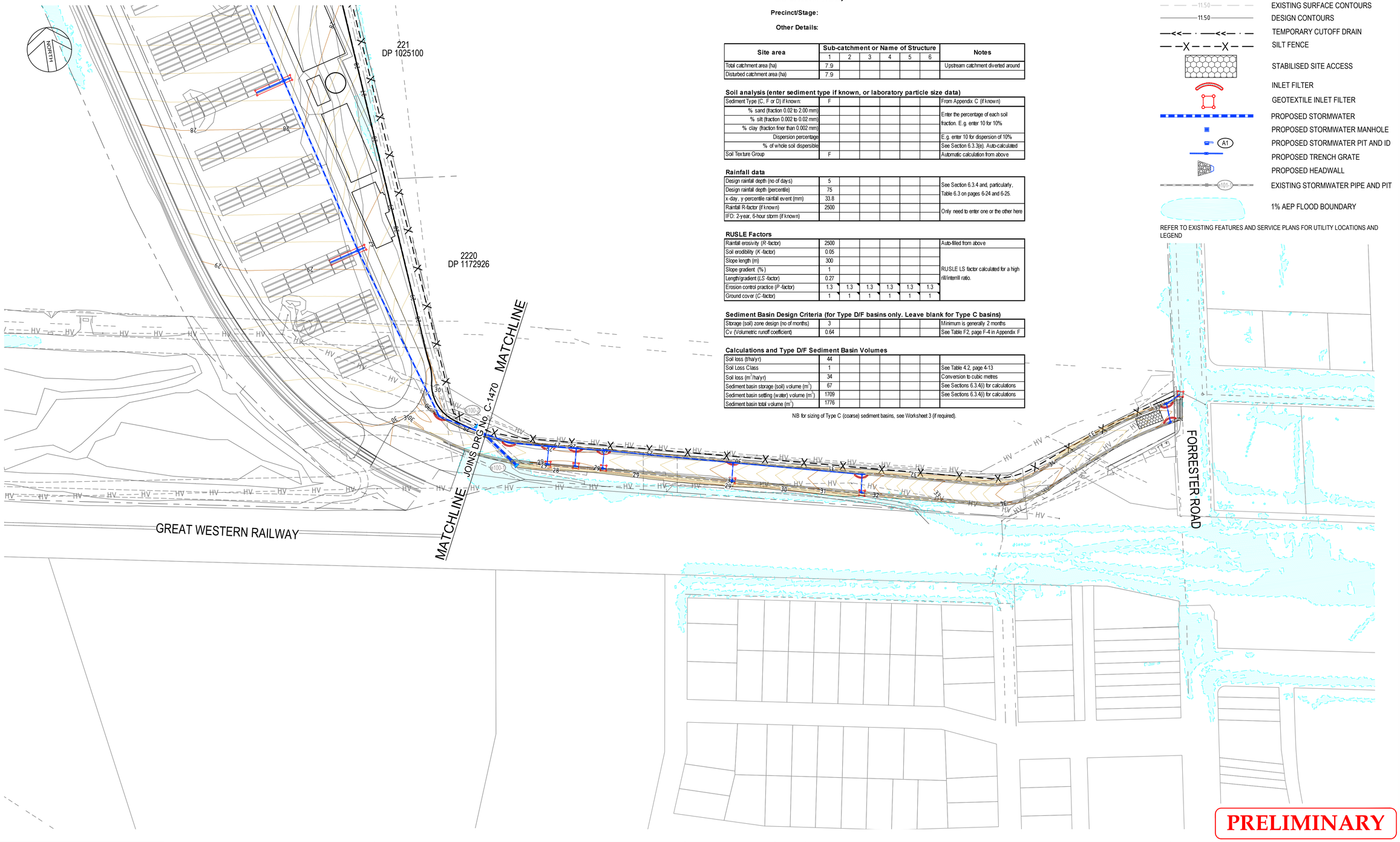
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SHEET SIZE A1

ST MARYS FREIGHT HUB
PHASE 1 - EROSION AND SEDIMENT CONTROL LAYOUT - SHEET 1

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1. Erosion Hazard and Sediment Basins

Site Name: St Marys Intermodal

Site Location: St Marys

Precinct/Stage:

Other Details:

Site area	Sub-catchment or Name of Structure 1	2	3	4	5	6	Notes
Total catchment area (ha)	7.9						Upstream catchment diverted around
Disturbed catchment area (ha)	7.9						

Soil analysis (enter sediment type if known, or laboratory particle size data)

Sediment Type (C, F or D) if known:	F						From Appendix C (if known)
% sand (fraction 0.02 to 2.00 mm)							Enter the percentage of each soil fraction. E.g. enter 10 for 10%
% silt (fraction 0.002 to 0.02 mm)							
% clay (fraction finer than 0.002 mm)							
Dispersion percentage							E.g. enter 10 for dispersion of 10%
% of whole soil dispersible							See Section 6.3.3(e). Auto-calculated
Soil Texture Group	F						Automatic calculation from above

Rainfall data

Design rainfall depth (no of days)	5						See Section 6.3.4 and, particularly, Table 6.3 on pages 6-24 and 6-25.
Design rainfall depth (percentile)	75						
x-day , y-percentile rainfall event (mm)	33.8						
Rainfall R-factor (if known)	2500						Only need to enter one or the other here
IFD: 2-year, 6-hour storm (if known)							

RUSLE Factors

Rainfall erosivity (*R*-factor)	2500						Auto-filled from above
Soil erodibility (*K*-factor)	0.05						RUSLE LS factor calculated for a high rill/interrill ratio.
Slope length (m)	300						
Slope gradient (%)	1						
Length/gradient (*LS*-factor)	0.27						
Erosion control practice (*P*-factor)	1.3	1.3	1.3	1.3	1.3	1.3	
Ground cover (*C*-factor)	1	1	1	1	1	1	

Sediment Basin Design Criteria (for Type D/F basins only. Leave blank for Type C basins)

Storage (soil) zone design (no of months)	3						Minimum is generally 2 months
Cv (Volumetric runoff coefficient)	0.64						See Table F2, page F-4 in Appendix F

Calculations and Type D/F Sediment Basin Volumes

Soil loss (t/ha/yr)	44						
Soil Loss Class	1						See Table 4.2, page 4-13
Soil loss (m^3/ha/yr)	34						Conversion to cubic metres
Sediment basin storage (soil) volume (m^3)	67						See Sections 6.3.4(l) for calculations
Sediment basin settling (water) volume (m^3)	1709						See Sections 6.3.4(l) for calculations
Sediment basin total volume (m^3)	1776						

NB for sizing of Type C (coarse) sediment basins, see Worksheet 3 (if required).

LEGEND

- PROJECT LIMIT OF WORKS
- PROPERTY BOUNDARY
- EXISTING SURFACE CONTOURS (11.50)
- DESIGN CONTOURS (11.50)
- TEMPORARY CUTOFF DRAIN
- SILT FENCE
- STABILISED SITE ACCESS
- INLET FILTER
- GEOTEXTILE INLET FILTER
- PROPOSED STORMWATER
- PROPOSED STORMWATER MANHOLE
- PROPOSED STORMWATER PIT AND ID (A1)
- PROPOSED TRENCH GRATE
- PROPOSED HEADWALL
- EXISTING STORMWATER PIPE AND PIT (101)
- 1% AEP FLOOD BOUNDARY

REFER TO EXISTING FEATURES AND SERVICE PLANS FOR UTILITY LOCATIONS AND LEGEND

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C-1471

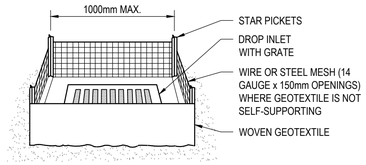
ST MARYS FREIGHT HUB

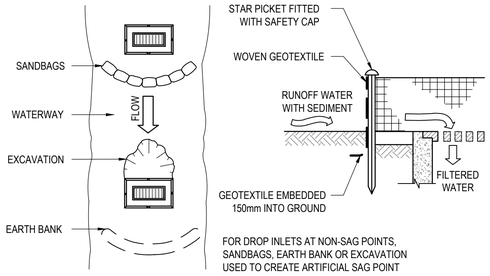
PHASE 1 - EROSION AND SEDIMENT CONTROL LAYOUT - SHEET 2

Sheet No. 2 of 2 | Scale: 1:1000 | SHEET SIZE A1

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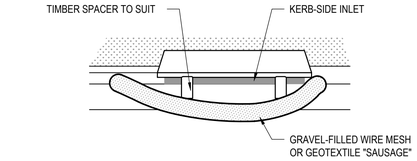


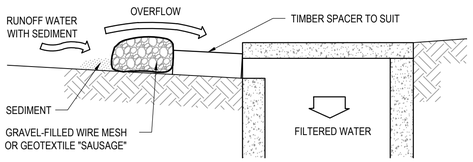
FOR DROP INLETS AT NON-SAG POINTS, SANDBAGS, EARTH BANK OR EXCAVATION USED TO CREATE ARTIFICIAL SAG POINT

GEOTEXTILE INLET FILTER CONSTRUCTION NOTES:

1. FABRICATE A SEDIMENT BARRIER MADE FROM GEOTEXTILE OR STRAW BALES.
2. PICKET SPACING TO BE A MAXIMUM 1.0m CENTRES.
3. IN WATERWAYS, ARTIFICIAL SAG POINTS CAN BE CREATED WITH SANDBAGS OR EARTH BANKS AS SHOWN IN THE DRAWING.
4. DO NOT COVER THE INLET WITH GEOTEXTILES UNLESS THE DESIGN IS ADEQUATE TO ALLOW FOR ALL WATERS TO BYPASS IT.

GEOTEXTILE INLET FILTER
SCALE N.T.S

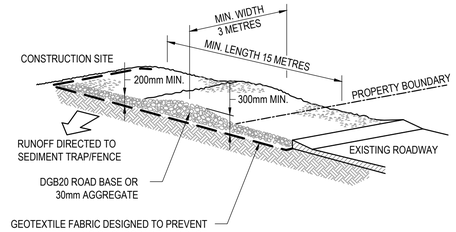




MESH & GRAVEL INLET FILTER CONSTRUCTION NOTES:

1. INSTALL FILTERS TO KERB INLETS ONLY AT SAG POINTS.
2. FABRICATE A SLEEVE MADE FROM GEOTEXTILE OR WIRE MESH LONGER THAN THE LENGTH OF THE INLET PIT AND FILL IT WITH 25mm TO 50mm GRAVEL.
3. FORM AN ELLIPTICAL CROSS-SECTION ABOUT 150mm HIGH x 400mm WIDE.
4. PLACE THE FILTER AT THE OPENING LEAVING AT LEAST A 100mm SPACE BETWEEN IT AND THE KERB INLET. MAINTAIN THE OPENING WITH SPACER BLOCKS.
5. FORM A SEAL WITH THE KERB TO PREVENT SEDIMENT BYPASSING THE FILTER.
6. SANDBAGS FILLED WITH GRAVEL CAN SUBSTITUTE FOR THE MESH OR GEOTEXTILE PROVIDING THEY ARE PLACED SO THAT THEY CAN FIRMLY ABUT EACH OTHER AND SEDIMENT-LADEN WATERS CANNOT PASS BETWEEN.

MESH & GRAVEL INLET FILTER
SCALE N.T.S

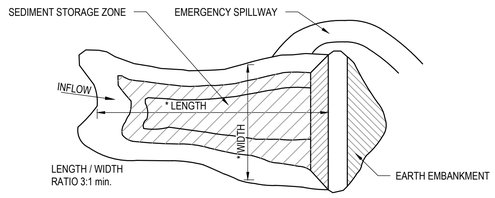


GEOTEXTILE MAY BE A WOVEN OR NEEDLE-PUNCHED PRODUCT WITH A MINIMUM CBR BURST STRENGTH (AS3706.4-90) OF 2500 N.

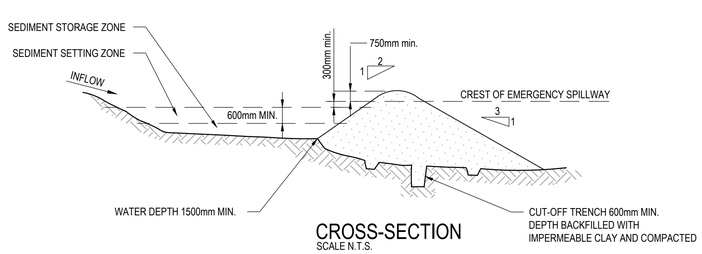
STABILISED SITE ACCESS CONSTRUCTION NOTES:

1. STRIP THE TOPSOIL, LEVEL THE SITE AND COMPACT THE SUBGRADE.
2. COVER THE AREA WITH NEEDLE-PUNCHED GEOTEXTILE
3. CONSTRUCT A 200mm THICK PAD OVER THE GEOTEXTILE USING ROAD BASE OR 30mm AGGREGATE.
4. ENSURE THE STRUCTURE IS AT LEAST 15 METRES LONG OR TO BUILDING ALIGNMENT AND AT LEAST 3 METRES WIDE.
5. WHERE A SEDIMENT FENCE JOINS ONTO THE STABILISED ACCESS, CONSTRUCT A HUMP IN THE STABILISED ACCESS TO DIVERT WATER TO THE SEDIMENT FENCE.

STABILISED SITE ACCESS
SCALE N.T.S



PLAN VIEW
SCALE N.T.S.

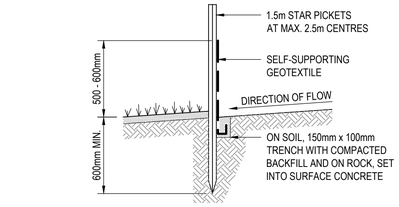


CROSS-SECTION
SCALE N.T.S.

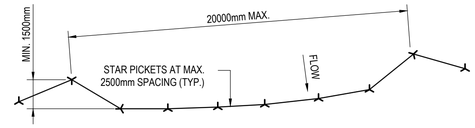
EARTH BASIN WET CONSTRUCTION NOTES:

1. REMOVE ALL VEGETATION AND TOPSOIL FROM UNDER THE DAM WALL AND FROM WITHIN THE STORAGE AREA.
2. * CONSTRUCT A CUT-OFF TRENCH 500mm DEEP AND 1,200mm WIDE ALONG THE CENTRELINE OF THE EMBANKMENT EXTENDING TO A POINT ON THE GULLY WALL LEVL WITH THE RISER CREST.
3. * MAINTAIN THE TRENCH FREE OF WATER AND RECOMPACT THE MATERIALS WITH EQUIPMENT AS SPECIFIED IN THE SWMP TO 95% STANDARD PROCTOR DENSITY.
4. * SELECT FILL FOLLOWING THE SWMP THAT IS FREE OF ROOTS, WOOD, ROCK, LARGE STONE OR FOREIGN MATERIAL.
5. * PREPARE THE SIRE UNDER THE EMBANKMENT BY RIPPING TO AT LEAST 100mm TO HELP BOND COMPACTED FILL TO THE EXISTING SUBSTRATE.
6. * SPREAD THE FILL IN 100mm TO 150mm LAYERS AND COMPACT IT AT OPTIMUM MOISTURE CONTENT FOLLOWING THE SWMP.
7. CONSTRUCT THE EMERGENCY SPILLWAY.
8. REHABILITATE THE STRUCTURE FOLLOWING THE SWMP.

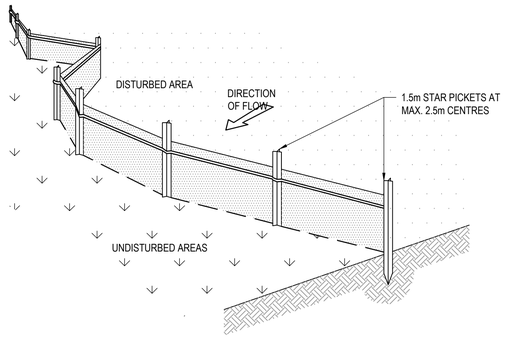
EARTH BASIN - WET
SCALE N.T.S



SECTION DETAIL



PLAN



SEDIMENT FENCE CONSTRUCTION NOTES:

1. CONSTRUCT SEDIMENT FENCES AS CLOSE AS POSSIBLE TO BEING PARALLEL TO THE CONTOURS OF THE SITE, BUT WITH SMALL RETURNS AS SHOWN IN THE DRAWING TO LIMIT THE CATCHMENT AREA OF ANY ONE SECTION. THE CATCHMENT AREA SHOULD BE SMALL ENOUGH TO LIMIT WATER FLOW IF CONCENTRATED AT ONE POINT TO 50 LITRES PER SECOND IN THE DESIGN STORM EVENT, USUALLY THE 10-YEAR EVENT.
2. CUT A 150mm DEEP TRENCH ALONG THE UPSLOPE LINE OF THE FENCE FOR THE BOTTOM OF THE FABRIC TO BE ENTRENCHED.
3. DRIVE 1.5m LONG STAR PICKETS INTO GROUND AT 2.5m INTERVALS (MAX.) AT THE DOWNSLOPE EDGE OF THE TRENCH. ENSURE ANY STAR PICKETS ARE FITTED WITH SAFETY CAPS.
4. FIX SELF-SUPPORTING GEOTEXTILE TO THE UPSLOPE SIDE OF THE POSTS ENSURING IT GOES TO THE BASE OF THE TRENCH. FIX THE GEOTEXTILE WITH WIRE TIES OR AS RECOMMENDED BY THE MANUFACTURER. ONLY USE GEOTEXTILE SPECIFICALLY PRODUCED FOR SEDIMENT FENCING. THE USE OF SHADE CLOTH FOR THIS PURPOSE IS NOT SATISFACTORY.
5. JOIN SECTIONS OF FABRIC AT A SUPPORT POST WITH A 150mm OVERLAP.
6. BACKFILL THE TRENCH OVER THE BASE OF THE FABRIC AND COMPACT IT THOROUGHLY OVER THE GEOTEXTILE.

SEDIMENT FENCE
SCALE N.T.S

PRELIMINARY

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PHASE 1 - EROSION AND SEDIMENT CONTROL DETAILS

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APPENDIX F

IECA Best Practice Management Guidelines

Construction Exits – General

SEDIMENT CONTROL TECHNIQUES



Photo 1 – Rock pad

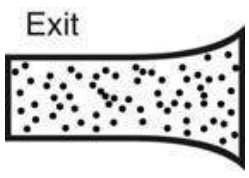
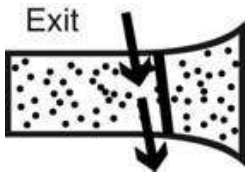
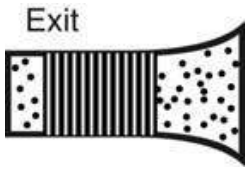
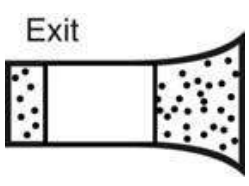


Photo 2 – Wash bay

Design Information

Table 1 provides guidance on the selection of best practice sediment control measures for construction site entry/exit points.

Table 1 – Use of stabilised construction exits

Technique	Code	Symbol	Typical use
Rock Pad	Exit	 OR  (above shows rock pad with cross drain)	• Suitable for all soil types. • Suitable for both building sites and civil construction sites. • Generally perform better than *Vibration Grids* during wet weather. • Drainage controls may need to be incorporated into the rock pad to direct sediment-laden runoff to an appropriate sediment trap. • Note: *Rock Pads* for use on building sites generally differ in design specifications from those used on construction sites (e.g. rock size and pad length and width). Care must be taken to ensure the adoption of the standard drawing appropriate for the site conditions.
Vibration Grid	Exit		• Best suited to sandy soils. • Can also be used in clayey soil regions to control sediment movement during dry weather.
Wash Bay	Exit		• Wash bays normally represent best practice on long-term construction sites. • Best use when working near fragile environments, when turbidity control is a major issue, or when working with highly cohesive clays. • Options include in-situ designs as well as portable (hire) units.

Sediment Basins

SEDIMENT CONTROL TECHNIQUE

Type 1 System	✓	Sheet Flow		Sandy Soils	✓
Type 2 System		Concentrated Flow	✓	Clayey Soils	✓
Type 3 System		Supplementary Trap		Dispersive Soils	[1]

[1] Settlement of dispersive soils may be achieved through the flocculation of 'wet' sediment basins.

Symbol

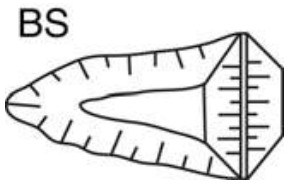




Photo 1 – Example of a 'dry' (Type C) sediment basin

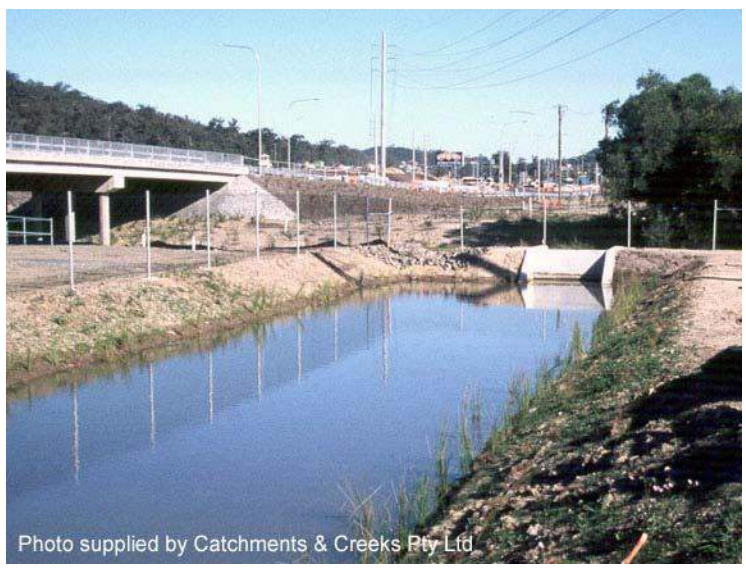


Photo 2 – Example of a 'wet' (Type F/D) sediment basin

Key Principles

1. Sediment trapping can be achieved by both particle settlement within the settling pond (all basin types), and by the filtration of minor flows passing through the aggregate or geotextile filter (dry basins).
2. For continuous flow basins (i.e. dry basins) the critical design parameter for optimising particle settlement is the 'surface area' of the settling pond. For plug flow basins (i.e. wet basins) the critical design parameter is the 'volume' of the settling pond.
3. The critical design parameter for the filtration process (dry basins) is the design flow rate for water passing through the filter, which is related to the depth of water (hydraulic head), and the surface area and flow resistance of the filter.
4. Even if a basin is full of water, it can still be effective in the removal of coarse sediment from any flows passing through the basin. Therefore, unlike permanent stormwater settling ponds, high flows resulting from storms in excess of the 'design storm' should **not** be bypassed around a construction site sediment basin.

Design Information

This fact sheet summaries design requirements for three types of temporary sediment basins, Type C for coarse-grained soils, Type F for fine-grained soils, and Type D for dispersive soils. Detailed design procedures are provided in Appendix B of the IECA (Australasia) "Best Practice Erosion and Sediment Control" document.

Sediment basins should be designed and operated in a manner that produces near clear-water discharges (i.e. total suspended solids concentrations not exceeding 50mg/L) during non-overtopping events, especially following periods of light rainfall.

Summary of design requirements

Table 1 provides a summary of the recommended design requirements.

Table 1 – Summary of sediment basin design requirements

Parameter	Type C basin	Type F & D basins
Soil characteristic	Less than 33% of soil finer than 0.02mm and no more than 10% of soil dispersive.	**Type F:** More than 33% of soil finer than 0.02mm. **Type D:** More than 10% of soil dispersive, or where turbidity control is essential.
Settling pond sizing, surface area (A_s), or settling volume (V_s)	$A_s = 3400\ H_e\ (Q)$ Q = 0.5 times 1 in 1yr flow	$V_s = 10\ R_{(Y\%,\ 5\text{-day})}\ C_v\ A$
Length to width ratio	Hydraulic efficiency factor (H_e) is reduce with increasing length to width ratio	L:W of 3:1 is highly desirable
Minimum depth of settling zone	0.6m	0.6m
Sediment storage volume	100% of settling volume	50% of settling volume
Use of inlet chamber	Desirable if length to width ratio is less than 3:1, or if inflow is concentrated with high flow velocity.	
Internal baffles	Desirable if length to width ratio is less than 3:1	
Use of outlet chamber	Essential if skimmer pipe outlet system is employed	Use depends on type of outlet system adopted
Control inflow conditions	Used to control erosion at inlets and, where practicable, ensure the inflow pipe invert is above the spillway crest elevation.	
Pre-treatment pond	Used to reduce the cost and frequency of de-silting operations.	
Primary outlet	Ensure choice of outlet system is compatible with basin type.	
Emergency spillway minimum design capacity	Less and 3 month design life: capacity of 1 in 10 year ARI. 3 to 12 months design life: capacity of 1 in 20 year ARI. Greater than 12 months design life: capacity of 1 in 50 yr ARI.	
Elevation from top of riser pipe outlet to spillway crest	300mm (min)	N/A
Freeboard from maximum pond water level to top of virgin soil bank	150mm (min)	150mm (min)
Freeboard from maximum pond water level to top of fill embankment	300mm (min)	300mm (min)
Minimum freeboard along spillway chute	300mm (min)	300mm (min)
Minimum embankment crest width	2.5m	2.5m
Maximum gradient of access ramp	6:1	6:1
Chemical flocculation	As required to satisfy water quality objectives.	**Type F:** As required to satisfy water quality objectives. **Type D:** Essential

Design procedure:

Step 1 – Assess the need for a sediment basin

Sediment basins are recommended for any sub-catchment with a catchment area exceeding 2500m^2 and an estimated soil loss rate that exceeds the equivalent of 150t/ha/yr.

Step 2 – Selection of the required type of basin

Selection of the type of sediment basin is governed by the site's soil properties as outlined in Table 2.

Table 2 – Selection of basin type

Soil and/or catchment conditions [1]	Basin type
Less than 33% of soil finer than 0.02mm (i.e. d_{33} > 0.02mm) and no more than 10% of soil dispersive. [2]	Type C basin
More than 33% of soil finer than 0.02mm (i.e. d_{33} < 0.02mm) and no more than 10% of soil dispersive. [2]	Type F basin
More than 10% of soil dispersive [2], or when a Stormwater Management Plan (SMP), or adopted Water Quality Objectives (WQOs) specify strict controls on turbidity levels and/or suspended solids concentrations for discharged waters.	Type D basin

[1] If more than one soil type exists on the site, then the most stringent criterion applies (i.e. Type D supersedes Type F, which itself supersedes Type C).

[2] The percentage of soil that is dispersive is measured as the combined decimal fraction of clay (<0.002mm) plus half the percentage of silt (0.002–0.02mm), multiplied by the dispersion percentage.

Step 3 – Determine the basin location

Sediment basins should be located within a sub-catchment so as to maximise its overall sediment trapping capabilities of that sub-catchment. Issues that need to be given appropriate consideration include:

- Locate all basins within the relevant property boundary.
- Locate sediment basins above the 1 in 5 year ARI flood level. Where this is not practicable, then all reasonable efforts should be taken to maximise the flood immunity of the basin.
- Avoid locating a basin in an area where adjacent construction works may limit the operational life of the basin.
- Ensure basins have suitable access for maintenance and de-silting.

Step 4 – Diversion of 'clean' water around a basin

Up-slope 'clean' water should be diverted around the sediment basin to decrease the size and cost of the basin and increase its efficiency. The adopted flow diversion systems may need to be modified for each stage of construction as new areas of land are first disturbed, then stabilised.

'Clean' water is defined as water that has not been contaminated within the property, or by activities directly associated with the construction/building works.

Step 5a – Sizing of the settling pond, Type C basins

The settling pond within a Type C sediment basin is divided (horizontally) into two zones: the upper *settling zone* and the lower *sediment storage zone* as shown in Figure 1.

The minimum volume of the upper settling zone is defined by Equation 1.

$$A_s = 3400\ H_e\ (Q) \qquad \text{(Eqn 1)}$$

where: A_s = Surface area of settling pond at the base of the settling zone [m^2]

H_e = Hydraulic efficiency correction factor

Q = design flow rate [m^3/s]

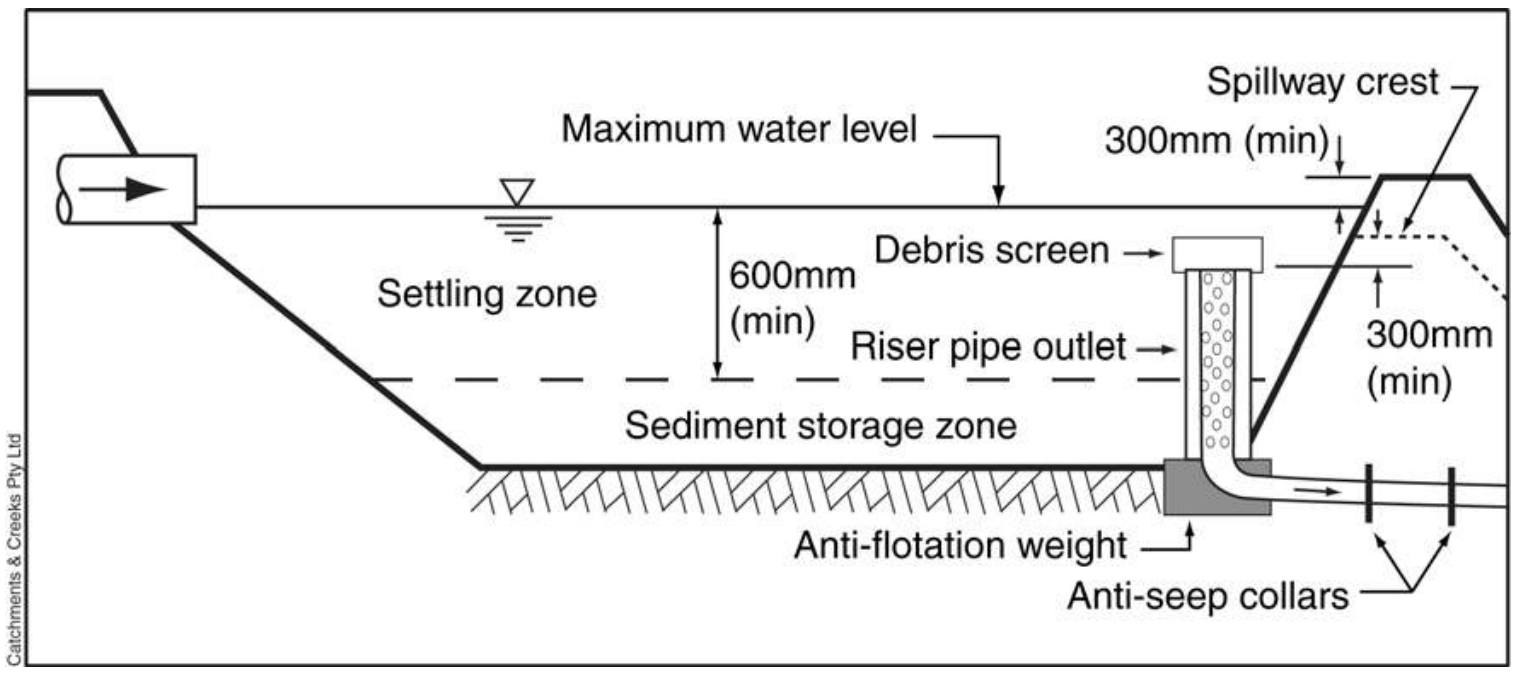


Figure 1 – Type C *Sediment Basin* with riser pipe outlet (long section)

Unless otherwise required by a regulatory authority, the design flow rate (Q) for a Type C sediment basin must be 0.5 times the peak discharge for the 1 in 1 year ARI storm.

The minimum recommended depth of the settling zone is 0.6m, or L/200 for basins longer than 120m (where L = effective basin length). Settling zone depths greater than 1m should be avoided if settlement velocities are expected to be slow.

The desirable minimum length to width ratio of 3:1, otherwise internal baffles need to be used wherever practicable to prevent short-circuiting of flows.

The hydraulic efficiency correction factor (H_e) depends on flow conditions entering the basin and the shape of the settling pond. Table 3 provides recommended values of the hydraulic efficiency correction factor.

Where available space does not permit construction of the ideal sediment basin, then a smaller basin may be used; however, erosion control and site rehabilitation standards need to be appropriately increased to a higher standard to compensate.

A Type C sediment basin that is less than the ideal size should be considered either a Type 2 or Type 3 sediment trap based on the effective particle settlement capabilities.

Table 3 – Hydraulic efficiency correction factor (H_e)

Flow condition within basin	Effective [1] length:width	H_e
Uniform or near-uniform flow conditions across the full width of basin. [2] For basins with concentrated inflow, uniform flow conditions may be achieved through the use of an appropriate inlet chamber arrangement.	1:1	1.2
	3:1	1.0
Concentrated inflow (piped or overland flow) primarily at one inflow point and no inlet chamber to evenly distribute flow across the full width of the basin.	1:1	1.5
	3:1	1.2
	6:1	1.1
	10:1	1.0
Concentrated inflow with two or more separate inflow points and no inlet chamber to evenly distribute flow across the full width of the basin.	1:1	1.2
	3:1	1.1

[1] The effective length to width ratio for sediment basins with internal baffles is measured along the centreline of the dominant flow path.

[2] Uniform flow conditions may also be achieved in a variety of ways including through the use of an inlet chamber and internal flow control baffles.

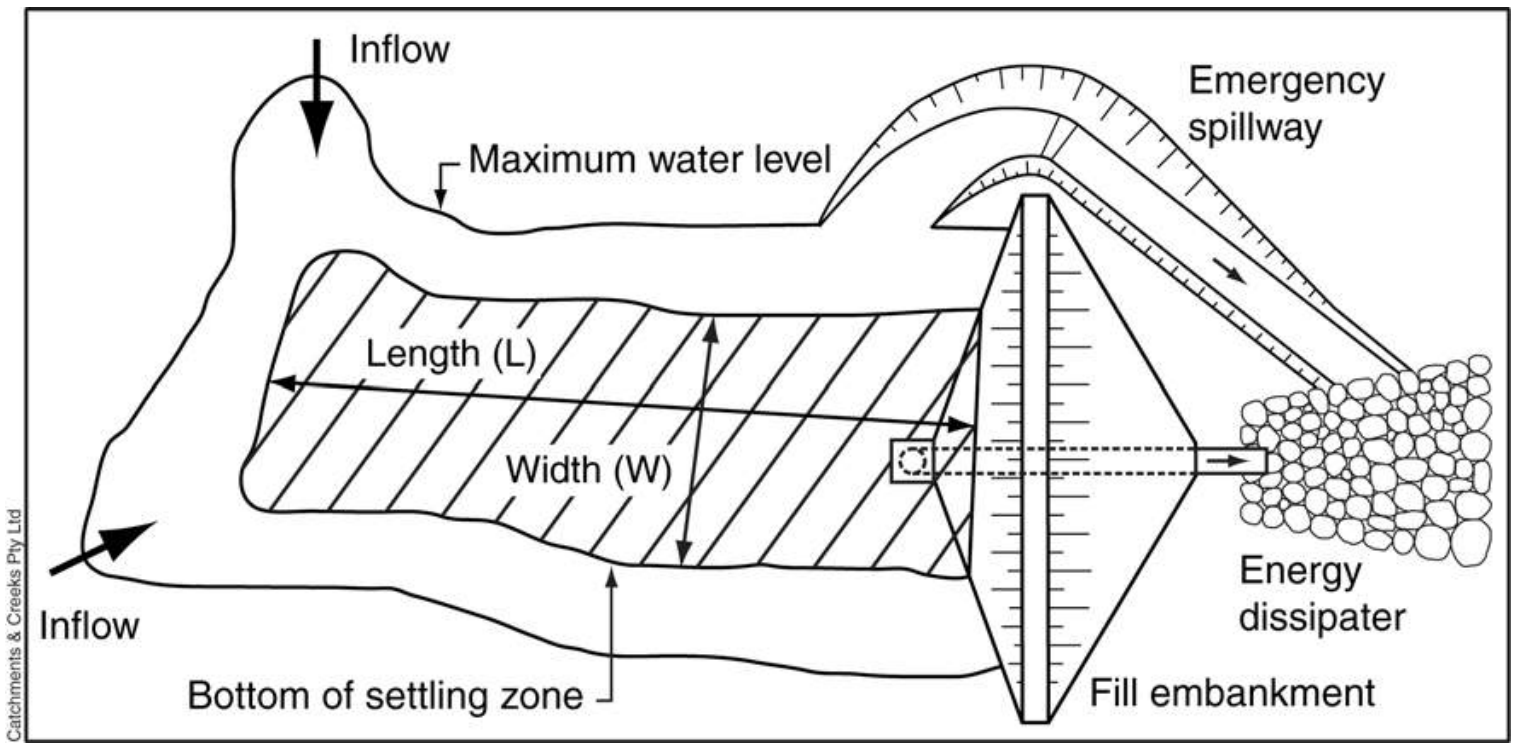


Figure 2 – Type C sediment basin with riser pipe outlet (plan view)

Step 5b – Sizing of the settling pond, Type F & D basins

The settling pond within a Type F or Type D sediment basin is divided (horizontally) into two zones: the upper *settling zone* and the lower *sediment storage zone* as shown in Figure 3.

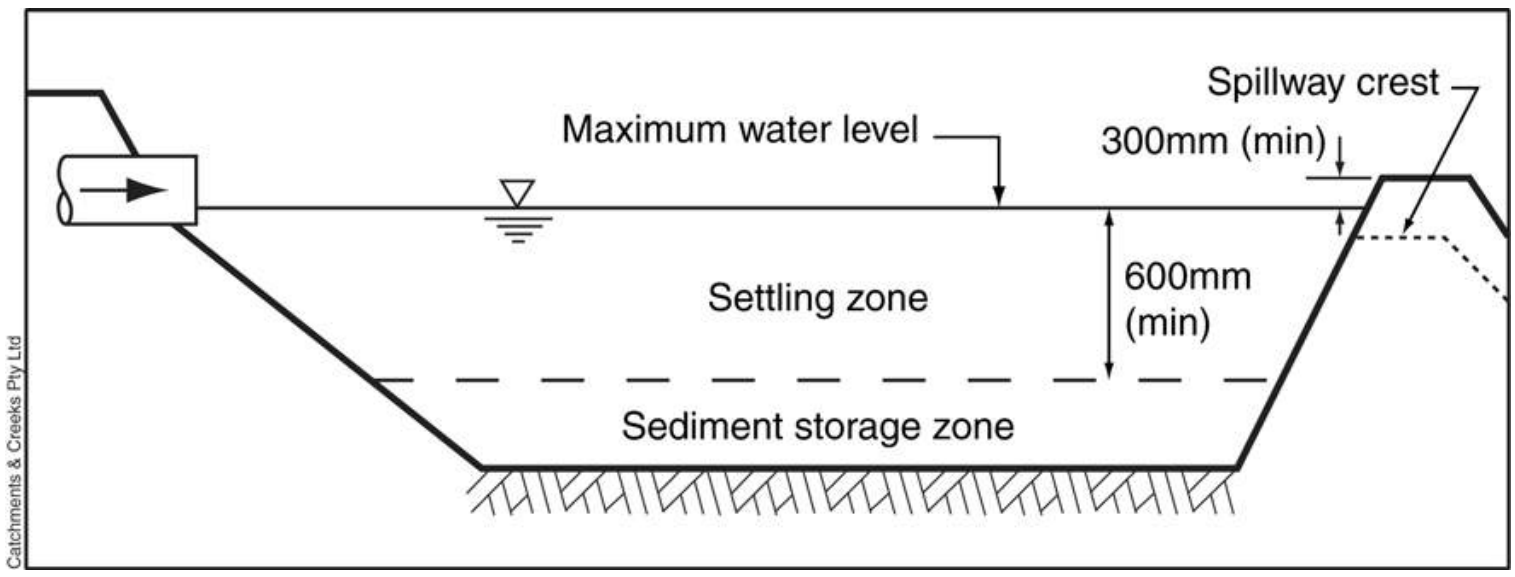


Figure 3 – Settling zone and sediment storage zone

The minimum volume of the upper settling zone is defined by Equation 2.

$$V_s = 10.\ R_{(Y\%,5\text{-day})}\ .\ C_v\ .\ A \qquad \text{(Eqn 2)}$$

where: V_s = volume of the settling zone [m^3]

$R_{(Y\%,5\text{-day})}$ = Y%, 5-day rainfall depth [mm]

C_v = volumetric runoff coefficient

A = effective catchment surface area connected to the basin [ha]

The regulatory authority should provide the required design rainfall probability (Y%) and rainfall depth (R) for a given location.

The minimum recommended depth of the settling zone is 0.6m, or L/200 for basins longer than 120m (where L = effective basin length). Settling zone depths greater than 1m should be avoided if settlement velocities are expected to be slow.

The desirable minimum length to width ratio of 3:1 is recommended for Type F and Type D basins. The length to width ratio is important for Type F and Type D basins because they operate as continuous-flow settling ponds (as per Type C basins) once flow begins to discharge over the emergency spillway.

Step 6 – Determination of sediment storage volume

The sediment storage zone lies below the settling zone as defined in Figure 4. The recommended sediment storage volume can be determined from Table 4.

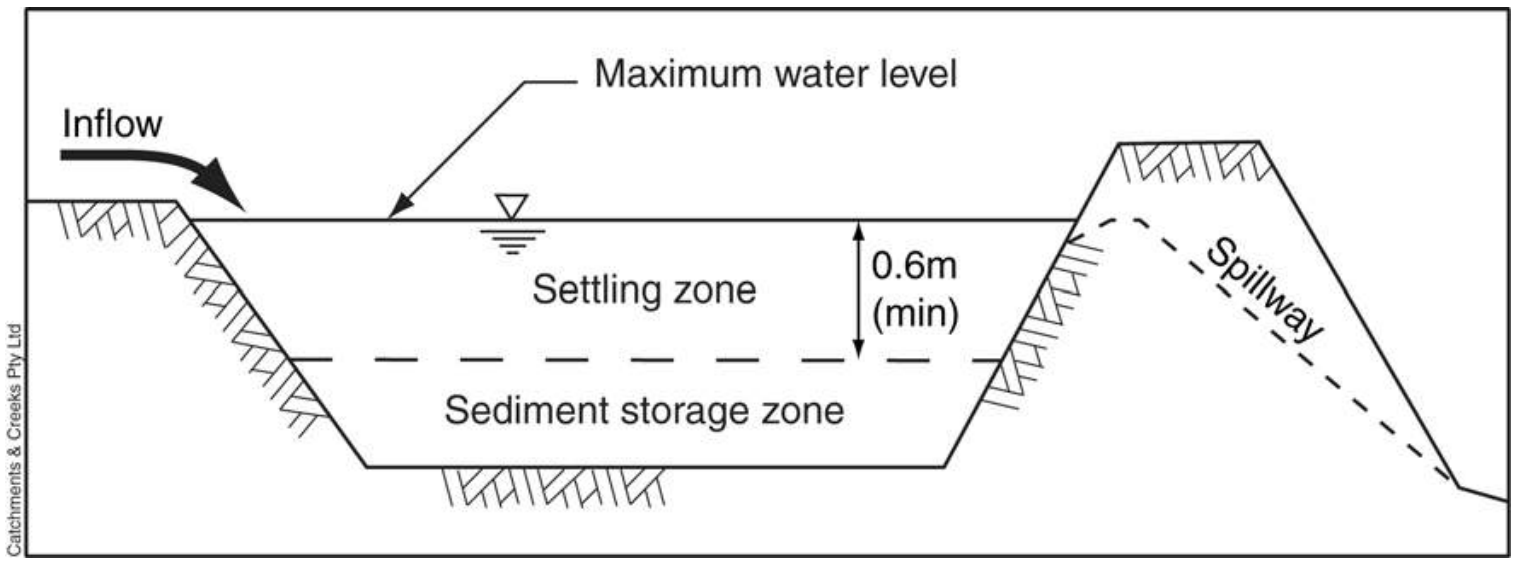


Figure 4 – Settling zone and sediment storage zone

Table 4 – Sediment storage volume

Basin type	Sediment storage volume
Type C	100% of settling volume
Type F and Type D	50% of settling volume

Alternatively, the volume of the sediment storage zone can be determined by estimating the expected sediment runoff volumes over the desired maintenance period, typically not less than 2 months.

Step 7 – Select internal and external bank gradients

Recommended bank gradients are provided in Table 5.

Table 5 – Suggested bank slopes

Slope (H:V)	Bank/soil description
2:1	Good, erosion-resistant clay or clay-loam soils
3:1	Sandy-loam soil
4:1	Sandy soils
5:1	Unfenced Sediment Basins accessible to the public
6:1	Mowable, grassed banks.

All earth embankments in excess of 1m in height should be certified by a geotechnical engineer/specialist as being structurally sound for the required design criteria and anticipated period of operation.

If public safety is a concern, and the basin is not to be fenced (not recommended), and the basin's internal banks are steeper than 5:1(H:V), then at least one bank should be turfed a width of at least 2m from top of bank to the toe of bank to allow egress during wet weather.

Step 8 – Design of flow control baffles

Baffles may be used for a variety of purposes including:

- energy dissipation (inlet chambers);
- the control of short-circuiting (internal baffles);
- minimising sediment blockage of the low-flow outlet structure (outlet chambers).

The need for flow control baffles should have been established in Step 5a based on the basin's length to width ratio. Both inlet baffles (inlet chambers) and internal baffles can be used to improve the hydraulic efficiency of the basin, and thus reduce the size of the settling pond through modification of the hydraulic efficiency correction factor.

(a) Inlet chambers

Flow control baffles or similar devices may be placed at the inlet end of a sediment basin to form an inlet chamber (Figures 5 & 6). These chambers are used to reduce the adverse effects of inlet jetting caused by concentrated, point source inflows. The objective of the inlet chamber is to produce near-uniform flow conditions across the full width of the settling pond.

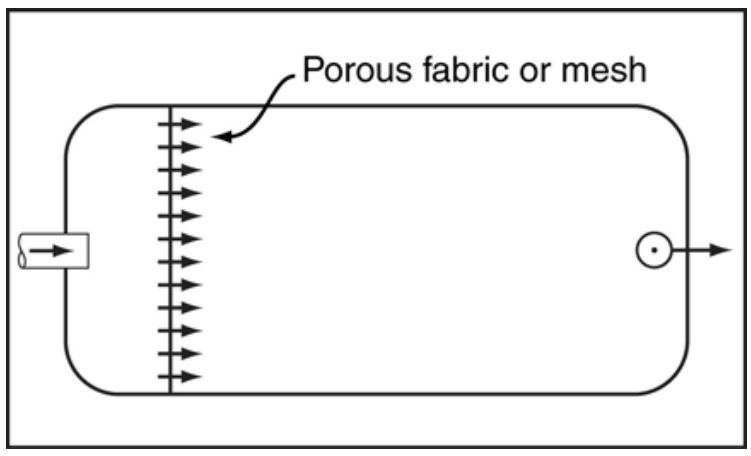


Figure 5(a) – Porous barrier inlet chamber

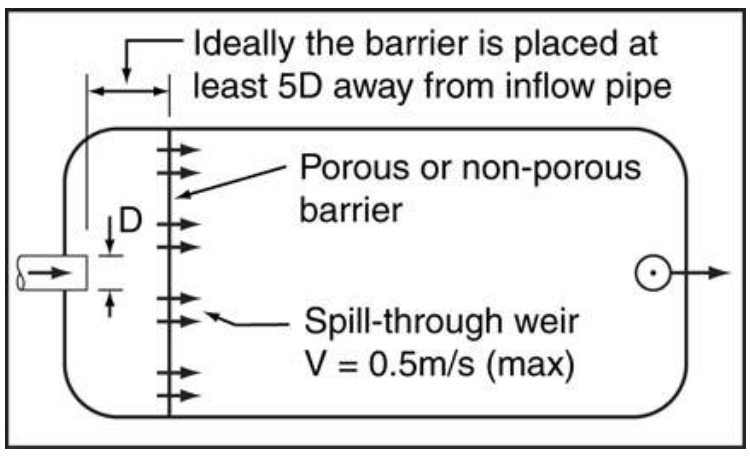


Figure 6(a) – Alternative inlet chamber design

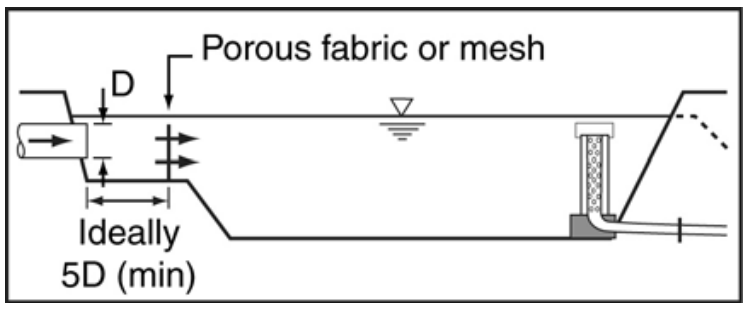


Figure 5(b) – Typical layout of inlet chamber with opposing inlet pipe (Type C basin)

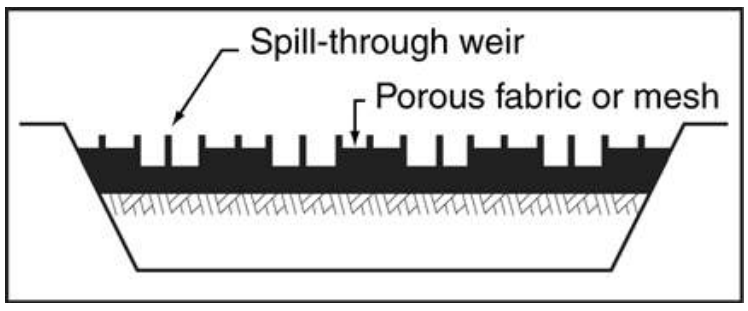


Figure 6(b) – Barrier with multiple spill-through weirs

The use of an inlet chamber is usually governed by the need to adopt a low hydraulic efficiency correction factor (H_e) in Step 5a. The incorporation of inlet baffles should be given serious consideration within Type C basins if the expected velocity of any concentrated inflows exceeds 1m/s.

Table 6 summaries the design of various inlet chambers.

Table 6 – Design of various inlet chambers

Baffle type	Discussion
Shade cloth	Typical spacing between support posts is 0.5 to 1.0m.
Perforated fabric	Heavy-duty plastic sheeting or woven fabric perforated with approximately 50mm diameter holes at approximately 300mm centres. Typical spacing between support posts is 0.5 to 1.0m.
Barrier with spill-through weirs	A porous or non-porous barrier constructed across the full width of the settling pond.

(b) Internal baffles

Internal baffles are used to increase the effective length-to-width ratio of the basin. Figure 7 demonstrates the arrangement of internal flow control baffles for various settling pond layouts.

If internal baffles are used, then the flow velocity within the settling pond must not exceed the sediment scour velocity of 0.2m/s for 0.02 to 0.10mm critical particle diameters respectively.

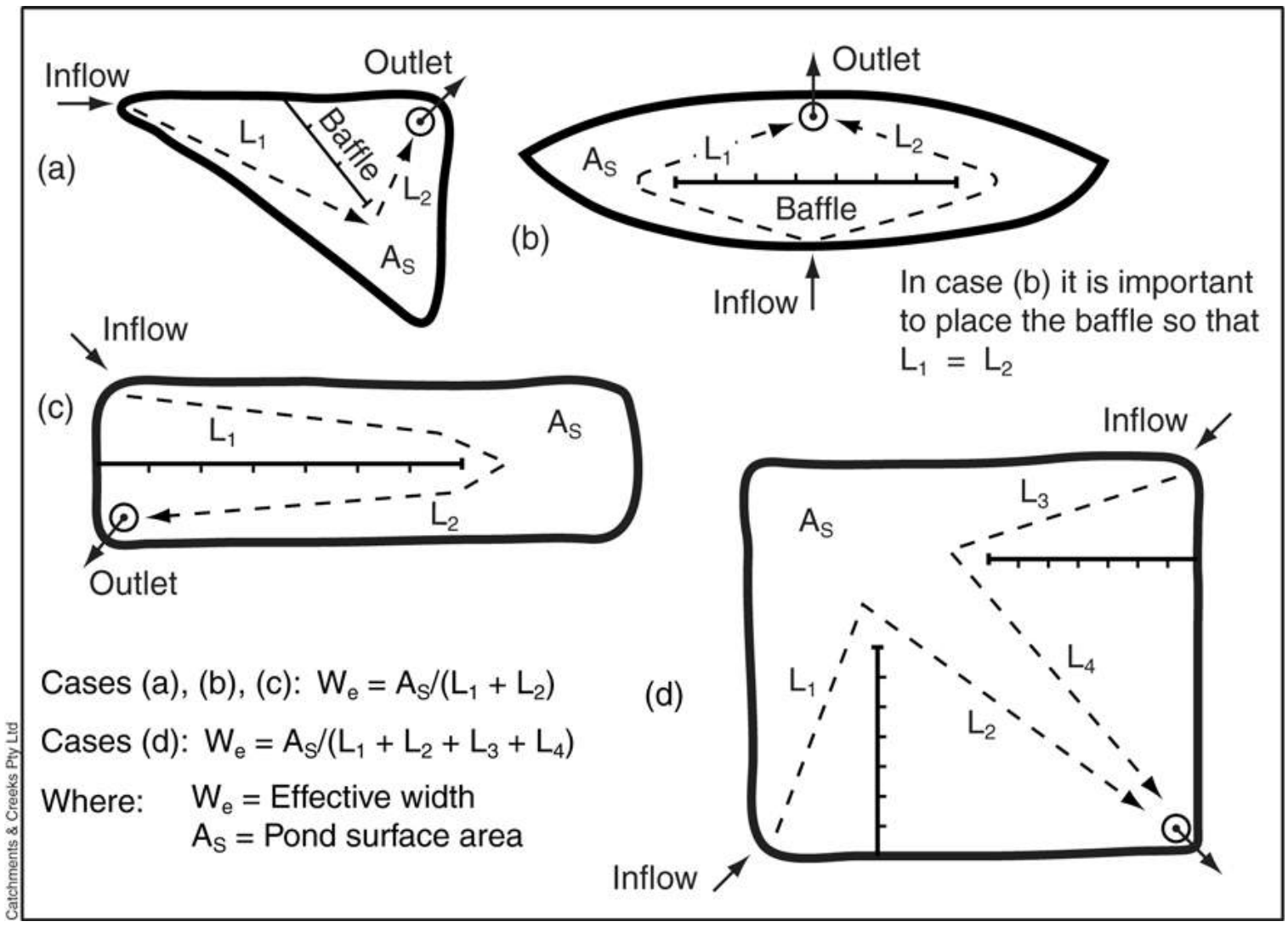


Figure 7 – Typical arrangement of internal flow control baffles (after USDA, 1975)

The crest of these baffles should be set level with, or just below, the crest of the emergency spillway. This is to prevent the re-suspension of settled sediment during severe storms (i.e. flows in excess of the basin's design storm should be allowed to overtop these baffles).

Photo 3 – Inlet chamber can also act as mixing chambers for the addition of flocculants

Photo 4 – Internal baffle extending the flow path between the basin inlet (left) and the basin outlet (right)

(c) Outlet chambers

Outlet chambers (Figures 8 & 9) are used to keep the bulk of the settled sediment away from certain low-flow outlet systems, particularly riser pipe outlets and flexible skimmer pipe outlets.

The use of an outlet chamber is mandatory when a flexible skimmer pipe outlet system is employed (Photo 6).

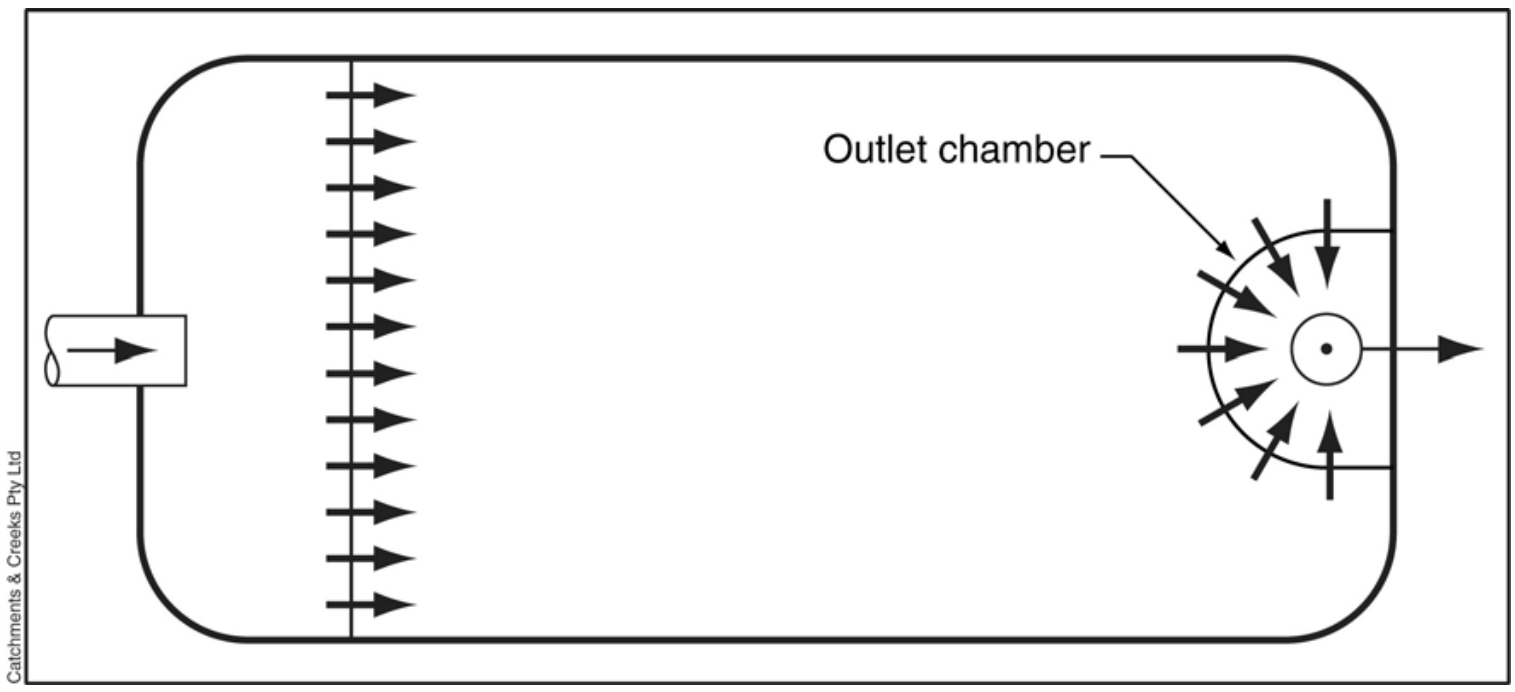


Figure 8 – Typical arrangement of outlet chamber (plan view)

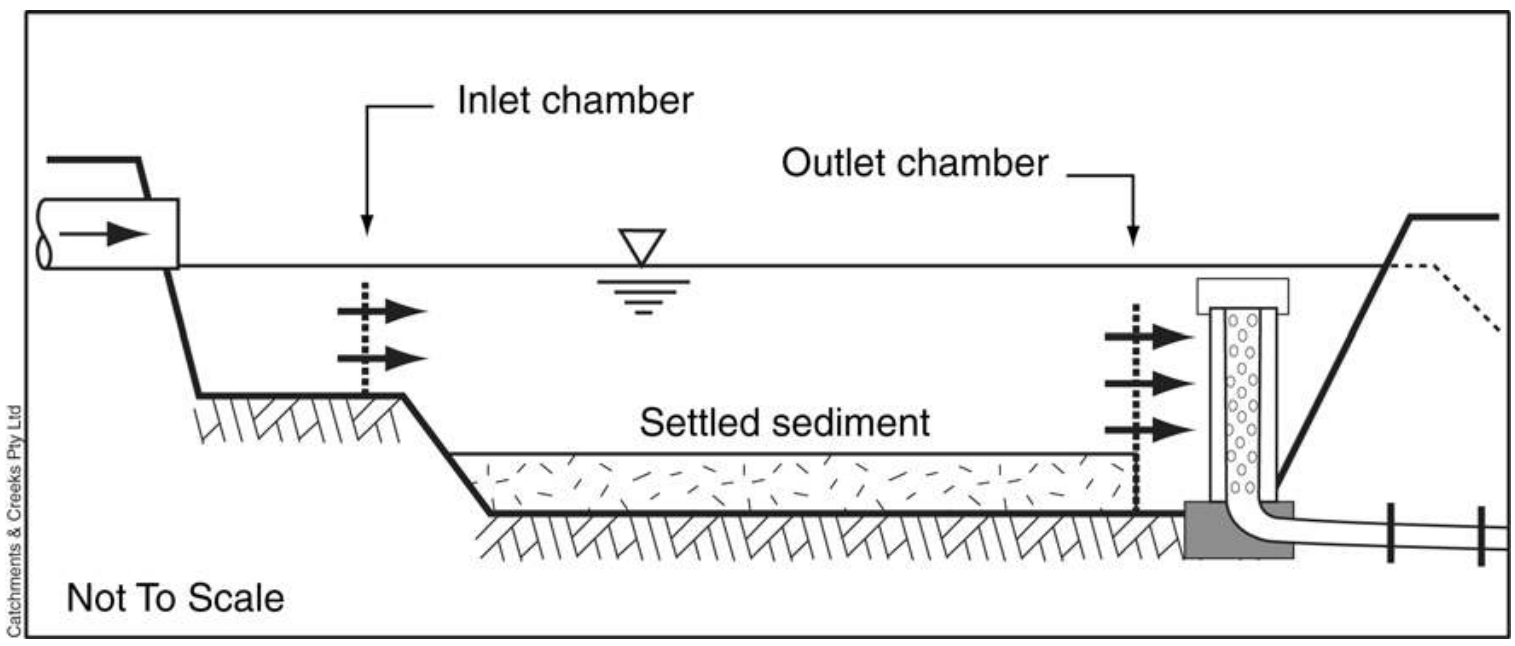


Figure 9 – Typical arrangement of outlet chamber (long section)



Photo 5 – Outlet chamber



Photo 6 – Outlet chamber surrounding a flexible skimmer outlet device

Step 9 – Design of the basin's inflow system

Surface flow entering the basin should not cause erosion down the banks of the basin. If concentrated surface flow enters the basin (e.g. via a *Catch Drain*), then an appropriately lined *Chute* (Photo 7) will need to be installed at each inflow point to control scour.

If flow enters the basin through pipes, then wherever practicable, the pipe invert should be above the spillway crest elevation to reduce the risk of sedimentation within the pipe. Submerged inflow pipes must be inspected and de-silted (as required) after each inflow event.

Constructing an appropriately designed pre-treatment pond or inlet chamber (Step 8) can be used to both improve the hydraulic efficiency of the settling pond, and reduce the cost and frequency of de-silting the main settling pond.

Where space is available, the construction of an inlet (pre-treatment) pond (Figure 10) or inlet chamber (Step 8) can significantly reduce the cost of regular de-silting activities for large and/or long-term basins.

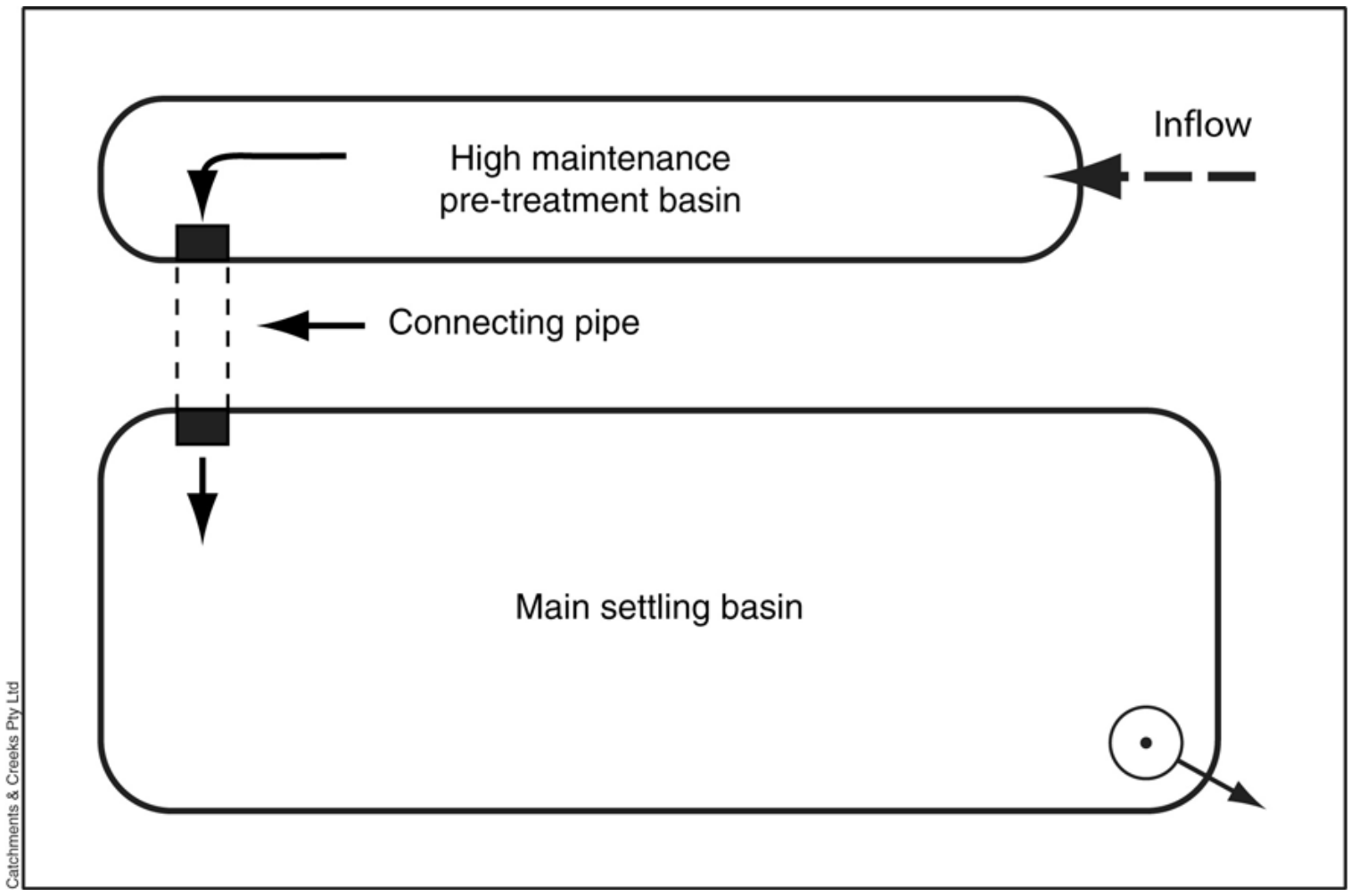


Figure 10 – Pre-treatment inlet pond



Photo 7 – Stabilise inflow chute



Photo 8 – Litter screen placed on inlet of permanent sediment basin

Step 10 – Design of the primary outlet system

Dry basins (Type C only) require a formal outlet system in the form of either a riser pipe outlet or floating skimmer system (Photo 11). Gabion wall, *Rock Filter Dam*, and *Sediment Weir* outlet systems are **not** recommended unless a Type 2 sediment retention system has been specified.

The hydraulics of a Type C basin's primary outlet system must ensure that the peak water level is at least 300mm below the crest of the emergency spillway during the basin's nominated design storm.

Wet basins (Type C, F or D) usually require a pumped outlet system. Alternatively, if a piped outlet exists, then a flow control valve must be fitted to the outlet pipe to allow full control of the basin discharge (note, Type C basins can be operated as wet basins with pumped outlets).



Photo 9 – Twin riser pipes in the process of being installed



Photo 10 – Riser pipe with aggregate filter and trash screen



Photo 11 – Skimmer outlet system

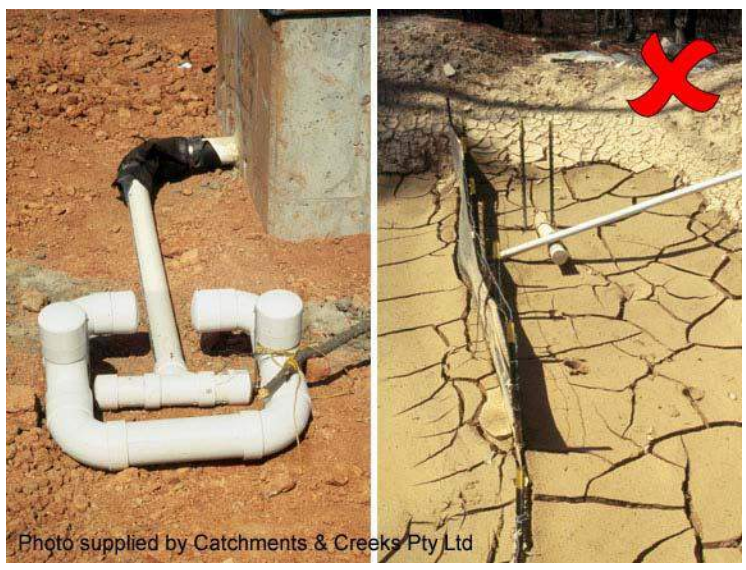


Photo 12 – Skimmer pipes must be protected from sediment build-up



Photo 13 – Low-flow sand filter outlet system on a permanent sediment basin



Photo 14 – Sand filter outlet system during installation

Step 11 – Design of the emergency spillway

All elevated sediment basins (i.e. not fully recessed below natural ground, Photo 17) require the construction of a formally designed emergency spillway. Spillways are critical engineering structures that need to be designed by suitably qualified persons.

The minimum design storm for sizing the emergency spillway is defined in Table 7.

Table 7 – Recommended design standard for emergency spillways

Design life	Minimum design storm ARI
Less than 3 months operation	1 in 10 year
3 to 12 months operation	1 in 20 year
Greater than 12 months	1 in 50 year
If failure is expected to result in loss of life	Probable Maximum Flood (PMF)

The crest of the emergency spillway is to be at least:

- 300mm above the primary outlet (if included);
- 300mm below a basin embankment formed in virgin soil;
- 450mm below a basin embankment formed from fill.

In addition to the above, design of the emergency spillway must ensure that the maximum water level within the basin during the design storm specified in Table 7 is at least:

- 300mm below a basin embankment formed from fill;
- 150mm plus expected wave height for large basins with significant fetch length.

The approach channel can be curved upstream of the spillway crest, but must be straight from the crest to the energy dissipater as shown in Figure 11. The approach channel should have a back-slope towards the impoundment area of not less than 2% and should be flared at its entrance, gradually reducing to the design width at the spillway crest.

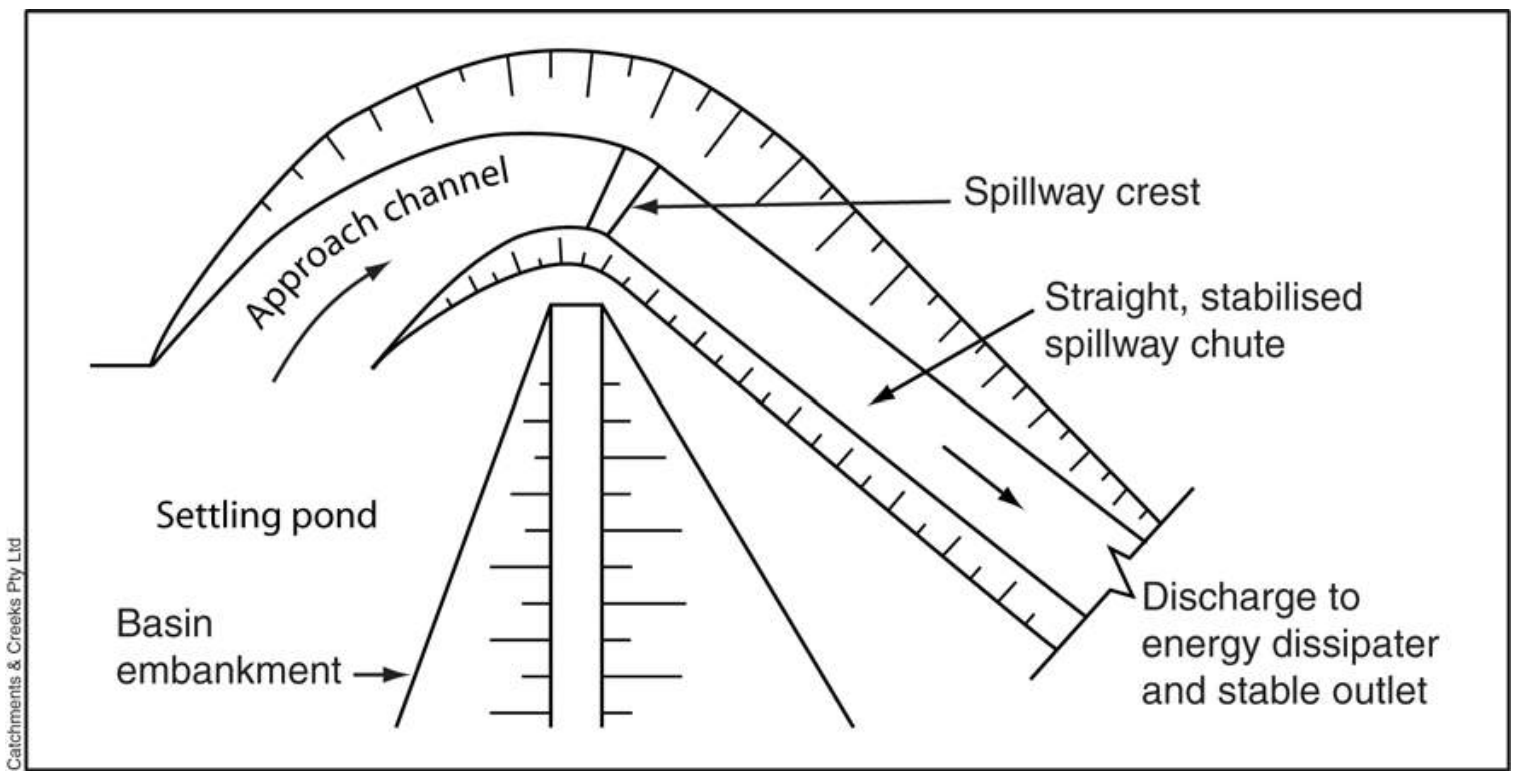


Figure 11 – Emergency spillway cut into virgin soil to side of fill embankment

All reasonable and practicable efforts must be taken to construct the spillway in virgin soil (Photo 16), rather than within a fill embankment (Photo 15). Placement of an emergency spillway within a fill embankment can significantly increase the risk of failure.

The downstream face of the spillway may be protected with grass, concrete, rock, rock mattresses, or other suitable material as required for the expected maximum flow velocity. Grass-lined spillway chutes are generally not recommended for sediment basins due to their long establishment time and relatively low scour velocity.



Photo 15 – Emergency spillway located within the fill embankment



Photo 16 – Emergency spillway located within virgin soil to the side of the embankment

For rock and rock mattress lined spillways, it is important to control seepage flows through the rocks located across the crest of the spillway. Seepage control is required so that the settling pond can achieve its required maximum water level prior to discharging down the spillway. Concrete capping of the spillway crest (Photo 18) can be used to control excess seepage flows.



Photo 17 – Fully recessed basin with natural ground forming the spillway



Photo 18 – Rock-lined spillway—note concrete sealing of the spillway crest

It is important to ensure that the spillway crest has sufficient depth and width to fully contain the nominated design storm peak discharge. Photo 20 shows a spillway crest with inadequate depth or flow profile.



Photo 19 – De-watering pipe intake must not rest on the basin floor



Photo 20 – Spillway crest with inadequate depth or profile

A suitable energy dissipater will be required at the base of the spillway. The recommended hydraulic freeboard down the spillway chute is 300mm to contain the turbulent whitewater.

Step 12 – Determination of the basin's overall dimensions

If a sediment basin is constructed with side slopes of say 3:1 (H:V), then the basin may be 5 to 10m longer and wider than the length and width of the settling pond determined in Step 5. It is important to ensure the overall dimensions of the basin can fit into the available space.

The minimum recommended embankment crest width is 2.5m, unless justified by hydraulic/ geotechnical investigations.

Where available space does not permit construction of the ideal sediment basin, then a smaller basin may be used; however, erosion control and site rehabilitation measures must be increased to an appropriate higher standard to compensate. If the basin's settling pond surface area/volume is less than that required in Step 5, than the basin must be treated as a Type 2 or Type 3 sediment control system.

Step 13 – Locate maintenance access (de-silting)

Sediment basins can either be de-silted using long-reach excavation equipment operating from the sides of the basin, or by allowing machinery access into the basin. If excavation equipment needs to enter directly into the basin, then it is better to design the access ramp so that trucks can be brought to the edge of the basin, rather than trying to transport the sediment to trucks located at the top of the embankment. Thus a maximum 6:1 (ideally 10H:1V) access ramp will need to be constructed.

If the sediment is to be removed from the site, then a suitable sediment drying area should be made available adjacent to the basin, or at least somewhere within the basin's catchment area.

Step 14 – Define the sediment disposal 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 prior to disposal. De-watering must occur within the catchment area of the sediment basin.

Step 15 – Assess need for safety fencing

Construction sites are often located in publicly accessible areas. In most cases it is not reasonable to expect a parent or guardian of a child to be aware of the safety risks associated with a neighbouring construction site. Thus fencing of a sediment basin is usually warranted even if the basins are located adjacent to other permanent water bodies such as a stream, lake, or wetland.

Responsibility for safety issues on a construction site ultimately rests with the site manager; however, each person working on a site has a duty of care in accordance with the State's work place safety legislation. Similarly, designers of sediment basins have a duty of care to investigate the safety requirements of the site on which the basin is to be constructed.



Photo 21 – Sediment basin with poor access for de-silting operations



Photo 22 – Temporary fencing of a construction site sediment basin

Step 16 – Define the rehabilitation requirements for the basin area

The Erosion and Sediment Control Plan (ESCP) needs to include details on the required decommissioning and rehabilitation of the sediment basin area. Such a process may involve the conversion of the basin into a component of the site's permanent stormwater treatment network.

On subdivisions and major road works, construction site sediment basins often represent a significant opportunity for conversion into either: a detention/retention basin (Photo 23), bioretention system, wetland, or pollution containment system. In rural areas, basins associated with road works are often constructed within adjacent properties where they remain under the control of the landowner as permanent farm dams.

In some circumstances it will be necessary to protect newly constructed permanent (future) stormwater treatment devices from sediment intrusion during the construction phase. With appropriate site planning and design the protection of these permanent stormwater treatment devices is generally made easier if the sediment basin is designed with a pre-treatment inlet pond (Figure 10). The pre-treatment pond can remain as a coarse sediment trap during the maintenance and building phases, thus protecting the newly formed wetland or bioretention system located within the basin's main settling pond.

Continued operation of the sediment basin during the building phase of subdivisions (i.e. beyond the specified maintenance phase) is an issue for negotiation between the regulatory authority and the land developer on a case-by-case basis.

During the construction, decommissioning, rehabilitation, or reconstruction of a sediment basin, the basin area including settling pond, embankment and spillway, must be considered a construction site in its on right. Thus, these works must comply with normal drainage, erosion, and sediment control standards. This means that appropriate temporary sediment control measures will be required down-slope of the sediment basin during its construction and decommissioning.

Upon decommissioning of a sediment basin, all water and sediment must be removed from the basin prior to removal of the embankment (if any). Any such material, liquid or solid, must be disposed of in a manner that will not create an erosion or pollution hazard.

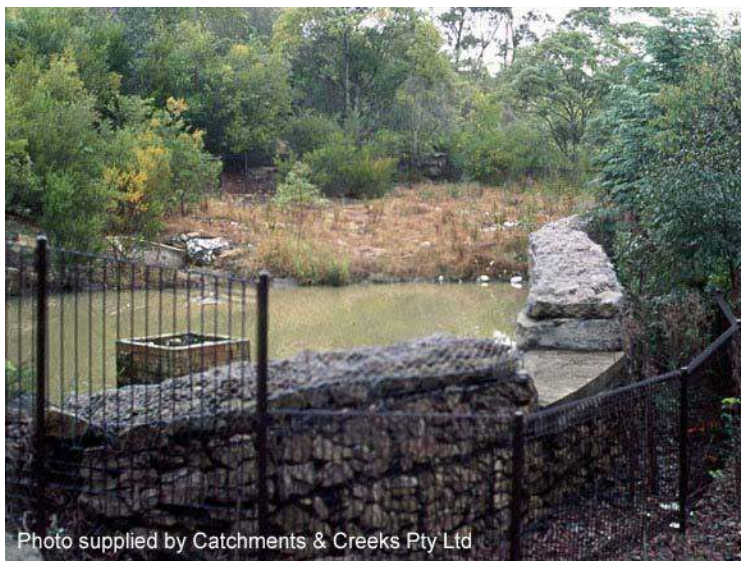


Photo 23 – Permanent sediment basin within residential estate



Photo 24 – Sediment basins converted to permanent stormwater treatment ponds on highway project

Under normal circumstances, a sediment basin must not be decommissioned until all up-slope site stabilisation measures have been implemented and are appropriately working to control soil erosion and sediment runoff in accordance with the specified ESC standard. This may require the basin to be fully operational during part of the maintenance and operational phases.

If an alternative, permanent, outlet structure is to be constructed prior to stabilisation of the up-slope catchment area, then this outlet structure must not be made operational if it will adversely affect the required operation of the sediment basin during the construction phase.

Step 17 – Specification of the basin's operational procedures

Sediment basins can be operated as either 'dry' or 'wet' basins as described below.

- Dry basins are free draining basins that allow water to commence discharging from the low-flow outlet system as soon as water enters the basin.
- Wet basins are designed to retain sediment-laden water for extended periods allowing adequate time for the gravitational settlement of fine sediment particles. Operation of these basins may be assisted through the use of chemical flocculants. Ideally these basins are not drained until a suitable water quality is obtained within the basin.

Type F and Type D basins must be operated as wet basins with the settled/treated water decanted from the basin as soon as a suitable water quality is achieved. Thus, as soon as conditions allow, the basin must be maintained in either a dry-bed condition, or with a water level no greater than the top of the sediment storage zone.

On each occasion when a Type F or Type D basin cannot be de-watered prior to being surcharged by a following rainfall event, the operator must record such an event and report it to the appropriate regulatory authority. Where appropriate, alternative operating procedures may need be adopted in consultation with the regulatory authority in order to achieve optimum environmental protection.

A Type C basin may be operated as either a dry basin or wet basin; however, when operated as a wet basin, the settled water does not necessarily need to be decanted from the settling pond after achieving the desired water quality. This means that the water can be retained on-site for revegetation purposes and dust control.

A Type C basin operating in a wet condition is still sized in accordance with the design requirements for a normal Type C basin; however, a low-flow drainage system is not necessarily incorporated into the basin, thus potentially saving significant construction and maintenance costs.

Table 8 provides a summary of the attributes of the various operational conditions.

Table 8 – Attributes of various types of *Sediment Basins*

Attribute	Type C dry basin	Type C wet basin	Type F and Type D wet basins
Soil type within catchment	Sandy soils	Sandy soils	Clayey or dispersive soils
Critical design parameter	Surface area at base of settling zone	Surface area at base of settling zone	Volume of settling zone
Desirable water level condition before a storm	Empty	Any condition	No greater than top of sediment storage zone
De-watering system	Low-flow piped drainage system (riser pipe)	Pumping	Pumping
Chemical flocculation	Only if specified water quality objectives fail to be achieved	Only if specified water quality objectives fail to be achieved	As necessary, but usually required for Type D basins

Type F and D basins are typically designed for a maximum 5-day cycle, that being the filling, treatment and discharge of the basin within a maximum 5-day period. In some tropical regions this may not be practicable, and either a shorter or longer time frame may be required. The use of a shorter time period usually requires application of fast acting coagulants, which may require a much higher degree of environmental management compared to gypsum.

Appropriate coagulation of sediment basins is required if the contained water does not achieve a specified water quality standard, usually 50mg/L. In cases where a poor discharge water quality is achieved, a Type C basin may need to be operated as if it was a Type F or Type D basin in order to satisfy specified water quality objectives.

Certification of Sediment Basin Construction

BASIN IDENTIFICATION CODE/NUMBER: . . . . . .

LOCATION: . . . . . .

Legend: ✓ OK ✗ Not OK N/A Not applicable

Construction:

Item	Consideration	Assessment
1	Sediment basin located in accordance with approved plans.	. . . . .
2	Embankment material compacted in accordance with specifications.	. . . . .
3	Critical basin and spillway dimensions and elevations confirmed by as-constructed survey.	. . . . .
4	Required freeboard adjacent embankments and spillway confirmed by as-constructed survey.	. . . . .
5	Placement of rock on chute and upstream face of spillway in accordance with design details and standards.	. . . . .
6	Placement of rock within energy dissipation zone downstream of spillway in accordance with design details and standard.	. . . . .
7	All other sediment basin requirements in accordance with design details and standards.	. . . . .
8	As-constructed plan prepared for basin and spillway.	. . . . .

INSPECTION OFFICER . . . . . **DATE** . . . . . .

SIGNATURE . . . . . .

Geotechnical:

Item	Consideration	Assessment
9	Suitable material used to form all embankments.	. . . . .
10	Appropriate compaction achieved in embankment construction (if observed).	. . . . .
11	No foreseeable concerns regarding stability or construction of the basin and spillway.	. . . . .

INSPECTION OFFICER . . . . . **DATE** . . . . . .

SIGNATURE . . . . . .

Description

A purpose built dam designed to collect and settle sediment from sediment-laden runoff. It usually consists of a settling pond, a low-flow drainage or manual decant system, and a high-flow emergency spillway.

Purpose

Sediment basins generally perform two main functions: firstly the settlement of coarse-grained sediment particles (e.g. sand and coarse silt) from waters passing through the basin, and secondly either:

(i) the filtration of fine sediments (e.g. fine silt and clay) from waters passing through the filtration system attached to the low-flow outlet;

(ii) the settlement of fine-grained particles from those waters retained within the basin following a storm event.

Limitations

Generally used on catchments greater than 0.25ha.

The installation of a sediment basin does not replace the need for appropriate on-site drainage and erosion control measures.

Sediment basins operating in a free-draining mode (dry basins) have limited control over turbidity, especially that resulting from dispersive soils, unless chemical treated.

Advantages

Sediment basins need be designed and operated in a manner that produces near-clear water discharge (i.e. total suspended solids concentrations not exceeding 50mg/L), especially following periods of light rainfall.

It is the ability of sediment basins to reduce turbidity levels (wet basins) that allows these Type 1 sediment traps to significantly reduce the potential ecological harm caused by urban construction.

Even when a basin is full of water, it can still be effective in the removal of coarse sediment from any flows passing through the basin.

Very high capture rate for coarse sediments.

Can be an effective control of fine sediment and turbidity during the frequent 'minor' storms if suitably operated.

Can be converted into a permanent wetland or detention basin for ongoing stormwater management after completion of the construction phase.

Disadvantages

Chemical dosing of basins can be difficult to automate.

Basins are difficult and expensive to relocate if the construction or drainage layout changes.

Decommissioned and backfilled sediment basins generally attract lower land values and are best integrated into open space areas, or the site's permanent stormwater management system.

Common Problems

Sediment blockage of free-flow outlet systems (dry basins).

Difficulties in repairing the low-flow outlet system once sediment blockage has occurred.

Inadequate room made available to construct the sediment basin.

Poor access available to maintain the basin.

Poor hydraulic design and/or construction of the emergency spillway.

Special Requirements

The sediment trapping efficiency of a sediment basin can be increased by:

- reducing the energy (jetting) of inflow;
- construction basins as close as practicable to the ideal 10:1 length to width ratio;
- avoiding bends in the flow path of water through the settling pond that may cause secondary currents and dead-water areas;
- avoiding wind shear on large basins that could cause secondary currents and sediment re-suspension.
- where practicable, operating both wet and dry basins in a manner that allows them to fully drain before the next significant inflow event, thus allowing settled sediment to 'cement' together on the bed of the basin.

Early integration of the basin into the construction phase is essential.

Avoid constructing sediment basins in dispersive soils. Where this is unavoidable, the basin should be lined with a non-dispersive or treated soil, especially the banks.

Overland flow should enter the basin via a stabilised chute. It should not be allowed to cause erosion down the banks of the settling pond.

Medium to high velocity piped inflows may require an energy dissipater or inlet baffle to break-up the inflow jet.

Internal baffles may be required in 'dry' basins to improve the movement of water through the settling pond.

An outlet baffle or barrier may be required to reduce the build-up of sediment and mud around the primary outlet filter (dry basins).

Sediment basins should be fenced if a public safety risk exists.

Location

Basins need to be located such that they intercept runoff from the largest possible portion of the disturbed site.

Basins generally should not collect runoff generated from off-site areas.

Must be located so that construction and maintenance access is available.

Where practicable, an area of level land should be available adjacent to the basin to allow de-watering of excavated sediment.

Preferably located above the 1 in 5 year flood level if located on or near a watercourse floodplain.

Allow room between the toe of the embankment and the downstream property boundary for provision for safety fencing, the spillway outlet, and all necessary energy dissipation measures.

Site Inspection

Check the dimensions of the basin.

Check for scouring around, or damage to the inlets and outlets.

Check for damage to the emergency spillway and displacement of rocks.

Check the level of sediment build-up.

Check all internal and external banks for erosion.

Check the measures introduced to control inflow jetting (wet and dry basins).

Check for trash build-up on inlet screens.

Check for water passing through earth embankments that could lead to a piping failure and bank collapse.

Materials

- Earth fill: clean soil with Emerson Class 2(1), 3, 4, or 5, and free of roots, woody vegetation, rocks and other unsuitable material. Soil with Emerson Class 4 and 5 may not be suitable depending on particle size distribution and degree of dispersion. Class 2(1) should only be used upon recommendation from geotechnical specialist. This specification may be replaced by an equivalent standard based on the exchangeable sodium percentage.
- Riser pipe: minimum 250mm diameter.
- Spillway rock: hard, angular, durable, weather resistant and evenly graded rock with 50% by weight larger than the specified nominal (d_{50}) rock size. Large rock should dominate, with sufficient small rock to fill the voids between the larger rock. The diameter of the largest rock size should be no larger than 1.5 times the nominal rock size. The specific gravity should be at least 2.5.
- Geotextile fabric: heavy-duty, needle-punched, non-woven filter cloth, minimum 'bidim' A24 or equivalent.

Construction

1. Notwithstanding any description contained within the approved plans or specifications, the Contractor shall be responsible for satisfying themselves as to the nature and extent of the specified works and the physical and legal conditions under which the works will be carried out. This shall include means of access, extent of clearing, nature of material to be excavated, type and size of mechanical plant required, location and suitability of water supply for construction and testing purposes, and any other like matters affecting the construction of the works.
2. Refer to approved plans for location, dimensions, and construction details. If there are questions or problems with the location, dimensions, or method of installation, contact the engineer or responsible on-site officer for assistance.
3. Before starting any clearing or construction, ensure all the necessary materials and components are on the site to avoid delays in completing the pond once works begin.

4. Install required short-term sediment control measures downstream of the proposed earthworks to control sediment runoff during construction of the basin.
5. The area to be covered by the embankment, borrow pits and incidental works, together with an area extending beyond the limits of each for a distance not exceeding five (5) metres all around must be cleared of all trees, scrub, stumps, roots, dead timber and rubbish and disposed of in a suitable manner. Delay clearing the main pond area until the embankment is complete.
6. Ensure all holes made by grubbing within the embankment footprint are filled with sound material, adequately compacted, and finished flush with the natural surface.

Cut-off trench:

7. Before construction of the cut-off trench or any ancillary works within the embankment footprint, all grass growth and topsoil must be removed from the area to be occupied by the embankment and must be deposited clear of this area and reserved for topdressing the completing the embankment.
8. Excavate a cut-off trench along the centre line of the earth fill embankment. Cut the trench to stable soil material, but in no case make it less than 600mm deep. The cut-off 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 600mm. Make the side slopes of the trench no steeper than 1:1 (H:V).
9. Ensure all water, loose soil, and rock are removed from the trench before backfilling commences. The cut-off trench must be backfilled with selected earth-fill of the type specified for the embankment, and this soil must have a moisture content and degree of compaction the same as that specified for the selected core zone.
10. Material excavated from the cut-off trench may be used in construction of the embankment provided it is suitable and it is placed in the correct zone according to its classification.

Embankment:

11. Scarify areas on which fill is to be placed before placing the fill.
12. Ensure all fill material used to form the embankment meets the specifications certified by a soil scientist or geotechnical specialist.
13. 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 250mm continuous layers over the entire length of the fill area and then compact before placement of further fill.
14. Place riser pipe outlet system, if specified, in appropriate sequence with the embankment filling. Refer to separate installation specifications.
15. Unless otherwise specified on the approved plans, compact the soil at about 1% to 2% wet of optimum and to 95% modified or 100% standard compaction.
16. Where both dispersive and non-dispersive classified earth-fill materials are available, non-dispersive earth-fill must be used in the core zone. The remaining classified earth-fill materials must only be used as directed by *[insert title]*.
17. Where specified, construct the embankment to an elevation 10% higher than the design height to allow for settling; otherwise finished dimensions of the embankment after spreading of topsoil must conform to the drawing with a tolerance of 75mm from the specified dimensions.
18. Ensure debris and other unsuitable building waste is not placed within the earth embankment.
19. After completion of the embankment all loose uncompacted earth-fill material on the upstream and downstream batter must be removed prior to spreading of topsoil.
20. Topsoil and revegetate/stabilised all exposed earth as directed within the approved plans.

Spillway construction:

21. The spillway must be excavated as shown on the plans, and the excavated material if classified as suitable, must be used in the embankment, and if not suitable it must be disposed of into spoil heaps.
22. Ensure excavated dimensions allow adequate boxing-out such that the specified elevations, grades, chute width, and entrance and exit slopes for the emergency spillway will be achieved after placement of the rock or other scour protection measures as specified in the plans.
23. Place specified scour protection measures on the emergency spillway. Ensure the finished grade blends with the surrounding area to allow a smooth flow transition from spillway to downstream channel.
24. If a synthetic filter fabric underlay is specified, place the filter fabric directly on the prepared foundation. If more than one sheet of filter fabric is required, overlap the edges by at least 300mm and place anchor pins at minimum 1m spacing along the overlap. Bury the upstream end of the fabric a minimum 300mm below ground and where necessary, bury the lower end of the fabric or overlap a minimum 300mm over the next downstream section as required. Ensure the filter fabric extends at least 1000mm upstream of the spillway crest.
25. Take care not to damage the fabric during or after placement. If damage occurs, remove the rock and repair the sheet by adding another layer of fabric with a minimum overlap of 300mm around the damaged area. If extensive damage is suspected, remove and replace the entire sheet.
26. Where large rock is used, or machine placement is difficult, a minimum 100mm layer of fine gravel, aggregate, or sand may be needed to protect the fabric.
27. Placement of rock should follow immediately after placement of the filter fabric. Place rock so that it forms a dense, well-graded mass of rock with a minimum of voids. The desired distribution of rock throughout the mass may be obtained by selective loading at the quarry and controlled dumping during final placement.
28. The finished slope should be free of pockets of small rock or clusters of large rocks. Hand placing may be necessary to achieve the proper distribution of rock sizes to produce a relatively smooth, uniform surface. The finished grade of the rock should blend with the surrounding area. No overfall or protrusion of rock should be apparent.
29. Ensure that the final arrangement of the spillway crest will not promote excessive flow through the rock such that the water can be retained within the settling basin an elevation no less than 50mm above or below the nominated spillway crest elevation.

Establishment of settling pond:

30. The area to be covered by the stored water outside the limits of the borrow pits must be cleared of all scrub and rubbish. Trees must be cut down stump high and removed from the immediate vicinity of the work.
31. Establish all required inflow chutes and inlet baffles, if specified, to enable water to discharge into the basin in a manner that will not cause soil erosion or the re-suspension of settled sediment.
32. Install a sediment storage level marker post with a cross member set just below the top of the sediment storage zone (as specified on the approved plans). Use at least a 75mm wide post firmly set into the basin floor.
33. If specified, install internal settling pond baffles. Ensure the crest of these baffles is set level with, or just below, the elevation of the emergency spillway crest.
34. Install all appropriate measures to minimise safety risk to on-site personnel and the public caused by the presence of the settling pond. Avoid steep, smooth internal slopes. Appropriately fence the settling pond and post warning signs if unsupervised public access is likely or there is considered to be an unacceptable risk to the public.

Maintenance of Sediment Basin

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. Inspect the erosion damage at flow entry and exit points. If damage has occurred, make the necessary repairs.
   (iii) At least weekly during the nominated wet season (if any) otherwise at least fortnightly.
   (iv) Prior to, and immediately after, periods of 'stop work' or site shutdown.
2. Clean out accumulated sediment when it reaches the marker board/post, and restore the original storage volume. 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 or pollution hazard.
4. Check all visible pipe connections for leaks, and repair as necessary.
5. Check all embankments 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.
7. Submerged inflow pipes must be inspected and de-silted (as required) after each inflow event.

Removal of Sediment Basin

1. When grading and construction in the drainage area above a temporary sediment basin is completed and the disturbed areas are adequately stabilised, the basin must be removed or otherwise incorporated into the permanent stormwater drainage system. In either case, sediment should be cleared and properly disposed of and the basin area stabilised.
2. Before starting any maintenance work on the basin or spillway, install all necessary short-term sediment control measures downstream of the sediment basin.
3. All water and sediment must be removed from the basin prior to the dam's removal. Dispose of sediment and water in a manner that will not create an erosion or pollution hazard.
4. Bring the disturbed area to a proper grade, then smooth, compact, and stabilise and/or revegetate as required to establish a stable land surface.

Sediment Fence

SEDIMENT CONTROL TECHNIQUE

Type 1 System		Sheet Flow	✓	Sandy Soils	✓
Type 2 System		Concentrated Flow	[1]	Clayey Soils	[2]
Type 3 System	✓	Supplementary Trap		Dispersive Soils	

[1] Not recommended in areas of concentrated flow—refer to *U-Shaped Sediment Traps*.

[2] Very limited capture of fine clay particles, but still useful for trapping sand and silt.

Symbol 



Photo 1 – Installation of a sediment fence



Photo 2 – Sediment fence located down-slope of multi-dwelling building site

Key Principles

1. Primarily used to collect coarse sediments. Sediment fences have a poor capture rate of the finer sediment particles, thus operators should not expect to see any significant change in the colour or turbidity of water passing through the fence.
2. Treatment is primarily achieved through gravity-induced ‘settlement’ resulting from the temporarily ponding of sediment-laden water up-slope of the fence. ‘Filtration’ is only a secondary function of the fabric, if at all.
3. Critical to the effectiveness of a sediment fence is the ‘surface area’ of the pond that forms up-slope of the fence. Therefore, sediment fences need to be installed such that the total surface area of ponding up-slope of the fence is maximised.
4. Optimum performance can be achieved by installing the fence in a manner that allows water to pond either:
   - uniformly along the fence (i.e. a fence located along a line of constant elevation); or
   - at regular intervals along the fence (i.e. a fence installed at a slight angle to the slope, but with regular ‘returns’ installed along the length of the fence).
5. Woven and composite fabrics perform slightly different tasks and their selection depends on site conditions.
6. Though often referred to as ‘silt fences’, a sediment fence is unlikely to trap significant quantities of fine silts (< 0.02mm), thus the term is considered an inappropriate description.
7. A sediment fence in its standard installation is only suitable for the treatment of ‘sheet’ flows. If concentrated flow exist, such as in a minor drain, then a *U-Shaped Sediment Trap*, or other more appropriate sediment trap should be used.

Design Information

Table 1 provides the recommended **maximum** slope length up-slope of a sediment fence.

Table 1 – Recommended <u>maximum</u> slope length up-slope of a sediment fence on non-vegetated slopes [1]

Batter slope			Horizontal spacing (m)	Vertical spacing (m)
Percentage	Degrees	(H):(V)		
1%	0.57	100:1	60 [2]	0.6 [2]
2%	1.15	50:1	60	1.2
4%	2.29	25:1	40	1.6
6%	3.43	16.7:1	32	1.9
8%	4.57	12.5:1	28	2.2
10%	5.71	10:1	25	2.5
15%	8.53	6.67:1	19	2.9
20%	11.3	5:1	16	3.2
25%	14.0	4:1	14	3.5
30%	16.7	3.33:1	12	3.5
40%	21.8	2.5:1	9	3.5
50%	26.6	2:1	6	3.0

[1] Maximum recommended spacings is based on minimising the risk of rill erosion on low to moderately erodible soil. In areas of highly erodible soil, the slope length may need to be reduced.

[2] Recommended maximum slope length above a sediment fence is 60m.

The maximum slope lengths presented in Table 1 for land slopes steeper than 2% may be represented by Equation 1.

$$\text{Maximum } \textbf{horizontal} \text{ slope length (m)} = 100/(\text{batter slope (\%)})^{0.64} \qquad \text{(Eqn 1)}$$

The allowable flow rate per meter length of sediment fence should, wherever possible, be determined from actual fabric testing. However, the actual flow rate at any point in time will depend on the degree of sediment blockage of the fabric.

In the absence of testing data, preliminary design flow rates can be obtained from Table 2.

Table 2 – Typical as-new and design flow rates for sediment fence fabric [1]

Depth up-slope of fence (m)	'As new' flow rate (L/s/m)		'Design' flow rate (L/s/m) [2]	
	Woven fabrics	Composite	Woven fabrics	Composite
0.2	2.6	4.8	1.3	2.4
0.4	5.6	10.6	2.8	5.3
0.6	9.0	17.8	4.5	8.9
0.8	12.6	26.2	6.3	13.1

[1] Flow rates are based on simplified test results that may not extrapolate well to actual field conditions.

[2] Suggested 'design' flow rates are based on an assumed 50% sediment blockage of the fabric.

Technical Note:

Australian Standards indicate that the flow rate through geotextiles for a given hydraulic head can be determined by extrapolating the measured flow rate at a hydraulic head of 100mm. Such analysis is **not** appropriate for woven fabrics such as sediment fence fabric. Hydraulic performance must be determined by appropriate physical testing at or above the required hydraulic head.

(a) Choice of fabric

Woven fabrics (Photo 3) are generally preferred on large sites when the service life is expected to extend over several storm events. Composite fabrics (Photo 5) are generally preferred on small soil disturbances such a building sites, or when the sediment fence is the last line of defence prior to the runoff discharging from the site or entering a water body.

Table 3 provides guidance on the selection of the preferred sediment fence fabric.

Table 3 – Preferred use of sediment fabrics

Fabric type	Preferred conditions of use
Woven fabrics	• Large sites when the service life is expected to extend over several storm events. • Up-slope of a Type 1 or Type 2 sediment trap.
Composite non-woven fabrics with a woven backing	• Small soil disturbances such a building sites. • When the sediment fence constitutes the last line of defence up-slope of a water body.

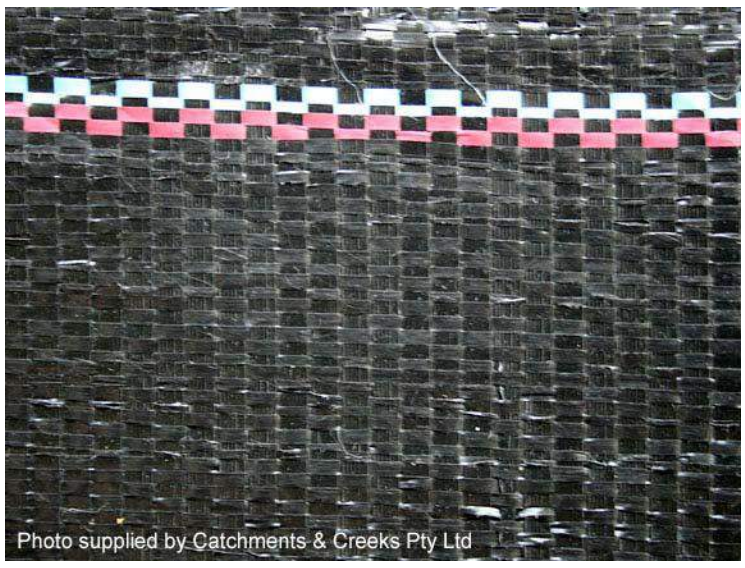


Photo 3 – Traditional woven sediment fence fabric



Photo 4 – Shade cloth MUST NOT be used

Composite fabrics, incorporating a non-woven fabric with woven fabric backing, typically have a higher flow rate (when first installed) due to the additional needle punching required to ‘sew’ the two fabrics together.

Composite fabrics are installed with the woven fabric as the down-slope face of the fence.

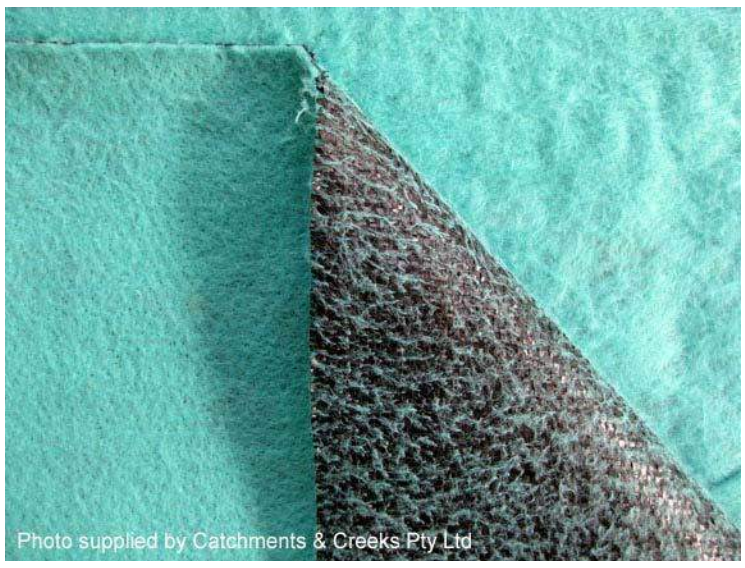


Photo 5 – Composite fabric with the woven (black) backing being the down-slope face of the sediment fence



Photo 6 – Filter cloth MUST NOT be used unless used in the construction of a ‘Filter Fence’ adjacent to a stockpile

Sediment fence fabric must be manufactured from either woven UV-stabilised polyester or polypropylene fabric, or a non-woven geotextile reinforced with a UV-stabilised polyester or polypropylene mesh.

Table 4 provides the recommended material properties of woven fabrics.

Table 4 – Recommended woven sediment fence material property requirements

Material property	Test method	Units	Typical value
Flow rate	AS 3706.9	$L/s/m^2$ (under 100 mm head)	15
Wide strip tensile strength	AS 3706.2	kN/m	10 both directions
Pore size (EOS) (O_{95})	AS 3706.7	mm x 10^{-3}	< 250
Mass per unit area	AS 3706.1	gsm	90
UV resistance	AS 3706.11	% retained (672 hours)	
Width	–	mm	730–910

Table 5 provides the recommended material properties of composite fabrics.

Table 5 – Recommended composite sediment fence material property requirements

Material property	Test method	Units	Typical value
Flow rate	AS 3706.9	$L/s/m^2$ (under 100 mm head)	145
Wide strip tensile strength	AS 3706.2	kN/m	17 both directions
Pore size (EOS) (O_{95})	AS 3706.7	mm x 10^{-3}	110
Mass per unit area	AS 3706.1	gsm	225
UV resistance	AS 3706.11	% retained (672 hours)	
Width	–	mm	730–910

(b) Location of a sediment fence

Wherever practical, the sediment fence should be installed along the contour, thus maintaining sheet flow conditions across the fence. If located at an angle to the contour, the fence needs to be installed with regular 'returns' to avoid water concentrating along the fence. Even if the fence is located along the contour, the use of regular returns is still recommended (refer to Figure 1).

The maximum spacing of fence 'returns' should be 20m if the fence is installed along the contour, or 5 to 10m (depending on slope) if located at an angle to the contour (Figure 2).

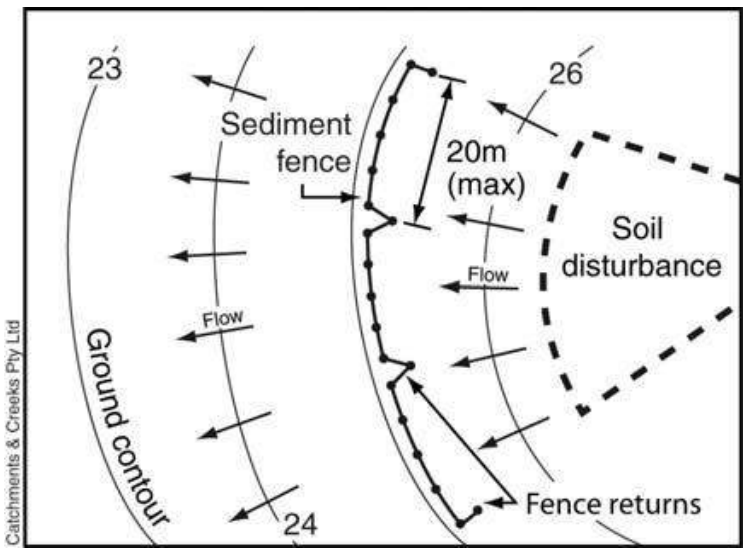


Figure 1 – Fence installed along the contour

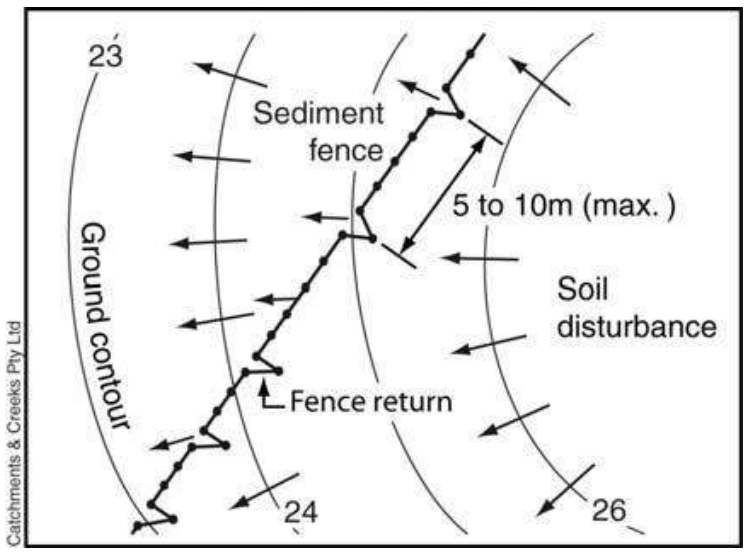


Figure 2 – Fence install down a slope

Wherever practical, allow at least 4.5m between the sediment fence and a single-storey building; 7.5m between the fence and a multiple-storey building; and at least 2m between the fence and the toe of a fill slope or stockpile (Figure 3).

A double sediment fence (Figure 4, Photo 8), or sediment fence with up-slope straw bale (Photo 7) can be used to reduce the risk of shifting fill damaging the fence.

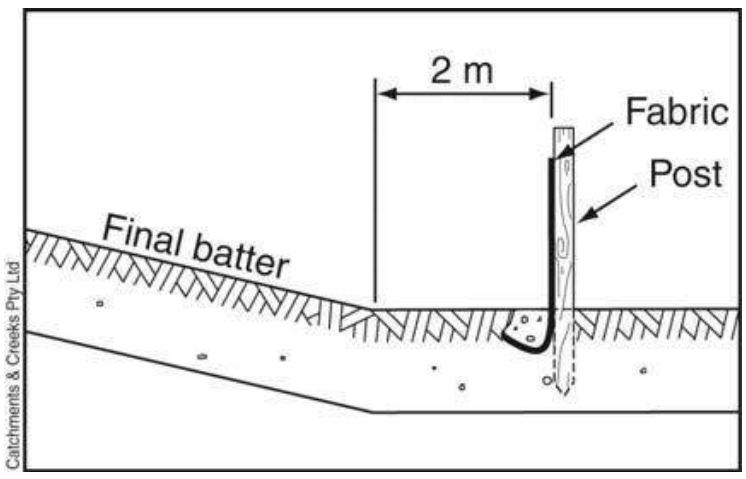


Figure 3 – Fence installation at base of slope

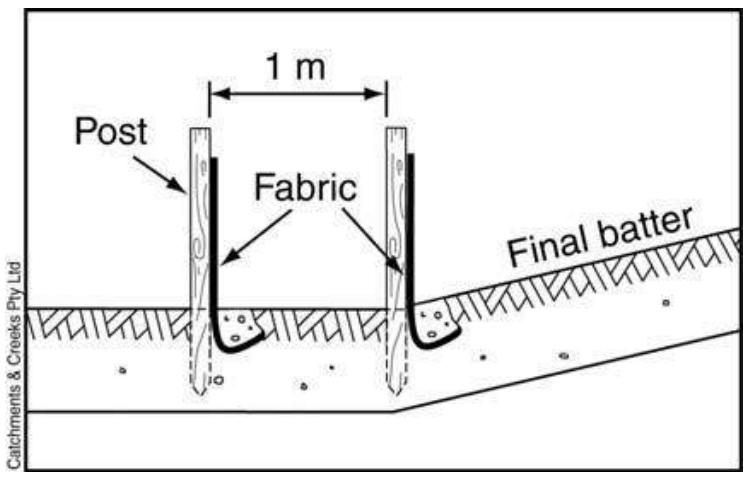


Figure 4 – Double sediment fence installed at the based of a fill slope



Photo 7 – Use of straw bales to prevent direct contact of stockpiles with the fence



Photo 8 – Double sediment fence

(c) Installation of a sediment fence

At least 300mm of fabric must be buried in either a 200mm trench (Figure 8, Photo 13), or under a continuous 100mm high layer of sand or aggregate (Photo 15), but **not** earth.

Straw bales can be placed up-slope of the fence (Figure 9) to retain settled sediment away from the fabric, thus improving the ease of ongoing maintenance (i.e. sediment removal). Alternatively, a small trench can be formed along the contour, up-slope of the fence.

Both ends of the fence should be turned up the slope to minimise the risk of flow bypassing around the ends of the fence (Figure 5, Photo 21).

Support posts should be spaced no greater than 3m if the fence is supported by a top support wire or weir mesh backing (Figure 7), otherwise no greater than 2m (Figure 6). The recommended maximum spacing of support posts is summarised in Table 6.

Table 6 – Maximum spacing of support post

Maximum post spacing	Installation condition
2m	No support wire or backing mesh.
3m	Support weir attached along top of the fabric at 1m intervals. Wire mesh or PVC safety mesh backing.

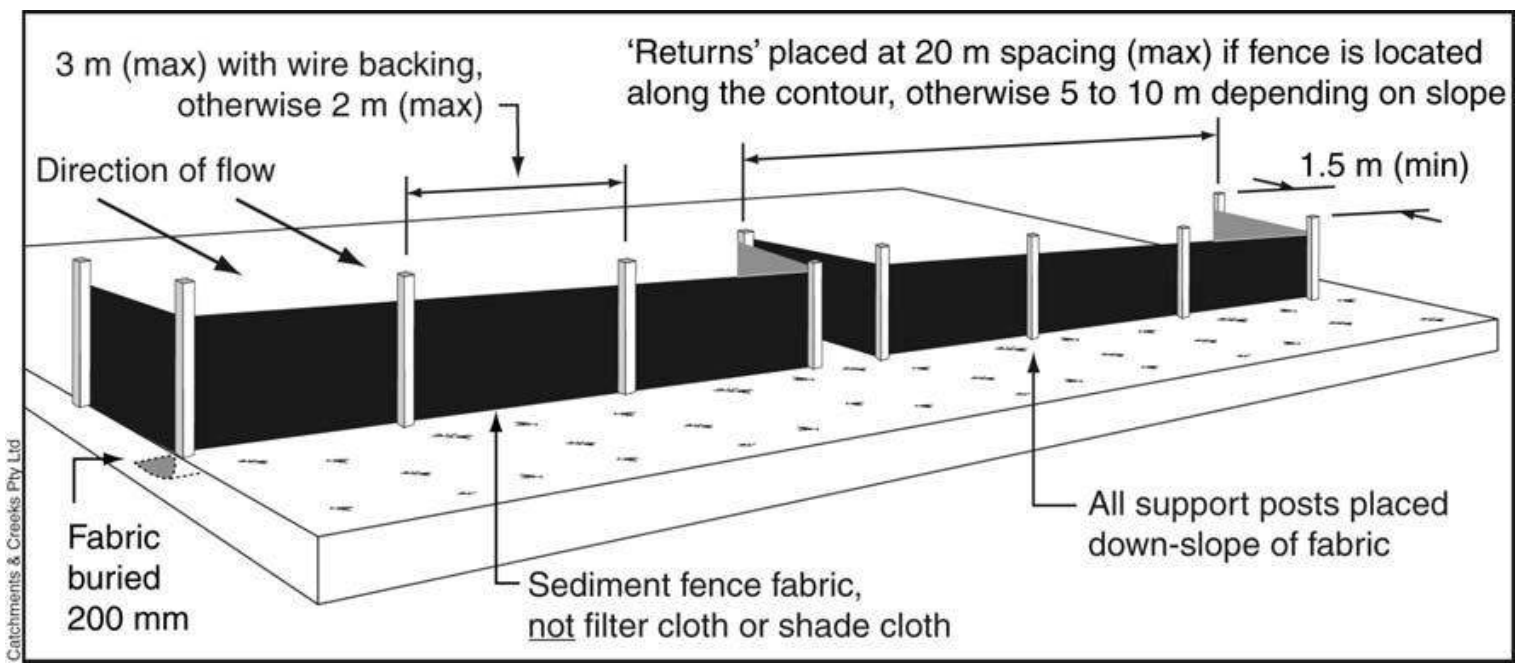


Figure 5 – Typical installation of a sediment fence

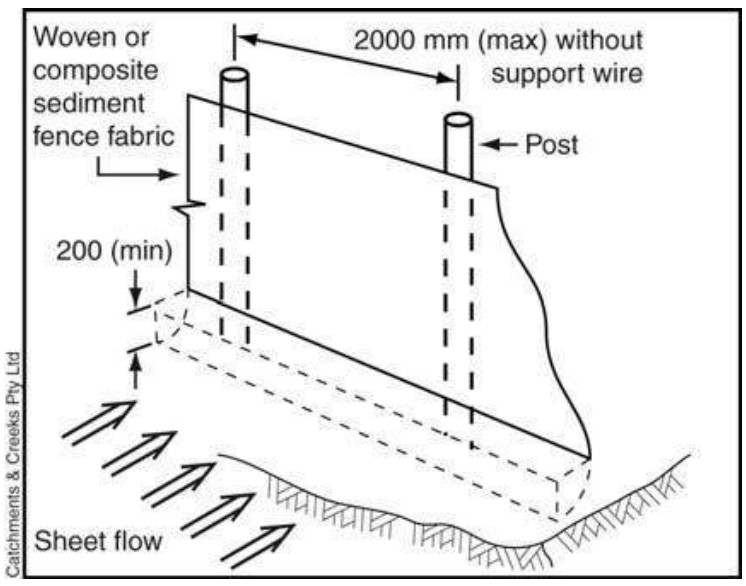


Figure 6 – Installation of a sediment fence without wire backing

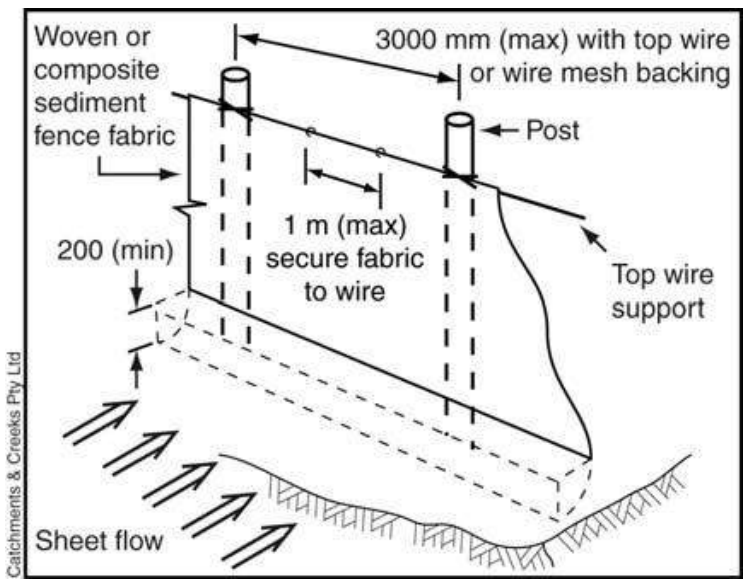


Figure 7 – Installation of a sediment fence with top wire support

Wherever possible, construct the sediment fence from a continuous roll. To join fabric either attach each end to individual stakes (Figure 10), holding the stakes together, rotate the stakes 180 degrees, then drive the two stakes into the ground; or overlap the fabric to the next support post (Figure 11).

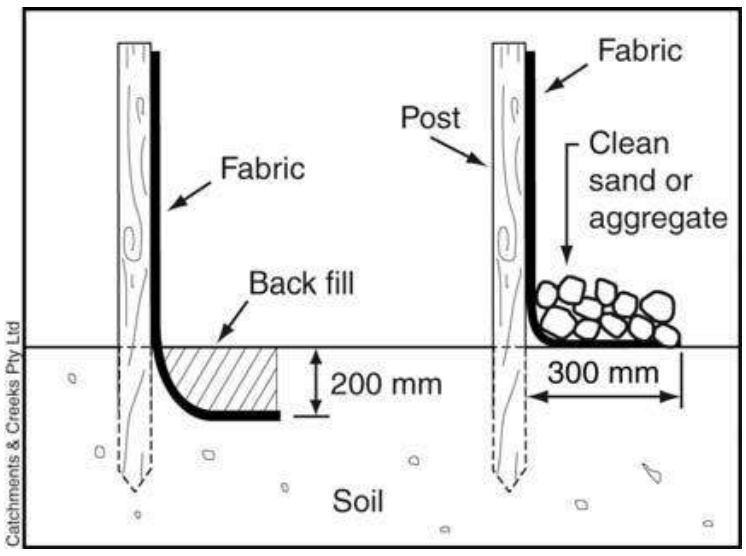


Figure 8 – Anchoring the fabric

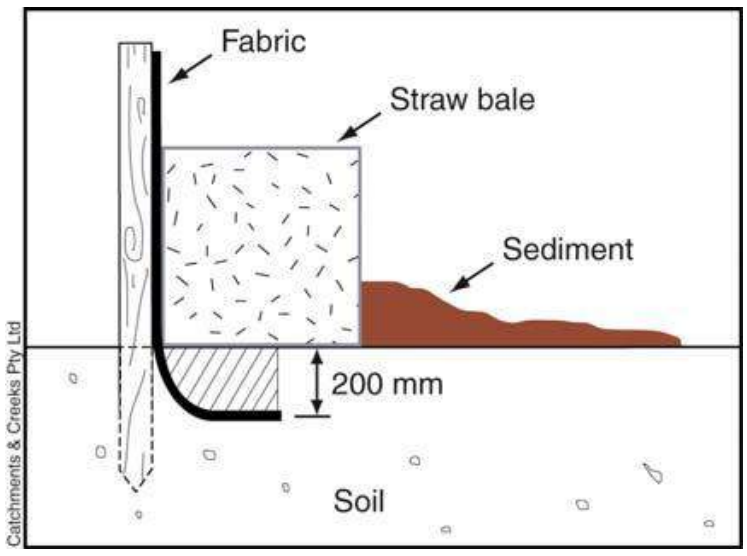


Figure 9 – Use of straw bales as a fabric-sediment separator

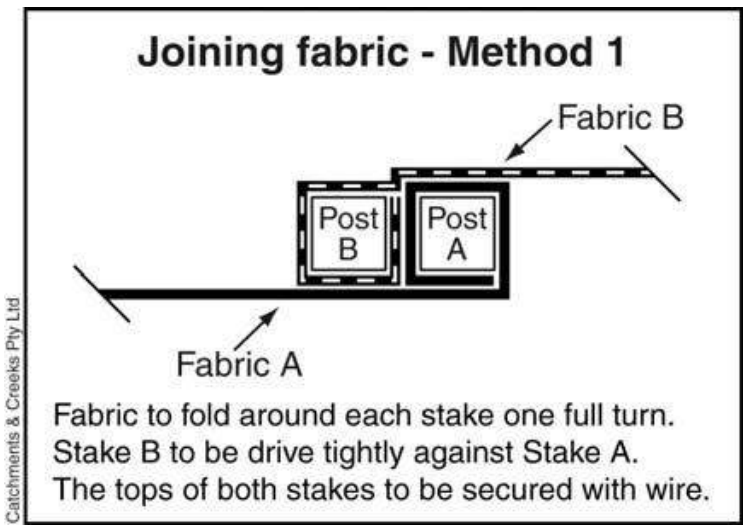


Figure 10 – Joining fabric (Option 1)

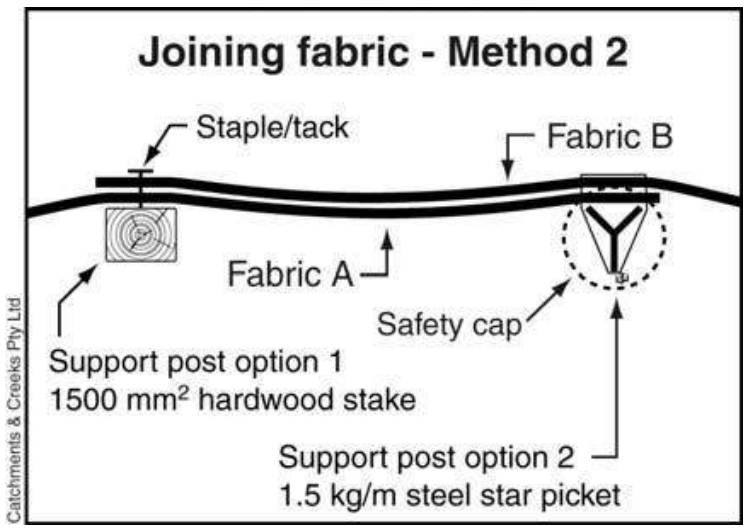


Figure 11 – Overlapping fabric (Option 2)



Photo 9 – Sediment fence placed along the contour



Photo 10 – Use of fence ‘returns’



Photo 11 – Placement of fence off the contour with regular fence ‘returns’



Photo 12 – Alternative design of a fence ‘return’



Photo 13 – Trenching the fabric



Photo 14 – Inappropriate installation



Photo 15 – Bottom of fabric buried under aggregate



Photo 16 – Inappropriate use of sand to bury the fabric



Photo 17 – Straw bales placed up-slope of fence to separate sediment and fabric



Photo 18 – Inappropriate installation of the posts up-slope of the fabric



Photo 19 – Inappropriate junction



Photo 20 – Gaps in fence are not allowed



Photo 21 – Installation without backing weir/mesh



Photo 22 – Installation with top wire support



Photo 23 – Installation with weir mesh



Photo 24 – Installation using fence support



Photo 25 – Installation with safety fencing used as support



Photo 26 – A sediment fence braced for possible high flows



Photo 27 – Example of tacking



Photo 28 – Safety cap on a steel stake



Photo 29 – Flow diversion by fence



Photo 30 – No end return



Photo 31 – Damage by shifting fill



Photo 32 – Fence placed too close to fill

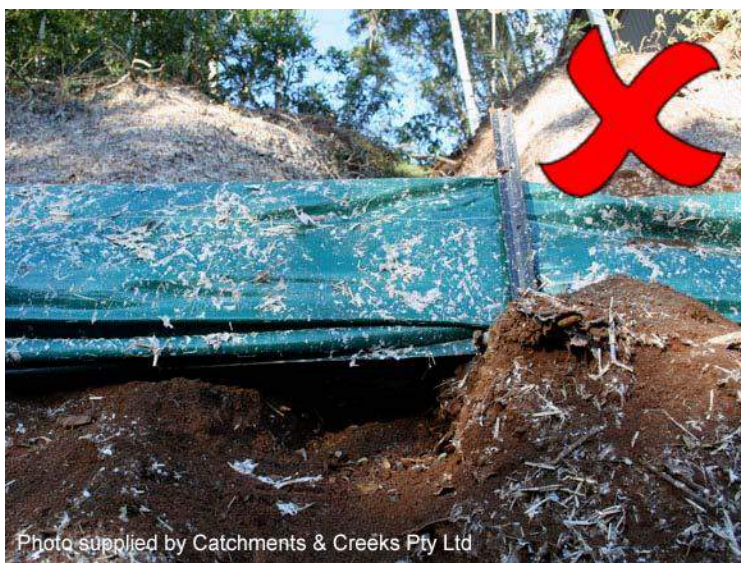


Photo 33 – Evidence of hydraulic wash-out under fence caused by poor trenching



Photo 34 – Sediment not removed after storm



Photo 35 – Flow allowed to bypass the fence



Photo 36 – Spill-through weirs must not discharge onto unstable land

(d) Use of spill-through weirs

Where appropriate, spill-through weirs can be installed into the fence to reduce hydraulic pressure and reduce the risk of hydraulic failure.

The required width (W) of the spill-through weir depends on the nominated design flow rate. The weir flow equation for a rectangular spill-through weir is provided below as Equation 2, as well as tabulated in Table 7.

$$Q = 1.7\ W\ H^{3/2} \qquad \text{(Eqn 2)}$$

where: Q = Design flow rate (usually 0.5 times the 1 in 1 year ARI peak discharge) [m^3/s]
W = Weir width [m]
H = Hydraulic head = height of upstream water level above weir crest [m]

Table 7 – Flow rates passing over a spill-through weir (m^3/s)

Hydraulic head, H (m)	Spill-through weir width, W (m)									
	0.3	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**
0.10	0.016	0.027	0.054	0.081	0.108	0.134	0.161	0.188	0.215	0.242
0.15	0.030	0.049	0.099	0.148	0.198	0.247	0.296	0.346	0.395	0.444
0.20	0.046	0.076	0.152	0.228	0.304	0.380	0.456	0.532	0.608	0.684
0.25	0.064	0.106	0.213	0.319	0.425	0.531	0.638	0.744	0.850	0.956
0.30	0.084	0.140	0.279	0.419	0.559	0.698	0.838	0.978	1.12	1.26
0.35	0.106	0.176	0.352	0.528	0.704	0.880	1.06	1.23	1.41	1.58
0.40	0.129	0.215	0.430	0.645	0.860	1.08	1.29	1.51	1.72	1.94

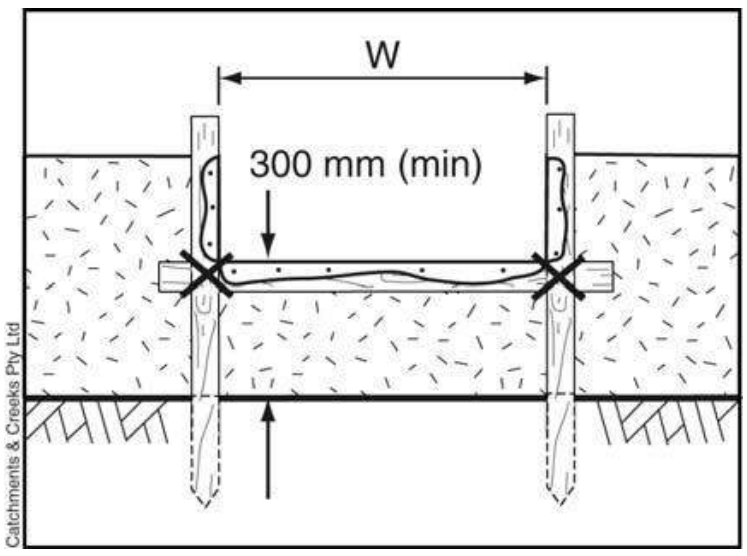


Figure 12 – Spill-through weir profile

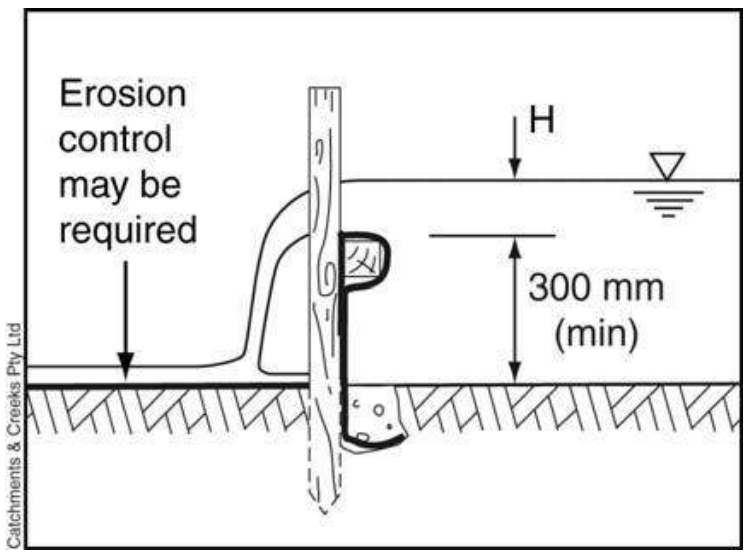


Figure 13 – Side profile of a spill-through weir



Photo 37 – Spill-through weir (down-slope side) with rock splash pad



Photo 38 – Spill-through weir with outlet chute



Photo 39 – Spill-through weir with up-slope aggregate filter



Photo 40 – Inappropriate placement of fence and installation of spill-through weir

If large sediment flows are expected, then a *Coarse Sediment Trap* can be used as an outlet structure for a sediment fence as shown in Figure 14. However, in most circumstances, a more elaborate outlet system would be required such as a Type 1 or Type 2 sediment trap.

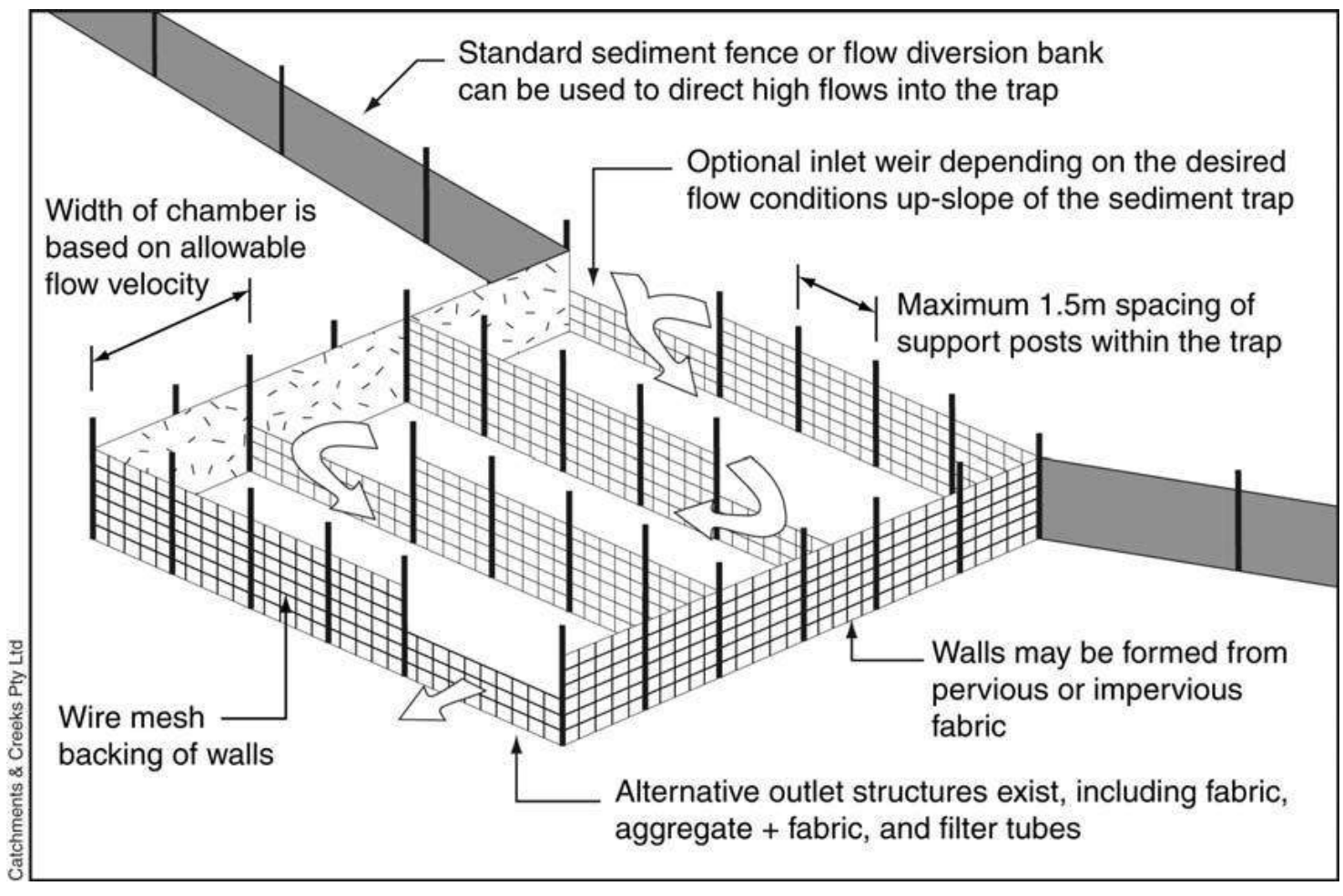


Figure 14 – Coarse sediment trap outlet structure

Description

A sediment fence consists of specially manufactured woven fabric attached to support posts. The typical height of the fence is around 600 to 700mm.

Most sediment fences are self-supporting; however, in appropriate circumstances the fence may be attached to an existing porous structure such as a property fence.

The fabric may be manufactured from either woven fabric, or a composite of woven and non-woven fabrics. The incorporation of a woven fabric is essential for the control of water flow needed to allow adequate temporary ponding up-slope of the fence.

Purpose

Used as a Type 3 sediment trap on small catchments, or as a supplement to Type 1 or 2 sediment traps on large catchments.

Limitations

Though often referred to as a ‘silt fence’, these Type 3 sediment traps have little impact on fine silts (< 0.02mm).

A sediment fence in its standard installation is only suitable for the treatment of ‘sheet’ flows. If concentrated flow exist, such as in a minor drain, then a *U-Shaped Sediment Trap*, or other more appropriate sediment trap should be used.

Most fabrics have an effective service life of around 6 months (check with manufacturer or distributor).

Advantages

Reasonably easy to install.

Has the ability to control sediment runoff close to the source of the erosion.

Disadvantages

Time-consuming to install, which often results in poor installation.

Easily damaged by construction equipment and shifting earth (Photos 31 & 32).

Can cause the concentration of stormwater runoff if poorly located, or installed.

Sediment fences are one of the most missed used sediment control devices, usually because they are either not installed in appropriate locations, or are installed in a manner that does not allow adequately water ponding up-slope of the fences.

Common Problems

If not installed along the contour, a sediment fence can result in flows being deflected along the fence (Photo 29).

If the ends of the fence are not turned up the slope, water and sediment can pass around the end of the fence (Photo 30).

If gaps exist in the fence (Photos 19 & 20), then water is prevented from ponding up-slope of the fence, thus sedimentation does not occur.

Excessive spacing between support posts is a common problem. In extreme cases this can result in the fabric sagging close to the ground.

Fabric not adequately connected to the support posts or backing wire.

The bottom of the fabric not adequately buried into the ground or under a suitable layer of sand or aggregate. If such fences are subjected to significant storms, the bottom of the fence can ‘blow-out’ causing erosion down-slope of the fence (Photo 33).

Spill-through weirs may not have been installed in large catchments or areas of high rainfall, thus increasing the risk of flow damage to the fence.

Crest of spill-through weir set too close to the ground (should be at least 300mm above ground level).

Crest of spill-through weir is set above the ground level at the ends of the fence, thus allowing flow bypassing rather than discharge over the weir (Photo 40).

Special Requirements

Woven fabrics are generally preferred on large sites when the service life is expected to extend over several storm events. Composite fabrics are generally preferred on small soil disturbances such a building sites, or when the sediment fence is the last line of defence prior to the runoff entering a water body.

Ideally, the sediment fence should be installed along the contour, thus maintaining sheet flow conditions across fence. If located across the contour, the fence should be installed with regular ‘returns’ to avoid water concentrating along the fence.

At least 300mm of fabric must be buried in either a 200mm trench, or under a continuous, 100mm high layer of sand or aggregate, but not earth.

Straw bales can be placed up-slope of the fence to retain bulk sediment away from the fabric, thus improving the ease of sediment removal. Alternatively, a small trench can be formed along the contour, up-slope of the fence. However, in all cases the aim should be to minimise high sediment flows so that such fence modifications become the exception, not the rule!

Where appropriate, spill-through weirs can be installed into the fence to reduce hydraulic pressure and reduce the risk of hydraulic failure.

Location

Install along the contour wherever possible.

Allow at least 4.5m between the fence and single-story buildings; 7.5m between the fence and multiple-story buildings; and at least 2m between the fence and the toe of a fill slope or stockpile.

Site Inspection

Ensure the sediment fence will adequately pond water up-slope of the fence.

Ensure the fabric is adequately buried.

Check the spacing of support posts/stakes.

Check for excessive sediment deposition.

Investigate the source of excessive sediment deposits.

Ensure the selection of appropriate fabric (i.e. woven or composite).

Check for damage to the fabric.

Check for erosion down-slope of any spill-through weirs.

Ensure the fence is not concentrating or diverting flows in an undesirable manner.

Materials

- Fabric: polypropylene, polyamide, nylon, polyester, or polyethylene woven or non-woven fabric, at least 700mm in width and a minimum unit weight of 140GSM. All fabrics to contain ultraviolet inhibitors and stabilisers to provide a minimum of 6 months of useable construction life (ultraviolet stability exceeding 70%).
- Fabric reinforcement: wire or steel mesh minimum 14-gauge with a maximum mesh spacing of 200mm.
- Support posts/stakes: 1500mm^2 (min) hardwood, 2500mm^2 (min) softwood, or 1.5kg/m (min) steel star pickets suitable for attaching fabric.

Installation

1. Refer to approved plans for location, extent, and required type of fabric (if specified). If there are questions or problems with the location, extent, fabric type, or method of installation contact the engineer or responsible on-site officer for assistance.
2. To the maximum degree practical, and where the plans allow, ensure the fence is located:
   (i) totally within the property boundaries;
   (ii) along a line of constant elevation wherever practical;
   (iii) at least 2m from the toe of any filling operations that may result in shifting soil/fill damaging the fence.
3. Install returns within the fence at maximum 20m intervals if the fence is installed along the contour, or 5 to 10m maximum spacing (depending on slope) if the fence is installed at an angle to the contour. The ‘returns’ shall consist of either:
   (i) V-shaped section extending at least 1.5m up the slope; or
   (ii) sandbag or rock/aggregate check dam a minimum 1/3 and maximum 1/2 fence height, and extending at least 1.5m up the slope.
4. Ensure the extreme ends of the fence are turned up the slope at least 1.5m, or as necessary, to minimise water bypassing around the fence.
5. Ensure the sediment fence is installed in a manner that avoids the concentration of flow along the fence, and the undesirable discharge of water around the ends of the fence.
6. If the sediment fence is to be installed along the edge of existing trees, ensure care is taken to protect the trees and their root systems during installation of the fence. Do not attach the fabric to the trees.
7. Unless directed by the site supervisor or the approved plans, excavate a 200mm wide by 200mm deep trench along the proposed fence line, placing the excavated material on the up-slope side of the trench.

8. Along the lower side of the trench, appropriately secure the stakes into the ground spaced no greater than 3m if supported by a top support wire or weir mesh backing, otherwise no greater than 2m.

9. If specified, securely attach the support wire or mesh to the up-slope side of the stakes with the mesh extending at least 200mm into the excavated trench. Ensure the mesh and fabric is attached to the up-slope side of the stakes even when directing a fence around a corner or sharp change-of-direction.

10. Wherever possible, construct the sediment fence from a continuous roll of fabric. To join fabric either:
    (i) attach each end to two overlapping stakes with the fabric folding around the associated stake one turn, and with the two stakes tied together with wire (Method 1); or
    (ii) overlap the fabric to the next adjacent support post (Method 2).

11. Securely attach the fabric to the support posts using 25 x 12.5mm staples, or tie wire at maximum 150mm spacing.

12. Securely attach the fabric to the support wire/mesh (if any) at a maximum spacing of 1m.

13. Ensure the completed sediment fence is at least 450mm, but not more than 700mm high. If a spill-though weir is installed, ensure the crest of the weir is at least 300mm above ground level.

14. Backfill the trench and tamp the fill to firmly anchor the bottom of the fabric and mesh to prevent water from flowing under the fence.

15. If it is not possible to anchor the fabric in an excavated trench, then use a continuous layer of sand or aggregate to hold the fabric firmly on the ground.

Additional requirements for the installation of a spill-through weir

1. Locate the spill-through weir such that the weir crest will be lower than the ground level at each end of the fence.

2. Ensure the crest of the spill-through weir is at least 300mm the ground elevation.

3. Securely tie a horizontal cross member (weir) to the support posts/stakes each side of the weir. Cut the fabric down the side of each post and fold the fabric over the cross member and appropriately secure the fabric.

4. Install a suitable splash pad and/or chute immediately down-slope of the spill-through weir to control soil erosion and appropriately discharge the concentrated flow passing over the weir.

Maintenance

1. Inspect the sediment fence at least weekly and after any significant rain. Make necessary repairs immediately.

2. Repair any torn sections with a continuous piece of fabric from post to post.

3. When making repairs, always restore the system to its original configuration unless an amended layout is required or specified.

4. If the fence is sagging between stakes, install additional support posts.

5. Remove accumulated sediment if the sediment deposit exceeds a depth of 1/3 the height of the fence.

6. Dispose of sediment in a suitable manner that will not cause an erosion or pollution hazard.

7. Replace the fabric if the service life of the existing fabric exceeds 6-months.

Removal

1. When disturbed areas up-slope of the sediment fence are sufficiently stabilised to restrain erosion, the fence must be removed.

2. Remove materials and collected sediment and dispose of in a suitable manner that will not cause an erosion or pollution hazard.

3. Rehabilitate/revegetate the disturbed ground as necessary to minimise the erosion hazard.

Dust Control

EROSION CONTROL TECHNIQUE

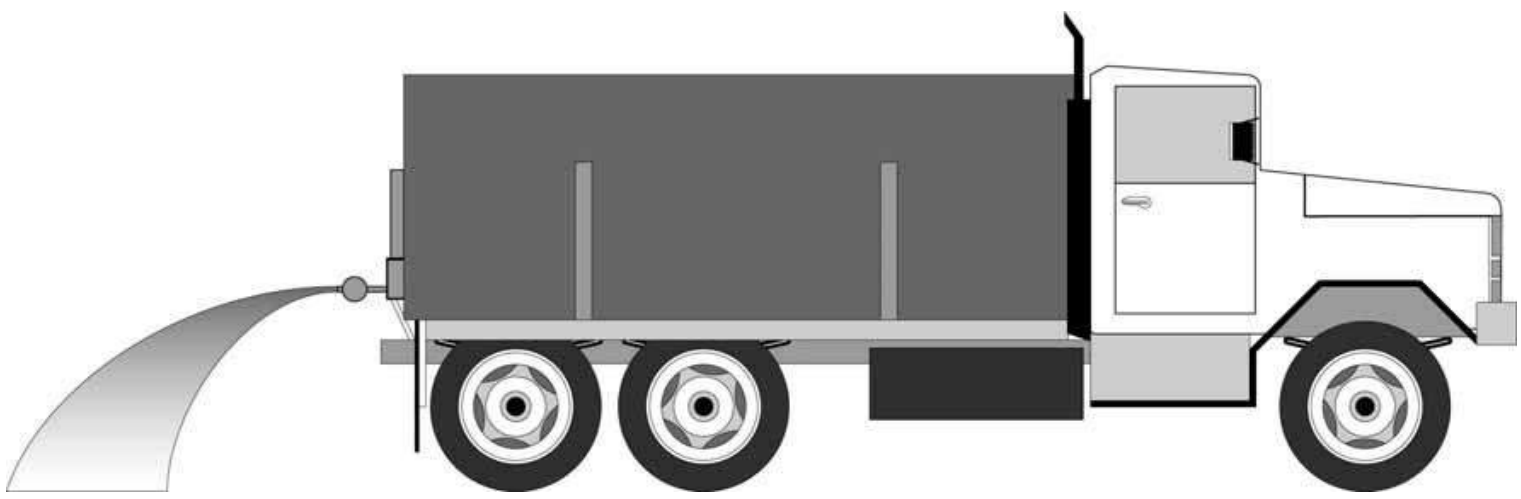
Revegetation	[1]	Temperate Climates	✓	Short-term	✓
Non Vegetation	[1]	Wet Tropics	✓	Long-term	[2]
Weed Control		Semi-Arid Zones	✓	Permanent	

[1] Treatment options can include temporary vegetation and non-vegetated treatment options.

[2] Most treatment options, excluding permanent revegetation, provide only short-term benefits.

Symbol





Key Principles

1. Potential adverse impacts of dust control products/chemicals on the environment (both short- and long-term) **must** not exceed the potential benefits achieved by their use, or any locally adopted measures of unacceptable environmental risk.
2. Critical design parameters include ability to control dust generation, suitability of the product to the work place conditions and the soil type.
3. Effectiveness and durability of most treatment measures depends on soil type, weather conditions, and frequency of disturbance (e.g. traffic movement).

Design Information

Dust control involves the suppression of dust particles generally in the range 0.001 to 0.1mm (1 to 100 microns). Much of the dust generated on construction sites is likely to be greater than 10 microns. Non-visible dust particles (less than 5 microns) are potentially the most harmful to human health.

Dust generation associated with wind erosion is normally controlled using one or more of the following techniques:

(i) Maintaining moist soil conditions (water trucks and sprinkler systems)

(ii) Chemical sealants placed over the soil surface (refer to *Soil Binders* fact sheet)

(iii) Surface roughening (refer to *Surface Roughening* fact sheet)

(iv) Revegetation (short- and long-term ground cover options)

(v) Wind breaks (e.g. retention of existing vegetation, or 60:40 fabric:opening shade cloth).

Dust problems can also be reduced by the following activities:

- Limiting the area of soil disturbance at any given time.
- Promptly replacing topsoil after completion of earthworks
- Programming works to minimise the life of soil stockpiles.
- Temporarily stabilising (e.g. vegetation or mulching) long-term stockpiles.
- Gravelling unsealed access and haul roads.
- Minimising traffic movements on exposed surfaces.
- Limiting vehicular traffic to 25kph.
- Retaining existing vegetation as wind breaks.

International Erosion Control Association (IECA, 1993) reports that:

- 30% soil cover will reduce soil losses by 80%.
- Roughening the soil to produce 150mm high ridges perpendicular to the prevailing wind can reduce soil losses by 80%.
- A small decrease in velocity can have a major impact in reducing wind erosion given that the erosive power of wind is proportional to the cube of the velocity.
- For wind barriers perpendicular to the wind, the width of the [protected] zone leeward of the barriers is around 8 to 10 times the height of the barrier.

Possible treatment options for dust are summarised in Table 1. A summary of dust suppressant agents is provided in Table 2. Discussion on the use of soil binders for dust control is provided in the *Soil Binders* fact sheet.

Table 1 – Dust control practices [1]

Site condition	Treatment options							
	Permanent vegetation	Mulching	Watering	Chemical surface stabiliser [2]	Gravel road [3]	Stabilised entry/exit pad	Haul truck covers	Minimise site disturbance
Areas not subject to traffic	✓	✓	✓	✓	✓			✓
Areas subject to traffic			✓	✓	✓	✓		✓
Material stockpiles			✓	✓				✓
Demolition areas			✓			✓	✓	
Clearing & excavation			✓	✓				✓
Unpaved roads			✓	✓	✓	✓	✓	
Earth transport					✓	✓		

[1] Sourced from: California Stormwater BMP Handbook – Construction (2003).

[2] Oil or oil-treated subgrade should not be used for dust control as this may migrate into downstream water bodies. It is also noted that surface stabilising chemicals (soil binder) may make the soil water repellent, possibly resulting in long-term revegetation problems.

[3] On long-term access and haul roads, the sealing of road with an application of 10mm single-coat bitumen seal can be more effective than the application of dust suppressants.

The following materials must not be used for dust suppression purposes:

- oil;
- landfill gas condensate;
- any contaminated leachate or stormwater when the use of such material is likely to cause unlawful environmental harm.

Table 2 – Summary of dust suppressant attributes [1]

Suppressant type	Typical attributes
Soil binders	• Refer to *Soil Binders* fact sheet
Chlorides: Calcium chloride ($CaCl_2$) Magnesium chloride ($MgCl_2$)	• Chloride compounds attract moisture from the air (hygroscopic) and attach themselves to soil particles if they are applied to wet soils • Less effective in dry climates • Ease of application, with 0 to 4 hours curing time • Can be applied when temperatures drop below freezing • Most suited to temperate and semi-humid conditions • Lose effectiveness in continual dry periods • Less effective than polymers during periods of heavy rainfall • Susceptible to leaching • Suitable for use on moderate surface fines (10–20%) • Not suitable on materials with a low-fines content • High fines content surfaces may become slippery in wet weather • Corrosive impacts associated with calcium chloride
Organic, non-bituminous: Calcium ligno-sulfonate Sodium ligno-sulfonate Ammonium ligno-sulfonate	• Ligno-sulfonate (lignin) is a by-product of the pulp-and-paper industry • React with negatively charged clay particles to agglomerate the soil • Perform well under arid conditions and in dry climates • Failures occur following rains • Susceptible to leaching by heavy rains • Suitable on high fines content (10–30%) in a dense graded material with nil loose gravel • Less effective on igneous, medium to low fines content materials and crushed gravels • High fines content surfaces may become slippery in wet weather • It is best to grade haul road to remove surface material, potholes, and corrugations before application of agent • Curing takes 4 to 8 hours
Petroleum-based products: Bitumen emulsion (slow-breaking non-ionic)	• Generally effective regardless of climate • Will pothole in wet weather and high traffic conditions • Suitable on materials with a low-fines content (<10%) • Non suitable where runoff could contaminate receiving waters
Electrochemical stabilisers: Sulfonated petroleum Enzymes	• Work over a wide range of climates • Suitable for clay materials but depends on clay mineralogy • Iron rich soils generally respond well • Least susceptible to leaching • Ineffective if surface is low in fines and contains loose gravel

[1] After UMA Engineering Ltd 1987, *Guidelines for Cost Effective use and Application of Dust Palliatives.* UMA Engineering Ltd, Ontario, Canada.

Water trucks and sprinkler systems

Water trucks have traditionally been used to control dust within construction sites, particularly on haul roads and for highway construction. The maintenance of moist soil conditions through watering remains a viable dust control measure.

The addition of wetting agents and polymer binders (refer to *Soil Binders* fact sheet) to the water can decrease both the water requirements and the required application frequency. Wetting agents can improve the depth and uniformity of the soil wetting process. Polymer binders improve the binding of individual soil particles, thus reducing dust generation even after drying of the soil surface. Dust suppressing agents can be applied by both water trucks and sprinkler systems.

Dust-suppressing fog and mist generators

High volume mist generating machines can be used to suppress airborne dust resulting from blasting operations. Large cannon-like systems can throw a mist some 250m to blanket the treatment area. On small sites, hydraulic atomising misting nozzles can be attached to sprinkler-like distribution system.

An ionic wetting agent can be added to the water to improve the performance of misting dust suppression systems.

Foaming agents

Foaming agent additives can be added to directional dust-suppressing sprinkler systems to apply a foam to the surface of conveyor belt materials to reduce dust resulting from crusher and material handling plants.

Vegetable oil based soil binders

Biodegradable vegetable oil based soil binders can be applied as a water-based emulsion to provide up to 3 months service life in heavy vehicular traffic areas.

Polymer based soil binders (refer to *Soil Binders* fact sheet)

Polymeric emulsion soil binders include: acrylic copolymers and polymers; liquid polymers of methacrylates and acrylates; copolymers of sodium acrylates and acrylamides; poly-acrylamide and copolymer of acrylamide; and hydro-colloid polymers.

In general terms, polymers can provide around 9 to 18 months service life if the treated area remain free of disturbance and traffic movement. On haul roads and permanent unsealed roads, polymer soil binders can be incorporated into road maintenance (grading and rolling) to improve surface stability and compaction.



Photo 1 – Dust generation on a construction site



Photo 2 – Dust control using a water truck

Stormwater Inlet Sediment Traps

SEDIMENT CONTROL TECHNIQUES



Photo 1 – Kerb inlet



Photo 2 – Field (drop) inlet

Table 1 provides the recommended default classification of various sediment control systems suitable for field (drop) inlet sediment control.

Table 1 – Default classification of sediment control techniques [1]

Type 1	Type 2	Type 3
	• Block & Aggregate Drop Inlet Protection [2] • Compost-Filled Filter Sock [2] • Mesh & Aggregate Drop Inlet Protection [2] • Rock & Aggregate Drop Inlet Protection [2]	• Excavated Drop Inlet Protection • Fabric Drop Inlet Protection • Fabric Wrap Drop Inlet Sediment Trap

[1] Classification is based on the technique being sized in accordance with best practice standards, otherwise the technique attracts a lower classification.

[2] Classification depends on design details.

'Supplementary sediment traps', such as most kerb inlet sediment traps, are not effective enough to be classified as Type 3 systems. Even though these sediment traps are relatively ineffective, their incorporation into most Erosion and Sediment Control Plans (ESCPs) is considered a relevant part of the best practice sediment control. It is, however, not considered sufficient for a sediment control scheme to rely solely on supplementary sediment traps.

Table 2 – Supplementary sediment control techniques

Flow condition	Sediment control technique
Roadside kerb inlets	• Filter Sock Drop Inlet Protection • Kerb Inlet Sediment Traps (on-grade and sag inlet traps, including Gully Filter Bags)
Field (drop) inlets	• Filter Sock Drop Inlet Protection • Gully Filter Bag • Straw Bale Barrier



Photo 3 – Block & aggregate system



Photo 4 – Compost-filled filter sock



Photo 5 – Excavated drop inlet protection



Photo 6 – Fabric drop inlet protection



Photo 7 – Fabric wrap drop inlet protection



Photo 8 – Filter sock drop inlet protection



Photo 9 – Gully filter bag

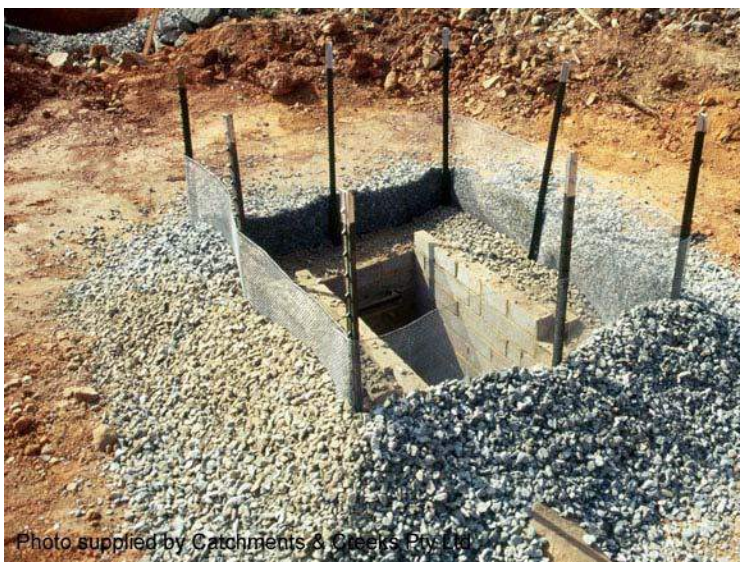


Photo 10 – Mesh & aggregate system



Photo 11 – On-grade kerb inlet control



Photo 12 – Rock & aggregate system



Photo 13 – Sandbags (filter sock)



Photo 14 – Kerb inlet control system



Photo 15 – Sediment weir



Photo 16 – Straw bale barriers are rarely adequate sediment traps



Photo 17 – No sediment control

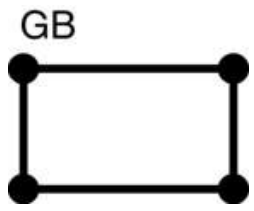
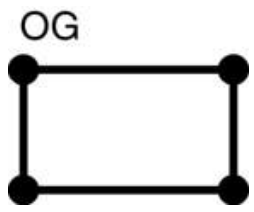
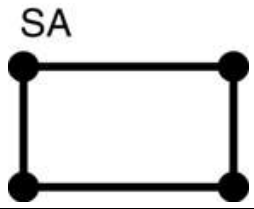


Photo 18 – Shade cloth should <u>not</u> be used

Roadside kerb inlets

Table 3 outlines the attributes of various sediment control techniques for roadside kerb inlets.

Table 3 – Kerb inlet sediment control techniques

Technique	Code	Symbol	Typical use
Gully Filter Bag	GB		• Generally considered to represent *best practice* as a form of kerb inlet sediment control. • Used when it is considered unsafe to cause ponding or sediment deposition on the roadway. • Includes the use of flexible filter bags, and filter boxes lined with filter fabric. • Significant variation in treatment standard of various commercial products.
On-grade Kerb Inlet Sediment Trap	OG		• Up-slope of on-grade kerb inlets (i.e. kerb inlets **not** located at a sag point on a road). • Used as a series of sediment traps to collect cement runoff during the preparation of exposed aggregate surfaces.
Sag Inlet Sediment Trap	SA		• Used as a minor sediment trap constructed around kerb inlets located at sag points along a roadway.

Due to the high risk of physical displacement and damage, most roadside kerb inlet sediment traps are classified as *supplementary sediment traps*. Gully filter bags and fixed, in-gully filter bags/boxes generally provide a higher treatment standard if correctly installed and appropriately maintained.

The following recommendations and procedures are considered to represent best practice roadside sediment control practices:

(i) Wherever practicable, sediment runoff is collected and retained wholly within the work site.

(ii) Where the work site includes roads, whether sealed or under construction, all reasonable and practicable measures are taken to trap sediment runoff prior to its entry onto a road surface.

(iii) Where the sediment runoff has originated from the road surface, then all reasonable and practicable measures are taken to prevent the sediment entering a sealed (e.g. hard lined drainage system), or permanent drainage system (e.g. piped or open channel drain).

(iv) Sediment control measures used within or adjacent a roadside stormwater inlet are to represent current best available practice. As a guide, this generally means that correctly installed and maintained *Gully Filter Bags* (including fixed filter bags/boxes) are used in preference to road-surface sediment traps such as *Sag* and *On-Grade Kerb Inlet Sediment Traps*.

(v) The use of kerb inlet sediment traps must not replace the need for appropriate Type 1, Type 2, or Type 3 sediment traps up-slope of all stormwater inlets as required by the specified sediment control standard.

Sediment controls at field (drop) inlets

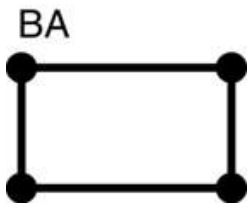
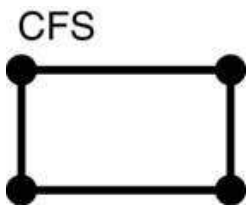
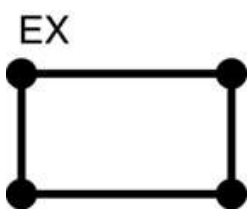
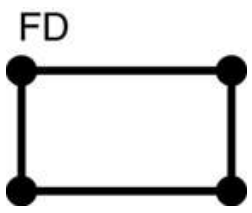
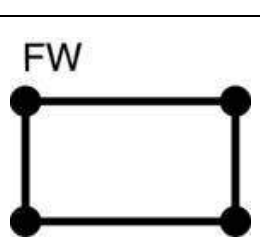
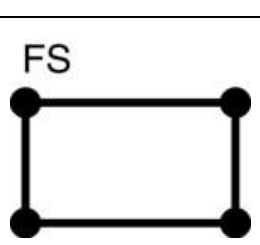
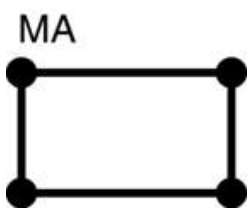
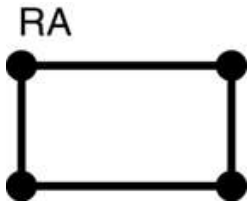
Table 4 provides guidance on the selection of the best sediment control technique for various site conditions.

Table 4 – Selection of the preferred field (drop) inlet sediment control technique

Location	Site condition	Technique preference
Building sites	Small catchment area	Fabric wrap drop inlet protection
	Larger catchment areas	Fabric drop inlet protection
Residential, industrial and commercial construction sites	Type 2 sediment trap formed in a basin or park where a field inlet can be used as the basin's outlet structure	Sediment weir
	Medium sized catchments	Block and aggregate (Type 2), or Compost berm (of adequate size)
	Above case, 2nd preferences	Block and aggregate (Type 3) Mesh and aggregate (Type 3)
	Small sized catchments	Compost-filled filter sock
	Above case, 2nd preferences	Fabric drop inlet protection, or Gully filter bag
	Above case, 3rd preferences	Filter sock, or Fabric wrap drop inlet protection
	Locations where it is not suitable to encourage aboveground ponding	Excavated drop inlet protection
Road and rail construction	Large, deep median within a dual carriage roadway	Sediment weir
	Above case, 2nd preferences	Rock and aggregate system
	Shallow median within a dual carriage roadway	Block and aggregate system – Type 2 or Type 3 as required
	Deep table drain	Block and aggregate (Type 3) Mesh and aggregate (Type 3)
	Above case, 2nd preferences	Compost-filled filter sock, or Gully filter bag
	Shallow table drain	Block and aggregate (Type 3), or Fabric wrap drop inlet protection with spill-through weir, or Excavated drop inlet protection
	Above case, 2nd preferences	Filter sock, or Fabric wrap drop inlet protection
	Locations where it is not suitable to encourage aboveground ponding	Excavated drop inlet protection

Table 5 outlines the attributes of various sediment control techniques for field (drop) inlets.

Table 5 – Field (drop) inlet sediment control techniques

Technique	Code	Symbol	Typical use
Block & Aggregate Drop Inlet Protection	BA		• Type 2 or 3 sediment trap. • Small to medium catchment areas. • Filter cloth may be placed between the aggregate and the support blocks to improve the removal of fine sediments. • The depth of ponding upstream of the field inlet is governed by the height of the blocks.
Compost-Filled Filter Sock	CFS		• For small inlets, the compost is usually contained within a larger-diameter filter sock. • Large compost or mulch berms usually require too much space to be located around most field inlets.
Excavated Drop Inlet Protection	EX		• Type 3 sediment trap. • Locations where water ponding around the stormwater inlet is not allowed to reach a level significantly higher than the existing ground level (i.e. water ponding and sediment collection occurs below finished ground level).
Fabric Drop Inlet Protection	FD		• Type 3 sediment trap. • Best used on sandy soils. • Small catchment areas containing sandy soils. • Locations where space is limited and a more substantial filter medium cannot be built.
Fabric Wrap Drop Inlet Protection	FW		• Type 3 sediment trap. • Very small catchment areas. • Most commonly used on building sites.
Filter Sock Drop Inlet Protection	FS		• Supplementary sediment trap. • Small catchments. • Compost contained within the sock can adsorb some dissolved and fine particulate matter.
Mesh & Aggregate (including Sediment Weir)	MA		• Type 2 or 3 sediment trap. • Small to medium catchments. • The depth of ponding upstream of the field (drop) inlet is governed by the height of the aggregate filter placed around the wire mesh.
Rock & Aggregate Drop Inlet Protection	RA		• Type 2 or 3 sediment trap. • Best used in coarse-grained (i.e. low clay) soil areas. • Large construction sites such as a duel-carriage road with the drop inlet located within the median strip. • Locations where space is not critical.

Fibre Rolls

SEDIMENT CONTROL TECHNIQUE

Type 1 System		Sheet Flow	✓	Sandy Soils	✓
Type 2 System		Concentrated Flow	[1]	Clayey Soils	✓
Type 3 System		Supplementary Trap		Dispersive Soils	

[1] Fibre rolls may be used to form *Check Dam Sediment Traps* in minor drains.

Symbol FR



Photo 1 – Fibre roll staked across a uniform slope



Photo 2 – Fibre roll supplementary sediment trap around a field (drop) inlet

Key Principles

1. Sediment trapping is primarily achieved through gravity-induced settlement resulting from ponding up-slope of the rolls. Therefore, it is essential for the fibre rolls to be placed perpendicular to the direction of flow (e.g. along the contour) to maximise the surface area of this pond.
2. Key design parameter is the maximisation of the pond surface area up-slope of the rolls.
3. Key operation issues include the control of traffic damage that may flatten the rolls, or water damage that may displace the rolls.

Design Information

Table 1 provides the recommended maximum spacing of fibre rolls placed along the contour on uniform slopes.

Table 1 – Maximum spacing down non-vegetated or newly seeded slopes

Maximum spacing	Conditions
3m	• Steep slopes (> 4H:1V). • Highly erosive soils on mild to steep slopes. • Sandy soils on mild to steep slopes.
5m	• Loamy soils on mild slopes (10:1 to 4:1). • Any soil not mulched, hydromulched or similar on low to mild slopes (< 4:1).
8m	• Erosion resistant soils on mild slopes (< 6:1). • Loamy soils on low gradient slopes (< 10:1).

Minimum sock diameter of 200mm.

Fibre rolls should be trenched 75 to 125mm in sandy soils and 50 to 75mm in clayey soils.

Maximum stake spacing of 1.2m or six (6) times the fibre roll diameter (whichever is the lesser). A maximum stake spacing of 0.3m applies when used to form check dams.

When used in areas of sheet flow, fibre rolls must be placed along the contour to maintain uniform flow conditions passing the fibre roll.

Adjoining socks must be overlapped at least 450mm.

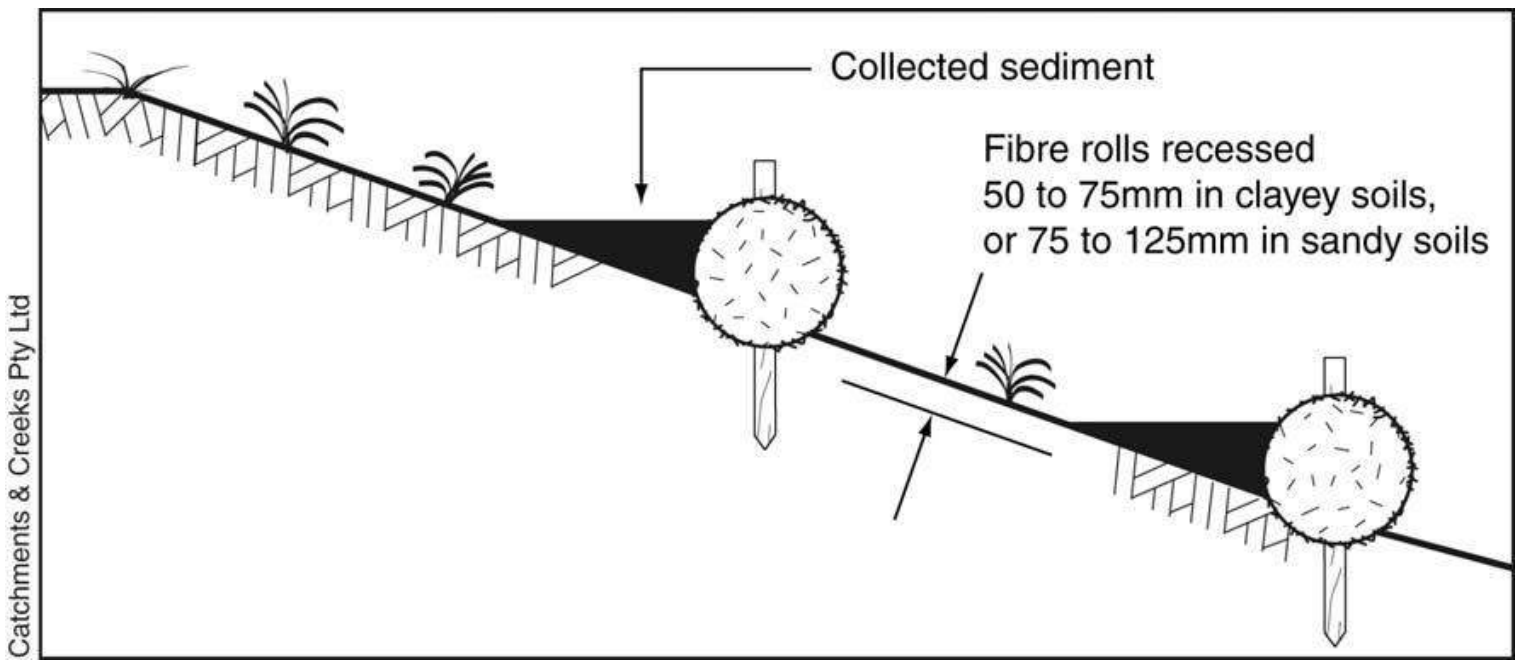


Figure 1 – Fibre rolls placed along the contour in areas of sheet flow



Photo 3 – Compost-filled socks used as a 'living' vegetated bank



Photo 4 – Fibre rolls used as an end-of-day flow and sediment control system



Photo 5 – Fibre rolls used as a minor sediment trap and flow protection for the adjacent mulched batter



Photo 6 – Fibre roll damaged (flattened) by traffic, but still functional

Description

Straw, cane mulch, or other similar fibrous materials bound into a tight tubular roll.

Fibre rolls normally have a tubular roll (sock) formed from open mesh that does not aid in the 'filtration' of pollutants.

Fibre rolls are usually significantly smaller in diameter than *Compost-filled Filter Socks* and the larger diameter *Geo Logs* used for stream bank protection.

Purpose

Used as a supplementary sediment trap on mild-sloping earth slopes and around field (drop) inlets.

They can also be used to form a *Check Dam Sediment Trap* in minor drainage channels.

Filter rolls can also be used to help maintain 'sheet' flow conditions down a disturbed slope, thus delaying the formation of rill erosion.

When placed at regular intervals down a newly mulched or hydromulched slope, the fibre rolls can reduce the risk of the mulch being washed from the slope, as well as capturing sediment and mulch displaced by storms.

Limitations

Sediment and pollutant trapping ability is generally significantly less than *Compost-filled Filter Socks*.

Fibre rolls generally do not provide the pollutant adsorption features of *Compost-filled Filter Socks*.

Fibre rolls are not suitable for use on slopes subject to slippage, slumping or creep.

Advantages

Light and easy to transport into difficult locations.

The fibre rolls usually can be left in place to biologically degrade, however, some products contain plastic mesh (outer roll), and thus have associated environmental risks.

Disadvantages

Rolls are easily damaged—this being the primary reason for their classification as a 'supplementary' sediment trap rather than a Type 3 system.

Difficult to move when wet.

Can float away if not adequately staked.

Very limited sediment retention volume.

Can aggravate bank erosion if not located along the contour.

Special Requirements

Fibre rolls should be trenched 75 to 125mm in sandy soils and 50 to 75mm in clayey soils.

Ensure both ends of the fibre roll are adequately turned up the slope to prevent flow bypassing prior to water passing over the rolls.

Location

Placed along the contour at regular intervals down mild-sloping earth batters.

Long, newly seeded slopes where it is important to maintain sheet flow conditions.

Filed inlets with small drainage catchments.

Common Problems

Often installed without adequate trenching.

Flattened by vehicular and pedestrian traffic.

Site Inspection

Check for sufficient anchorage (pegging) along its full length.

Ensure the fibre rolls have been placed along the contour such that water will pond evenly along the length of each roll.

Check for damage to the fibre rolls and actual or potential wash-outs.

Materials

- Fibre rolls: typically 200 to 250mm jute, coir or straw roll tied with synthetic or biodegradable mesh.
- Stakes: minimum 20 by 20mm timber stakes.

Installation

1. Refer to approved plans for location and installation details. If there are questions or problems with the location, dimensions or method of installation contact the engineer or responsible on-site officer for assistance.
2. When placed across non-vegetated or newly seeded slopes, the rolls must be placed along the contour.
3. If placed on open or loose soil, ensure the fibre rolls are trenched 75 to 125mm in sandy soils and 50 to 75mm in clayey soils.
4. Ensure the outer most ends of the fibre roll are turned up the slope to allow water to adequately pond up-slope of the roll, and to minimise flow bypassing.
5. When placed across the invert of minor drains, ensure the socks are placed such that:
   (i) the crest of the downstream roll is level with the channel invert at the immediate upstream sock (if any);
   (ii) each roll extends up the channel banks such that the crest of the fibre roll at its lowest point is lower than the ground level at either end of the roll.
6. Ensure the anchoring stakes are driven into the end of each roll and along the length of each roll at a spacing not exceeding 1.2m or six times the roll diameter, whichever is the lesser. A maximum stake spacing of 0.3m applies when used to form check dams.
7. Adjoining roll must be overlap at least 450mm, not abutted.

Maintenance

1. Inspect all fibre rolls prior to forecast rain, daily during extended periods of rainfall, after significant runoff producing storms or otherwise at weekly intervals.
2. Repair or replace damaged fibre rolls.
3. Remove collected sediment and dispose of in a suitable manner that will not cause an erosion or pollution hazard.

Removal

1. All excessive sediment trapped by the rolls must be removed from the drain or slope if such sediment is likely to be washed away by expected flows.
2. Dispose of collected sediment in a suitable manner that will not cause an erosion or pollution hazard.
3. The biodegradable content of the straw rolls may not necessarily need to be removed from the site.
4. All synthetic (plastic) mesh or other non readily biodegradable material must be removed from the site once the slope or drain is stabilised, or the rolls have deteriorated to a point where they are no longer providing their intended drainage or sediment control function.

APPENDIX G

Non-Conformance Report Template

NON-CONFORMANCE REPORT

Job Name:	Job No:
Date:	Client:
Details of non-conformance:	
Details of specification/procedure not conforming to:	
Non-conformance raised by:	Date:
Short-term preventative action:	
Estimated cost of rework/re-training/waste:	
Long-term preventative action:	
Accepted/rejected by the Client: Signed:	Date:
Non-conformance resolved: Signed:	Date: