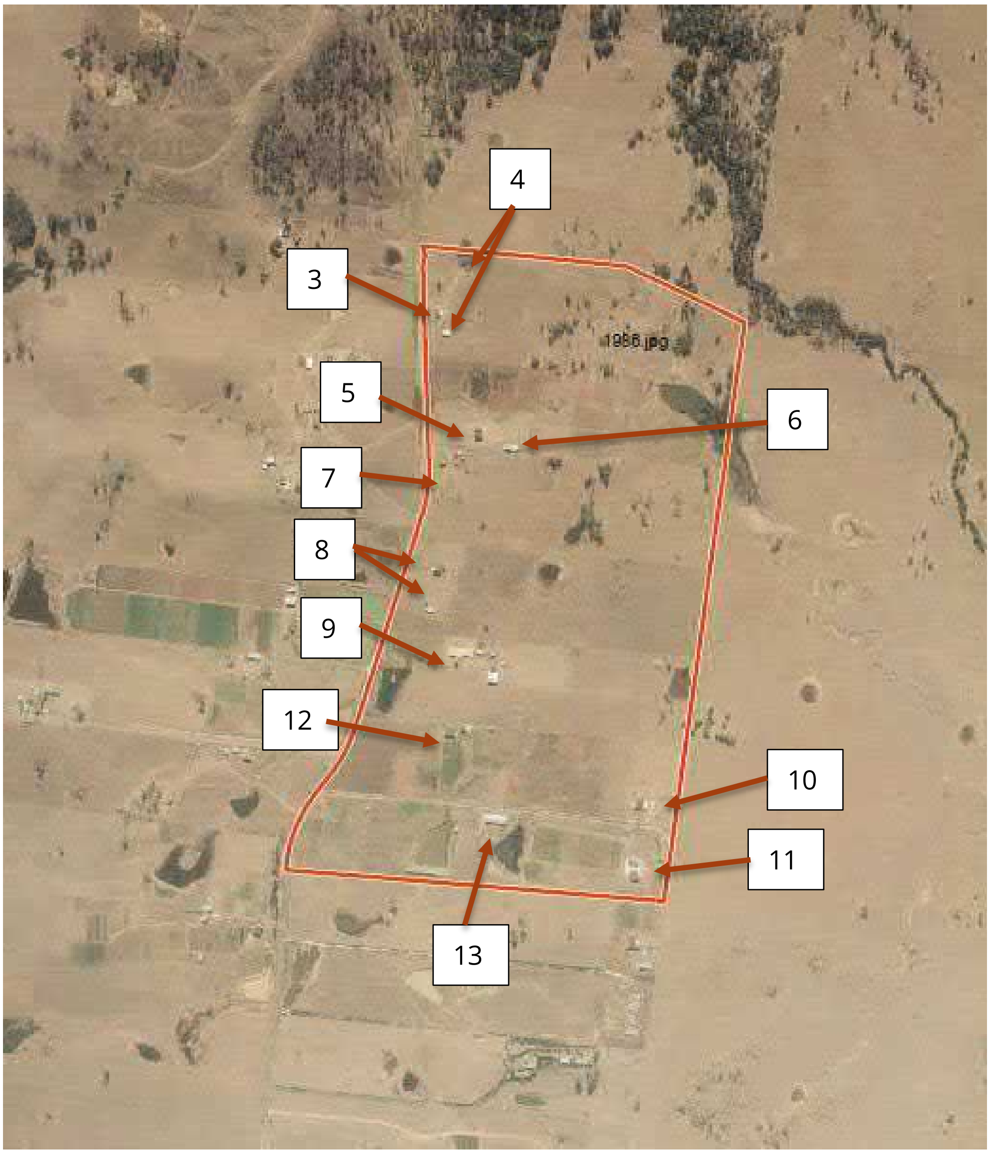


Photo 5 1986 aerial photograph of the study area (Source: NSW aerial imagery)

A later aerial taken in 1998 (Photo 6) shows crop farming practices had intensified in the study area with extensive cropping visible throughout. A dam in the north western corner has been filled in and a residential property constructed [14]. A shed [6] associated with the original house in that area has also been expanded, in addition to the construction of a shed [15] in the central southern portion of the study area. As well as cropping, the southern portion displays evidence of orcharding, reflecting the increased use of the study area.

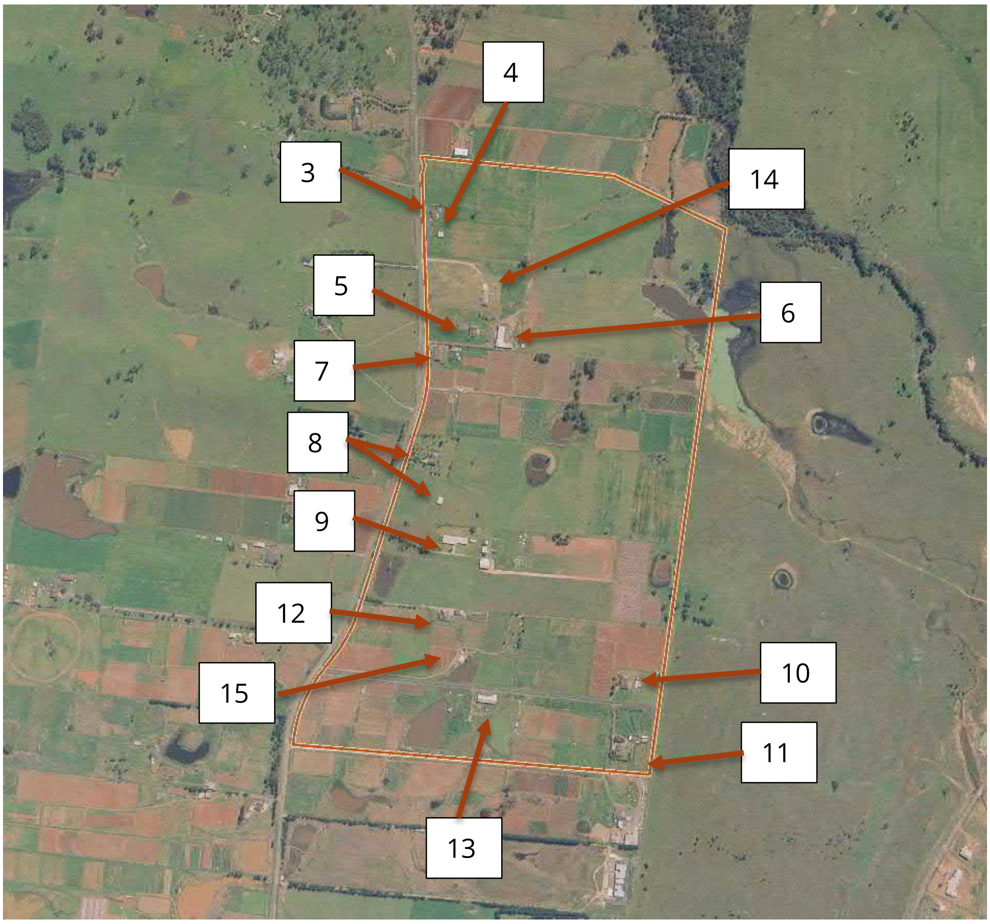


Photo 6 1998 aerial photograph of the study area (Source: NSW aerial imagery)

A current aerial photograph of the study area shows continued development has occurred (Photo 7). A residential property [16] has been constructed in the north western corner of the study area. A pool has been added to a property [14] to the south of this, while the construction of hothouses dominates areas within the central [17] and [18] and southern portion [19] and [20] of the study area. Water tanks have also been developed in the south in addition to small sheds in the south west.

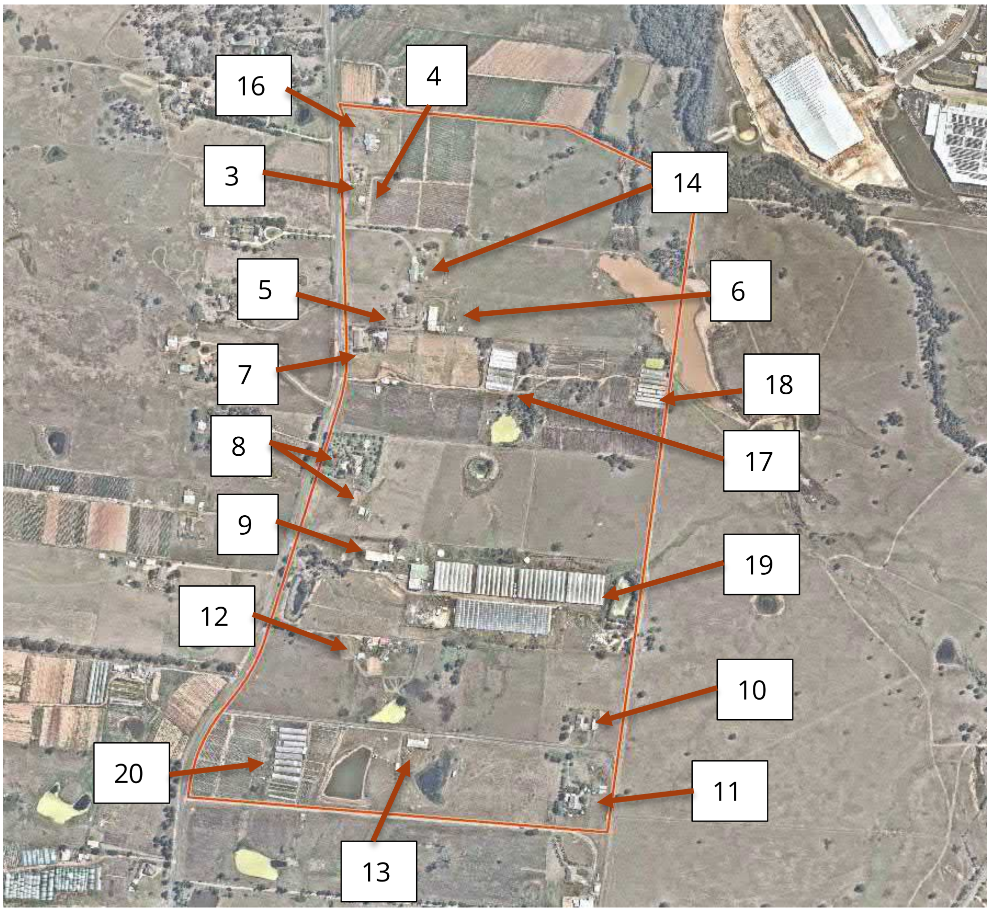


Photo 7 **A current aerial photograph with the study area outlined in red (Source: Department of Customer Service)**

3.4 Chronology of the study area

Based upon the historical research presented it is possible to summarise the chronology of the study area, this is presented in Table 2.

Table 2 **Chronological development of the study area**

No.	Building	Date
1	Transmission line	1963
2	Fence line	Pre 1970
3	Residential property in north-west	Pre 1986
4	Sheds associated with residential property in north-west	Pre 1986
5	Residential property in north west	Pre 1986
6	Large shed associated with residential property	Pre 1986
7	Residential property in central-west and associated structures	Pre 1986
8	Residential property in central-west and associated structures	Pre 1986
9	Residential property in central-west and associated structures	Pre 1986

No.	Building	Date
10	Residential property in south and associated structures	Pre 1986
11	Residential property in south and associated structures	Pre 1986
12	Residential property in south and associated structures	Pre 1986
13	Large shed in south	Pre 1986
14	Residential property in north-west	Pre 1998
15	Shed in central-south	Pre 1998
16	Residential property in north-west	Pre 2020
17	Hot house in centre	Pre 2020
18	Hot house in east	Pre 2020
19	Hot house in south-east	Pre 2020
20	Hot house in south-west	Pre 2020

3.5 Research themes

Contextual analysis is undertaken to place the history of a particular site within relevant historical contexts in order to gauge how typical or unique the history of a particular site actually is. This is usually ascertained by gaining an understanding of the history of a site in relation to the broad historical themes characterising Australia at the time. Such themes have been established by the Australian Heritage Commission and the Heritage Office and are outlined in synoptic form in Historical Themes.[36]

There are 38 State historical themes, which have been developed for NSW, as well as nine National historical themes. These broader themes are usually referred to when developing sub-themes for a local area to ensure they complement the overall thematic framework for the broader region.

A review of the contextual history in conjunction with the local historical thematic history has identified two historical themes which relates to the occupational history of the study area.[37] This is summarised in Table 3.

Table 3 Identified historical themes for the study area

Australian theme	NSW theme	Local theme
Developing local, regional and national economies	Agriculture	Activities relating to the cultivation and rearing of plant and animal species, usually for commercial purposes, can include aquaculture
Developing Australia's cultural life	Domestic life	Activities associated with creating, maintaining, living in and working around houses and institutions.

[36] NSW Heritage Council 2001
[37] Kass 2005

4 Physical inspection

A physical inspection of the study area was undertaken on 13 August 2020, attended by Biosis Archaeologist Mathew Smith. The principal aims of the survey were to identify heritage values associated with the study area; this included any heritage items and places (Heritage items can be buildings, structures, places, relics or other works of historical, aesthetic, social, technical/research or natural heritage significance. 'Places' include conservation areas, sites, precincts, gardens, landscapes and areas of archaeological potential).

4.1 Site setting

The study area consists of seven lots located across undulating hills and slopes which gradually descends towards unnamed tributaries of Ropes Creek in the north-east and Kemps Creek in the south. It is bordered on its west by Aldington Road, with alluvial flats to the east (Photo 8). The study area consists primarily of cleared paddocks, market gardens, and scattered residential dwellings. These residential dwelling are primarily located on the western side of the study area, near to road access, although two residential dwellings are located on the eastern boundary in the southern section of the study area. The study area appears to have been used primarily for grazing and agricultural practices, with sheep livestock, orcharding and market gardening observed (Photo 9).

Photo 8 East views from study area out across alluvial flats

Photo 9 Photo showing example of orcharding occuring in study area, photo facing east

4.2 Built fabric assessment

A number of modern structures and elements of the built environment were present within the study area, reflecting the relatively recent development of the study area. The primary built elements consisted of fronted brick veneer residential dwellings which are common across Western Sydney. Roofing styles were a mixture of hipped, gable and hip and gable combinations with roof cladding consisting of tiles primarily, although the most modern house in the study area displayed corrugated sheet roof cladding (Photo 10 and Photo 11).

Photo 10 Modern brick veneer house in the northern extent of the study area with gable sheet metal roof, photo facing east.

Photo 11 1970s hipped brick veneer house and shed in southern extent of the study area, photo facing south west

A number of sheds were present throughout the study area reflecting the semi-rural nature of land use. These sheds were primarily constructed of corrugated sheet metal and timber (Photo 12). The study area also featured temporary market garden structures showcasing the modern agricultural uses (Photo 13).

Photo 12 Modern corrugated steel farm shed, photo facing south east

Photo 13 Temporary market garden structures, photo facing south east

5 Archaeological assessment

The potential archaeological resource relates to the predicted level of preservation of archaeological resources within the study area. Archaeological potential is influenced by the geographical and topographical location, the level of development, subsequent impacts, levels of onsite fill and the factors influencing preservation such as soil type. An assessment of archaeological potential has been derived from the historical analysis undertaken during the preparation of this report.

5.1.1 Archaeological resource

The potential archaeological resource relates to the predicted level of preservation of archaeological resources within the study area. Archaeological potential is influenced by the geographical and topographical location, the level of development, subsequent impacts, levels of onsite fill and the factors influencing preservation such as soil type. An assessment of archaeological potential has been derived from the historical analysis undertaken during the preparation of this report.

Background research undertaken for the project did not identify any existing or potential heritage items within the study area. Review of Crown plans and aerial imagery indicated that no physical structures were constructed in the study area until after 1970, with the primary use up until then low intensity agricultural use. As a result the only potential archaeological resource in the area would be associated with the agricultural activities undertaken in the study area and could include fence lines and post holes, and agricultural marks such as plough lines.

The results of the field survey confirm this as built structures in the study area are typical of post 1970s brick veneer architecture that is common throughout Western Sydney. The study area has also been used for market gardens, orcharding and stock grazing continuously from the 1970 until the present, resulting in large areas of ground disturbance and removal of potential archaeological resources associated with agricultural uses.

5.1.2 Research potential

Archaeological research potential refers to the ability of archaeological evidence to provide information about a site that could not be derived from any other source and which contributes to the archaeological significance of that site. Archaeological research potential differs from archaeological potential in that the presence of an archaeological resource (i.e. archaeological potential) does not mean that it can provide any additional information that increases our understanding of a site or the past (i.e. archaeological research potential).

The research potential of a site is also affected by the integrity of the archaeological resource within a study area. If a site is disturbed, then vital contextual information that links material evidence to a stratigraphic sequence may be missing and it may be impossible to relate material evidence to activities on a site. This is generally held to reduce the ability of an archaeological site to answer research questions.

Assessment of the research potential of a site also relates to the level of existing documentation of a site and of the nature of the research done so far (the research framework), to produce a 'knowledge' pool to which research into archaeological remains can add.

Agriculture

Archaeological remains that may be present which fall under the research theme of agriculture include agricultural marks, such as plough lines and hoe marks, and post holes. While there may be multiple fence lines and post holes present due to the numerous subdivisions, it is unlikely these archaeological remains will contribute any information that is not already known about this area as these land divisions have been well documented on certificate of titles. The study area has also been used for market gardens and orchards since the 1970s resulting in significant disturbances across the study area.

Domestic life

The history of the study area indicates it was used primarily for agricultural purposes after the initial grant, going through several land holder changes until subdivision into 20 acre lots in the early 20th century. No residential development occurred in the study area until after 1970, by which time the lives of western Sydney residents were becoming well documented in newspapers and other historical sources. The residential buildings constructed in the study area are all still in use and represent the brick veneer house types common across western Sydney. The study area would therefore contribute no information that is not currently available.

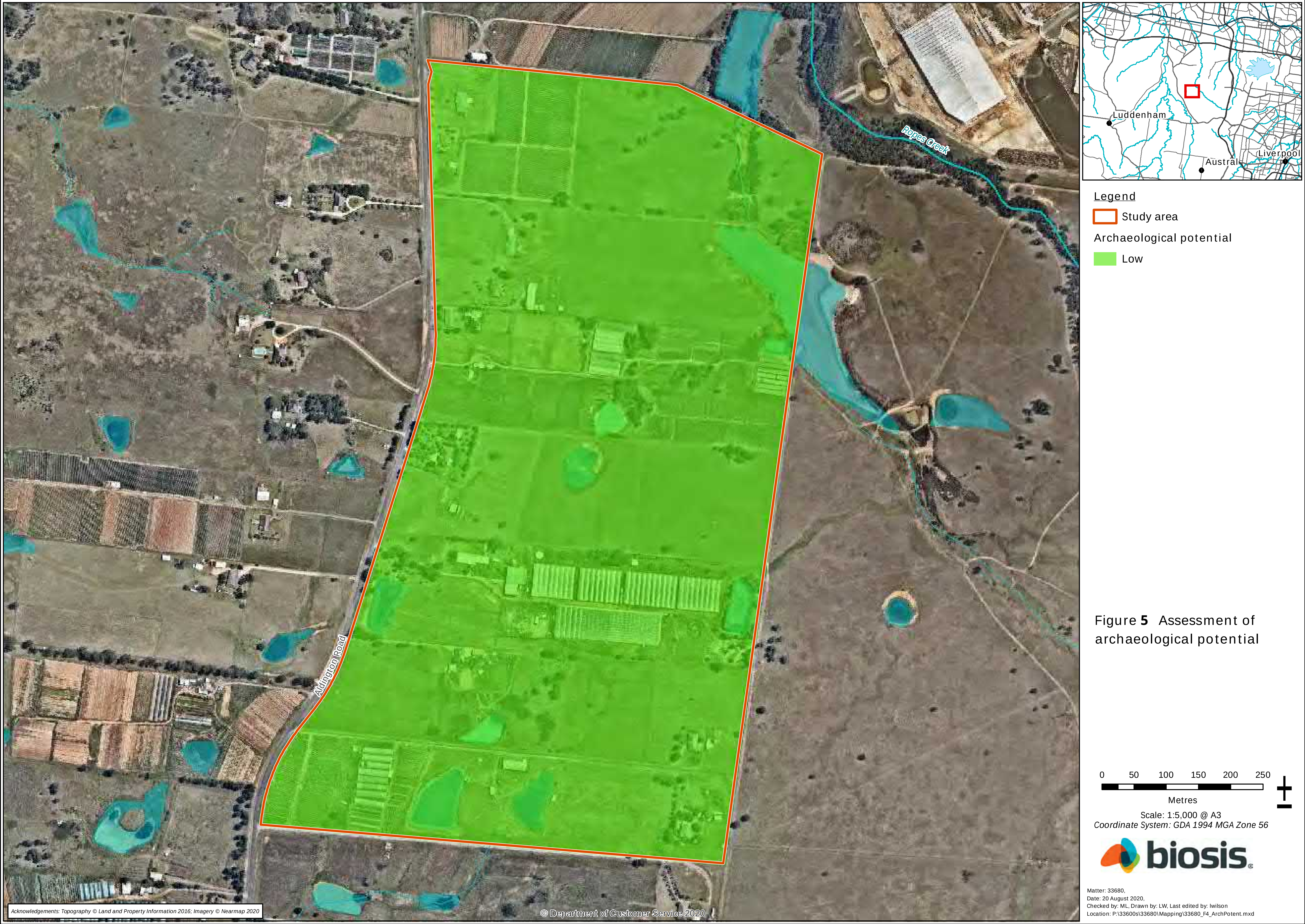
5.1.3 Summary of archaeological potential

Through an analysis of the above factors a number of assumptions have been made relating to the archaeological potential of the study area that is presented in Figure 5.

The assessment of archaeological potential has been divided into three categories:

- **High archaeological potential** – based upon the historical context and documentary evidence presented within this report there is a high degree of certainty that archaeologically significant remains relating to this period, theme or event will occur within the study area.
- **Moderate archaeological potential** – based upon the historical context and documentary evidence presented within this assessment it is probable that archaeological significant remains relating to this period, theme or event could be present within the study area.
- **Low archaeological potential** – based upon the historical context and documentary evidence presented within this assessment it is unlikely that archaeological significant remains relating to this period, theme or event will occur within the study area.

Based upon the historical context and documentary evidence presented within this assessment it is unlikely that the study area contains any archaeologically significant remains which have research potential. Therefore the archaeological potential of the study area is considered to be low.



Legend

Study area

Archaeological potential

Low

Figure **5** Assessment of archaeological potential

0 50 100 150 200 250

Metres

Scale: 1:5,000 @ A3

Coordinate System: GDA 1994 MGA Zone 56

biosis

Matter: 33680,
Date: 20 August 2020,
Checked by: ML, Drawn by: LW, Last edited by: lwilson
Location: P:\33600s\33680\Mapping\33680_F4_ArchPotent.mxd

6 Significance assessment

An assessment of heritage significance encompasses a range of heritage criteria and values. The heritage values of a site or place are broadly defined as the 'aesthetic, historic, scientific or social values for past, present or future generations.[38] This means a place can have different levels of heritage value and significance to different groups of people.

The archaeological significance of a site is commonly assessed in terms of historical and scientific values, particularly by what a site can tell us about past lifestyles and people. There is an accepted procedure for determining the level of significance of an archaeological site.

A detailed set of criteria for assessing the State's cultural heritage was published by the (then) NSW Heritage Office. These criteria are divided into two categories: nature of significance, and comparative significance.

Heritage assessment criteria in NSW fall broadly within the four significance values outlined in the Burra Charter. The Burra Charter has been adopted by state and Commonwealth heritage agencies as the recognised document for guiding best practice for heritage practitioners in Australia. The four significance values are:

- Historical significance (evolution and association).
- Aesthetic significance (scenic/architectural qualities and creative accomplishment).
- Scientific significance (archaeological, industrial, educational, research potential and scientific significance values).
- Social significance (contemporary community esteem).

The NSW Heritage Office issued a more detailed set of assessment criteria to provide consistency with heritage agencies in other States and to avoid ambiguity and misinterpretation. These criteria are based on the Burra Charter. The following SHR criteria were gazetted following amendments to the Heritage Act that came into effect in April 1999:

- Criterion (a) - an item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).
- Criterion (b) - an item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area).
- Criterion (c) - an item is important in demonstrating the aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area).
- Criterion (d) - an item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.
- Criterion (e) - an item has potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area).
- Criterion (f) - an item possesses uncommon, rare or endangered aspects of NSW's cultural or natural history (or the cultural or natural history of the local area).

[38] Heritage Office 2001

- Criterion (g) - an item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places; or cultural or natural environments; or a class of the local area's cultural or natural places; or cultural or natural environments.

6.1 Levels of heritage significance

Items, places, buildings, works, relics, movable objects or precincts can be of either local or state heritage significance, or have both local and state heritage significance. Places can have different values to different people or groups.

Local heritage items

Local heritage items are those of significance to the local government area. In other words, they contribute to the individuality and streetscape, townscape, landscape or natural character of an area and are irreplaceable parts of its environmental heritage. They may have greater value to members of the local community, who regularly engage with these places and/or consider them to be an important part of their day-to-day life and their identity. Collectively, such items reflect the socio-economic and natural history of a local area. Items of local heritage significance form an integral part of the State's environmental heritage.

State heritage items

State heritage items, places, buildings, works, relics, movable objects or precincts of state heritage significance include those items of special interest in the state context. They form an irreplaceable part of the environmental heritage of NSW and must have some connection or association with the state in its widest sense.

The following evaluation attempts to identify the cultural significance of the study area. This significance is based on the assumption that the site contains intact or partially intact archaeological deposits.

6.2 Evaluation of significance

Criterion A: An item is important in the course, or pattern, of NSW's cultural or natural history (or the cultural or natural history of the local area).

Archaeological remains that may be present include fence post holes and agricultural marks. However, archaeological remains such as these are unlikely to be of importance in the pattern of NSW's cultural history.

The current structures in the study area are a combination of residential and rural (sheds etc.) which were constructed and altered post 1970s. Structures such as these are common throughout the Western Sydney region and the history does not indicate that they are particularly important in the course, or pattern, of NSW's cultural history.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

Criterion B: An item has strong or special association with the life or works of a person, or group of persons, of importance in NSW's cultural or natural history (or the cultural or natural history of the local area).

The study area formed a part of the 1070 acre land grant to Nicolas Bayly in 1810, which was then acquired by Richard Jones in 1826 following Bayly's death. The land was then subdivided in 1891 but sales did not commence until the 1930s. The land was used for pastoral and agricultural uses; however there are no special associations relating to tenure of the land by Bayly, Jones or subsequent owners and the historical research did not indicate the study area had any association with anyone of importance in NSW's cultural history, or the history of the local area.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

The study area does not satisfy this criterion at a local or state level.

Criteria C: An item is important in demonstrating aesthetic characteristics and/or a high degree of creative or technical achievement in NSW (or the local area).

Archaeological remains that may be present include fence post holes and agricultural marks. Archaeological remains such as these would not demonstrate aesthetic characteristics of a high degree of creative or technical achievement in NSW or the local area.

The current structures in the study area are a combination of residential and rural (sheds etc.) which were constructed and altered post 1970s. The majority of these are brick veneer houses and corrugated sheet metal sheds which do not demonstrate aesthetic characteristics and/or a high degree of creative or technical achievement in NSW.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

Criterion D: An item has strong or special association with a particular community or cultural group in NSW (or the local area) for social, cultural or spiritual reasons.

While no community consultation has been undertaken for this report, the history has not indicated that the potential archaeological remains or current structures would have an association with a particular community or cultural group in NSW or the local area.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

Criterion E: An item has the potential to yield information that will contribute to an understanding of NSW's cultural or natural history (or the cultural or natural history of the local area).

Archaeological remains that may be present include fence post holes and agricultural marks. Archaeological remains such as these are not uncommon in a study area which has been used for agricultural purposes.

The current structures in the study area are a combination of residential and rural (sheds etc.) which were constructed and altered post 1970s. It is unlikely that these structures, which are still found throughout Western Sydney would have the potential to yield information that will contribute to an understanding of NSW's cultural or natural history.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

Criterion F: An item possesses uncommon, rare or endangered aspects of the area's cultural or natural history (or the cultural or natural history of the local area).

Archaeological remains that may be present include fence post holes and agricultural marks. Archaeological remains such as these are not uncommon in a study area which has been used for agricultural purposes.

The current structures in the study area are a combination of residential and rural (sheds etc.) which were constructed and altered post 1970s. Structures such as these are common throughout the Western Sydney region and are not uncommon, rare or endangered aspects of the area's cultural or natural history.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

Criterion G: An item is important in demonstrating the principal characteristics of a class of NSW's cultural or natural places, or cultural or natural environments (or a class of the local area's cultural or natural places, or cultural or natural environments).

The history has not indicated that the types of archaeological remains present across the study area or current built structures within the study area would be important in demonstrating the principal characteristics of a class of NSW's cultural places or environments.

The potential archaeological remains and built structures do not satisfy this criterion at a local or state level.

6.1 Statement of significance

6.1.1 Statement of significance

Based upon the evaluation criteria outlined above the following statement of significance has been formulated for the study area:

The study area forms a small part (80 acres) of the larger 1070 acre land grant given to Nicholas Bayly in 1810. Following Nicholas Bayly's death in 1823, the study area was then acquired by Richard Jones in 1826, and became known as Fleurs Estate. No evidence has been uncovered that the study area was used by Bayly or Jones for any specific purpose; however it is likely that it was used for farming and/or grazing purposes.

The land was subdivided into 20 acre farms in 1891, with sales beginning in the 1930s. From this point, the study area was likely utilized for grazing purposes, but it was not until after 1970 that scattered residential development occurred in the study area, resulting in intense market garden farming and orcharding.

This assessment has not revealed any evidence of items, activities, or events occurring within the study area which are historically significant, either to the local area or NSW. Archaeological remains that may be present within the study area are likely to include fence post holes and agricultural marks which hold no research potential and are unlikely to provide information that is of importance in the pattern of NSW's cultural history at a state or local level. The study area is not associated with a significant figure or community group within the local area and possesses low aesthetic value.

7 Conclusions and recommendations

7.1 Conclusions

The study area formed a part of an initial land grant to Nicolas Bayly in 1810, which was then acquired by Richard Jones in 1826 following Bayly's death. The land was then subdivided in 1891 but sales did not commence until the 1930s. The land was likely used for pastoral and agricultural uses in this time, but no residential structures were constructed in the study area until after the 1970s. Following the residential development of the study area, intense orcharding and market gardening occurred resulting in large disturbances to the study area.

The potential archaeological remains in the study area are associated with agriculture and domestic themes. Archaeological evidence associated with this theme within the study area may include agricultural marks and post holes; although, the high levels of disturbance from the continuous use of the study area since the 1970s for market gardening makes it unlikely these remains will still be present in the study area.

The archaeological evidence associated with the domestic theme include current residential and rural structures such as sheds and houses. Historical research and a field survey have identified that these structures have been constructed post 1970s and are common element still present throughout the Western Sydney region. These structures would not contribute information that is not already available and are of low significance.

7.2 Recommendations

These recommendations have been formulated to respond to client requirements and the significance of the site. They are guided by the ICOMOS *Burra Charter* with the aim of doing as much as necessary to care for the place and make it useable and as little as possible to retain its cultural significance.[39]

Recommendation 1: The proposed works may proceed with caution

There are no recorded items of heritage significance in or adjacent to the study area. Works can proceed in the study area with caution as it has been assessed as possessing low archaeological potential. Should unexpected archaeological remains be uncovered during the course of the proposed works, Recommendation 2 should be implemented.

Recommendation 2: Discovery of unanticipated historical relics

Relics are historical archaeological resources of local or State significance and are protected in NSW under the Heritage Act. Relics cannot be disturbed except with a permit or exception/exemption notification. Should unanticipated historical archaeology be discovered during the course of the project, work in the vicinity must cease and an archaeologist contacted to make a preliminary assessment of the find. The Heritage Council will require notification if the find is assessed as a relic.

[39] Australia ICOMOS 2013

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Appendix F

Construction Erosion and Sediment Control Plans

Primary erosion and sediment control plan

200 Aldington Road Industrial Estate Kemps Creek

Prepared for Fife Kemps Creek Limited

April 2022

EMM Newcastle
Level 3, 175 Scott Street
Newcastle NSW 2300

T 02 4907 4800
E info@emmconsulting.com.au

www.emmconsulting.com.au

Primary erosion and sediment control plan

200 Aldington Road Industrial Estate Kemps Creek

Report Number

E220208 RP#1

Client

Fife Kemps Creek Limited

Date

22 April 2022

Version

v2 Draft

Prepared by	**Approved by**
Michael Frankcombe	**Amanda Weston**
National Technical Leader - Land, Water and Rehabilitation	Team Leader - Land and Rehabilitation
d mmmm yyyy	d mmmm yyyy

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Appendices

Tables

Figures

1 Introduction

1.1 Background

The site is located approximately 4 kilometres (km) north-west of the Western Sydney Airport (currently under construction), 13 km south-east of the Penrith CBD and 40 km west of the Sydney CBD.

This Primary Erosion and Sediment Control Plan forms a Request for Additional Information for the proposed Concept State Significant Development Application for a new industrial estate on land at 106 – 228 Aldington Road, Kemps Creek.

The EIS for the project was placed on public exhibition between 18 November 2020 and 15 December 2020. During this period, a total of 18 submissions were received. These submissions were addressed and subsequent amendments to the project were made, as outlined in the Response to Submissions Report (dated 23 March 2021) prepared by Ethos Urban.

In written correspondence dated 28 April 2021, it was requested that FKC provide a further response to additional commentary raised by DPE, as well as additional comments raised by public authorities in their review of the first Response to Submissions Report. This was responded to via a second a Response to Submissions Report outlined by Ethos Urban (dated 22 September 2021).

Additional correspondence was received from DPE dated 15 November 2021 which has necessitated updates and additional information, as contained within this report.

1.2 Summary of the project for which development consent is now sought

Consent is sought for the following development. It represents minor amendments and does not represent a significant material change to what was previously proposed under the second RTS Report (22 September 2021).

A concept masterplan with an indicative total building area of 342,865 sqm, comprising:

- 325,865 sqm of warehouse gross floor area (GFA);
- 17,010 sqm of ancillary office GFA;
- 13 individual development lots for warehouse buildings with associated hardstand areas and two lots for water management infrastructure purposes (each including a bio-retention basin);
- roads, including:
  - internal road layouts;
  - southern road connection to Aldington Road;
  - northern boundary road (half road corridor) connecting to Aldington Road;
  - road connections to adjoining landholdings to the north and east;
- provision for 1,517 car parking spaces;
- associated concept site landscaping;

- detailed consent for progressive delivery of site preparation, earthworks and infrastructure works (ie Stage 1 works) on the site, including:
  - demolition and clearing of all existing built form structures;
  - drainage and infill of existing farm dams and any ground dewatering;
  - clearing of existing vegetation;
  - subdivision of the site into 15 individual lots;
  - construction of a warehouse building with a total of 50,300 sqm of GFA, including:
  - 47,800 sqm of warehouse GFA;
  - 2,500 sqm of ancillary office GFA; and
  - 222 car parking spaces;
- bulk earthworks including 'cut and fill' to create level development platforms for the warehouse buildings, and site stabilisation works (if required);
- roadworks and access infrastructure, including an interim access road and a temporary junction with Aldington Road;
- stormwater works including stormwater basins, diversion of stormwater;
- utilities services including sewer and potable water reticulation; and
- Road and boundary retaining walls.

The project layout is shown in Figure 1.1.

The proposed construction works will involve disturbance of the entire project area which will expose soil to the erosive forces of wind and water however the potential impacts to soil and water can be suitably mitigated by the correct implementation of the control measures described in this Primary ESCP.

1.3 Scope

This Primary Erosion and Sediment Control Plan (Primary ESCP) has been prepared to describe the overarching soil and water management design approach for the development and to provide erosion and sediment control guidance and standards for the contractors that will construct the development. It specifically addresses the requirements of SSD10479, *Western Sydney Employment Area Mamre Road Precinct Development Control Plan 2021* (DPIE 2021) (DCP) and *Managing Urban Stormwater Soil and Construction Volume 1* 4th edition (Landcom 2004) that are relevant to this phase of the project.

It includes plans showing indicative drainage, erosion and sediment control measures for the following project development phases:

- demolition;
- construction; and

- building.

The final sizing and location of drainage, erosion and sediment control measures will be dependent on the contractors proposed construction sequencing and will be detailed in the contractors Progressive Erosion and Sediment Control Plans (PESCP's).

1.3.1 Objectives

The objectives of this Primary ESCP are to:

- minimise potential impacts on receiving land and waters from construction activities and operation of the project;
- conserve and protect site soil resources; and
- ensure compliance with relevant regulatory requirements.

1.4 Approach and document hierarchy

A two-level approach and document hierarchy to erosion and sediment control planning and site water management will be applied to the project, comprising:

- Primary ESCP (this document); and
- stage-specific PESCPs prepared by the demolition and construction contractors.

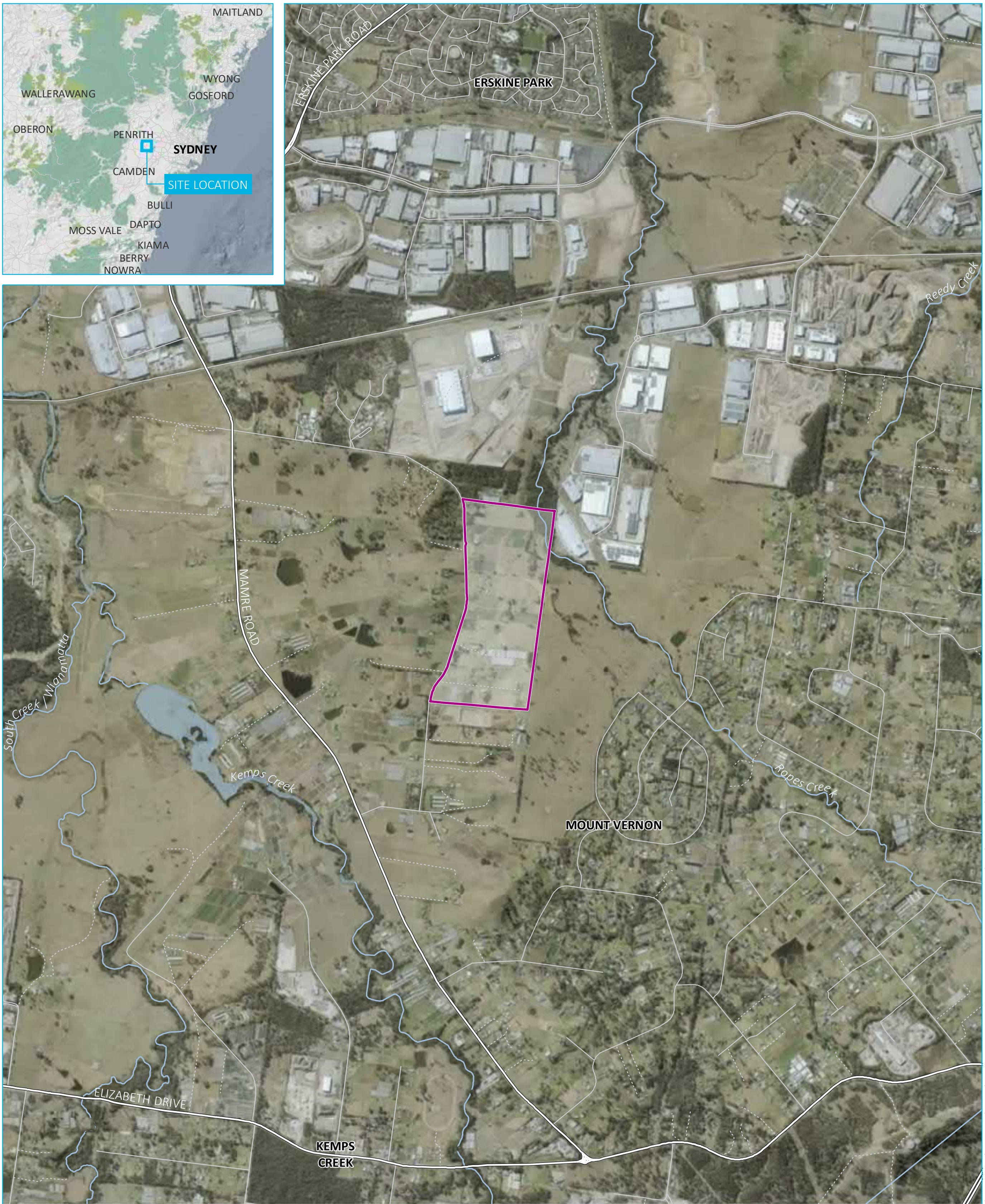
This Primary ESCP for the project provides detailed background information, erosion hazard assessment, overall drainage and water management approach, erosion and sediment control approach, design standards and management strategies.

PESCPs will ultimately be prepared for all disturbance areas by contractors Certified Professional in Erosion and Sediment Control (CPESC), prior to disturbance commencing. Each PESCP will address erosion and sediment control for each stage of the project and will be progressively updated as required as construction works progress.

1.5 Document revisions

Changes to the Primary ESCP shall only be implemented with the approval of Fife Kemps Creek Ltd (FKC) CPESC.

This Primary ESCP will be revised to reflect agency comments, monitoring outcomes, lessons learned and as otherwise necessary in accordance with continuous improvement.



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Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

0 0.5 1 km
GDA2020 MGA Zone 56
N

KEY

- Project boundary
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Named waterbody

INSET KEY

- Major road
- NPWS reserve
- State forest

DRAFT

Regional setting

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 1.1

EMM
creating opportunities

2 Legislative and guideline requirements

2.1 General

The project will be undertaken in accordance with all relevant legislation, development approval conditions, permits and licencing requirements, as described in this section.

2.2 Legislation

2.2.1 Environmental Planning and Assessment Act 1079

i State Significant Development 10479

The Ministers conditions of approval have yet to be issued for the project. This Primary ESCP will be updated if required to address the conditions of approvals.

ii Western Sydney Employment Area Mamre Road Precinct Development Control Plan 2021

The DCP has been prepared in accordance with Part 3, Division 3.6 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Environmental Planning and Assessment Regulation 2000* (Regulation). The DCP came into force 19 November 2021.

The requirements of the DCP as it relates to erosion and sediment control and where they have been addressed in the document are provided in Table 2.1.

Table 2.1 DCP erosion and sediment control requirements

Reference	Aspect	Requirements	Where addressed
Section 2.4, Table 5	TSS and pH	All exposed greater 2,500 m^2 must be provided with sediment controls designed, implemented and maintained to a standard achieving at least 80% of the average annual runoff volume of the contributing catchment treated (ie 80% hydrological effectiveness) to 50 mg/L TSS or less, and pH in the range 6.5 – 8.5.	Section 5.3
Section 2.4, Table 5	Stabilisation	Prior to completion of works for the development, and prior to removal of sediment controls, all site surfaces must be effectively stabilised including all drainage systems. An effectively stabilised surface is defined as one that does not, or is not, likely to result in visible evidence of soil loss caused by sheet, rill or gully erosion or lead to sedimentation water contamination.	Sections 5.2, 6.1, 6.3 and 6.4

Table 2.1 DCP erosion and sediment control requirements

Reference	Aspect	Requirements	Where addressed
Section 4.4.2	Erosion and Sediment Control	1. Development applications must include an Erosion and Sediment Control Plan (ESCP) prepared by a Certified Professional in Erosion and Sediment Control (CPESC).	This document
		2. The ESCP is to be implemented under the supervision of a CPESC. The relevant consent authority will require the CPESC to regularly audit and certify that the works are suitable to protect Wianamatta-South Creek and its tributaries, including audit reports.	Section 6.6
		3. Soil erosion and sediment control measures are to be provided on-site before the commencement of any earthworks or development activity, in accordance with the approved ESCP. These must be maintained throughout the course of construction until disturbed areas have ben revegetated and the soil stabilised to the satisfaction of the relevant consent authority.	Section 6
		4. Development is to comply with the construction phase targets in Table 5.	Section 5.3
		5. Erosion and sediment control measures are to be installed in accordance with best practice (including Managing Urban Stormwater – Soils and Construction and Best Practice Erosion and Sediment Control, IECA).	Noted
		6. The ESCP is to consider the following measures:	
		• identify all areas likely to cause pollution of waterways from stormwater run-off and implement appropriate devices to stop the risk of pollution;	Sections 1.1, 6.3 and Appendices A1, A2 and A3
		• divert clean water around the construction site to prevent contamination;	Site topography limits the ability to diver run-on water and the HES basins have been sized accordingly
		• retain as much natural vegetation as possible and limit site disturbance;	Not possible due to the required earthworks however construction of the project will be staged as detailed in section 6.1
		• control stormwater that enters the construction site from upstream;	Site topography limits the ability to diver run-on water and the HES basins have been sized accordingly
		• divert stormwater from undisturbed upper slopes onto stable areas;	Site topography limits the ability to diver run-on water and the HES basins have been sized accordingly
		• retain and stockpile all excavated topsoil for future landscaping;	Section 6.4
		• prevent sediment/silt from entering adjoining property by installing sediment control devices at the low side of sites and wash down areas;	Sections 5.3 and 6.5 and Appendices A1, A2 and A3

Table 2.1 DCP erosion and sediment control requirements

Reference	Aspect	Requirements	Where addressed
		• install high efficiency sediment basins to ensure compliance with the water quality target throughout the construction and building phases;	Sections 5.3 and 6.5 and Appendices A1, A2 and A3
		• provide a single, stabilised entry/exit point to the site;	During demolition works existing driveways will be used for site entry/exit. During construction there will be two main entry/exit points as shown in Appendix A2
		• prevent sediment, including building materials, from reaching the road or stormwater system. Sediment is to be removed by sweeping, shovelling or sponging. Under no circumstances shall sediment be hosed;	Sections 5.3 and 6.5 and Appendices A1, A2 and A3
		• where a work zone permit over public property is applicable, debris control devices are to prevent spillage of building materials into stormwater drains;	Noted
		• compact all drainage lines when backfilling;	Noted
		• connect downpipes to the stormwater system as early as possible;	Section 6.2
		• revegetate all disturbed areas, after on-site works are completed; and	Section 6.4. Refer also to the landscaping plans for the project.
		• maintain all sediment control devices during earthworks and construction.	Sections 6.6, 7.1, 7.2, 7.3 and 7.4

2.2.2 Protection of the Environment Operations Act 1994

The *Protection of the Environment Operations Act 1997* (PoEO Act) establishes offences for polluting the environment and procedures for the granting of licences for environmental protection including waste, air, water, land and noise pollution control. It is an offence to pollute water, air, land, noise and waste. It is also an offence to allow a substance to leak, spill or escape from its container in a manner that results or is likely to result in harm to the environment (s116).

Water pollution is prohibited under section 120 of the PoEO Act.

3 Existing environment

3.1 General

This section provides a brief description of the existing environment relevant to soil and water management.

3.2 Site location and topography

The site is located within Kemps Creek with the Penrith Local Government Area. The site also forms parts of the Mamre Road Precinct which sits within both the Western Sydney Employment Area and the Western Sydney Aerotropolis.

It is located approximately 60 km west of the Sydney CBD and 20 km south-east of the Penrith CBD. It is located on Aldington Road which connects with Mamre Road. Mamre Road provides support connections to the Western Sydney Motoway (M4), the Northern Road and Westlink M7, that allows vehicular connections across Greater Sydney.

The land surrounding the site is generally rural in nature comprising a variety of rural dwellings, rural land, farm dams and scattered vegetation. Proximate to the site, land comprises a range of uses including the Oakdale South industrial estate to the north-east, aged care and retirement village as well as a childcare centre, Trinity Primary School and Emmaus Catholic College to the north-west. An established residential housing community is located approximately 600 m to the east of Mount Vernon.

The site comprises an undulating topography, with high points in the north-western portion (86 m AHD) and south-eastern portion (86 m AHD), and a northwest/southwest ridge through the middle. From the ridge line, the topography slopes down towards the north-eastern site boundary to 62 m AHD and the southwestern site boundary to 60 m AHD (Figure 3.1). The topographical slope at the site ranges from 0 to 20 degrees.

3.3 Soil landscapes

Soil landscape mapping for the western Sydney area was done by Bannerman and Hazelton (1990) presented as the 'Soil Landscapes of the Penrith 1:100,000 sheet'. With reference to the NSW Soil and Land Information (SALIS) System (DPIE 2015-2020) through the 'eSPADE' Soil Profile Database (Version 2.0, OEH 2016) the soil landscape unit mapped for the site are the Blacktown soil landscape, Luddenham soil landscape and South Creek soil landscape. (OEH 2019) as described in Table 3.1 and shown in Figure 3.2.

Table 3.1 Soil landscape units applicable to the project site

Soil landscape unit	Description
Blacktown (bt)	• Landscape – gently undulating rises on Wianamatta Group shales. Local relief to 30 m, slopes usually >5%. Broad rounded crests and ridges with gently inclined slopes. Cleared Eucalypt woodland and tall open forest (dry schlerophyll). • Soils – typically shallow to moderately deep (>100 cm) hard setting mottled texture contrast soils, red and brown podzolic soils (Dr3.21, Dr3.31, Db2.11, Db2.21) on crests grading to yellow podzolic soils (Dy2.11, Dy3.11) on lower slopes and in drainage lines. • Limitations – localised seasonal waterlogging, localised water erosion hazard, moderately reactive highly plastic subsoil, localised surface movement potential. • Development – high capability for urban development with appropriate foundation design. Small portions of this landscape not yet urbanised are capable of sustaining cultivation and grazing.

Table 3.1 Soil landscape units applicable to the project site

Soil landscape unit	Description
Luddenham (lu)	• Landscape – undulating to rolling low hills on Wianamatta Group shales, often associated with Minchinbury Sandstone. Local relief 50-80 m, slope 5-20%. Narrow ridges, hillcrests and valleys. Extensively cleared tall open forest (wet sclerophyll). • Soils – shallow (<100 cm) dark Podzoloic Soils (Dr2.11, Dr2.41, Dr3.11) on upper slopes; moderately deep (<150 cm) Yellow Podzolic Soils (Dy4.22) and Prairie Soils (Gn3.26) on lower slopes and drainage lines. • Limitations – water erosion hazard, localised steep slopes, localised mass movement hazard, localised shallow soils, localised surface movement potential, localised imperable highly plastic subsoil, moderately reactive.
South Creek (sc)	• Landscape – floodplains, valley flats and drainage depressions of the channels on the Cumberland Plain. Usually flat with incised channels; mainly cleared. Flat to gently sloping alluvial plain with occasional terraces or levees providing low relief. Slopes <5%. Local relief <10 m. • Soils – often very deep layered sediments over bedrock or relict soils. Where pedogenesis has occurred structured plastic clays (Uf6.13) or structured loams (Um6.1) in and immediately adjacent to drainage lines; red and yellow podzolic soils (Dr5.11, Dy2.41, Dr2.21) are most common terraces with small areas of structured grey clays (Gn4.54), leached clay (Uf4.42) and yellow solodic soils (Dy4.42, Dy5.23). • Limitation – flood hazard, seasonal waterlogging, localised permanently high watertables, localised water erosion hazard, localised surface movement potential. • Development – not capable of urban development due to flood hazard. Capable of supporting grazing and regular cultivation.

The typical soil profile and dominant soil materials are summarised in Table 3.2. From this information the soils across both soil landscape units can be generally characterised as:

- slightly to strongly acid;
- often hard setting with low permeability and water holding capacity;
- localised saline, sodic subsoils prone to erosion and with low chemical fertility and elevated aluminium; and
- generally low fertility.

Table 3.2 Soil landscape units – soil profile descriptions

Soil Landscape	Dominant Soil Materials	Description
Blacktown (bt)	bt1 – friable brownish black loam	• Occurs as topsoil (A horizon). • Friable brownish black loam to clay loam with moderately pedal subangular blocky structure and rough-faced porous ped fabric. • pH varies from moderately acid (pH 5.5) to neutral (pH 7.0). • **Limitations to development: strongly acid.**
	bt2 – hard-setting brown clay loam	• Occurs as topsoil (A2 horizon). • Brown clay loam to silty clay loam which is hard setting on exposure or when completely dried out. • Apedal massive to weakly pedal structure and slowly porous earthy fabric. Peds when present are weakly developed, subangular blocky and are rough faced and porous. They range in size between 20–50 mm. This material is water repellent when extremely dry. • pH varies from moderately acid (pH 5.0) to slightly acid (pH 6.5). • **Limitations to development: hard-setting, low fertility, strongly acid, high aluminium toxicity.**
	bt3 – strongly pedal, mottled brown light clay.	• Usually occurs as subsoil (B horizon). • Brown light to medium clay with strongly pedal polyhedral or sub-angular to blocky structure and smooth-faced dense ped fabric. • pH varies from strongly acid (pH 4.5) to slightly acid (pH 6.5). • **Limitations to development: high shrink-swell (localised), low wet strength, low permeability, low available water capacity, salinity (localised), sodicity (localised), very low fertility, very strongly acid.**
	bt4 – light grey plastic mottled clay.	• Usually occurs as deep subsoil above shale bedrock (B3 or C horizon). • Plastic light grey silty clay to heavy clay with moderately pedal polyhedral to subangular blocky structure and smooth-faced dense ped fabric. • **Limitations to development: high shrink-swell (localised), low wet strength, stoniness, low available water capacity, salinity (localised), sodicity (localised), low fertility, strongly acid, very high aluminium toxicity, high erodibility.**

Table 3.2 Soil landscape units – soil profile descriptions

Soil Landscape	Dominant Soil Materials	Description
Luddenum	lu1 – Friable dark brown loam	• Occurs as topsoil (A1 horizon). • Dark brown, friable loam, silt loam or silty clay loam with moderate to strong structure and porous rough-faced ped fabric. • Surface condition is distinctly friable but may become hardsetting when compacted and dry. • **Limitations to development: High erodibility and stoniness (localised).**
	lu2 – Hard setting brown clay loam	• Occurs as a topsoil (A2 horizon). • Brown to dull yellowish brown and reddish brown clay loam to reddish brown clay loam to fine sandy clay loam with an apedal massive or weakly pedal; structure and earthy or porous, rough-faced ped fabric. • It is occasionally hardsetting when exposed at the surface. • **Limitation to development: Very hardsetting surface, stoniness (localised), low available water capacity.**
	lu3 – Whole coloured, strongly pedal clay	• Occurs as a subsoil (B horizon). • Reddish brown, bright reddish brown and bright yellowish brown medium clay with strong structure and smooth-faced, dense ped fabric. • pH varies from strongly acidic (pH 4.0) to moderately acidic (pH 5.5). • **Limitations to development: low wet strength, low permeability (localised), low fertility, high shrink-swell (localised), low available water capacity.**
	lu4 – Mottled grey plastic clay	• Occurs as a deep subsoil. • Light grey to light reddish grey with yellow and red mottles (common) medium clay with strongly pedal structure and dense, smooth-ped fabric. • pH ranges from strongly acidic (pH 4.0) to moderately acidic (pH 5.5). • **Limitations to development: low wet strength, low permeability, low available water capacity, stoniness, low fertility, high shrink-swell (localised).**
	lu5 – Apedal brown sandy clay	• Occurs as subsoil (B horizon). • Brown (ranges from dull reddish brown to dull yellowish brown apedal sandy clay to light clay with dense earthy fabric. • pH is moderately acidic (pH 5.0) to neutral (pH 7.0). • **Limitation to development: low wet strength, low fertility, high shrink-swell (localised), very high aluminium toxicity, low available water capacity.**

Table 3.2 Soil landscape units – soil profile descriptions

Soil Landscape	Dominant Soil Materials	Description
South Creek	sc1 – Brown apedal single-grained loam	• Commonly occurs as topsoil (A horizon). • Dull reddish brown to dull yellowish brown sandy loam to sandy clay loam with generally apedal single-grained structure and porous earthy fabric. • pH is usually moderately acidic (pH 5.5) but varies from strongly acidic (pH 4.5) to slightly acidic (pH 6.5). • **Limitations to development: high erodibility.**
	sc2 – Dull brown clay loam	• Occurs as a topsoil (A horizon). • Dull brown (ranges from greyish brown to yellowish brown) clay loam to fine sandy clay loam, usually with apedal massive structure and porous earthy fabric. • pH varies from moderately acidic (pH 5.5) to neutral (pH 7.0). • **Limitations to development: high erodibility (localised), hardsetting surface, strongly acid, low fertility.**
	sc3 – Light Brown clay	• Usually occurs as subsoil (B horizon) • Reddish brown to bright yellowish brown light to medium clay with strongly pedal structure and dense smooth-faced ped fabric. Mottles when they do occur, are yellow or grey and occupy up to 15%of the volume of he material • pH is highly variable, ranging from extremely acid (pH 3.0) to neutral (pH 7.0) • **Limitations to development: shrink-swell potential (localised), stoniness (localised), very high erodibility, saline, low fertility**

3.4 Australian Soil Classification

The ASC scheme (Isbell 2016) is a multi-category scheme with soil classes defined based on diagnostic horizons and their arrangement in vertical sequence as seen in an exposed soil profile.

The Australian soil resource information system (ASRIS) mapping indicates that soil type is present in the project Area, Kurosols (Table 3.3). They have very low agricultural potential due to low chemical fertility and poor soil structure (Gray and Murphy 2002).

The ASC soil map for the project site (from OEH 2017a) is presented in Figure 3.3.

Table 3.3 Summary of regional ASC soil mapping: Greater Luddenham area

Soil Type	ASC description	Agricultural potential
Kurosols (KU/KUn)	• Soils with strong texture contrast between A and *strongly acid B horizons*. • Soils other than Hydrosols with: – with a *clear or abrupt textural B horizon;* and – in which the major part of the upper 0.2 m of the B2t horizon (or the major part of the entire B2t horizon if it is less than 0.2 m thick) is *strongly acid.*	• Generally low agricultural potential. • High acidity, low chemical fertility, generally low water holding capacity. • Frequent sodic conditions (natric great group under the ASC indicates the major part of the upper 0.2 m of the B2 horizon is sodic).

3.5 Hydrologic context

The site comprises pervious surfaces and includes several unnamed first order water courses and farm dams (Figure 3.4). A tributary of Ropes Creek is present in the north-eastern portion of the site. Surface water flows at the site follow the topography, drainage either to the northern or southern catchments (Figure 3.5).

3.5.1 Hydrologic soil group

The hydrologic soil groups (OEH 2017c) present in the Project area are Groups C and D, defined as:

- **Group C**: soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

- **Group D**: soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

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Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

0 250 500 m
GDA2020 MGA Zone 56
N

KEY

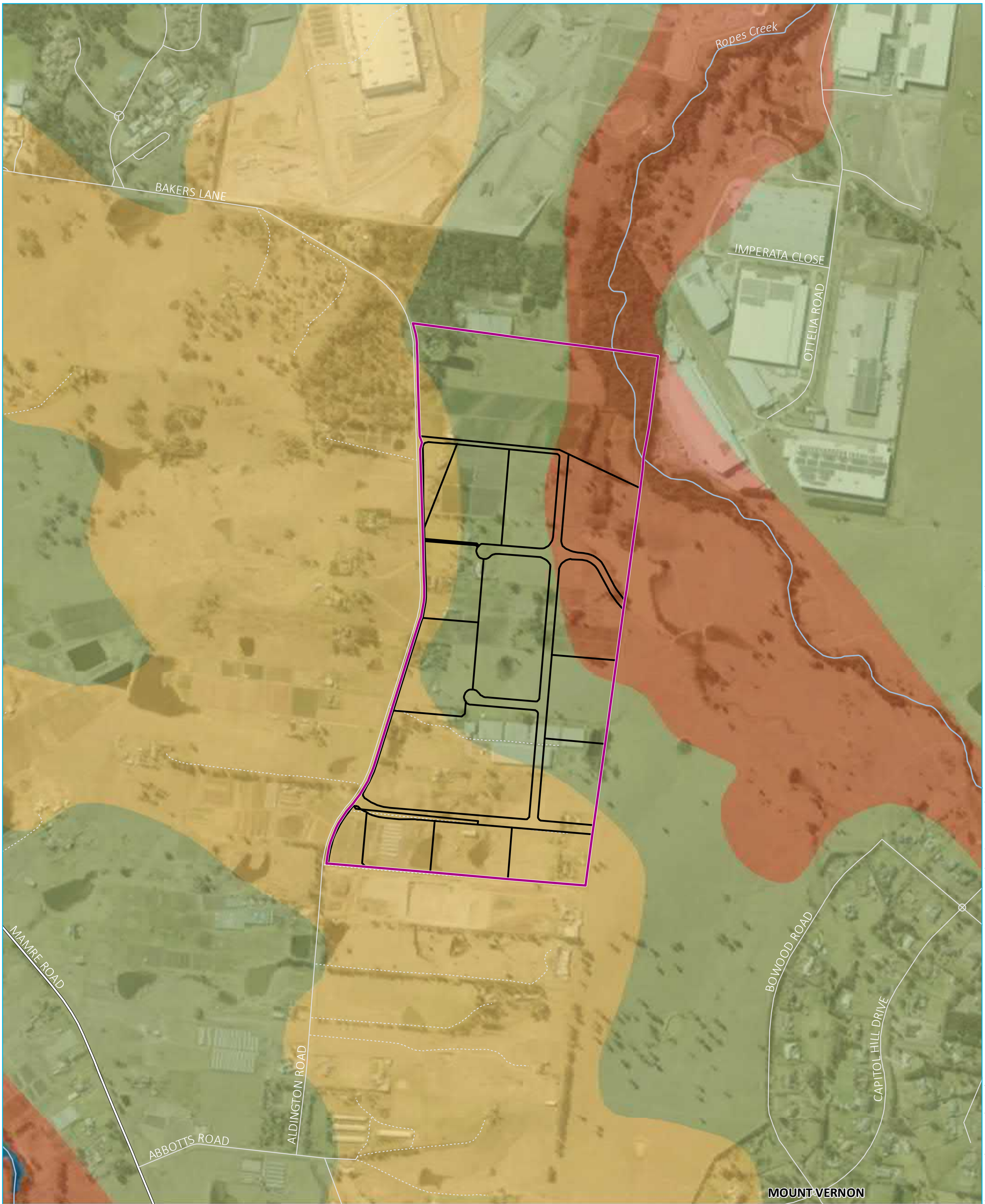
- Project boundary
- Design boundaries
- Topographical contour (2 m)
- Major road
- Minor road
- Vehicular track
- Named watercourse
- Named waterbody

DRAFT

Project topography

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 3.1

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

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KEY

- Project boundary
- Design boundaries
- Major road
- Minor road
- Vehicular track
- Named watercourse

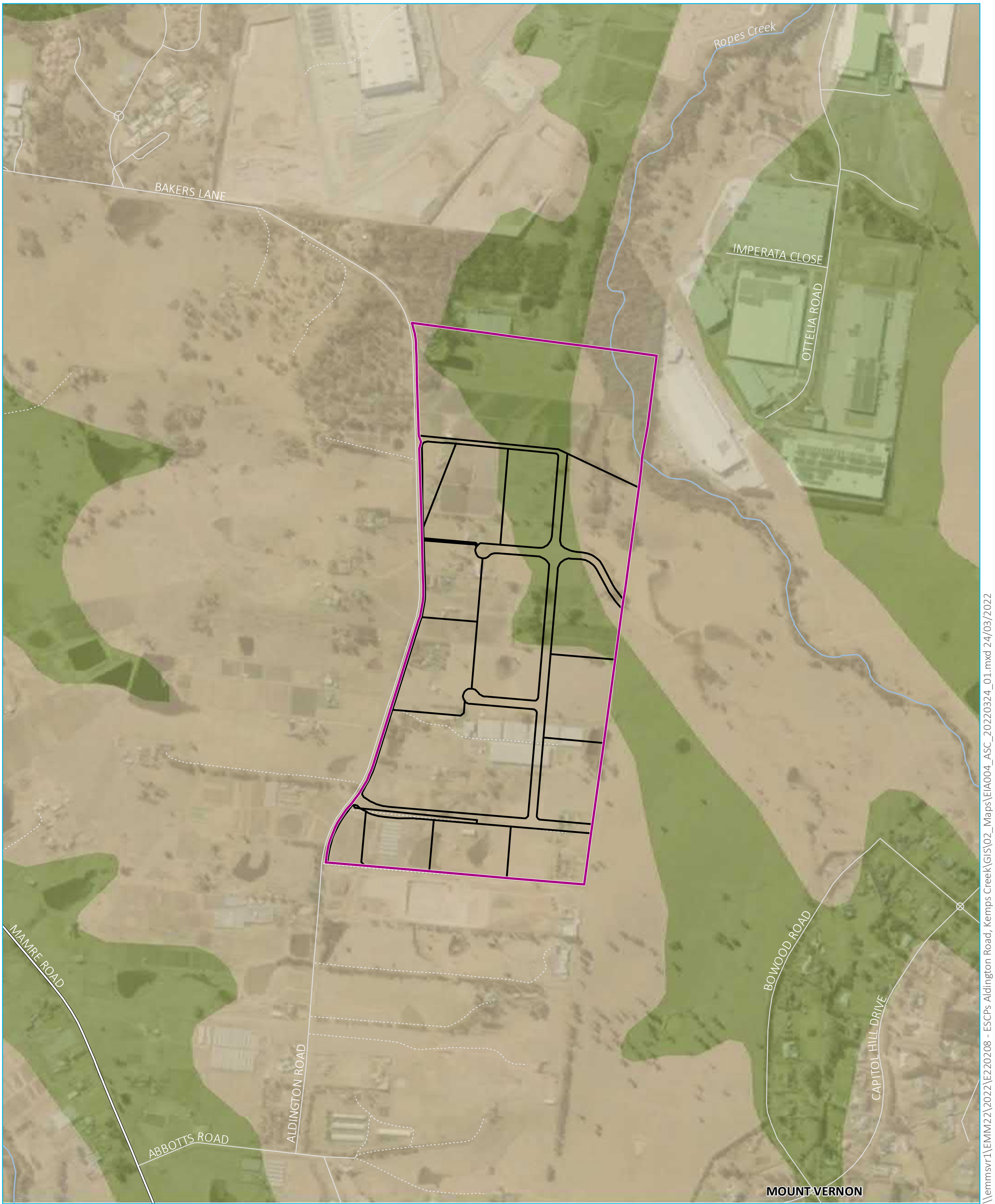
Soil landscape (process)

- Blacktown (residual)
- Luddenham (erosional)
- South Creek (alluvial)
- Water

Project area soil landscapes

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 3.2

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

KEY

- Project boundary
- Design boundaries
- Major road
- Minor road
- Vehicular track
- Named watercourse

Dominant ASC - Order

- Kurosols (KU)
- Kurosols - natric (KUn)

DRAFT

Project areas ASC mapping

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 3.3

EMM
creating opportunities

Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

0 250 500 m
GDA2020 MGA Zone 56
N

KEY

Project boundary

Design boundaries

Minor road

Vehicular track

Named watercourse

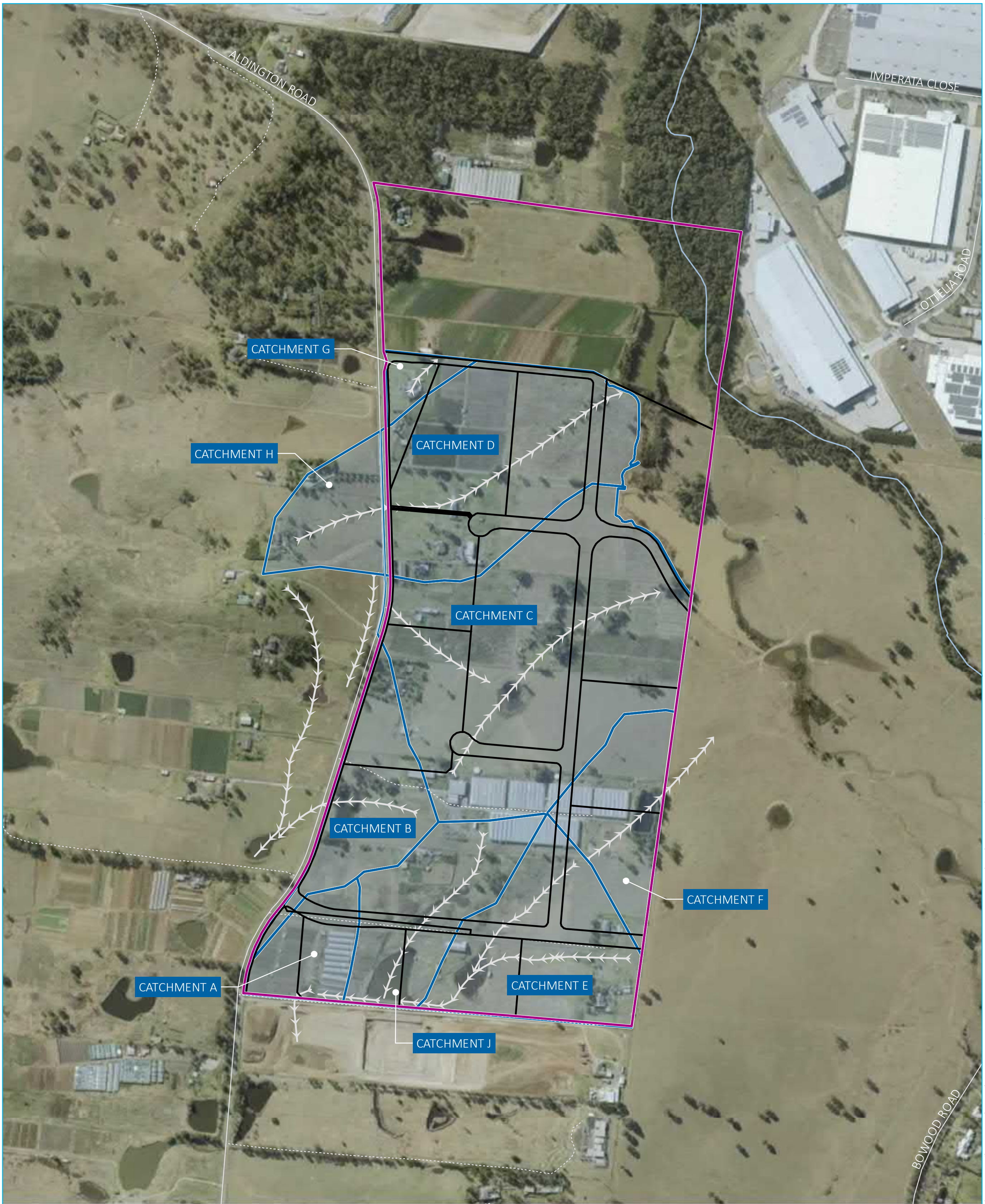
Existing farm dam

Existing farm dam locations

DRAFT

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 3.4

EMM
creating opportunities



Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

0 250 500 m
GDA2020 MGA Zone 56
N

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KEY

- Project boundary
- Design boundaries
- Minor road
- Vehicular track
- Named watercourse
- Catchment flow line
- Stormwater drainage catchment

Project surface water catchments

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 3.5

DRAFT

EMM
creating opportunities

3.6 Climate and rainfall

The climate is typical of that for south-east Australia being temperate with warm to hot summers and mild to cold winters. The long-term maximum average temperature is 23.2° and a long-term average annual rainfall of 756 millimetres (mm) based on data from Badgerys Creek McMasters F.Stn Bureau of Meteorology (BOM) station number 67068 .

The high rainfall erosion hazard (rainfall erosivity) occurs during the summer storm season from November through to March (Figure 3.6).

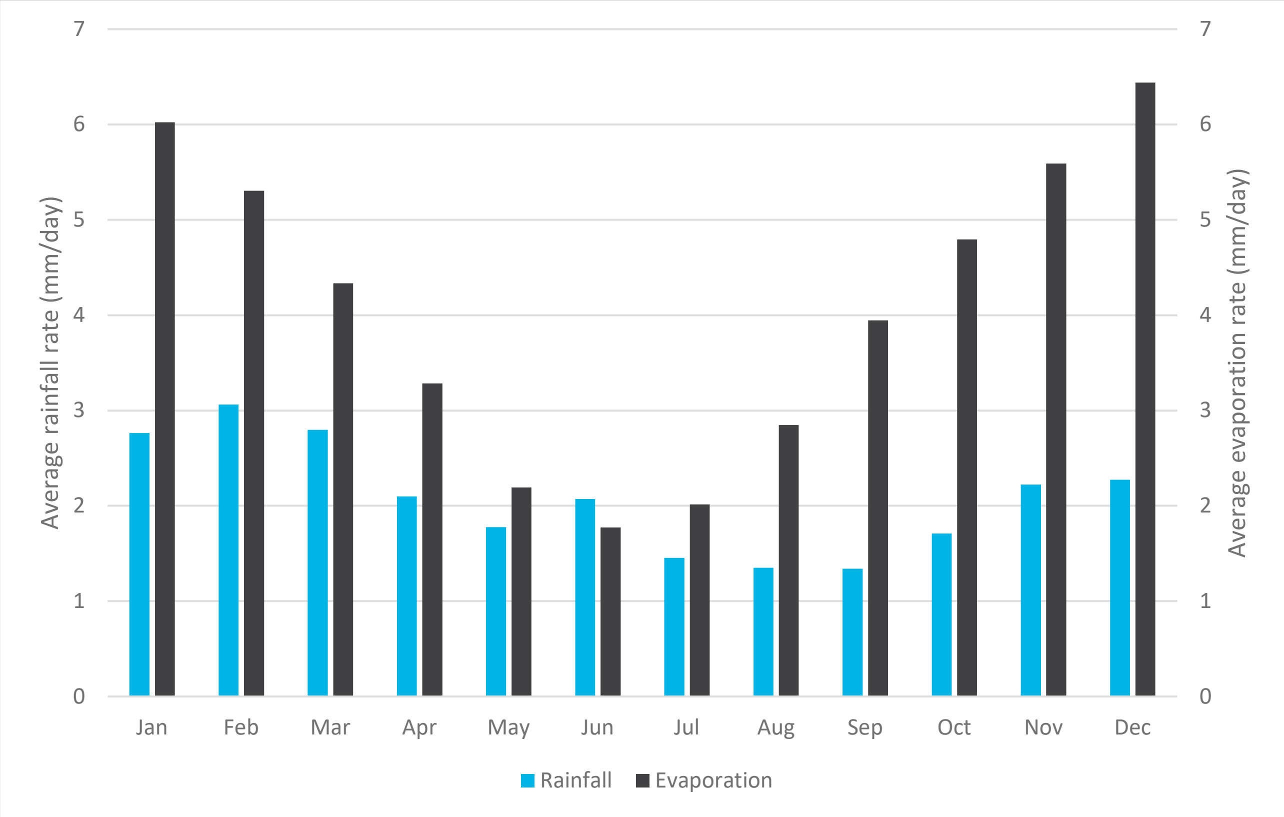


Figure 3.6 Average daily rainfall and evaporation rates (BOM station number 67068)

3.6.1 Rainfall erosivity

Rainfall Erosivity (R-Factor) is a measure of the ability of rainfall to cause erosion and is calculated based on total energy and maximum 30-minute storm intensity (Landcom 2004). It is a multi-annual average index that measures rainfall's kinetic energy and intensity to describe the effect of rainfall on sheet and rill erosion. It can either be interpolated from the R-factor maps in Landcom 2004 or more accurately calculated using the formula:

$$R = 164.74\ (1.1177)^{S}\ S^{0.6444}$$

where, S is the 2-year average recurrence interval (ARI), 6-hour rainfall event (ie 0.5 exceedances per year (EY), 6-hour event) in millimetres per hour (mm/h) (Rosewell & Turner 1992).

For the project S equals 9.13 mm/h.

The calculated R-Factor for the project is 1,892 $MJ.mm.ha^{-1}year^{-1}$.

4 Erosion hazard assessment

The process for the assessment of erosion hazard in NSW is detailed in Section 4.4.1 of Landcom (2004). It is a two-step process that considers overall project erosion hazard via consideration of slope and rainfall erosivity (R-Factor). A more detailed assessment of land soil loss classes (SLCs) is then determined using annual soil loss calculated using the revised universal soil loss equation (RUSLE). Site-specific slopes have been used with a nominal slope length of 80 m. The SLC dictates specific erosion management and mitigation measures as detailed in Landcom (2004).

An assessment of the erodibility of the soil itself is important as the presence or absence of a highly erodible dispersive soil will significantly influence the project drainage, erosion and sediment control requirements.

When a sodic soil (exchangeable sodium percentage (ESP) >6%), or a magnesic soil (exchangeable magnesium percentage (EMP) >20%) contacts non-saline water, water molecules are drawn in between the clay platelets causing the clay to swell to such an extent that individual clay platelets are separated from the aggregate. This process is known as dispersion. Dispersive soils have an extreme rill, gully and tunnel erosion risk and can erode irrespective of surface treatments (e.g., rock lining) applied to the soil surface.

4.1 Soil erosion hazard analysis

Erosion potential of a soil is determined by its physical and chemical properties.

The clay soils of the project area have low surface infiltration rates and potentially sodic and magnesic chemical properties and due to the high vegetation cover, have low water erosion risk provided they are not disturbed. During construction surface soils will be stripped, compacted and have cover removed, increasing erosion risk. Sodic and/or magnesic soils have a higher risk of soil dispersion and increased runoff due to compaction, particularly at depth. Exposed subsoils have high potential to generate highly turbid runoff during rainfall.

As detailed soil sampling for erodibility and agronomic parameters has not been undertaken of the project area, site specific soil erodibility factors (K-factors) have not been determined, however Loch et al (1998) measured and estimated K-Factors for a range of Australian dispersive soils and a K-Factor of 0.071 has therefore been adopted. An assessment of project K-Factors against the Rosewell (1993) soil erosion ranking (Table 4.1) demonstrates a 'high' soil erosion potential.

Table 4.1 Rosewell (1993) Soil Erosion Ranking

K factor (t ha h $ha^{-1}MJ^{-1}mm^{-1}$)	Erosion Potential
<0.02	Low
>0.02 to <0.04	Moderate
>0.04	High

4.2 Slope and rainfall erosion hazard analysis

As detailed above, the overall project water and slope erosion hazard is determined using the process described in Section 4.4.1 of Landcom (2004). If a low erosion hazard is determined, no further delineation of erosion hazard is required. If a high erosion hazard is determined, then further assessment to determine the SLC is required.

SLCs are determined by calculating the annual average soil loss using the Revised Universal Soil Loss Equation (RUSLE) with a nominal 80 m slope length and soil surface cover factor (C-Factor); RUSLE calculates the annual average erosion in tonnes per hectare (t/ha) from rill and inter-rill (sheet) erosion. It does not consider gully or tunnel erosion and does not calculate peak erosion. Section 4.4.2(c) of Landcom (2004) nominates additional requirements for land of SLC 4 and higher.

The first step in the hazard assessment uses a nomograph from Figure 4.6 of Landcom (2004) (reproduced as Figure 4.1) that considers slope of the land and the Rainfall Erosivity (R-Factor) to provide a low or high erosion hazard.

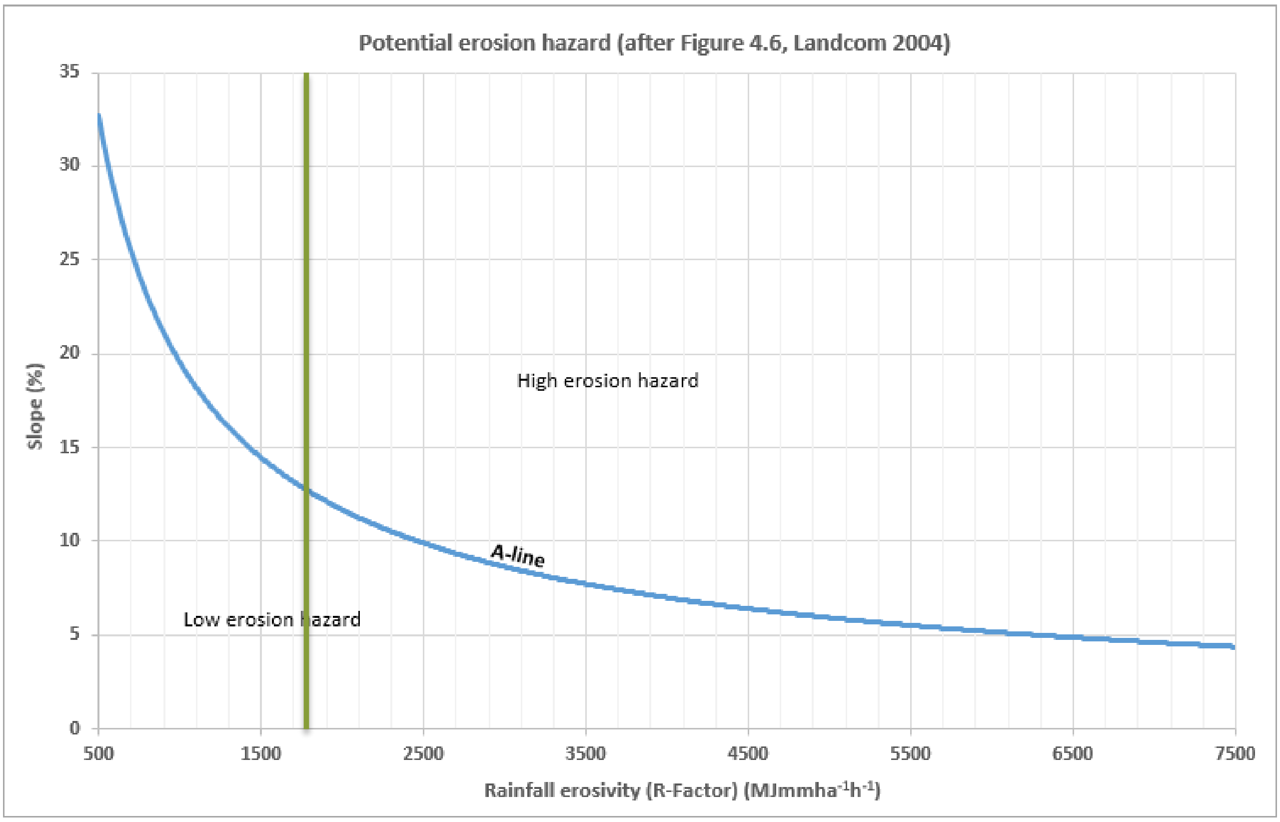


Figure 4.1 Assessment of potential erosion hazard

As detailed in Section 3.6, the calculated R-Factor for the project is 1,892 MJ.mm.ha^{-1}.h^{-1} and the maximum slope is approximately 20° (36.4%), the erosion hazard ranges from low to high depending on slope.

A high erosion hazard requires further detailed assessment in accordance with section 4.4.2 of Landcom (2004) to determine soil loss classes (Table 4.2).

Table 4.2 *Soil loss classes*

Soil Loss Class (SLC)	Calculated soil loss (t/ha/yr)	Erosion hazard
1	0–150	Very low
2	151–225	Low
3	226–350	Low-moderate
4	351–500	Moderate

Table 4.2 *Soil loss classes*

Soil Loss Class (SLC)	Calculated soil loss (t/ha/yr)	Erosion hazard
5	501–750	High
6	751–1,500	Very high
7	>1,500	Extremely high

Adapted from Table 4.2 Landcom (2004)

Figure 4.1 demonstrates that there are lands of both low and high erosion hazard within the project area and therefore determination of soil loss classes is required. Calculated indicative soil loss in t/ha/yr for slopes ranges from 1–40% for the project are provided in Table 4.3.

Table 4.3 Soil loss calculations to determine soil loss classes

Slope %	1	5	10	14	20	25	30
R-Factor (section 3.6.1	1,892	1,892	1,892	1,892	1,892	1,892	1,892
K-Factor (Loch et al. 1998)	0.071	0.071	0.071	0.071	0.071	0.071	0.071
LS-Factor (Landcom 2004)	0.19	1.19	2.81	4.61	7.32	9.51	11.6
Area	1	1	1	1	1	1	1
P-Factor (Landcom 2004)	1.3	1.3	1.3	1.3	1.3	1.3	1.3
C-Factor (Landcom 2004)	1	1	1	1	1	1	1
Soil loss (t/ha/yr)	106	208	491	842	1278	1661	1769
Soil Loss Class (SLC)	1	2	4	6	6	7	7

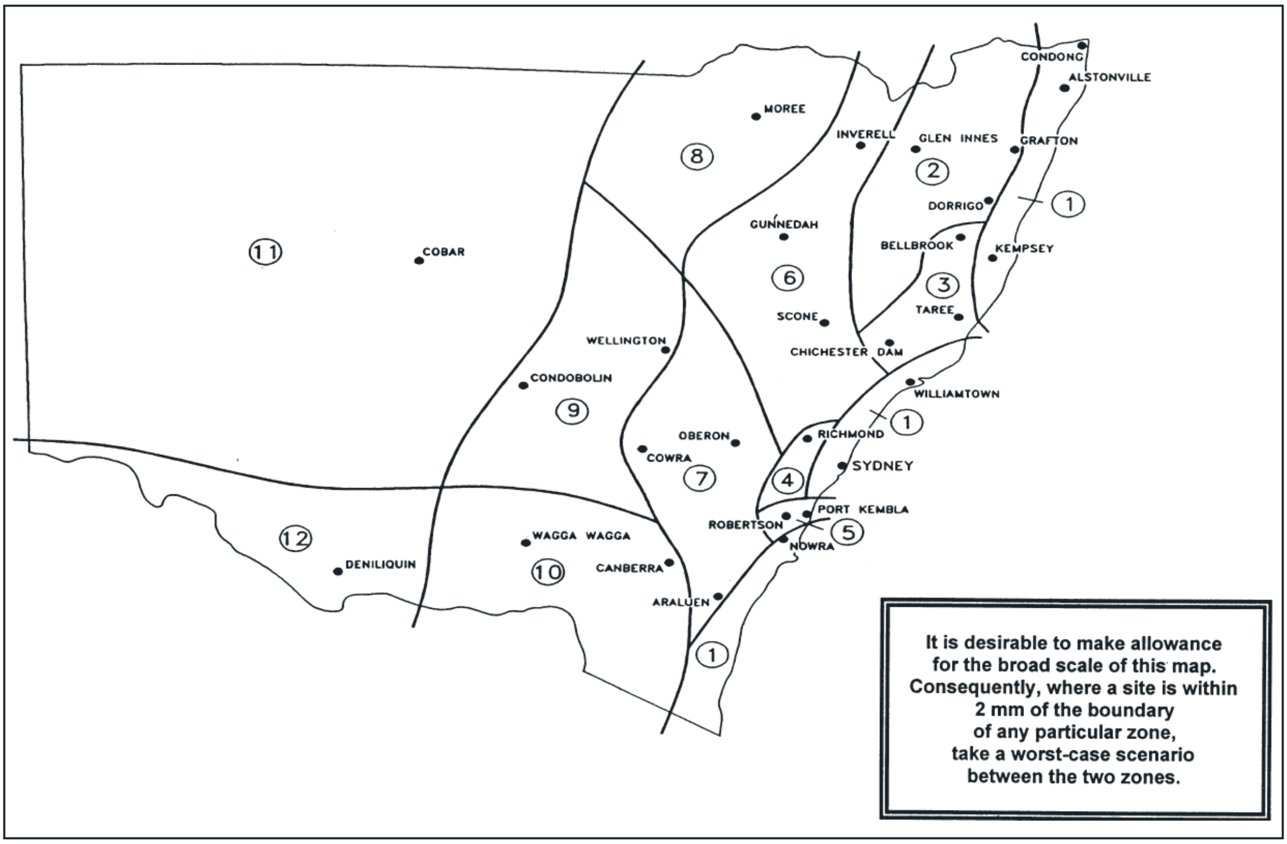
Lands with SLCs ≥4 trigger increased erosion and sediment control management requirements as stipulated in section 4.4.2 of Landcom (2004). The project area is in rainfall zone 1 (refer Figure 4.2).

Land disturbing works in highly sensitive lands should be scheduled for periods when rainfall erosivity is low. Landcom (2004) defines highly sensitive lands as:

1. always on SLC 7 lands; and
2. at certain times of the year:
   a) on SLC 5 or 6 lands in all rainfall zones; and
   b) on SLC 4 lands in rainfall zones 5 and 11.

Where scheduling activities on highly sensitive land to periods when rainfall erosivity is low is not possible or is impractical, ideally ensure that any disturbed lands have C-Factors lower than 0.1 when the 3-day rainfall forecast suggests that rain is likely.

Further project specific management and mitigation measures are provided in section 6.



Source: Landcom (2004)

Figure 4.2 Rainfall zones

Table 4.4 Zone 1 high and low rainfall erosivity periods

SLC	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
1-4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
5	L	L	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
6	H	H	H	H	H	H	H	H	H	H	L	L	L	L	L	L	L	L	L	L	L	H	H	H
7	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

Source: Landcom (2004)

5 Design standards

Recommended design standards for drainage, erosion and sediment control are derived from:

- legislative requirements;
- Penrith Council guidelines;
- industry guidelines; and
- site-specific risk assessments for design life and consequence of failure.

The Penrith City Council *Design Guidelines for Engineering Works for Subdivision and Development* (PCC 1997) references temporary drainage, erosion and sediment control standards from Landcom (2004) ((Table 5.1) below.

5.1 Drainage

The minimum recommended drainage standards for the project are show below in Table 5.1.

Table 5.1 Recommended drainage design standards (IECA 2008, Landcom 2004 and PCC 1997)

Drainage structure	Landcom (2004)	PCC (1997)	Adopted standard
Drains	10-year ARI	10-year ARI	10-year ARI
Clean water diversion drains	10-year ARI	10-year ARI	10-year ARI
culvert crossing	2 -year ARI		2 -year ARI
Road drainage (Industrial)		20-year ARI	20-year ARI

The 200 Aldington Road Industrial Estate, Kemps Creek, Lots 20-23 DP2555560 and Lots 30-32 DP258949 Civil Infrastructure Report (AT&I 2021) nominates that:

- Pipe drainage shall be designed to accommodate the 20-year ARI storm event.
- The combined piped and overland flow paths shall be designed to accommodate the 100-year ARI storm event.
- Where trapped low points are unavoidable and potential for flooding private property is a concern, an overland flow path capable of the carrying the total 100-year ARI storm event shall be provided. Alternatively, the pipe and inlet system may be upgraded to accommodate the 100-year storm event.

Several unsealed roads will be required on site for access and haul purposes.

If construction of mitre drains is necessary for internal unsealed roads, spacing of the mitre drains is generally dependent on-site topography and conditions however the horizontal spacing proposed in Table 5.2 will be used to provide guidance.

Haul roads from the borrow areas will be treated with trafficable polymers to minimise dust and turbid water missions. Polymer emulsion pavements are achieved by treating the top 50 mm of the unsealed track or road using the following process:

- Scarify the surface to a depth of 50 mm.
- Apply trafficable soil polymer such as GRT 5000 (1 part polymer to 6 parts water) to the ripped surface at a rate of 300 mL/m^2.
- Re-scarify before the polymer dries to mix.
- Apply additional polymer at the same rate.
- Grade to achieve the necessary trail profile before the polymer dries.
- Compact with sheeps foot roller followed by a steel drum roller.
- Apply a polymer seal coat (1 part polymer to 8 parts water) at a rate of 300 mL/m^2.

The resultant pavement will have greater California Bearing Strength Ratio (CBR) strength (approximately 2 to 4 times (Mawal and Ojaimi 2019)) compared with the untreated surface, less potential for rutting, potholing and corrugations, reduced dust emissions, reduced erosion and reduced watering requirements.

Unsealed tracks and roads are recommended to have a minimum cross slope of 4% to minimise the potential for corrugations to form (WSC 2012).

Table 5.2 Recommended mitre drain spacing (IECA 2008)

Table drain slope (%)	Horizontal spacing of mitre drains (m)
0–2%	120
>2% but ≤4%	60
>4% but ≤8%	30
> 8%	15

Adopted from Table 4.3.12 from IECA (2008)

On tracks used by light vehicle and small trucks, cross banks (trafficable inclined diversion banks) are an effective means on reducing slope length and flow velocity. Cross banks should be constructed on light vehicle access tracks at the horizontal spacing proposed in Table 5.3.

Table 5.3 Recommended cross bank spacing (IECA 2008)

Road grade	Cross bank spacing
Up to 14% (8º)	60–70 m
14–21% (8º–12º)	50–60 m

5.2 Erosion control

Erosion control standards are generally addressed in section 5.1. There are, however, several important erosion control standards that are recommended to be adopted for the project additional to those described.

In accordance with Landcom (2004) FKC will adopt a 70% soil surface cover as the indicator for the provision of adequate erosion protection in sheet flow environments and the target C-Factors and timings nominated in Table 5.4. Soil covers that may be utilised on site include:

- polymer soil stabilisers;
- grasses and legumes;
- gravel; and
- hydro-mulches and Hydraulic Growth Mediums (HGM).

Table 5.4 Target C factors and timing

Lands	Target C-factor	Description
Waterways and other areas subjected to concentrated flows, post construction	0.05	A target C factor of 0.05 (approx. 70% soil surface cover) will aim to be achieved ten (10) days from completion of construction and prior to exposure to concentrated flows.
All lands, including waterways and stockpiles during construction	0.15	A target C factor of 0.15 (approx. 50% soil surface cover) will aim to be achieved twenty (20) working days of inactivity or from completion of construction.
Stockpiles, post construction	0.10	A target C factor of 0.10 (approximately 60% soil surface cover) will aim to be achieved ten (10) working days from completion of construction.

For concentrated flow environments erosion protection must be employed when the maximum permissible velocity of the soil is exceeded. The maximum permissible velocities for various soil types are shown in Table 5.5.

Table 5.5 Maximum permissible velocities for various soil types (IECA 2008)

Soil description	Allowable velocity (m/s)	Anticipated to be impacted by the project	Comments
Extremely erodible soils	0.3	Yes	Dispersive clays are highly erodible at low flow velocities and must be gypsum treated or capped with stable soil.
Sandy soils	0.45	No	
Highly erodible soils	0.4–0.5	Yes	Highly erodible soils may include: Lithosols, Alluvials, Podzols, Silicious sands, Soloths, Solodized solonetz, Grey podzolics, some Black earths, fine surface texture-contrast soil and Soil Groups ML and CL.
Sandy loam soils	0.5	No	
Moderately erodible soils	0.6	No	Moderately erodible soils may include: Red earths, Red or Yellow podzolics, some Black earths, Grey or Brown clays, Prairie soils and Soil Groups SW, SP, SM, SC.
Silty loam soils	0.6	No	
Low erodible soils	0.7	No	
Firm loam soils	0.7	No	

Table 5.5 Maximum permissible velocities for various soil types (IECA 2008)

Soil description	Allowable velocity (m/s)	Anticipated to be impacted by the project	Comments
Stiff clay very colloidal soils	1.1	No	Erosion-resistant soils may include: Xanthozem, Euchrozem, Krasnozems, some Red earth soils and Soil Groups GW, GP, GM, GC, MH and CH.

Adapted from Table A23 IECA (2008)

Data in Table 5.5 demonstrate that the anticipated maximum permissible velocities for soils impacted by the project ranges from 0.3–0.5 metres per second (m/s). FKC will ensure that flows are maintained below those permissible velocities for bare soils or line concentrated flow areas where the maximum permissible velocity of the soil will or is likely to be exceeded.

Channel liners appropriate for use on the project and their allowable flow velocities are provided in Table 5.6.

Table 5.6 Allowable flow velocity for various channel linings

Product	Allowable velocity (m/s)	Comments
Jute mesh with bitumen emulsion	1.3–1.7	Design life 1 year
Coir mesh	1.7	Design life 1 to 2 years. Minimum of 400 g/m^2 is recommended.
Turf	1.5–2.0	Turf must be anchored to the soil, soil must suitable for plant growth.
Spray on hydro-colloid cementitious channel liner (Geospray™)	2.6–3.2	1 L water/1 kg product applied at 4 kg (of equivalent dry matter)/m^2.
Rock	Dependent of the rock size and density and shear stress from flow	Must be durable, angular igneous rock. Dispersive soil under the rock must be treated with gypsum to minimise tunnel and gully erosion.
3D polyamide soil filled turf reinforcement mat	5.5 m/s for 30mins 3 m/s for durations up to 50 hours	
Concrete	7	

Adapted from Tables A25 and A26 IECA (2008) and Landloch (2018).

Dispersive soils are present within the project area. Dispersive soils are sodium dominated soils with weak ionic bonding. When the soil contacts non-saline water, water molecules are drawn in-between the clay platelets causing the clay to swell to such an extent that individual clay platelets are separated from the aggregate resulting in the soil losing its structure. Magnesic soils can demonstrate similar behaviour.

The most effective treatment for soil dispersion is the incorporation of calcium sulphate (gypsum) into the soil. The calcium ions in the gypsum displace the sodium ions in the soils resulting in a more cohesive soil. Lime cannot be used as lime does not dissolve at pH >6.5.

Dispersive soils disturbed by the project will be treated such that the exchangeable sodium percentage (ESP) is less than 4% an exchangeable magnesium percentage (EMP) is less than 20%.

5.3 Sediment control

Soil loss calculations, the need for TSS control due to the DCP water quality limits and calculated soil loss, triggers the requirement for sediment basins on the project.

The DCP specifies the use of high efficiency sediment (HES) basins capable of treating 80% of the average annual runoff volume of the contributing catchment treated (ie 80% hydrological effectiveness) to 50mg/L TSS or less, and pH in the range 6.5 – 8.5. Type B basins have been adopted as they are designed to retain water that can be used for construction purposes and are less complex to construct and operate than a Type A basin.

Minimum basin sizing will be in accordance with Appendix B and locations shown in Figure 5.1 and Appendices A1, A2 and A3. The two permanent biorention basins will be constructed to operate as Type B basins during the construction phase and then converted to biofiltration basins once more than 70% soil surface cover has been achieved. Final basin sizing will be confirmed in the construction contractor's progressive erosion and sediment control plans.

The HES basins will be designed and operated in accordance with *Best Practice Erosion and Sediment Control – Appendix B Sediment basin design and operation* (IECA 2016a). This will include the use of flow activated coagulants and/or flocculant dosing systems. The selection of appropriate coagulants and/or flocculants and determination of indicative dosing rates will be in accordance with the IECA fact sheet *Chemical coagulants and flocculants* (IECA 2016b).

Type B basins will be used during the demolition and earthworks phases and Type A during the building phase due to the need to link the basin decant systems to the permanent stormwater management system.

A typical long section of a Type B basin is provided in Figure 5.1.

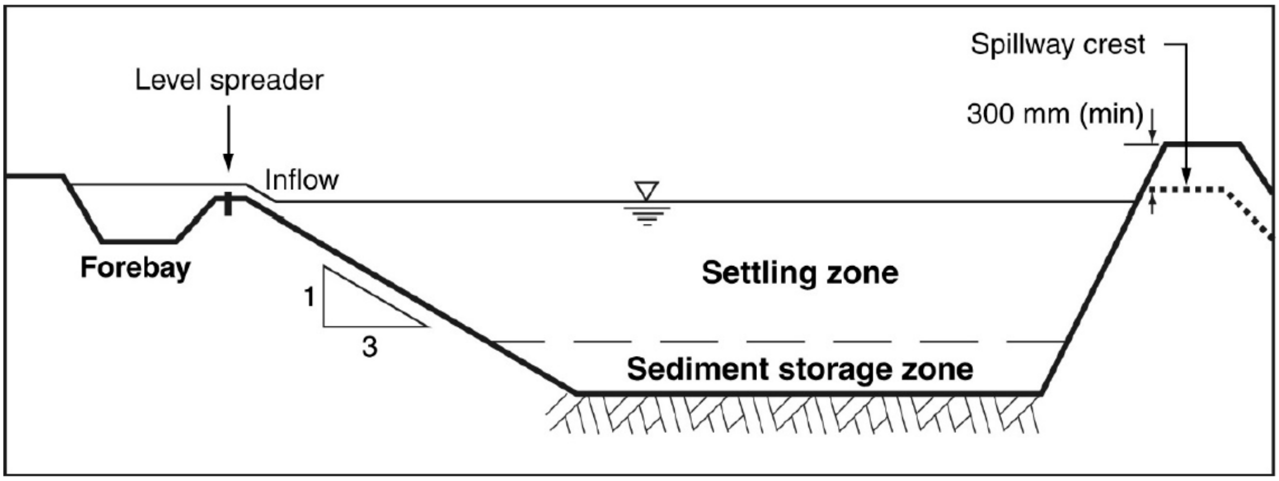


Figure 5.1 Typical Type B basin long section (Figure B7 IECA 2016)

Suitable coagulants and/or flocculants are dosed into the basin inlet drains upslope of the forebay. The chemicals mix in the inlet drain and the sand and silt sized particles (and some of the clay sized particles) will settle out of the water column in the forebay.

The forebay also reduces the flow velocity of the incoming water and as it passes over the level spreader flow reverts from concentrated flow to uniform flow creating conditions that allow the remaining coagulated/flocculated particles to settle out of the water column prior to the treated water discharging over the spillway.

\\emmsvr1\EMM2\2022\E220208 - ESCPs Aldington Road, Kemps Creek\GIS\02_Maps\EIA007_PermTempBasinLocations_20220405_01.mxd 5/04/2022

Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

0 250 500 m

GDA2020 MGA Zone 56 N

KEY

- Project boundary
- Design boundaries
- Minor road
- Vehicular track
- Named watercourse
- Topographical contour (2 m)
- Permanent basin
- Temporary basin

DRAFT

Permanent and temporary basin locations

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 5.2

EMM creating opportunities

6 Management and mitigation measures

The erosion hazard assessment generally demonstrates a low to high hazard due to:

- the erodibility of soils;
- calculated soil loss from site;
- slope steepness; and
- rainfall erosivity from November to April.

FKC will apply the following drainage, erosion and sediment control management strategies and measures to address the identified project erosion hazard.

6.1 Minimising the extent and duration of land disturbance

The project will be developed in three stages to minimise the extent and duration of disturbance as shown in Figure 6.1. Initial earthworks and major land disturbing activities will be scheduled to avoid high rainfall erosivity periods for SLCs 5, 6 and 7 lands (Table 4.4) where practical to minimise erosion. Where major land disturbing works need to occur in high rainfall erosivity periods then there will be an appropriate increase in the levels of control measures to compensate for the increased erosion risk.

Sediment and turbid runoff only generally occur when erosion occurs, therefore progressive stabilisation and rehabilitation of disturbed areas is fundamental to successful erosion and sediment control. The timing of stabilisation and rehabilitation works needs to consider:

- proximity to sensitive receptors;
- soil erosivity;
- slope gradient and length;
- time of year (rainfall risk); and
- site access.

Table 6.1 provides guidance on the recommended timing of stabilisation and rehabilitation works with soil erosion risk as the main determining factor.

Table 6.1 Maximum C-Factors during construction and post-construction

During Construction		
Waterways and land below the 2-yr ARI flood levels including stockpiles	0.10	When working in waterways and flood prone lands a C-Factor of ≤0.1 is to be achieved if the 3-day forecast indicates rain causing runoff is likely.
Land above 2-yr ARI flood levels flood levels (including stockpiles).	0.15	A C-Factor of ≤0.15 is to be achieved within 20 working days of inactivity, even though works might continue later.

Table 6.1 Maximum C-Factors during construction and post-construction

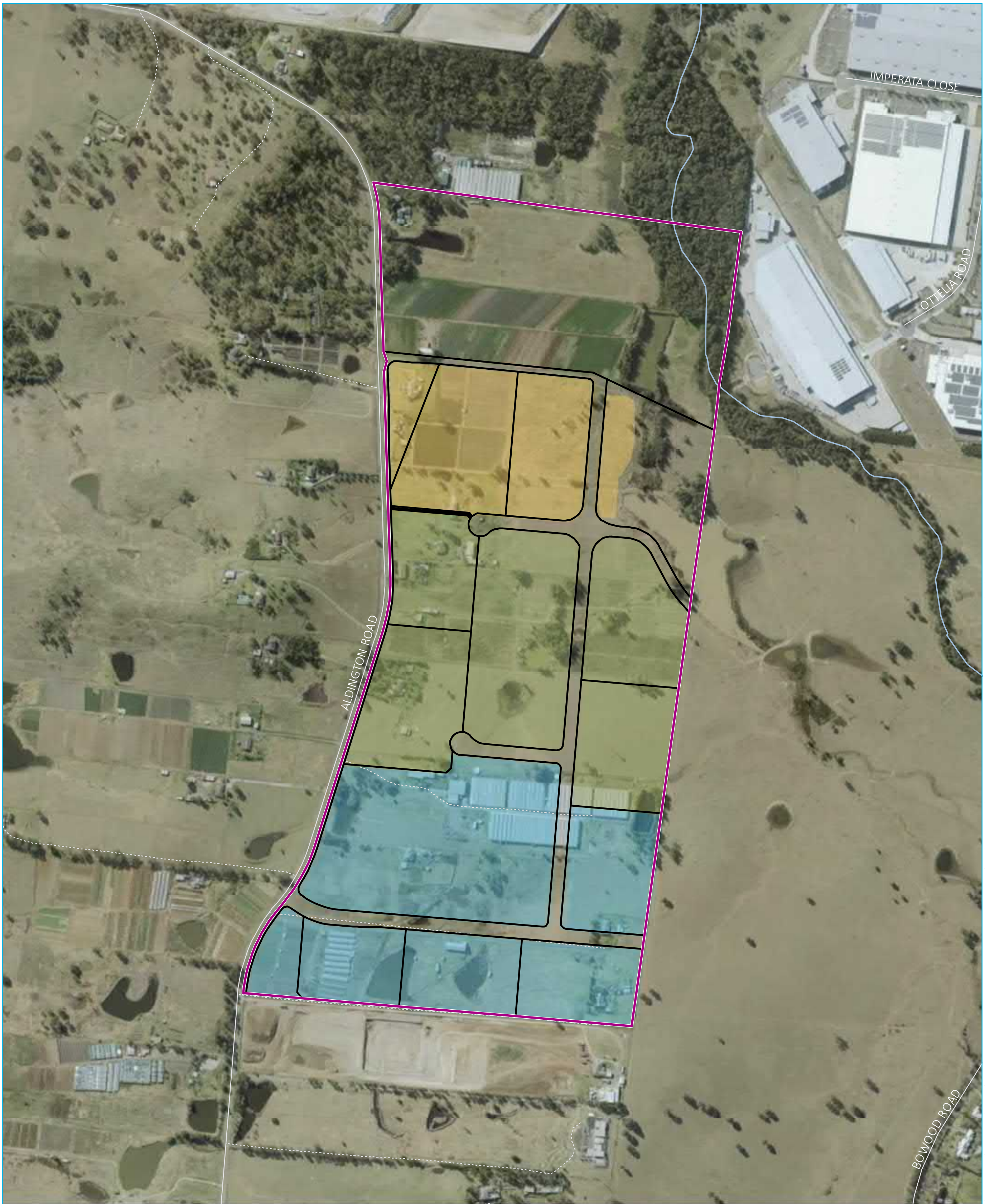
Post Construction		
Waterways and other areas subjected to concentrated flows	0.05	Applies after 10 working days from completion of formation and before they are allowed to carry any concentrated flows.
Stockpiles	0.10	Applies after 10 working days from completion of formation. Maximum C-factor of 0.10 equals 60% ground cover
All other land	0.15	In periods of expected 'low' rainfall erosivity during the rehabilitation period, achieve a C-Factor of less than 0.15. Maximum C-Factor of 0.15 equals 50% ground cover
	0.10	In periods of 'moderate' to 'high' rainfall erosivity during the rehabilitation period, achieve a C-factor of less than 0.1. Set in motion a program that should ensure it will reduce permanently to less than 0.05 within a further 60 days.

Adapted from Section 7.1.2, Tables 7.1 and 9.3 in Landcom (2004)

Indicative C-Factors for some common stabilisation products are provided in Table 6.2 (the lower the C-Factor the better the erosion protection).

Table 6.2 Indicative C-Factors for common soil stabilising products/techniques

Product	C-Factor range	Rate/cover	Duration	Source
Grass cover	0.09	60%	Permanent	Landcom (2004)
Grass cover	0.05	70%	Permanent	Landcom (2004)
Turf (Kikuyu)	<0.01	100%	Permanent	Landcom (2004)
Soil stabilising polymer (GRT Enviro Binder)	0.01–0.002	25% solution 100 mL/m^2	Not tested	Landloch (2015)
Soil stabilising polymer (Vital Bon Mat P47)	0.12–0.66	10% solution 1 L/m^2	2 months	Landloch and SEEC (2013)
Soil stabilising polymer (EnviroStraw EnviroBond^{TM})	0.004–0.023	10% solution 1 L/m^2	Not tested	Landloch (2018)
Hydro-mulch	0.00–0.10	1,500 kg/ha 300-L binder/ha	3 months	Landcom (2004)
BFM hydro-mulch (wood fibre)	0.00–0.10	5,000 kg/ha	6 months	Landcom (2004)
BFM hydro-mulch (straw fibre (EnviroStraw BFM plus))	0.006 – 0.008	4,000 kg/ha	Not tested	Landloch (2016)
Hydraulically applied growth medium (EnviroStraw EnviroMatrix^{TM})	0.006–0.008	4,500 kg/ha	Not tested	Landloch (2015)
Jute mesh	0.10–0.60	Not provided but expected to be 350 g/m^2	6–12 months	Landcom (2004)



Source: EMM (2022); ABS (2021); DFSI (2017, 2021); GA (2011); Metromap (2022)

0 250 500 m
GDA2020 MGA Zone 56 N

KEY

- Project boundary
- Design boundaries
- Minor road
- Vehicular track
- Named watercourse

Construction staging plan

- Stage 1
- Stage 2
- Stage 3

Construction staging plan

200 Aldington Road Industrial Estate Kemps Creek
Primary Erosion and Sediment Control Plan
Figure 6.1

EMM
creating opportunities

Soil stabilising polymers will be used for temporary stabilisation within the project area and bonded fibre matrix hydro-mulches and hydraulically applied growth mediums will be used for permanent vegetative stabilisation solutions.

6.2 Controlling water movement through or around site

There are two small clean run-on water catchments that impact the project area.

Clean and dirty water catchments will be segregated to the maximum practical extent to minimise erosion potential and the volume of turbid water that needs to be contained and treated on site via diversion around disturbed areas and/or safe conveyance through the site without meeting exposed soils or mixing with turbid water.

During the building phase, roof runoff will be connected to the permanent stormwater drainage system as soon as practicable.

Treated runoff from the floating decants on the Type A HES basins during the building phase will be connected to the permanent piped stormwater drainage system.

6.3 Minimise soil erosion

The most effective form of sediment control is erosion control. Sediment and turbid water are only generated when erosion occurs. Effective erosion control is therefore a fundamental component of FKC's drainage, erosion and sediment control strategies.

The types of erosion that can potentially occur on the project are:

- raindrop splash erosion;
- sheet erosion;
- rill erosion;
- gully erosion;
- chemical erosion (dispersion); and
- wind erosion (dust).

Raindrop splash erosion is most effectively controlled by providing soil surface cover. FKC's contractors will achieve by:

- minimising the extent and duration of soil disturbance;
- covering and binding exposed soils with soil stabilising polymers and gravel; and
- progressively rehabilitating disturbed areas.

Rill erosion is effectively controlled by minimising slope length and gradient. This will be achieved within the project area by:

- minimising disturbance to steeply grading areas where possible;
- using retaining walls to minimise the creation of long, steep earthen slopes;

- treating dispersive soils with gypsum;
- covering and binding exposed soils with soil stabilising polymers and gravel;
- progressively stabilising and revegetating disturbed areas; and
- early installation and connection of permanent stormwater drainage systems.

Gully erosion is effectively controlled by minimising the concentration of flow and slowing flow velocity. This will be achieved within the project area by:

- maintaining sheet flow where possible;
- avoiding the use of 'v' shaped drains;
- lining drains where flow velocities exceed the maximum permissible velocity of the soil (temporary and permanent);
- treating dispersive soils with gypsum if disturbed; and
- early installation and connection of permanent stormwater drainage systems.

Chemical erosion is effectively controlled by minimising the disturbance of dispersive soils and maintaining sheet flow conditions. This will be achieved in the project area by:

- avoiding the concentration of flow where possible;
- avoiding ponding water on areas of dispersive soil (not using check dams, channel banks, benches, etc);
- lining drains where flow velocities exceed the maximum permissible velocity of the soil (temporary and permanent);
- treating dispersive soils with gypsum particularly pipe trench back fill material; and
- installing trench breakers to minimise tunnel erosion in stormwater, sewer and potable water pipe trenches (Figure 6.2).

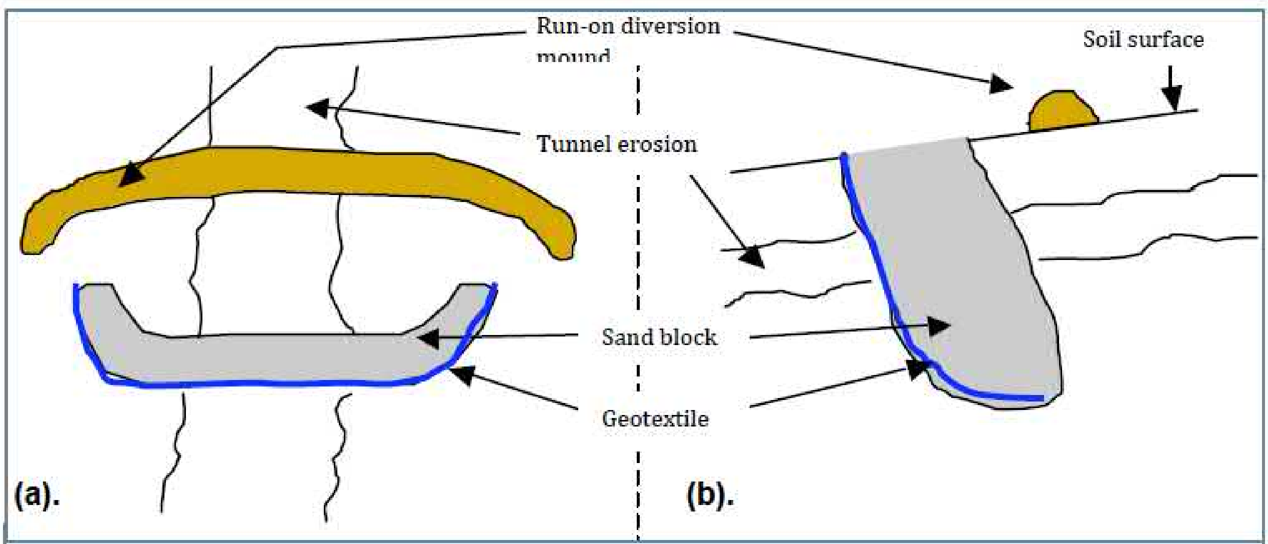


Figure 14. Modified sand block design. (a) plan view, (b) cross section view. The depth of the sand block is determined by the depth of dispersive soils or tunnel erosion. The span length of the structure is determined by the width of the tunnelling.

Figure 6.2 Pipe trench breaker concept design

Energy dissipaters will need to be used at the outlets of drains and spillways to reduce flow velocities to less than the maximum permissible velocity for the soil type. Stilling pond and roughness type dissipators are recommended.

Wind erosion is effectively controlled by minimising disturbance and utilising soil stabilising polymers and wetting agents. This will be achieved in the project area by:

- minimising disturbance;
- gypsum treatment of dispersive soils;
- progressively stabilising disturbed areas temporarily with soil stabilising polymer or gravel or permanently with BFM hydromulch and grass;
- reducing speeds of machinery and vehicles and/or suspending operations during excessively dry and/or windy periods; and
- using trafficable soil polymers and water trucks on tracks and haul roads.

6.4 Prompt stabilisation of disturbed areas

As detailed in sections 6.1 and 6.2, progressive stabilisation and rehabilitation of disturbed areas will be undertaken to minimise erosion and the generation of sediment and turbid runoff. Due to maximum batter gradients being 1(v):3(h) or flatter, permanent revegetation seeding will be undertaken using site won topsoil and BFM hydro-mulches.

EMM's experience is that the Australian made straw based HGMs are the most appropriate and cost effective for direct seeding of vegetation. HGM will be applied at the following rates specified in Table 6.3.

Table 6.3 BFM hydro-mulch application rates

Slope gradient	Organic matter	Binder
<1(v):3(h)	4,000 kg/ha	As supplied in the product bags
>1:3 but ≤1:2	5,000 kg/ha	As supplied in the product bags

6.5 Maximise sediment retention on site

As discussed in section 6.3, the most effective form of sediment control is erosion control. Irrespective of how well designed and implemented erosion control is on site, sediment and turbid water will always be generated during rainfall events.

Type 2 and 3 sediment controls will be ineffective at reducing turbidity due to the presence of dispersive clay soils but will be utilised during the demolition phase when soil surface disturbance, particularly subsoil disturbance will be minimal. As discussed in section 5.3, Type B HES basins will be reconstructed and used to capture and treat turbid runoff. These will have automated flow activated dosing systems.

Bench testing of site turbid water will be undertaken by FKC's CPESC in accordance with IECA (2016b) to determine the most appropriate coagulants and/or flocculants to be used and indicative dosing rates. Products to be tested include:

- aluminium chlorohydrate;
- chitosan lactate;
- non-ionic polyacrylamide; and
- anionic polyacrylamide.

FKC will require their contractors to implement a Water Movement Permit system on site to minimise the potential for accidental turbid water discharge during pumping and dewatering activities on site. Water Movement Permits will be issued by the Contractors Environmental Management Representative or delegate.

6.6 Inspection and maintenance of control measures

Drainage, erosion and sediment control measures will remain in place at all times until their function is no longer required. Technical notes for drainage, erosion and sediment control measures recommended to be used on the project are included as Appendix C. These technical notes include construction and maintenance requirements for the control measures.

Inspections of control measures will be undertaken prior to predicted rainfall and following rainfall that causes run-off or weekly during dry conditions.

Inspections will be undertaken by the Contractors Environmental Management Representative or delegate. That person will have the following knowledge:

- an understanding of site environmental values that could be impacted by site construction and operation;
- an understanding of the requirements of the Development Approval that are relevant to drainage, erosion and sediment control;

- a good working knowledge of drainage, erosion and sediment control fundamentals and the project specific application thereof;
- ability to provide advice and guidance on appropriate measures and procedures to maintain the site at all time in a condition representative of regionally specific best practice, and that is reasonably likely to achieve the required standards; and
- a good working knowledge of the correct installation, operation and maintenance procedures for the full range of drainage, erosion and sediment control measures used on the project.

FKC's independent CPESC will undertake fortnightly inspections during periods of high rainfall erosivity and monthly during periods of low rainfall erosivity in accordance with the requirements of the DCP.

FKC's contractor will maintain control measures to maximum practicable extent so that control measures:

- will best achieve the sites required environmental protection including achieving the water quality criteria specified in the Development Approval and this Primary ESCP for the nominated design storm event;
- are in accordance with the specified operational standard for each drainage, erosion and sediment control measure; and
- prevents or minimises safety risks.

All water, debris and sediment removed from control measures shall be disposed of in a manner that will not create an erosion or pollution hazard.

6.7 Monitoring and adjustment of control practices

FKC has adopted a hierarchical esc planning system be adopted for construction of the project consisting of an overarching project wide Primary ESCP (this document) with Progressive ESCPs (PESCPs) for all disturbance areas prepared by the construction contractor) to ensure that the project PESCPs are living documents that can and will be modified as site conditions change, or if the adopted control measures fail to achieve the desired treatment standard.

The PESCPs will be prepared and certified by a CPESC.

If a site inspection or environmental monitoring identifies a significant failure of the adopted drainage, erosion and sediment control measures, a critical evaluation of the failure should be undertaken to determine the cause and appropriate modifications made to the control measures on site and PESCPs amended.

6.8 Drainage, erosion and sediment control competence

All project personnel including contractors are recommended to have an appropriate level drainage, erosion and sediment training. Two levels of competency training for personnel are proposed:

- Level 1 – basic awareness level training and provided during the site induction; and
- Level 2 – half day training for foreman, engineers, project managers etc on the legal aspects of drainage, erosion and sediment control, fundaments and site-specific strategies, techniques and requirements prepared and presented by FKC's CPESC.

7 Phase specific control measures

The project will be constructed in three stages as shown in Figure 6.1. Within each of the stages will be several phases of construction:

- Demolition;
- clearing, grubbing and topsoil stripping;
- cut to fill and general earthworks; and
- building construction and landscaping (Stage H only).

Each phase will require a different level of erosion and sediment controls primarily as a function of the extent of land disturbance and modification to the existing landforms and drainage patterns.

Planned erosion and sediment controls for each phase are detailed as follows:

7.1 Demolition

The demolition phase will involve the demolition of all existing buildings and surface infrastructure including but not limited to:

- Houses
- Sheds
- Greenhouses
- Animal years
- Fences
- Tanks

Soil surface disturbance will be minimal as no soil stripping will be required and existing access tracks and driveways will be used.

This phase will also include the treatment and dewatering of the existing farm dams. There will be no alteration of existing drainage patterns during this phase. Planned erosion and sediment control measures for this phase are detailed in Table 7.1.

Table 7.1 Demolition phase drainage, erosion and sediment control measures

Control Measure	Purpose
Drainage control	
Temporary	
Maintain existing surface water flows paths and culvert crossings	Allow clean water to pass through the site without coming into contact with exposed soil.
Pipe culverts	To allow vehicle access over drainage lines and to allow clean up-stream water to pass through the construction zone without contamination.
Erosion Control	
Temporary	
Delineate no-go areas with flagging tape or bunting	To minimise unnecessary soil and vegetation disturbance.
Utilise existing access tracks and driveways	Minimise disturbance to existing stable vegetated areas and minimise mud tracking to Aldington Road.
Polymer soil stabiliser.	To protect and exposed soil from erosion and to control dust and minimise turbid runoff from access tracks.
Sediment Control	
Temporary	
Sediment fence	Installed immediately downslope of demolition works to capture coarse sediment in sheet flow environments resulting from exposed soil during demolition works.
Grass filter strips	Maintain existing exotic grass cover to slow flow velocity to encourage the removal of sediment via gravity and infiltration.
Coagulants and/or flocculants	To treat any turbid water in the existing dams to achieve a TSS < 50mg/L prior to dewatering.
Trash pumps, dosing pumps and pipes	To create a circulation in and dose coagulant and/or flocculant into the existing farm dams.
Stabilised construction entry/exits	Installed at each public road access point to minimise mud tracking to Aldington Road.
Vacuum/sweeper truck	To remove any sediment tracked to Aldington Road.

Indicative drainage, erosion and sediment control measures for this phase are shown in Appendix A.1.

7.2 Clearing, grubbing and topsoil stripping

During this phase trees will be felled, roots will be grubbed, and topsoil will be stripped to facilitate cut to fill and general earthworks and stormwater infrastructure installation.

Any cleared trees and roots will be mulched and re-used on site for temporary sediment controls (mulch bunds).

The Type B sediment basins will be constructed and will be operational prior to any topsoil stripping to ensure that any eroded sediment and turbid runoff is captured to the maximum possible extent. The two proposed bio-basins will be constructed as Type B basins and the converted to bio-basins. Topsoil will be either pushed into windrows and stabilised and used as temporary clean water diversions (back-push banks) or stockpiled for later re-use.

Planned erosion and sediment control measures for this phase are detailed in Table 7.2.

Table 7.2 Clearing, grubbing and topsoil stripping drainage, erosion and sediment control measures

Control Measure	Purpose
Drainage control	
Temporary	
Utilise existing access tracks and driveways	Minimise disturbance to existing stable vegetated areas and minimise mud tracking to Aldington Road.
Pipe culverts	To allow vehicle access over flow paths and to allow clean up-stream water to pass through the construction zone without contamination. Maintain natural drainage paths.
Clean water diversion banks/drains	Do divert clean water around areas being stripped and to minimise the volume of turbid water to be treated.
Diversion banks/drains	To reduce slope length and divert turbid runoff to sediment basins.
Erosion Control	
Temporary	
Delineate no-go areas with flagging tape or bunting	To minimise unnecessary soil and vegetation disturbance.
Check dams	To reduce flow velocity in the access track table drains and mitre drains until permanent drain linings can be installed.
Cover crops	Rapid vegetation establishment until permanent vegetation germinates and grows.
Polymer soil stabiliser.	To protect exposed soil from erosion, to minimise turbid runoff and dust emissions from unsealed tracks.
Cementitious hydrocolloid hydraulically applied soils stabiliser (Geospray)	Spray on channel liner to protect drains and other concentrated flow paths from erosion.
Amelioration of dispersive soils with Gypsum	Reducing the ESP of dispersive soils to <4% to minimise dispersion.
BFM hydro-mulch	To protect newly seeded areas from erosion and to facilitate rapid vegetation establishment.
Rock energy dissipator (stilling pond type)	To reduce flow velocities from drains and culvert outlets to below the maximum permissible velocity for the downstream soil.
Sediment Control	
Temporary	
Check dams	Capture small quantities of coarse sediment in the table drains and mitre drains.
Floc blocks and/or topical application of Gypsum	To increase sediment particle size to improve the efficiency of Type 2 and Type 3 sediment controls.
Sediment Fence	To capture coarse sediment in sheet flow environments.
Mulch bunds	To capture coarse and medium sized sediment in sheet flow environments.
Type B sediment basin	To capture and treat sediment and turbid runoff.
Flow activated dosing system	To supply coagulants/flocculants into the inlet drains of sediment basins at the required rate and volume to treat 80% of the average annual runoff volume of the contributing catchment.
Stabilised construction entry/exits	Installed at each public road access point to minimise mud tracking to Aldington Road.
Vacuum/sweeper truck	To remove any sediment tracked to Aldington Road.

Indicative drainage, erosion and sediment control measures for this phase are shown in Appendix A.2.

7.3 Cut to fill and general earthworks

This is the most challenging phase from and erosion and sediment control perspective and the greatest modification to the existing landforms occurs during this phase. Clean water run-on water will either be diverted around the active construction zones or temporary lined drains isolated on either side with sediment controls or pipes will be used to safely convey clean water though the construction zone without coming contact with exposed soil or turbid runoff. Clean water drains will be lined with an impervious channel liner such as Geospray™ spray on liner or a high-density polyethylene rolled erosion control product. Geofabric will not be used as it is pervious, and water can flow under the geofabric resulting in erosion under the geofabric and the generation of sediment and turbid runoff.

Permanent retaining walls will be constructed to retain both fills and cuts which will minimise both the length and steepness of any earth embankments and batters thereby reducing their erosion potential. Remaining batters will generally be 1(v):4(h) or flatter to facilitate stabilisation using topsoil and vegetation.

Installation the permanent stormwater drainage system and construction of the access roads and associated drainage will be a priority during this phase to maximise the safe conveyance of clean-run on water through the project.

At the completion of this phase all roads will be constructed, sealed and verges vegetated and storms water systems and services installed and functional. Lots will have been constructed to finished levels and temporarily stabilised for soil stabilising polymer in preparation for the building construction phase

Planned erosion and sediment control measures for this phase are detailed in Table 7.3.

Table 7.3 Cut to fill and general earthworks phase drainage, erosion and sediment control measures

Control Measure	Purpose
Drainage control	
Temporary	
Pipe culverts	To allow vehicle access over flow paths and to allow clean up-stream water to pass through the construction zone without contamination. Maintain natural drainage paths.
Clean water diversion banks/drains	Do divert clean water around areas being stripped and to minimise the volume of turbid water to be treated.
Diversion banks/drains	To reduce slope length and divert turbid runoff to sediment basins.
Permanent	
Permanent piped stormwater system	Diversion of clean run-on water and conveyance of stormwater.
Permanent road drainage	Diversion of clean run-on water and conveyance of stormwater.
Permanent access and internal road network	Minimise erosion, generation of dust and turbid runoff, minimise mud tracking to Aldington Road.

Table 7.3 Cut to fill and general earthworks phase drainage, erosion and sediment control measures

Control Measure	Purpose
Erosion Control	
Temporary	
Delineate no-go areas with flagging tape or bunting	To minimise unnecessary soil and vegetation disturbance
Check dams	To reduce flow velocity in the access track table drains and mitre drains until permanent drain linings can be installed.
Cover crops	Rapid vegetation establishment until permanent vegetation germinates and grows.
Polymer soil stabiliser.	To protect and exposed soil from erosion and to control dust and minimise turbid runoff from access tracks.
Cementitious hydrocolloid hydraulically applied soils stabiliser (Geospray)	Spray on channel liner to protect drains and other concentrated flow paths from erosion.
Permanent	
Amelioration of dispersive soils with Gypsum	Reducing the ESP of dispersive soils to <4% to minimise dispersion, reduce the potential for rill, gully and tunnel erosion, increase CBR's and reduce turbid runoff.
Topsoil and seeding	Facilitate stabilisation of the more erodible subsoil and establish vegetation.
BFM hydro-mulch	To protect newly seeded areas from erosion and to facilitate rapid vegetation establishment.
Rock energy dissipator (stilling pond type)	To reduce flow velocities from drains and culvert outlets to below the maximum permissible velocity for the downstream soil.
Trench breakers	To minimise the potential for tunnel erosion within pipe trenches.
Sediment Control	
Temporary	
Check dams	Capture small quantities of coarse sediment in the table drains and mitre drains.
Floc blocks and/or topical application of Gypsum	To increase sediment particle size to improve the efficiency of Type 2 and Type 3 sediment controls.
Sediment Fence	To capture coarse sediment in sheet flow environments.
Mulch bunds	To capture coarse and medium sized sediment in sheet flow environments.
Type B sediment basin	To capture and treat sediment and turbid runoff.
Flow activated dosing system	To supply coagulants/flocculants into the inlet drains of sediment basins at the required rate and volume to treat 80% of the average annual runoff volume of the contributing catchment.
Stabilised construction entry/exits	Installed at each public road access point to minimise mud tracking to Aldington Road.
Vacuum/sweeper truck	To remove any sediment tracked to Aldington Road.

Indicative drainage, erosion and sediment control measures for this phase are shown in Appendix A.2. The size and location will change depending on how the contractor to stage the constructions works.

7.4 Warehouse construction (Lot H) only

This phase involves the construction of:

- 48,430 m^2 of warehouse GFA;
- 2,500 m^2 of ancillary office GFA;
- 231 car parking spaces; and
- associated landscaping works.

As Lot H will be generally level, run-on water will be diverted by the permanent stormwater management system and the Type A sediment basins will be in place as shown on Appendix A.3, the complexity of erosion and sediment controls required for this phase is reduced and will focus on:

- minimising the extent and duration of disturbance to the surface densely graded base material (DGB);
- minimising loss and spillage of loose materials imported for construction purposes;
- minimising mud tracking to Road 03 (not yet named);
- progressing building construction such that roof drainage can be temporarily and permanently connect to tanks and the stormwater drainage system;
- landscaping works are implemented; and
- the Type A sediment basin is operated and maintained until untreated runoff quality less than 50 mg/L TSS is achieved from Lot H.

Planned erosion and sediment control measures for this phase are detailed in Table 7.4.

Table 7.4 warehouse construction phase drainage, erosion and sediment control measures

Control Measure	Purpose
Drainage control	
Temporary	
Diversion banks/drains	To reduce slope length and divert turbid runoff to sediment basins.
Temporary downpipes to connect roof drainage to tanks	To prevent the contamination of clean roof run-off water, to maintain safe working conditions and to minimise the volume of turbid water to be treated.
Permanent	
Permanent piped stormwater system	Diversion of clean run-on water and conveyance of stormwater.
Permanent road drainage	Diversion of clean run-on water and conveyance of stormwater.
Permanent access and internal road network	Minimise erosion, generation of dust and turbid runoff, minimise mud tracking to Aldington Road.
Downpipes	To prevent the contamination of clean roof run-off water, to maintain safe working conditions and to minimise the volume of turbid water to be treated.

Table 7.4 warehouse construction phase drainage, erosion and sediment control measures

Control Measure	Purpose
Erosion Control	
Temporary	
Delineate no-go areas with flagging tape or bunting	To minimise unnecessary soil and vegetation disturbance.
Polymer soil stabiliser.	To protect and exposed soil from erosion and to control dust and minimise turbid runoff from access tracks.
Permanent	
Amelioration of dispersive soils with Gypsum	Reducing the ESP of dispersive soils to <4% to minimise dispersion, reduce the potential for rill, gully and tunnel erosion, increase CBR's and reduce turbid runoff.
Landscaping works	Cover exposed subsoil/DGB to minimise erosion and run-off and reduce the generation of turbid runoff.
BFM hydro-mulch	To protect newly seeded areas from erosion and to facilitate rapid vegetation establishment.
Trench breakers	To minimise the potential for tunnel erosion within pipe trenches.
Sediment Control	
Temporary	
Bulka bags	Contain loose construction materials to minimise sediment release to drainage systems.
Check dams	Capture small quantities of coarse sediment in the table drains and mitre drains.
Floc blocks and/or topical application of Gypsum	To increase sediment particle size to improve the efficiency of Type 2 and Type 3 sediment controls.
Sediment Fence	To capture coarse sediment in sheet flow environments.
Mulch bunds	To capture coarse and medium sized sediment in sheet flow environments.
Type B sediment basin	To capture and treat sediment and turbid runoff.
Flow activated dosing system	To supply coagulants/flocculants into the inlet drains of sediment basins at the required rate and volume to treat 80% of the average annual runoff volume of the contributing catchment.
Stabilised construction entry/exits	Installed at each public road access point to minimise mud tracking to Aldington Road.
Vacuum/sweeper truck	To remove any sediment tracked to Aldington Road.

Indicative drainage, erosion and sediment control measures for this phase are shown in Appendix A.3.

8 Inspections, maintenance and monitoring

8.1 Incidents and complaints

All incidents will be reported and investigated, and corrective actions assigned to prevent future occurrences in accordance with the CEMP.

An incident may involve:

- actual or potential pollution incidents where material harm to the environment is caused or threatened. In this case, a 'duty to notify' relevant authorities applies under the POEO Act for material harm (which includes actual or potential harm) to the health or safety of human beings or to ecosystems that is not trivial or that results in actual or potential loss or property damage exceeding a threshold dollar value; or
- any other action or activity deemed to be in non-compliance with this Primary ESCP or associated PESCPs.

8.2 Inspections

Inspections of drainage, erosion and sediment control measures will be undertaken by the Contractors Environmental Management Representative:

- weekly during normal construction hours;
- daily during periods of rainfall; and
- within 24 hours of the cessation of a rainfall event causing runoff to occur on or from the project (≥10 mm).

Joint inspections will be undertaken by the FKC's CPESC with the Contractors Environmental Management Representative to verify the adequacy of PESCPs and control measures for site conditions.

8.3 Water quality monitoring

Upstream and downstream water quality monitoring will be undertaken at the locations detailed in Table 8.1 and shown in Figure 8.1 for TSS, pH and visible hydrocarbon sheens.

Table 8.1 Surface water quality monitoring locations

Site number	Location	Frequency	Purpose
SW1	Clean water dam above the project	Monthly and prior to sediment basin discharge	To understand clean run-on water quality
SWA	BioBasin A	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria
SWB	HES Basin B	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria

Table 8.1 Surface water quality monitoring locations

Site number	Location	Frequency	Purpose
SWC	HES Basin C	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria
SWD	BioBasin B	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria
SWE	HES Basin E	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria
SWF	HES Basin F	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria
SWJ	HES Basin J	Following treatment prior to discharge and during discharge	To determine compliance with discharge criteria

8.4 Maintenance and remedial actions

Various types of drainage, erosion and sediment control measures will be utilised for the project. A description of the key measures used and maintenance and remedial actions likely to be required are provided in Table 8.2.

Table 8.2 Maintenance and remedial actions

Control measure	Maintenance and remedial actions
Drainage control	
Lined clean water diversion drains and banks	Repair any damage to the liner (replace, re-anchor), repair any bunding or silt fence isolating the clean water catchment from the dirty water catchment.
Dirty water diversion drains and banks	Repair any erosion, re-line if necessary.
Drain blocks	Ensure turbid water cannot enter the drain or pipe. Monitor for damage and sediment accumulation and repair as necessary.
Erosion control	
Temporary	
Polymer soil stabiliser and covers	Reapply or adjust/repair following rainfall, heavy vehicle traffic or other disturbance.
Permanent	
Gypsum amelioration of dispersive soil	Check for rill, gully and tunnel erosion. Re-test soil and incorporate additional gypsum in accordance with the soil testing results.
Lined channel, drains and batter chutes	Look for water flows under or beside the structure and repair and/or modify as necessary. Look for erosion around and downstream of the energy and repair and/or modify as necessary.

Table 8.2 Maintenance and remedial actions

Control measure	Maintenance and remedial actions
Sediment control	
Temporary	
Silt fences	Ensure silt fences pond water. If not, install additional panels. Check for blow-outs in the anchor trench. Re-anchor as necessary. Replace any ripped or damaged sediment fence.
Check dams	Check for erosion between check dams. Install additional check dams if necessary. Remove accumulated sediment.
Stabilised construction exits	Ensure rock is free from accumulated sediment. Replace as necessary.
Construction sediment basins	Treat accumulated water with high efficiency coagulants and flocculants. Dewater when water quality is less than nominated water quality limits. Check basin inlets and outlets for erosion and repair as necessary. Check the basin wall for slumping or tunnel erosion. Repair as necessary. Remove accumulated sediment from the basin when it reaches the sediment storage zone marker.
Coagulants and flocculants	Check coagulant/flocculent levels in flow activated dosing units and replenish as necessary.

9 Review and Improvement

9.1 Continuous improvement

Continuous improvement of this Primary ESCP will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

9.2 Document update and amendment

The Primary ESCP will be revised whenever the construction program, scope of work or work methods change, or whenever the work methods and control structures are found to be ineffective after each site inspection, or if so directed by authorities.

A copy of the updated plans and changes will be distributed to all relevant personnel and discussed at pre-start and toolbox talks.

10 Certification

I Michael John Frankcombe, CPESC No. 1351 from EMM Consulting Pty Limited certify that:

- This Primary ESCP complies with the intent of the Landcom (2004) given the phase of the project and available information.
- This Primary ESCP does not include all details required for ESCPs as this information will not be available until the construction tender process has been completed, contract(s) have been awarded and construction sequencing and methods have been finalised.
- The successful contractor(s) will prepare compliant Progressive ESCPs as an addendum to this Primary ESCP as explained in the hierarchy of documentation.
- The recommended drainage, erosion and sediment control management and mitigation strategies if implemented correctly and competently, will achieve TSS levels equal to or less than 50 mg/L in the sediment basins up to and including the design event.

Michael Frankcombe

National Technical Leader - Land, Water and Rehabilitation
21 April 2022

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Appendix A

Progressive erosion and sediment control plan

A.1 Demolition phase Progressive ESCP

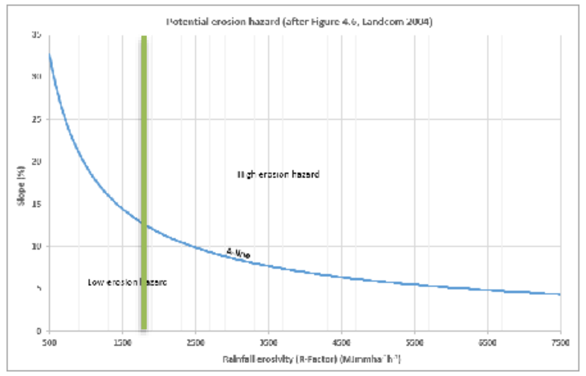
CONSTRUCTION NOTES:

1. THIS EROSION AND SEDIMENT CONTROL PLAN (PESCP) SHOULD BE READ IN CONJUNCTION WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN.
2. NUMBERING (1,2,3) INDICATES ORDER OF WORKS AND CONTROL IMPLEMENTATION.
3. CONTROLS SHOWN ON PLAN ARE INDICATIVE ONLY. EXACT LOCATION WILL BE MODIFIED TO SUIT CONDITIONS AND FUNCTION PROVIDED THEY ARE LOCATED WITHIN CLEARING LIMITS AND REF LIMITS WHERE APPROPRIATE AS DETERMINED BY THE CONTRACTOR(S).
4. CONTROLS WILL BE INSPECTED FOLLOWING RAINFALL CAUSING RUNOFF, WHEN RAINFALL IS PREDICTED AND AT A MINIMUM WEEKLY.
5. 'CLEAN WATER' FLOW IS TO BE MAINTAINED AROUND THE SITE WITH SEPARATION BETWEEN CONSTRUCTION OR 'DIRTY' WATERS IF RUN-ON WATER CATCHMENTS ARE PRESENT.
6. 'CLEAN WATER' DIVERSION CHANNELS WILL BE SIZED TO CONVEY THE 1:2 YR ARI STORM EVENT WHERE TOPOGRAPHY AND CLEARING LIMITS PERMIT.
7. 'DIRTY WATER' FLOW TO SEDIMENT CONTROLS IS TO BE MAXIMISED THROUGH THE USE OF DIVERSION BANKS, CUT OFF DRAINS.
8. SEDIMENT TRAPS ARE TO BE MANAGED IN ACCORDANCE WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN AND DEWATERING EWMS.
9. 'DIRTY WATER' THAT CAN NOT BE DIRECTED TO SEDIMENT BASIN MUST BE DIVERTED TO LOCAL TYPE 2 AND TYPE 3 SEDIMENT CONTROL MEASURES.
10. DEWATERING IS TO BE UNDERTAKEN IN ACCORDANCE WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN AND EWMS.
11. THE DEPOSITION OF SEDIMENT ON PUBLIC ROADS (TRACKING) IS TO BE MONITORED AND REMOVED USING A VACUUM TRUCK.
12. DUST TO BE MINIMISED WITH WATER CARTS, LIMITING VEHICLE SPEEDS AND THE USE OF SOIL POLYMERS.
13. DISTURBED AREAS ARE TO BE PROGRESSIVELY REVEGETATED WITH STERILE COVER CROP OR PERMANENT REVEGETATION DESIGN. TEMPORARY CONTROLS ARE TO REMAIN UNTIL SITE IS STABILISED (60% SOIL SURFACE COVER).
14. THIS PLAN IS TO BE REVISED AS SITE CONDITIONS OR CONSTRUCTION METHODS DETERMINE.

SOIL LOSS CLASS:

SOIL LOSS CLASS (SLC)	CALCULATED SOIL LOSS T/HA/YR	EROSION HAZARD
1	0–150	VERY LOW
2	151–225	LOW
3	226–350	LOW-MODERATE
4	351–500	MODERATE
5	501–750	HIGH
6	751–1,500	VERY HIGH
7	>1,500	EXTREMELY HIGH

EROSION HAZARD:



COVER PAGE

200 ALDRINGTON ROAD KEMPS CREEK EROSION AND SEDIMENT CONTROL PLAN – DEMOLITION PHASE

SEDIMENT BASINS: HES Basin Type 2B

BASIN IDENTIFIER	Settling zone surface area (m^2)	Settling zone depth (m)	Settling zone vole (m^3)	Basin storage (soil) volume (m^3)	Total basin volume to spillway level (m^3)
BioBasin A	802.7	0.90	722.4	217	939.4
HESB_F	3723.6	1.3	4840.7	1452	6292.7

WET WEATHER SHUTDOWN PREPAREDNESS:

INSPECTION EROSION AND SEDIMENT CONTROL MEASURES 24 HOURS PRIOR TO PREDICTED RAINFALL AND UNDERTAKE ANY NECESSARY MAINTENANCE (TRIGGERED IF 60% CHANCE OF 10 MM OF RAIN).

ENSURE SUFFICIENT QUANTITIES OF SOIL POLYMER, SILT FENCE AND APPROVED COAGULANTS AND/OR FLOCCULANTS.

ENSURE ALL SITE TURBID RUNOFF IS DIRECTED TO SEDIMENT CONTROL MEASURES.

ENSURE THE STABILISED CONSTRUCTED EXIT IS FREE FROM ACCUMULATED SOIL AND MUD. REMOVE AND REPLACE WITH CLEAN ROCK AS NECESSARY.

APPLY SOIL POLYMER TO ANY EXPOSED SOIL PARTICULARLY STOCKPILES.

APPLY APPROVED COAGULANTS AND/OR FLOCCULANTS TO THE INLET DRAINS TO SEDIMENT BASIN.

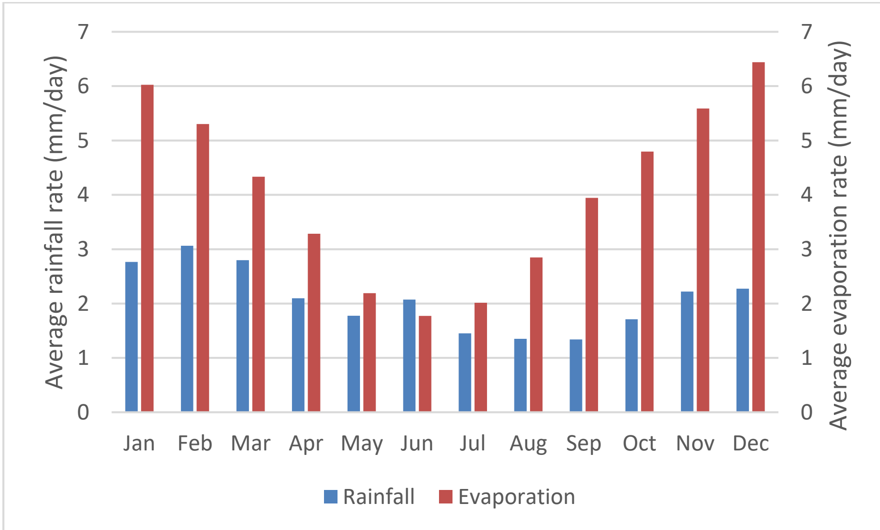
ENSURE ANY CHEMICALS AND HYDROCARBON CONTAINERS ARE PLACED IN BUNDED AREAS OR ON BUNDED PALLETS.

INSPECT CONTROL MEASURES DURING AND AFTER RAINFALL.

SCHEDULE OF WORKS:

ORDER OF WORKS	TASKS	BMPS REQUIRED	TIMING	PURPOSE
1	INSTALL STABILISED CONSTRUCTION EXITS	ROCK/ SHAKER GRIDS	PRIOR TO DEMOLITION WORKS	MINIMISE MUD TRACKING TO PUBLIC ROADS
2	CONSTRUCT HES BASIN A AND ASSOCIATED INLET DRAINS	HES TYPE B BASIN, FLOW ACTIVATED DOSING UNIT, COAGULANTS AND/OR FLOCCULANTS	PRIOR TO DEMOLITION WORKS	TO TRAP SEDIMENT GENERATED DURING DEMOLITION WORKS IN LOT M
3	MODIFY LOT K FARM DAM TO HES BASIN TYPE B (SB2) AND CONSTRUCT DIRTY WATER DIVERSION DRAINS AND BANKS	DEWATERING PUMPS, TSS METER, FLOCCULANTS/COAGULANTS, FLOW ACTIVATED DOSING SYSTEMS	PRIOR TO DEMOLITION WORKS	TO TRAP SEDIMENT GENERATED DURING DEMOLITION WORKS IN LOT K
5	MAINTAIN EXISTING CLEAN WATER FLOWS	NIL	PRIOR TO AND DURING DEMOLITION WORKS	MINIMISE THE POTENTIAL FOR CLEAN RUN ON WATER TO MIX WITH ANY TURBID WATER
6	STABILISE EXISTING ACCESS TRACKS	GRAVEL/ TRAFFICABLE SOIL STABILISING POLYMER	PRIOR TO DEMOLITION WORKS	MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF, MINIMISE MUD TRACKING TO PUBLIC ROADS
7	INSTALL TEMPORARY SEDIMENT CONTROL DOWNSLOPE OF DEMOLITION WORKS	SILT FENCE	PRIOR TO DEMOLITION WORKS	TO TRAP COARSE SEDIMENT
8	STABILISE EXPOSED AREAS	SOIL STABILISING POLYMER	IMMEDIATELY FOLLOWING DEMOLITION WHEN SOIL IS EXPOSED	TO MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF

LIKELIHOOD OF RAINFALL DURING THE CONSTRUCTION PERIOD:



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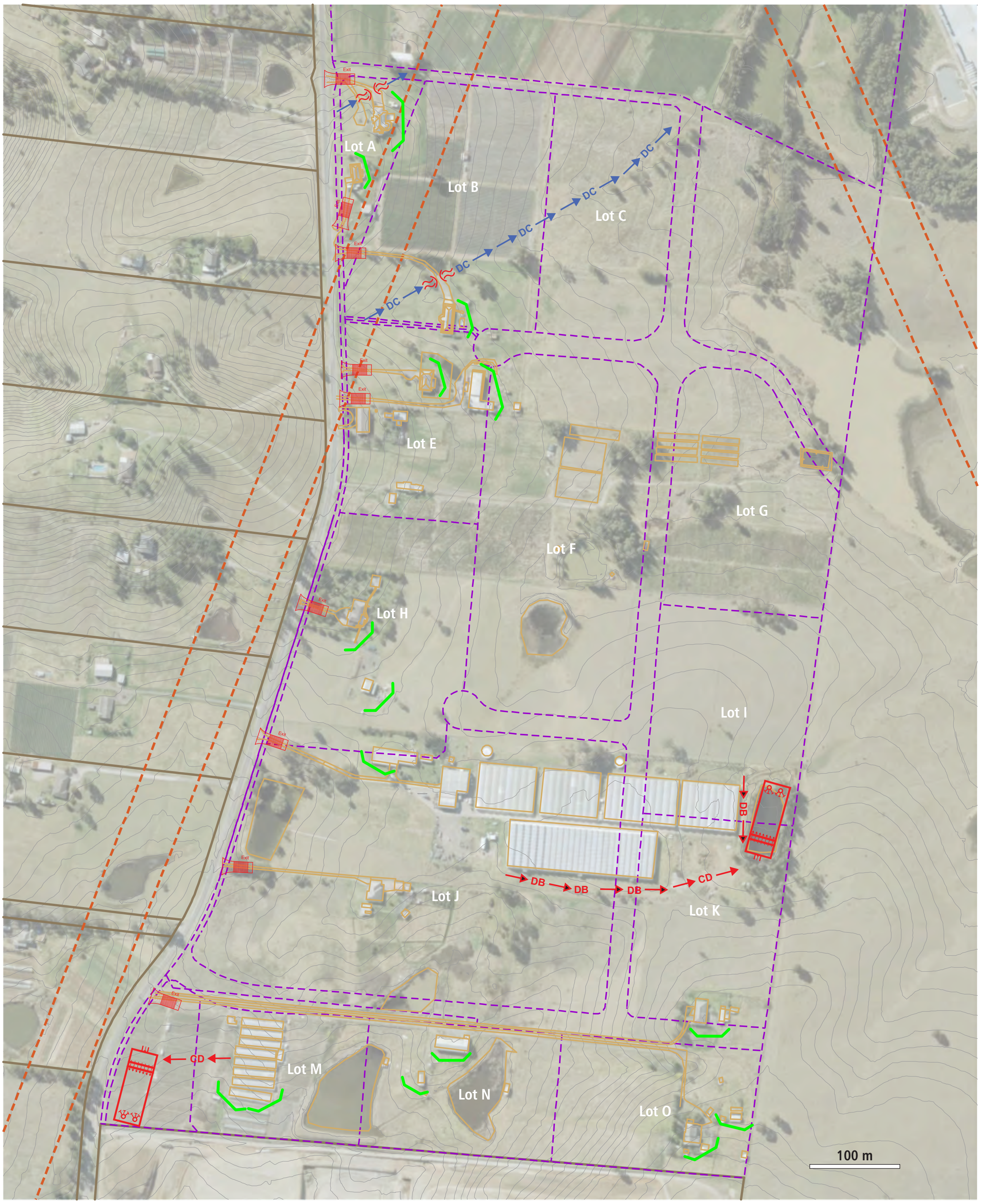
DATE	COMMENTS



LEGEND

- Topographic contour
- Existing boundary
- Existing buildings/layout
- Easement
- Proposed boundary

CONTROL MEASURES

- CD — Catch drain
- DB — Diversion bank
- DC — Diversion channel (existing clean water channel)
- Silt fence
- Exit — Stabilised construction exit with shaker grid and cross bank
- Type A high efficiency sediment basin
- Pipe culvert

EMM creating opportunities

Demolition Phase – Erosion and sediment control plan

200 Aldington Road Industrial Estate Kemps Creek

A.2 Earthworks phase Progressive ESCP

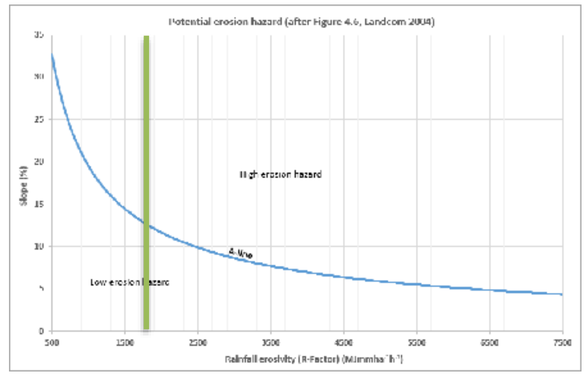
CONSTRUCTION NOTES:

1. THIS EROSION AND SEDIMENT CONTROL PLAN (PESCP) SHOULD BE READ IN CONJUNCTION WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN.
2. NUMBERING (1,2,3) INDICATES ORDER OF WORKS AND CONTROL IMPLEMENTATION.
3. CONTROLS SHOWN ON PLAN ARE INDICATIVE ONLY. EXACT LOCATION WILL BE MODIFIED TO SUIT CONDITIONS AND FUNCTION PROVIDED THEY ARE LOCATED WITHIN CLEARING LIMITS AND REF LIMITS WHERE APPROPRIATE AS DETERMINED BY THE CONTRACTOR(S).
4. CONTROLS WILL BE INSPECTED FOLLOWING RAINFALL CAUSING RUNOFF, WHEN RAINFALL IS PREDICTED AND AT A MINIMUM WEEKLY.
5. 'CLEAN WATER' FLOW IS TO BE MAINTAINED AROUND THE SITE WITH SEPARATION BETWEEN CONSTRUCTION OR 'DIRTY' WATERS IF RUN-ON WATER CATCHMENTS ARE PRESENT.
6. 'CLEAN WATER' DIVERSION CHANNELS WILL BE SIZED TO CONVEY THE 1:2 YR ARI STORM EVENT WHERE TOPOGRAPHY AND CLEARING LIMITS PERMIT.
7. 'DIRTY WATER' FLOW TO SEDIMENT CONTROLS IS TO BE MAXIMISED THROUGH THE USE OF DIVERSION BANKS, CUT OFF DRAINS.
8. SEDIMENT TRAPS ARE TO BE MANAGED IN ACCORDANCE WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN AND DEWATERING EWMS.
9. 'DIRTY WATER' THAT CAN NOT BE DIRECTED TO SEDIMENT BASIN MUST BE DIVERTED TO LOCAL TYPE 2 AND TYPE 3 SEDIMENT CONTROL MEASURES.
10. DEWATERING IS TO BE UNDERTAKEN IN ACCORDANCE WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN AND EWMS.
11. THE DEPOSITION OF SEDIMENT ON PUBLIC ROADS (TRACKING) IS TO BE MONITORED AND REMOVED USING A VACUUM TRUCK.
12. DUST TO BE MINIMISED WITH WATER CARTS, LIMITING VEHICLE SPEEDS AND THE USE OF SOIL POLYMERS.
13. DISTURBED AREAS ARE TO BE PROGRESSIVELY REVEGETATED WITH STERILE COVER CROP OR PERMANENT REVEGETATION DESIGN. TEMPORARY CONTROLS ARE TO REMAIN UNTIL SITE IS STABILISED (60% SOIL SURFACE COVER).
14. THIS PLAN IS TO BE REVISED AS SITE CONDITIONS OR CONSTRUCTION METHODS DETERMINE.

SOIL LOSS CLASS:

SOIL LOSS CLASS (SLC)	CALCULATED SOIL LOSS T/HA/YR	EROSION HAZARD
1	0–150	VERY LOW
2	151–225	LOW
3	226–350	LOW-MODERATE
4	351–500	MODERATE
5	501–750	HIGH
6	751–1,500	VERY HIGH
7	>1,500	EXTREMELY HIGH

EROSION HAZARD:



SEDIMENT BASINS: HES Basin Type 2B

BASIN IDENTIFIER	Settling zone surface area (m^2)	Settling zone depth (m)	Settling zone vole (m^3)	Basin storage (soil) volume (m^3)	Total basin volume to spillway level (m^3)
BioBasin A	802.7	0.90	722.4	217	939.4
BioBasin B	4530.6	1.25	5663.2	1699	7362.2
HESB_B	1848	0.7	1293.6	388	1681.6
HESB_C	4814.5	1.50	7221.8	2167	9388.8
HESB_E	3723.6	1.3	4840.7	1452	6292.7
HESB_F	1690	0.7	1183	355	1538

COVER PAGE

200 ALDRINGTON ROAD KEMPS CREEK EROSION AND SEDIMENT CONTROL PLAN – EARTHWORKS PHASE

WET WEATHER SHUTDOWN PREPAREDNESS:

INSPECTION EROSION AND SEDIMENT CONTROL MEASURES 24 HOURS PRIOR TO PREDICTED RAINFALL AND UNDERTAKE ANY NECESSARY MAINTENANCE (TRIGGERED IF 60% CHANCE OF 10 MM OF RAIN).

ENSURE SUFFICIENT QUANTITIES OF SOIL POLYMER, SILT FENCE AND APPROVED COAGULANTS AND/OR FLOCCULANTS.

ENSURE ALL SITE TURBID RUNOFF IS DIRECTED TO SEDIMENT CONTROL MEASURES.

ENSURE THE STABILISED CONSTRUCTED EXIT IS FREE FROM ACCUMULATED SOIL AND MUD. REMOVE AND REPLACE WITH CLEAN ROCK AS NECESSARY.

APPLY SOIL POLYMER TO ANY EXPOSED SOIL PARTICULARLY STOCKPILES.

APPLY APPROVED COAGULANTS AND/OR FLOCCULANTS TO THE INLET DRAINS TO SEDIMENT BASIN.

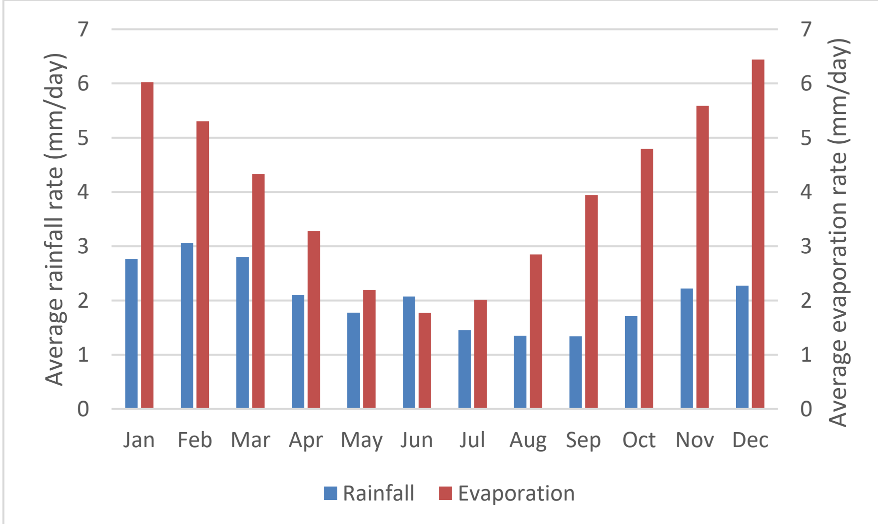
ENSURE ANY CHEMICALS AND HYDROCARBON CONTAINERS ARE PLACED IN BUNDED AREAS OR ON BUNDED PALLETS.

INSPECT CONTROL MEASURES DURING AND AFTER RAINFALL.

SCHEDULE OF WORKS:

ORDER OF WORKS	TASKS	BMPS REQUIRED	TIMING	PURPOSE
1	INSTALL STABILISED CONSTRUCTION EXITS	ROCK/ SHAKER GRIDS	PRIOR TO LAND DISTURBANCE WORKS	MINIMISE MUD TRACKING TO PUBLIC ROADS
2	CONSTRUCT BIOBASIN B AS A TYPE B HES BASIN AND ASSOCIATED INLET DRAINS AND DIVERSION BANKS	HES TYPE B BASIN, FLOW ACTIVATED DOSING UNIT, COAGULANTS AND/OR FLOCCULANTS	PRIOR TO LAND DISTURBANCE WORKS	TO TRAP SEDIMENT GENERATED DURING CLEARING AND GRUBBING AND CUT TO FILL WORKS
3	MODIFY FARM DAMS AS REQUIRED TO HES BASIN TYPE B (SB2) AND CONSTRUCT DIRTY WATER DIVERSION DRAINS AND BANKS	DEWATERING PUMPS, TSS METER, FLOCCULANTS/COAGULANTS, FLOW ACTIVATED DOSING SYSTEMS	PRIOR TO LAND DISTURBANCE WORKS	TO TRAP SEDIMENT GENERATED DURING CLEARING AND GRUBBING AND CUT TO FILL WORKS
4	INSTALL TEMPORARY SEDIMENT CONTROLS IN ANY AREAS DISTURBED AREAS UNABLE TO DIVERTED TO SEDIMENT BASINS. USE POLYMER FLOC BLOCKS TO INCREASE SEDIMENT RAPPING EFFICIENCY AND SOIL STABILISING POLYMER TO MINIMISE EROSION AND THE GENERATION OF SEDIMENT AND TURBID RUNOFF	SEDIMENT FENCE, POSTS, PAM FLOC BLOCKS, SOIL STABILISING POLYMER	PRIOR TO LAND DISTURBANCE WORKS	TO TRAP SEDIMENT AND MINIMISE EROSION IN DISTURBED AREAS THAT CANNOT BE DIVERTED TO SEDIMENT BASINS
5	STABILISE ACCESS TRACKS AND HAUL ROADS	GRAVEL/ TRAFFICABLE SOIL STABILISING POLYMER	PRIOR TO INITIAL USE	MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF AND DUST, MINIMISE MUD TRACKING TO PUBLIC ROADS
6	STRIP, SAVE, STOCKPILE AND STABILISE TOPSOIL STOCKPILES FOR FUTURE REVEGETATION AND LANDSCAPING WORKS	POLYMER SOIL STABILISER, SEED, HYDROMULCH	FOLLOWING CLEARING AND GRUBBING	TO CAP ERODIBLE SUBSOILS AND FOR FUTURE REVEGETATION AND LANDSCAPING WORKS
7	PROGRESSIVEKL STABILISE AND REVEGETATE EXPOSED AREAS	SOIL STABILISING POLYMER, TOPSOIL, SEED, BIOLOGICALLY INOCULATED MINERAL BASED, NON WATER SOLUBLE FERTILISER, GYPSUM, BFM HYDROMULCH	TEMPORARY STABILISATION PRIOR TO PREDICTED RAINFALL	TO MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF

LIKELIHOOD OF RAINFALL DURING THE CONSTRUCTION PERIOD:



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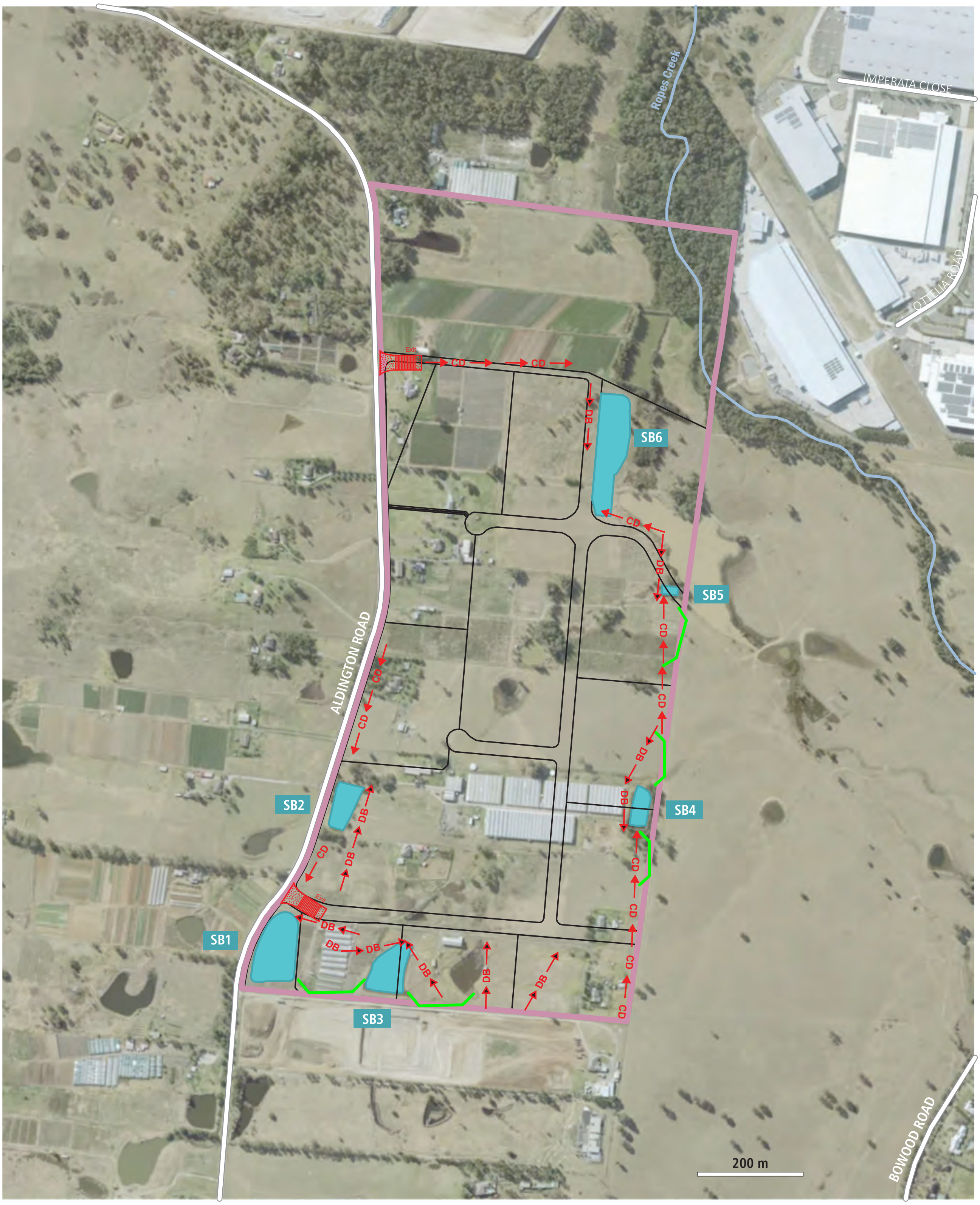
DATE	COMMENTS



LEGEND

Project boundary

Design boundaries

Sediment basin

CONTROL MEASURES

CD Catch drain

DB Diversion bank

Silt fence

Exit Stabilised construction exit with shaker grid and cross bank

EMM creating opportunities

Earthworks Phase – Erosion and sediment control plan

200 Aldington Road Industrial Estate Kemps Creek

A.3 Building phase Progressive ESCP

CONSTRUCTION NOTES:

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6. 'CLEAN WATER' DIVERSION CHANNELS WILL BE SIZED TO CONVEY THE 1:2 YR ARI STORM EVENT WHERE TOPOGRAPHY AND CLEARING LIMITS PERMIT.
7. 'DIRTY WATER' FLOW TO SEDIMENT CONTROLS IS TO BE MAXIMISED THROUGH THE USE OF DIVERSION BANKS, CUT OFF DRAINS.
8. SEDIMENT TRAPS ARE TO BE MANAGED IN ACCORDANCE WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN AND DEWATERING EWMS.
9. 'DIRTY WATER' THAT CAN NOT BE DIRECTED TO SEDIMENT BASIN MUST BE DIVERTED TO LOCAL TYPE 2 AND TYPE 3 SEDIMENT CONTROL MEASURES.
10. DEWATERING IS TO BE UNDERTAKEN IN ACCORDANCE WITH THE PRIMARY EROSION AND SEDIMENT CONTROL PLAN AND EWMS.
11. THE DEPOSITION OF SEDIMENT ON PUBLIC ROADS (TRACKING) IS TO BE MONITORED AND REMOVED USING A VACUUM TRUCK.
12. DUST TO BE MINIMISED WITH WATER CARTS, LIMITING VEHICLE SPEEDS AND THE USE OF SOIL POLYMERS.
13. DISTURBED AREAS ARE TO BE PROGRESSIVELY REVEGETATED WITH STERILE COVER CROP OR PERMANENT REVEGETATION DESIGN. TEMPORARY CONTROLS ARE TO REMAIN UNTIL SITE IS STABILISED (60% SOIL SURFACE COVER).
14. THIS PLAN IS TO BE REVISED AS SITE CONDITIONS OR CONSTRUCTION METHODS DETERMINE.

SOIL LOSS CLASS:

SOIL LOSS CLASS (SLC)	CALCULATED SOIL LOSS T/HA/YR	EROSION HAZARD
1	0–150	VERY LOW
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3	226–350	LOW-MODERATE
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5	501–750	HIGH
6	751–1,500	VERY HIGH
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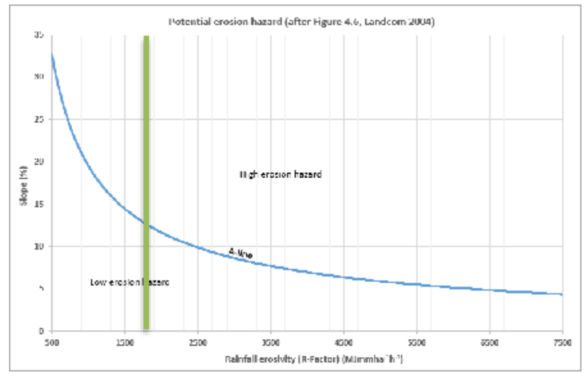
EROSION HAZARD:



SEDIMENT BASINS: HES Basin Type 2B (see Appendix B1)

COVER PAGE

200 ALDRINGTON ROAD KEMPS CREEK EROSION AND SEDIMENT CONTROL PLAN – BUILDING PHASE

WET WEATHER SHUTDOWN PREPAREDNESS:

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ENSURE SUFFICIENT QUANTITIES OF SOIL POLYMER, SILT FENCE AND APPROVED COAGULANTS AND/OR FLOCCULANTS.

ENSURE ALL SITE TURBID RUNOFF IS DIRECTED TO SEDIMENT CONTROL MEASURES.

ENSURE THE STABILISED CONSTRUCTED EXIT IS FREE FROM ACCUMULATED SOIL AND MUD. REMOVE AND REPLACE WITH CLEAN ROCK AS NECESSARY.

APPLY SOIL POLYMER TO ANY EXPOSED SOIL PARTICULARLY STOCKPILES.

APPLY APPROVED COAGULANTS AND/OR FLOCCULANTS TO THE INLET DRAINS TO SEDIMENT BASIN.

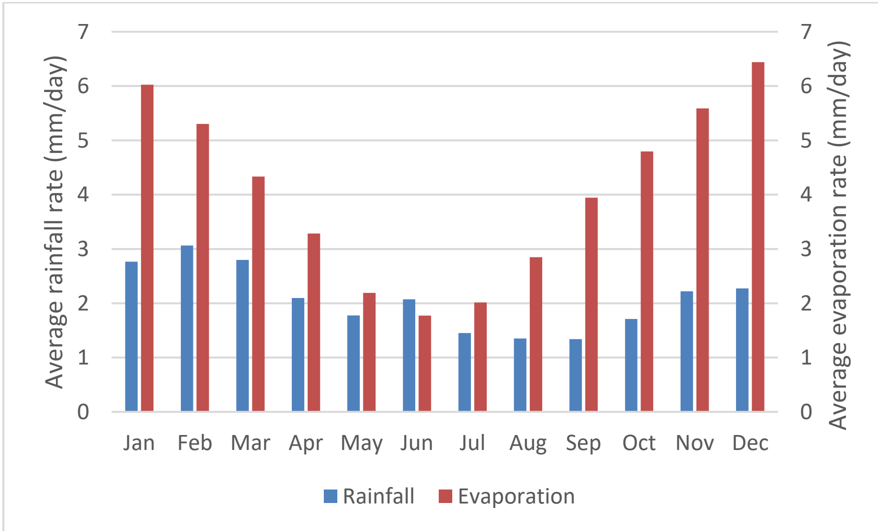
ENSURE ANY CHEMICALS AND HYDROCARBON CONTAINERS ARE PLACED IN BUNDED AREAS OR ON BUNDED PALLETS.

INSPECT CONTROL MEASURES DURING AND AFTER RAINFALL.

SCHEDULE OF WORKS:

ORDER OF WORKS	TASKS	BMPS REQUIRED	TIMING	PURPOSE
1	INSTALL STABILISED CONSTRUCTION EXITS	ROCK/ SHAKER GRIDS	PRIOR TO BUILDING WORKS	MINIMISE MUD TRACKING TO PUBLIC ROADS
2	CONSTRUCT HES BASINS AND ASSOCIATED INLET DRAINS	HES TYPE A BASINS, FLOW ACTIVATED DOSING UNIT, COAGULANTS AND/OR FLOCCULANTS	PRIOR TO BUILDING WORKS	TO TRAP SEDIMENT GENERATED DURING BUILDING WORKS
3	MAINTAIN POLYMER GROUND COVER	DEWATERING PUMPS, TSS METER, FLOCCULANTS/COAGULANTS, FLOW ACTIVATED DOSING SYSTEMS	AT ALL TIMES	TO MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF
4	CONNECT DOWNPIPES TO STORMATER SYSTEM	DOWNPIPES	AS SOON AS POSSIBLE	MINIMISE CONTAMINATION OF CLEAN WATER AND THE VOLUME OF TURBID WATER TO BE TREATED
5	INSTALL PERMANENT DRIVEWAYS, ACCESS ROADS, HARDSTANDS AND PARKING AREAS	PERMANENT PAVEMENTS	AS SOON AS POSSIBLE	TO MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF
6	INSTALL PERMANENT LANDSCAPING	PLANTS, MULCH, EDGING, TREE GUARDS	AS SOON AS POSSIBLE	TO MINIMISE EROSION AND THE GENERATION OF TURBID RUNOFF

LIKELIHOOD OF RAINFALL DURING THE CONSTRUCTION PERIOD:



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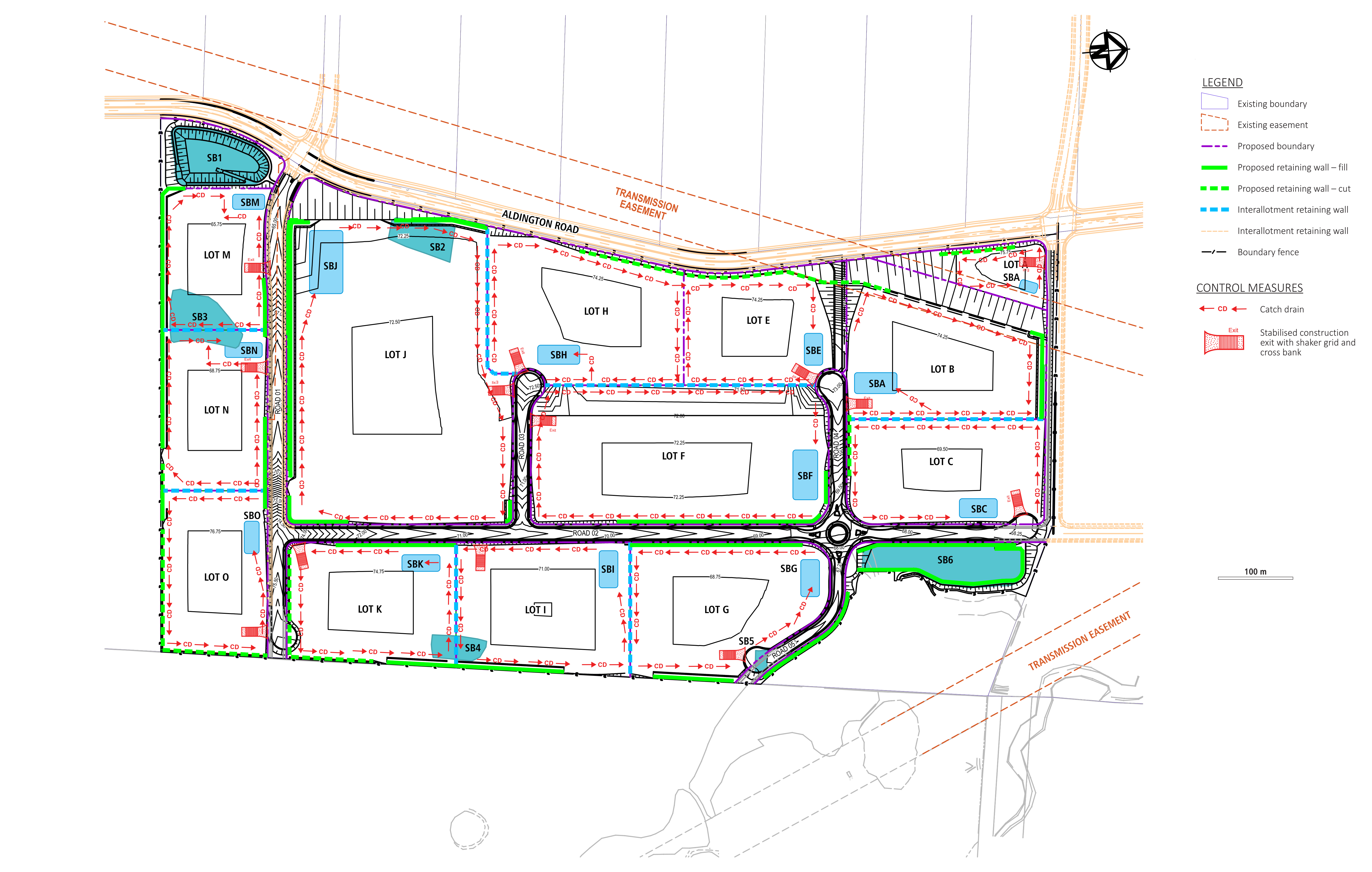
DATE	COMMENTS



Building Phase – Erosion and sediment control plan

200 Aldington Road Industrial Estate Kemps Creek

Appendix B

SEEC's sediment basin sizing report

TABLE 1 - STAGE 1 (INITIAL EARTHWORKS) SEDIMENT BASIN SIZING SCHEDULE

ALL BASIN DESIGNS ARE IN ACCORDANCE WITH IECA (2008).

					Refer to Figures on ESCP06					Spillway Dimensions (Refer to Figure 1 below)						Chute Dimensions (Refer to Figure 1 below)					Energy Dissipater (Refer to Figure 10 on ESCP08)						
BASIN ID	Catchment area (ha)	LS	Soil loss (t/ha/yr)	Adopted Sediment Basin Type	Average settling zone surface area (m^2)	Min. Depth of Settling (DS) zone (m)	Sediment basin settling volume (m^3)	Sediment basin storage (soil) volume (m^3)	Total sediment basin volume (m^3) (does not include forebay)	Q50 (m^3/s) Q20*	Min. Weir Crest Width (b) (m)	Min. Weir Top Width (T) (m)	Flow Depth (y) (m)	Critical Velocity (m/s)	Weir Depth Inc. 300mm freeboard (D) (m)	Min. Chute Base Width (b) (m)	Min. Chute Top Width (T) (m)	ChuteDepth Inc. min. 150mm freeboard (D) (m)	$_d50$ (mm)	$_d50$ thickness (mm)	Base Width (W_1) (m)	Base Width (W_2) (m)	Unit Flow Rate (m^3/s/m)	Length (L) (m)	$_d50$ (mm)	$_d50$ thickness (mm)	Additional Comments
SB-1	23.71	1.64	205	B	5382	1.3	6996.6	2099	9095.6	5.624	6.2	9.8	0.6	1.9	0.9	6.2	8.4	0.55	600	1200	9	9.48	0.59	2.7	200	400	SB1 sizing is based on largest catchment reporting to sediment basin during the three stages of works. Construct spillway to permananent design where possible.
SB-2	5.74	1.19	148	B	1848.0	0.7	1293.6	388	1681.6	1.431*	3.6	3.2	0.35	1.46	0.65	3.6	2.5	0.4	400	800	3.1	3.58	0.31	2.7	200	400	Utilise exisitng farm dam as sediment basin during initial earthworks.
SB-3	16.7	1.19	148	B	3723.6	1.3	4840.7	1452	6292.7	3.289*	6	9	0.45	1.67	0.75	6	7.8	0.45	500	1000	8.4	8.88	0.46	2.7	200	400	Utilise exisitng farm dam as sediment basin during initial earthworks.
SB-4	5.33	1.19	148	B	1690	0.7	1183	355	1538.0	1.329*	3.5	6.1	0.35	1.46	0.65	3.5	5.1	0.4	400	800	5.7	6.18	0.29	2.7	200	400	Utilise exisitng farm dam as sediment basin during initial earthworks.
SB-5	23.09	0.78	97	B	4814.5	1.5	7221.8	2167	9388.8	4.223*	6.5	9.7	0.5	1.76	0.8	6.5	8.5	0.5	500	1000	9.1	9.58	0.56	2.7	200	400	Utilise exisitng farm dam as sediment basin during initial earthworks.
SB-6	47	1.47	183	B	9839.2	1.5	14758.8	4428	19186.8	9.403	10	13.8	0.65	2	0.95	10	12.2	0.55	600	1200	12.8	13.28	0.71	2.7	200	400	SB6 sizing is based on largest catchment reporting to sediment basin during the three stages of works. Construct spillway to permananent design where possible.

* ASSUMES SEDIMENT BASINS AN SPILLWAYS ARE IN PLACE FOR <12 MONTHS.

TABLE 2 - STAGE 2 (MAIN EARTHWORKS) SEDIMENT BASIN SIZING SCHEDULE

					Refer to Figures on ESCP06								Spillway Dimensions (Refer to Figure 1 below)						Chute Dimensions (Refer to Figure 1 below)					Energy Dissipater (Refer to Figure 10 on ESCP08)						
BASIN ID	Catchment area (ha)	LS	Soil loss (t/ha/yr)	Adopted Sediment Basin Type	Min. average settling zone surface area (m^2)	Min depth of settling Zone - V_s (m^3)	Min. Depth of sediment storage zone (D_{ss}) (m)	Sediment basin settling volume (m^3)	Sediment basin storage (soil) volume (m^3)	Min. free water zone V_{FW} (m^3)	Total sediment basin volume (m^3) (does not include forebay)	No. of decant arms	Q50 (m^3/s)	Min. Weir Crest Width (b) (m)	Min. Weir Top Width (T) (m)	Flow Depth (y) (m)	Critical Velocity (m/s)	Weir Depth Inc. 300mm freeboard (D) (m)	Min. Chute Base Width (b) (m)	Min. Chute Top Width (T) (m)	ChuteDepth Inc. min. 150mm freeboard (D) (m)	$_d50$ (mm)	$_d50$ thickness (mm)	Base Width (W_1) (m)	Base Width (W_2) (m)	Unit Flow Rate (m^3/s/m)	Length (L) (m)	$_d50$ (mm)	$_d50$ thickness (mm)	Additional Comments
SB-1	23.71	1.64	205	B	5382	1.3	-	6996.6	2099	-	9095.6	-	5.624	6.2	9.8	0.6	1.9	0.9	6.2	8.4	0.55	600	1200	9	9.48	0.59	2.7	200	400	SB1 sizing is based on largest catchment reporting to sediment basin during the three stages of works. Construct spillway to permananent design where possible.
SB-6	47	1.47	183	B	9839.2	1.5	-	14758.8	4428	-	19186.8	-	9.403	10	13.8	0.65	2	0.95	10	12.2	0.55	600	1200	12.8	13.28	0.71	2.7	200	400	SB6 sizing is based on largest catchment reporting to sediment basin during the three stages of works. Construct spillway to permananent design where possible.
SB-A	0.88	1.75	218	A	200.5	0.6	0.31	120.3	37.03	29.87	187.2	2	0.37	1.5	3.9	0.3	1.2	0.55	1.5	2.9	0.35	300	600	3.5	3.74	0.10	2.1	200	400	
SB-B	9.38	1.90	238	A	1025.6	1.25	0.54	1282.0	385.15	162.9	1830.1	19	2.687	6	8.8	0.4	1.6	0.7	6	7.6	0.4	400	800	8.2	8.68	0.31	2.7	200	400	
SB-C	4.18	0.65	81	A	571.3	1	0.46	571.3	172.32	88.25	831.9	9	1.403	3.5	6.1	0.35	1.46	0.65	3.5	5.1	0.4	400	800	5.7	6.18	0.23	2.7	200	400	
SB-E	3.12	1.47	183	A	473.8	0.9	0.42	426.4	129.53	73.06	629.0	7	1.124	3	5.6	0.35	1.46	0.65	3	4.6	0.4	400	800	5.2	5.68	0.20	2.7	200	400	
SB-F	7.43	0.78	97	A	846.3	1.2	0.54	1015.5	307.73	132.26	1455.5	15	2.261	5	7.8	0.4	1.57	0.7	5	6.6	0.4	400	800	7.2	7.68	0.29	2.7	200	400	
SB-G	4.52	0.78	97	A	686.4	0.9	0.38	617.8	186.24	111.08	915.1	10	1.517	3.5	6.3	0.4	1.6	0.7	3.5	5.1	0.4	400	800	5.7	6.18	0.25	2.7	200	400	
SB-H	4.49	1.19	148	A	681.9	0.9	0.38	613.7	184.81	110.26	908.8	9	1.507	3.5	6.3	0.4	1.6	0.7	3.5	5.1	0.4	400	800	5.7	6.18	0.24	2.7	200	400	
SB-I	4.13	0.45	57	A	627.2	0.9	0.39	564.5	171.18	100.41	836.1	9	1.386	3.5	6.1	0.35	1.46	0.65	3.5	5.1	0.4	400	800	5.7	6.18	0.22	2.7	200	400	
SB-J	11.48	1.19	148	A	1207.0	1.3	0.55	1569.1	471.93	193.97	2235.0	23	3.186	6	9	0.45	1.67	0.75	6	7.8	0.45	500	1000	8.4	8.88	0.36	2.7	200	400	
SB-K	3.32	2.50	66	A	567.2	0.8	0.34	453.8	137.32	91.8	682.9	7	1.152	3	5.6	0.35	1.46	0.65	3	4.6	0.4	400	800	5.2	5.68	0.20	2.7	200	400	
SB-M	2.79	1.47	183	A	476.7	0.8	0.35	381.3	114.28	75.52	571.1	6	1.005	3	5.6	0.35	1.46	0.65	3	4.4	0.35	300	600	5	5.24	0.19	2.1	200	400	
SB-N	3.25	1.33	166	A	555.3	0.8	0.34	444.2	133.87	89.64	667.7	7	1.171	3	5.6	0.35	1.46	0.65	3	4.6	0.4	400	800	5.2	5.68	0.21	2.7	200	400	
SB-O	2.76	2.05	256	A	471.5	0.8	0.36	377.2	115.68	74.6	567.5	6	0.994	3	5.6	0.35	1.46	0.65	3	4.4	0.35	300	600	5	5.24	0.19	2.1	200	400	

TABLE 3 - STAGE 3 (FINAL EARTHWORKS) SEDIMENT BASIN SIZING SCHEDULE

					Refer to Figures on ESCP06					Spillway Dimensions (Refer to Figure 1 below)						Chute Dimensions (Refer to Figure 1 below)					Energy Dissipater (Refer to Figure 10 on ESCP08)						
BASIN ID	Catchment area (ha)	LS	Soil loss (t/ha/yr)	Adopted Sediment Basin Type	Min. average settling zone surface area (m^2)	Min depth of settling Zone - V_s (m^3)	Sediment basin settling volume (m^3)	Sediment basin storage (soil) volume (m^3)	Total sediment basin volume (m^3) (does not include forebay)	Q50 (m^3/s)	Min. Weir Crest Width (b) (m)	Min. Weir Top Width (T) (m)	Flow Depth (y) (m)	Critical Velocity (m/s)	Weir Depth Inc. 300mm freeboard (D) (m)	Min. Chute Base Width (b) (m)	Min. Chute Top Width (T) (m)	ChuteDepth Inc. min. 150mm freeboard (D) (m)	$_d50$ (mm)	$_d50$ thickness (mm)	Base Width (W_1) (m)	Base Width (W_2) (m)	Unit Flow Rate (m^3/s/m)	Length (L) (m)	$_d50$ (mm)	$_d50$ thickness (mm)	Additional Comments
SB-1	23.71	1.64	205	B	5382	1.3	6996.6	2099	9095.6	5.624	6.2	9.8	0.6	1.9	0.9	6.2	8.4	0.55	600	1200	9	9.48	0.59	2.7	200	400	Construct spillway to permananent design where possible.
SB-6	47	1.47	183	B	9839.2	1.5	14758.8	4428	19186.8	9.403	10	13.8	0.65	2	0.95	10	12.2	0.55	600	1200	12.8	13.28	0.71	2.7	200	400	Construct spillway to permananent design where possible.

DRAFT

NOTES:

- CATCHMENT AREA IS THE LARGEST CATCHMENT THAT WILL REPORT TO EACH BASIN.
- R FACTOR IS 1920 FOR ALL BASINS
- K FACTOR IS 0.05 FOR ALL BASINS
- P FACTOR IS 1.3 FOR ALL BASINS
- C FACTOR IS 1 FOR ALL BASINS
- JAR TEST SETTLEMENT RATE OF 150mm AFTER 15min HAS BEEN USED FOR ALL TYPE A & B BASIN CALCULATIONS.
- Q1 24HOUR STORM INTENSITY = 3.27 mm/hr FOR ALL TYPE A BASINS.
- No. OF DECANT ARMS FOR TYPE A BASINS ASSUMES 2m WIDE ARMS AT 2.25 L/s/m.

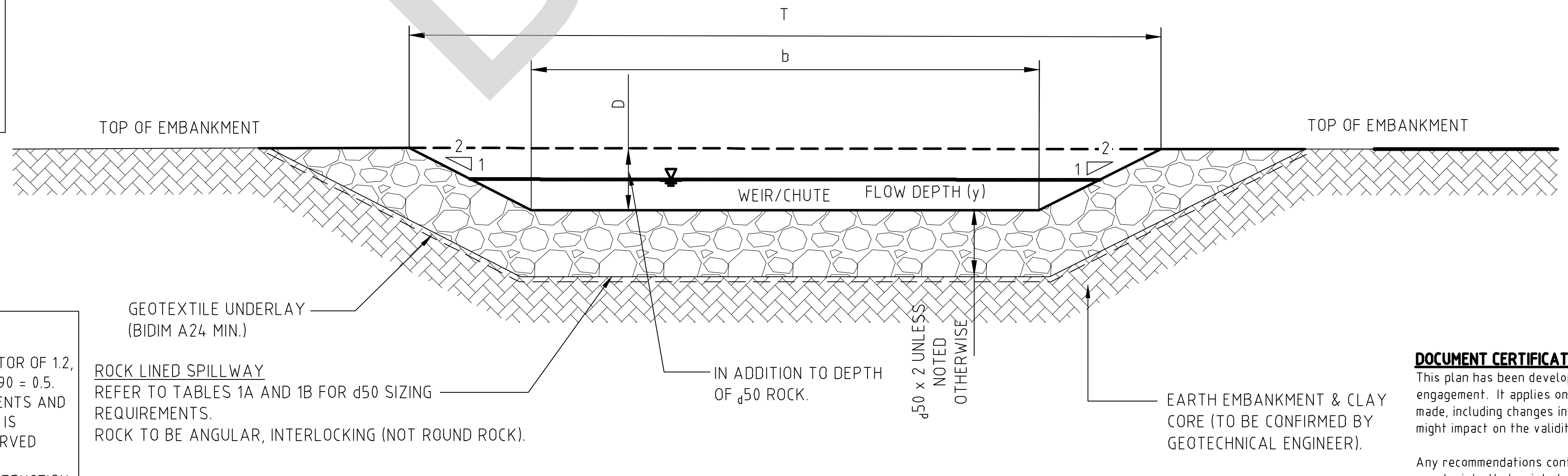


FIGURE 1: TYPICAL PROFILE OF TRAPEZOIDAL SPILLWAY AND CHUTE.

NOTES:

- CHUTES ASSUMED TO BE AT A LONGITUDINAL GRADE OF 1 IN 2.
- ROCK SIZE OF CHUTE LINING BASED ON IECA 2008 WITH A SAFETY FACTOR OF 1.2, SPECIFIC GRAVITY OF ROCK = 2.4 WITH A SIZE DISTRIBUTION OF d50/d90 = 0.5.
- MONITOR ALL ROCK OUTLET STRUCTURES OVER SEVERAL STORMS EVENTS AND ANY SUBSEQUENT LARGE EVENTS TO CONFIRM THAT THE ROCK LINING IS PERFORMING AS EXPECTED. IF SIGNS OF SCOUR OR MOVEMENT IS OBSERVED CONTACT THE DESIGNERS FOR FURTHER ADVICE.
- SEEC HAVE ONLY PROVIDED HYDRAULIC CALCULATIONS FOR THE CONSTRUCTION OF SEDIMENT BASINS, WEIRS, CHUTES AND DISSIPATER OUTLETS.

DOCUMENT CERTIFICATION

This plan has been developed based on agreed requirements as understood by SEEC at the time of engagement. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects. Changes to the project scope or extent might impact on the validity of this plan.

Any recommendations contained in this plan are based on an honest appraisal of the opportunities and constraints that existed at the site at the time of investigation, or as advised to us. Such recommendations are potentially subject to the limited scope and resources available.

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	11/04/22	L.O.	L.O.	B.J.	CONCEPT ISSUE - FOR CONSULTATION

DRAWING STATUS

DESIGN BY	L.O.
DRAWN BY	L.O.
FINAL APPROVAL	B.J.
SCALE: (on A3 Original)	N.T.S.

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PROJECT TITLE

INDUSTRIAL ESTATE
LOTS 20-23 IN DP 255560 &
LOTS 30-32 IN DP 258949
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE

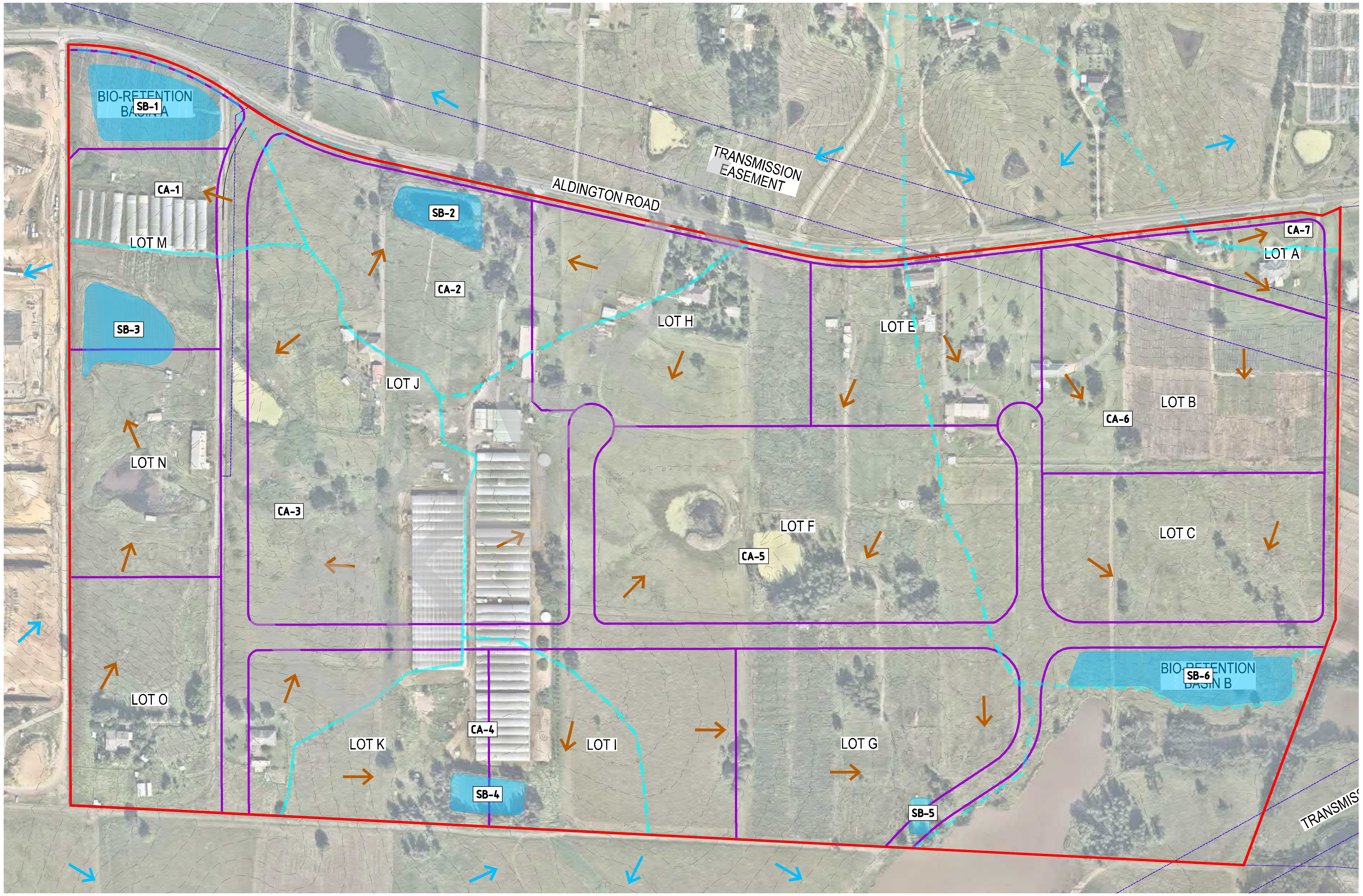
TABLES 1, 2 & 3 BASIN SIZING SCHEDULE AND CHUTE/WEIR DETAIL SHEET 1 OF 8

PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
22000119	P01	ESCP01	A

LEGEND:

(red line)	PROJECT BOUNDARY
(yellow dashed line)	PROPOSED RETAINING WALLS
(blue arrow)	CLEAN WATER FLOW DIRECTION
(brown arrow)	DIRTY WATER FLOW DIRECTION
(blue shape)	SEDIMENT BASIN (REFER TO TABLE 1 ON ESCP01 MIN. SIZING REQUIREMENTS)
(cyan dashed line)	CATCHMENT BOUNDARY
(dashed line)	EXISTING CONTOURS (1m INTERVALS)

NOTE UNDERLYING AERIAL SOURCED FROM NEARMAP, 2022. UNDERLYING CONTOURS SOURCED FROM ELVIS ELEVATIONS, 2021. UNDERLYING DESIGN PROVIDED BY CLIENT.



0 20 30 60 80 100m

Scale: 1:4000 (A3 SHEET)

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	11/04/22	L.O.	L.O.	B.J.	CONCEPT ISSUE – FOR CONSULTATION

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FINAL APPROVAL	B.J.
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PROJECT TITLE

INDUSTRIAL ESTATE
LOTS 20–23 IN DP 255560 &
LOTS 30–32 IN DP 258949
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE

EROSION AND SEDIMENT CONTROL PLAN – INITIAL EARTHWORKS SHEET 2 OF 8

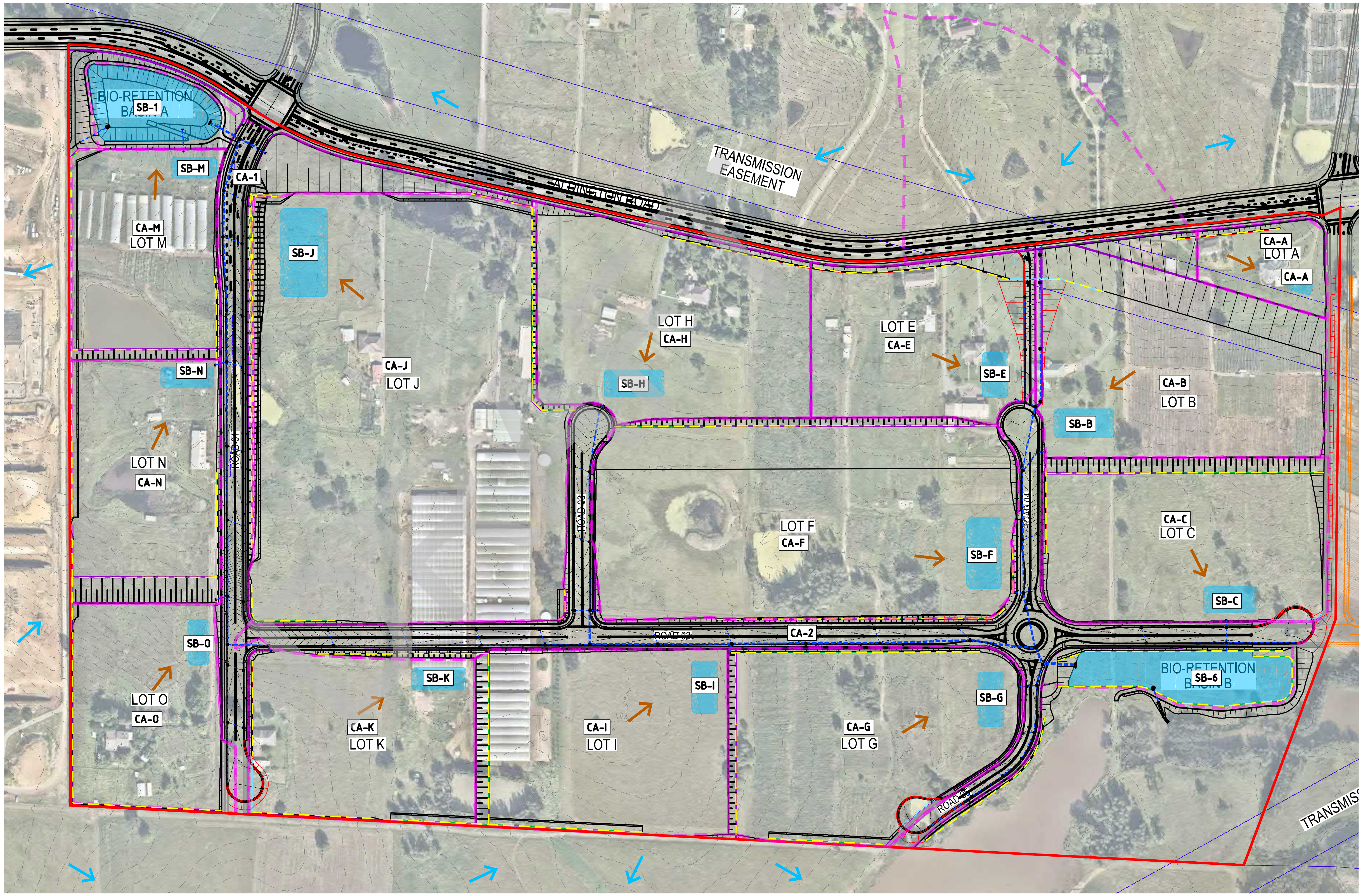
PROJECT NO.	SUB–PR NO.	DRAWING NO.	REV
22000119	P01	ESCP02	A

Plot Date: Monday, 11 April 2022 10:53:25 AM CAD File Name: M:\22000119 Aldrington Road Kemps Creek – HES Basins\Drawings\22000119_P01_ESCP_REV A.dwg

LEGEND:

- PROJECT BOUNDARY
- PROPOSED RETAINING WALLS
- CLEAN WATER FLOW DIRECTION
- DIRTY WATER FLOW DIRECTION
- SEDIMENT BASIN (REFER TO TABLE 2 ON ESCP01 MIN. SIZING REQUIREMENTS)
- CATCHMENT BOUNDARY
- EXISTING CONTOURS (1m INTERVALS)

NOTE UNDERLYING AERIAL SOURCED FROM NEARMAP, 2022. UNDERLYING CONTOURS SOURCED FROM ELVIS ELEVATIONS, 2021. UNDERLYING DESIGN PROVIDED BY CLIENT.



0 20 30 60 80 100m

Scale: 1:4000 (A3 SHEET)

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	11/04/22	L.O.	L.O.	B.J.	CONCEPT ISSUE – FOR CONSULTATION

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DRAWN BY	L.O.
FINAL APPROVAL	B.J.
SCALE: (on A3 Original)	1:4000

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PROJECT TITLE
INDUSTRIAL ESTATE
LOTS 20–23 IN DP 255560 &
LOTS 30–32 IN DP 258949
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE
EROSION AND SEDIMENT CONTROL PLAN – MAIN EARTHWORKS
SHEET 3 OF 8

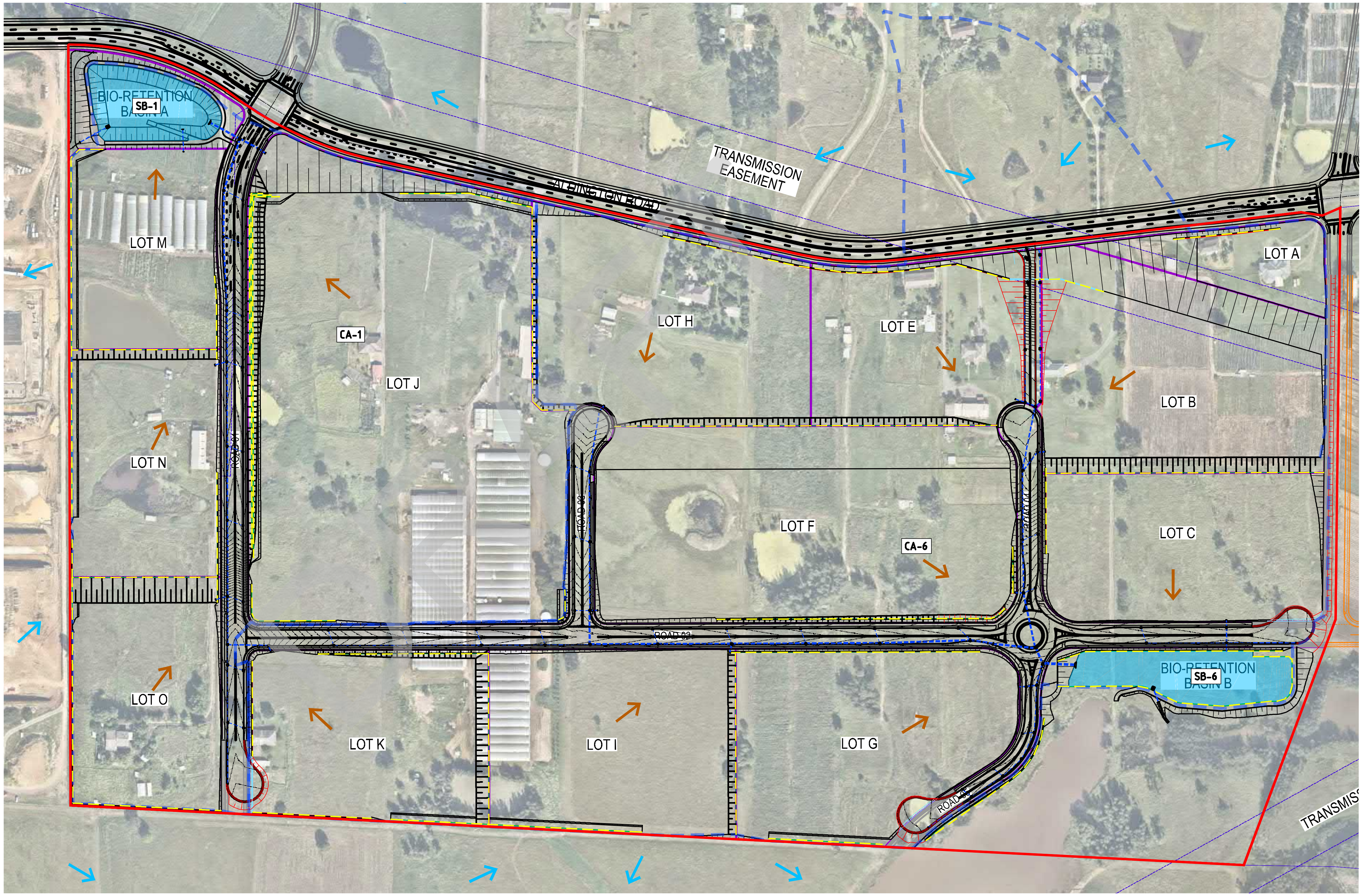
PROJECT NO.	SUB–PR NO.	DRAWING NO.	REV
22000119	P01	ESCP03	A

Plot Date: Monday, 11 April 2022 10:53:34 AM CAD File Name: M:\22000119 Aldrington Road Kemps Creek – HES Basins\Drawings\22000119_P01_ESCP_REV A.dwg

LEGEND:

- PROJECT BOUNDARY
- PROPOSED RETAINING WALLS
- CLEAN WATER FLOW DIRECTION
- DIRTY WATER FLOW DIRECTION
- SEDIMENT BASIN (REFER TO TABLE 3 ON ESCP01 MIN. SIZING REQUIREMENTS)
- CATCHMENT BOUNDARY
- EXISTING CONTOURS (1m INTERVALS)

NOTE UNDERLYING AERIAL SOURCED FROM NEARMAP, 2022. UNDERLYING CONTOURS SOURCED FROM ELVIS ELEVATIONS, 2021. UNDERLYING DESIGN PROVIDED BY CLIENT.



0 20 30 60 80 100m

Scale: 1:4000 (A3 SHEET)

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	11/04/22	L.O.	L.O.	B.J.	CONCEPT ISSUE – FOR CONSULTATION

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PROJECT TITLE

INDUSTRIAL ESTATE
LOTS 20–23 IN DP 255560 &
LOTS 30–32 IN DP 258949
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE

EROSION AND SEDIMENT CONTROL PLAN – FINAL EARTHWORKS
SHEET 4 OF 8

PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
22000119	P01	ESCP04	A

INSTRUCTIONS FOR BASIN CONSTRUCTION

1. Monitor weather forecasts and schedule basin construction for a period of relatively dry weather.
2. Peg out or use tape to delineate the proposed areas of disturbance for basin construction.
3. Install a sediment fence, mulch bund or coir log filter immediately downslope of the proposed basin construction area as a short-term backup control. Alternatively, a bund can be formed at the downslope edge of the basin construction area by pushing topsoil and vegetation into a windrow.
4. Clear vegetation and strip topsoil from sediment basin and embankment footprint. Stockpiles are to be located and formed as per the Master ESCP instructions.
5. Undertake dust suppression as required.

MATERIALS -

6. Using competent earth-fill material (assessed by the project geotechnical engineer), form the basin wall (including cut-off trench if required) in layers and compact each progressively.
7. Geotextile fabric: heavy duty, needle-punched, non-woven cloth, minimum 'bidim' A24 or equivalent.

CONSTRUCTION -

8. Notwithstanding any description contained with approved plans or specifications, the Contractor shall be responsible for satisfying themselves as to the nature and extent of the specified works and ensuring they have all the required approvals prior to carrying out works. This shall include means of access, extent of clearing, nature of materials to be excavated, type and size of mechanical plant required, location and suitability of water supply for construction and testing purposes, and any other likely matters affecting the construction of the works.
9. Refer to approved plans for location, dimensions, and construction details. If there are any questions or problems with the location, dimensions, or method of installation, contact the engineer or responsible on-site officer for assistance.
10. Before starting any clearing or construction, ensure all the necessary materials and components are on the site to avoid delays in completing the sediment basins once work begins.
11. Install requires short term sediment controls measures downstream of the proposed earthworks to control sediment runoff during construction of the sediment basin. Refer to Instruction 3 above.
12. 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, shrubs, stumps, roots, dead timber and rubbish and disposed of in a suitable manner. Delay clearing the main basin area until the embankment is complete.
13. Ensure all holes made by grubbing within the embankment footprint are filled with sound material (to be assessed by the project geotechnical engineer), adequately compacted, and finished flush with the natural surface.

CUT OFF TRENCH -

14. Project geotechnical engineer to advise if any basin embankment requires a cut-off trench.
15. Project geotechnical engineer to advise depth, location and extent of any cut-off trench.
16. Project geotechnical engineer to advise cut-off wall material, construction methodology and compaction requirements.

EMBANKMENT-

17. Scarify areas on which fill is to be placed before placing fill.
18. Ensure all fill material used to form the embankment meets the specifications certified by the project geotechnical engineer.
19. 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 specified dimensions.
20. Ensure debris and other unsuitable building waste is not placed within the earth embankment.
21. Embankment construction method (e.g. moisture content and compaction method and limits) to be advised by the project geotechnical engineer.
22. After completion of the embankment all loose uncompacted earth-fill material on the upstream and downstream batter must be removed prior to spreading topsoil.
23. Topsoil and re-vegetate/stabilise all exposed earth.

ESTABLISHING SETTLING POND-

24. The area to covered by the stored water outside of the limits of the borrow pits must be cleared of rubbish. Trees must be cut down stump high and removed from the immediate vicinity of works.
25. 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. If pipes are used for basin inlets, ensure they have at least 5% (1 in 20) grade on them to minimise the risk of sediment accumulating in the pipe.
26. Ensure dirty water from the upstream catchment reports to the basin forebay.
27. Install a sediment storage level marker post with a cross member set to just below the top of the sediment storage zone (as specified on Tables 1, 2 and 3 on ESCP01). Use at least a 75mm wide post firmly set into the basin floor.
28. Install internal settling pond baffle (75% weave shade cloth and pool noodle) across the full width of the sediment basins where the required 3:1 length:width ratio cannot be achieved.
29. Install all appropriate measures to minimise safety risk to onsite 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.

SPILLWAY-

30. Shape the spillway (weir, chute and energy dissipater), line with geofabric and rock to the dimensions noted in Tables 1, 2 and 3 on ESCP01. The fabric must extend all the way to the edge of the work area, onto undisturbed or natural ground.
31. Spillway outlet made up of spillway crest, chute and energy dissipater. Refer to Tables 1, 2 and 3 on ESCP01 for rock sizes and dimensions and details on ESCP01.

ADDITIONAL INSTRUCTIONS -

32. For Type A and B basins, install a level spreader (100-200mm above emergency spillway level) between Forebay Chamber and the Main Chamber of the basin. Check it is level (survey pickup).
33. Check that the basin capacity achieves the required surface area and volumes as shown in the basin sizing Tables 1, 2 and 3 on ESCP01.

MAINTENANCE OF SEDIMENT BASINS

1. Inspection the sediment basin during the following periods:
   - 1.1. During construction to determine whether machinery, falling trees, or construction activity has damaged any components of the sediment basins. If damage has occurred, repair sediment basin immediately;
   - 1.2. After each runoff event inspect the erosion damage at flow entry and exit points. If damage has occurred, make the necessary repairs immediately;
   - 1.3. At least weekly during the nominated wet season (if any) otherwsie at least fortnightly;
   - 1.4. Prior to, and immediately after, periods of 'stop work' or site 'shutdown'.
2. Clean out accumulated sediment when it reaches the sediment storage marker board/post, and restore the original storage volume. Place sediment in a disposal area or, if appropriate, mix with dry soil on site.
3. Do not dispose 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 fill material in the dam/embankment for excessive settlement, slumping of the slopes or piping between the conduit and the embankment; make all necessary repairs immediately.
6. Remove all trash and other debris from the basin (including any risers, decant arms etc).
7. Submerged inflow pipes must be inspected and de-silted (as required) after each inflow event.

DE-WATERING

Type B Sediment Basin -

- Type B settling ponds must be de-watered prior to a rain event that is likely to produce runoff; however, during dry conditions water may be retained in the settling pond as a source of water for usage on the construction site (i.e. dust suppression).

Note: High risk (i.e. proximity to sensitive environments and/or undersized sediment basins) Type B sediment basin should be prioritised for de-watering.

DIRTY WATER TREATMENT AND DISCHARGE REQUIREMENTS

- Any active discharge of water from the project (i.e. where water is moved offsite via direct action such as pumping rather than flowing off the project as a result of heavy rainfall) is to achieve:
  - 50mg/L or less TSS (Total Suspended Sediment); and
  - neutral pH (6.5 to 8.5); and
  - <10mg/L oil and grease and visible trace.
- For any dirty water collected in sumps/excavations flocculation can be achieved by using gypsum (or similar) at a rate of approximately 30 kg/100m³ of stormwater. Refer to manufacturers guidelines for dosage details.
- Ensure the flocculant/coagulant is thoroughly mixed/diluted with water (e.g. within an IBC) prior to spreading evenly over entire water surface for proper treatment. Dirty water from the basins can be used for mixing the flocculant/coagulant.
- These de-watering requirements apply to dirty water accumulating in any sort of excavation, sump, or other ponded water body on the project.

DE-SILTING PROCEDURES

- An appropriately marked (e.g. painted) de-silting marker post must be installed in the sediment basins to indicate the top of the sediment storage zone. The sediment basins must be de-silted if the next storm is likely to cause the settled sediment to rise above this marker point, or if the settled sediment has exceeded 90% of the nominated sediment storage volume.

REMOVAL OF SEDIMENT BASIN

1. When grading and construction works in the drainage area above a temporary sediment basin is completed and the disturbed areas are adequately stabilised, the sediment basin must be removed or otherwise incorporated into the permanent stormwater drainage system. In either case, sediment should be cleared and properly disposed of an 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 embankments 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.

AUTODOSER

1. Autodosers to be provided by others.
2. Autodosers to achieve settling rate 150mm in 15 minutes unless noted otherwise on Tables 1, 2 and 3 on ESCP01.
3. Consult with and refer to manufacturers recommendations regarding set up and operation of the dosing unit.
4. Autodoser and supply of flocculent to be provided on level pad 4m x 4m within 10m of dosing plant.
5. All weather access track to be provided to dosing unit.

SAFETY

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 maybe warranted even if the basins are located adjacent to other permanent water bodies such as a stream, lake, or wetland.

Responsibility of 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.

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 as much as possible. 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.

If the basins internal banks are steeper than 1:5 (V:H), and the basin will not be fenced, then a suitable method of egress during wet weather needs to be installed. Examples include a ladder, steps cut into the bank, or at least one bank turfed for a width of at least 2m from the top of bank to the toe of bank.

NOTE: A geotechnical engineer is required to design, review, approve and certify all earthworks associated with sediment basins, embankments, weirs, chutes and dissipater outlet construction. SEEC have only provide hydraulic calculations for the construction of sediment basins, weirs, chutes and dissipater outlets.

HYDRAULIC ASPECTS REVIEWED BY
William (Bill) Johnson RPEQ No. 6728

ALL BASIN DESIGNS ARE IN ACCORDANCE WITH IECA (2008).

REV	DATE	DES.	DRN.	APP.	REVISION DETAILS
A	11/04/22	L.O.	L.O.	B.J.	CONCEPT ISSUE – FOR CONSULTATION

DRAWING STATUS	
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CONCEPT	

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PROJECT TITLE
INDUSTRIAL ESTATE
LOTS 20–23 IN DP 255560 &
LOTS 30–32 IN DP 258949
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE
SEDIMENT BASIN CONSTRUCTION & MAINTENANCE INSTRUCTIONS
SHEET 5 OF 8

PROJECT NO.	SUB–PR NO.	DRAWING NO.	REV
22000119	P01	ESCP05	A

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TYPICAL SEDIMENT BASIN LAYOUTS

ALL BASIN DESIGNS ARE IN ACCORDANCE WITH IECA (2008).

FOREBAY TO BE:
- MIN. 10% OF SETTLING ZONE VOLUME;
- MIN. LENGTH OF 5m; AND
- MIN. DEPTH OF 1m.
- FOREBAY VOLUME NOT INCLUDED IN TOTAL SEDIMENT BASIN VOLUME SHOWN IN TABLES 1, 2 & 3 ON ESCP01.

Average Settling Zone Surface Area (m^2) measured at mid depth of settling zone. Refer to Tables 1, 2 & 3 on ESCP01 for Average Settling Zone Surface Area.

LEVEL SPREADER CREST

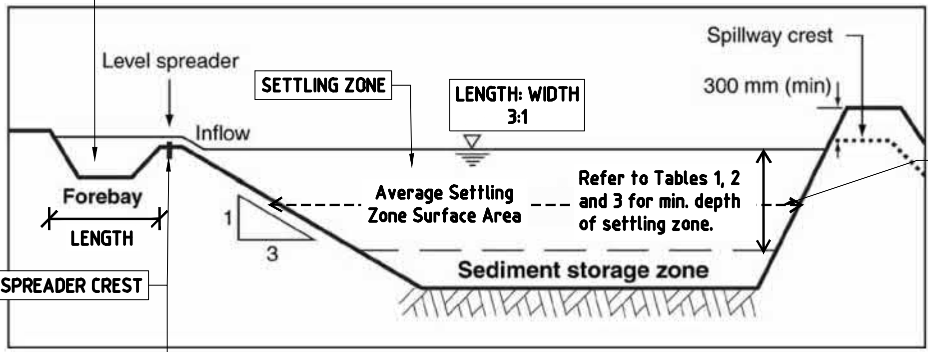


FIGURE 2: TYPICAL LONG-SECTION OF A TYPE B SEDIMENT BASIN (FROM IECA, 2018).

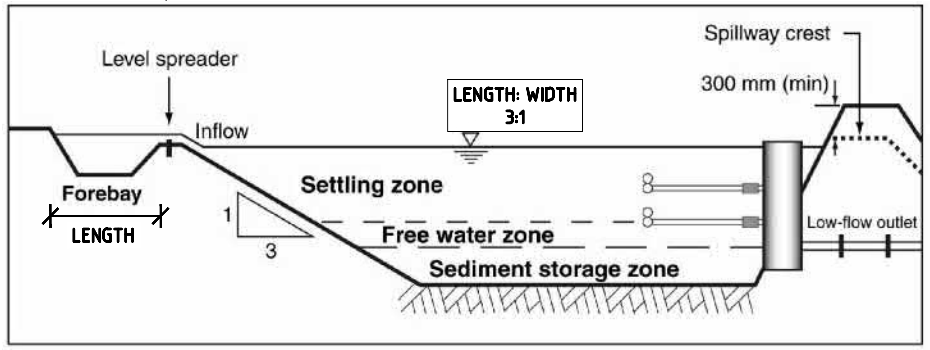


FIGURE 3: TYPICAL LONG-SECTION OF A TYPE A SEDIMENT BASIN (FROM IECA, 2018).

PIPE INLETS TO BE MIN. 5% GRADE TO MINIMISE THE RISK OF SEDIMENT ACCUMULATING IN THE PIPE. ALL PIPE INLETS TO BE A MINIMUM OF 200mm ABOVE THE LEVEL SPREADER CREST.

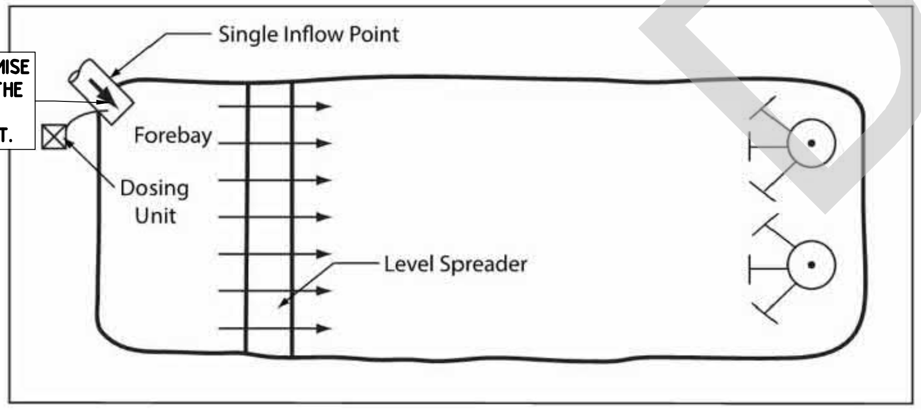


FIGURE 4: SINGLE INFLOW TO TYPE A & B SEDIMENT BASINS (FROM IECA, 2018).

PIPE INLETS TO BE MIN. 5% GRADE TO MINIMISE THE RISK OF SEDIMENT ACCUMULATING IN THE PIPE. ALL PIPE INLETS TO BE A MINIMUM OF 200mm ABOVE THE LEVEL SPREADER CREST.

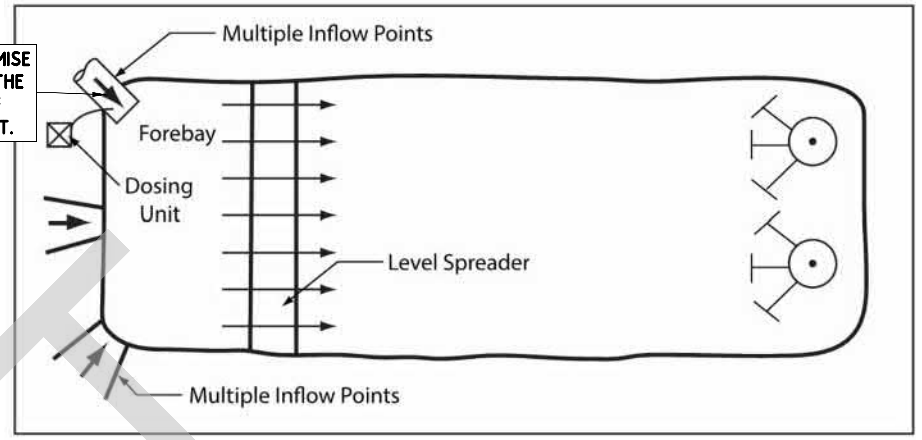


FIGURE 5: MULTIPLE INFLOWS TO TYPE A & B SEDIMENT BASINS (FROM IECA, 2018).

PIPE INLETS TO BE MIN. 5% GRADE TO MINIMISE THE RISK OF SEDIMENT ACCUMULATING IN THE PIPE. ALL PIPE INLETS TO BE A MINIMUM OF 200mm ABOVE THE LEVEL SPREADER CREST.

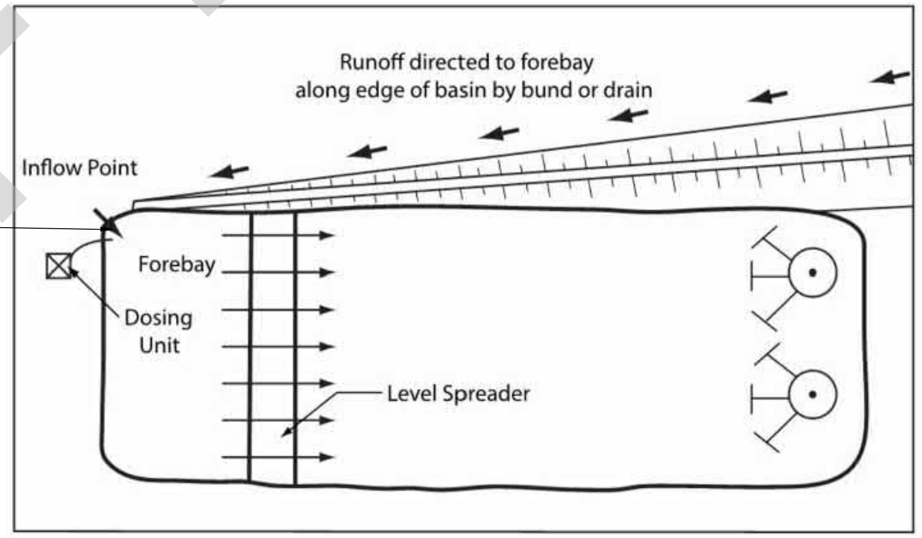
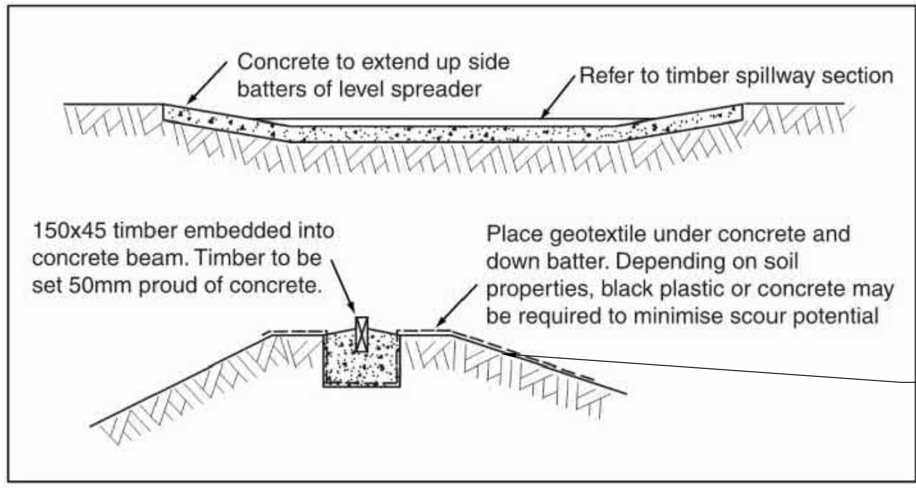


FIGURE 6: ENSURE ALL INFLOWS TO TYPE A & B SEDIMENT BASINS ARE INTO THE FOREBAY (FROM IECA, 2018).



Downstream side must have a smooth transition to limit turbulence (i.e. no sudden drops).

FIGURE 7: TYPICAL DETAIL FOR TYPE B SEDIMENT BASIN LEVEL SPREADER BETWEEN FOREBAY AND MAIN CHAMBER (FROM IECA, 2018). ALL SEE PHOTO 1.

NOTE: ALL INFLOWS MUST BE DIRECTED INTO THE SEDIMENT FOREBAY FOR TYPE A and B BASINS.

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LOTS 20–23 IN DP 255560 &
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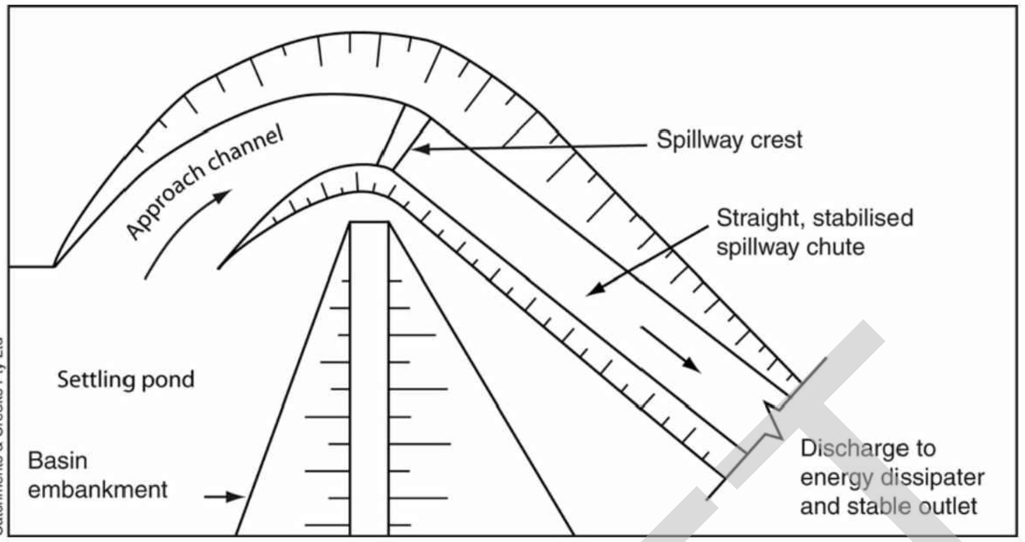
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE
TYPICAL SEDIMENT BASIN LAYOUTS
SHEET 6 OF 8

PROJECT NO.	SUB–PR NO.	DRAWING NO.	REV
22000119	P01	ESCP06	A

TYPICAL EMERGENCY SPILLWAY DETAILS



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MATERIALS

ROCK: HARD, ANGULAR, DURABLE, WEATHER RESISTANT AND EVENLY GRADED WITH 50% BY WEIGHT LARGER THAN THE SPECIFIED NOMINAL ROCK SIZE AND 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. SPECIFIC GRAVITY TO BE AT LEAST 2.5.

GEOTEXTILE FABRIC: HEAVY-DUTY, NEEDLE-PUNCHED, NON-WOVEN FILTER CLOTH, MINIMUM BIDIM A24 OR EQUIVALENT.

INSTALLATION (CHUTE FORMATION)

1. REFER TO APPROVED PLANS FOR LOCATION AND CONSTRUCTION DETAILS. IF THERE ARE QUESTIONS OR PROBLEMS WITH THE LOCATION OR METHOD OF INSTALLATION, CONTACT THE ENGINEER OR RESPONSIBLE ON-SITE OFFICER FOR ASSISTANCE.
2. ENSURE ALL NECESSARY SOIL TESTING (e.g. SOIL pH, NUTRIENT LEVELS) AND ANALYSIS HAS BEEN COMPLETED, AND REQUIRED SOIL ADJUSTMENTS PERFORMED PRIOR TO PLANTING.
3. CLEAR THE LOCATION FOR THE CHUTE CLEARING ONLY WHAT IS NEEDED TO PROVIDE ACCESS FOR PERSONNEL AND EQUIPMENT FOR INSTALLATION.
4. REMOVE ROOTS, STUMPS, AND OTHER DEBRIS AND DISPOSE OF THEM PROPERLY.
5. CONSTRUCT THE SUBGRADE TO THE ELEVATIONS SHOWN ON THE PLANS. REMOVE ALL UNSUITABLE MATERIAL AND REPLACE WITH STABLE MATERIAL TO ACHIEVE THE DESIRED FOUNDATIONS.
6. IF THE CHUTE IS TEMPORARY, THEN COMPACT THE SUBGRADE TO A FIRM CONSISTENCY. IF THE CHUTE IS INTENDED TO BE PERMANENT, THEN COMPACT AND FINISH THE SUBGRADE AS SPECIFIED WITHIN THE DESIGN PLANS.
7. AVOID COMPACTING THE SUBGRADE TO A CONDITION THAT WOULD PREVENT THE TURF FROM BONDING WITH THE SUBGRADE.
8. ENSURE THE SIDES OF THE CHUTE ARE NO STEEPER THAN A 1.5:1 (H:V) SLOPE.
9. ENSURE THE COMPLETED CHUTE HAS SUFFICIENT DEEP ALONG ITS FULL LENGTH.
10. ENSURE THE CHUTE IS STRAIGHT FROM ITS CREST TO THE TOE OF THE CHUTE.
11. ON FILL SLOPES, ENSURE THAT THE SOIL IS ADEQUATELY COMPACTED FOR A WIDTH OF AT LEAST ONE METRE EACH SIDE OF THE CHUTE TO MINIMISE THE RISK OF SOIL EROSION, OTHERWISE PROTECT THE SOIL WITH SUITABLE SCOUR PROTECTION MEASURES SUCH AS TURF OR EROSION CONTROL MATS.
12. PLACE AND SECURE THE TURF AS DIRECTED.
13. INSTALL AN APPROPRIATE OUTLET STRUCTURE (ENERGY DISSIPATER) AT THE BASE OF THE CHUTE (REFER TO SEPARATE SPECIFICATIONS).
14. ENSURE WATER LEAVING THE CHUTE AND THE OUTLET STRUCTURE WILL FLOW FREELY WITHOUT CAUSING UNDESIRABLE PONDING OR SCOUR.
15. APPROPRIATELY STABILISE ALL DISTURBED AREAS IMMEDIATELY AFTER CONSTRUCTION.

INSTALLATION (ROCK PLACEMENT)

1. OVER-CUT THE CHANNEL TO A DEPTH EQUAL TO THE SPECIFIED DEPTH OF ROCK PLACEMENT SUCH THAT THE FINISHED ROCK SURFACE WILL BE AT THE ELEVATION OF THE SURROUNDING LAND.
2. ROCK MUST BE PLACED WITHIN THE CHANNEL AS SPECIFIED WITHIN THE APPROVED PLANS, INCLUDING THE PLACEMENT OF ANY SPECIFIED FILTER LAYER.
3. IF DETAILS ARE NOT PROVIDED ON THE ROCK PLACEMENT, THEN THE PRIMARY ARMOUR ROCK MUST BE EITHER PLACED ON:
(i) A FILTER BED FORMED FROM A LAYER OF SPECIFIED SMALLER ROCK (ROCK FILTER LAYER);
(ii) AN EARTH BED LINED WITH FILTER CLOTH;
(iii) AN EARTH BED NOT LINED IN FILTER CLOTH, BUT ONLY IF ALL VOIDS BETWEEN THE ARMOUR ROCK ARE TO BE FILLED WITH SOIL AND POCKET PLANTED IMMEDIATELY AFTER PLACEMENT OF THE ROCK.
4. IF A ROCK/AGGREGATE FILTER LAYER IS SPECIFIED, THEN PLACE THE FILTER LAYER IMMEDIATELY AFTER THE FOUNDATIONS ARE PREPARED. SPREAD THE FILTER ROCK IN A UNIFORM LAYER TO THE SPECIFIED DEPTH BUT A MINIMUM OF 150mm. WHERE MORE THAN ONE LAYER OF FILTER MATERIAL HAS BEEN SPECIFIED, SPREAD EACH LAYER SUCH THAT MINIMAL MIXING OCCURS BETWEEN EACH LAYER OF ROCK.
5. IF A GEOTEXTILE (FILTER CLOTH) UNDERLAY IS SPECIFIED, PLACE THE FABRIC DIRECTLY ON THE PREPARED FOUNDATION. IF MORE THAN ONE SHEET OF FABRIC IS REQUIRED TO OVER THE AREA, OVERLAP THE EDGE OF EACH SHEET AT LEAST 300mm AND PLACE ANCHOR PINS AT MINIMUM 1m SPACING ALONG THE OVERLAP.
6. ENSURE THE GEOTEXTILE FABRIC IS PROTECTED FROM PUNCHING OR TEARING DURING INSTALLATION OF THE FABRIC AND THE ROCK. REPAIR ANY DAMAGE BY REMOVING THE ROCK AND PLACING WITH ANOTHER PIECE OF FILTER CLOTH OVER THE DAMAGED AREA OVERLAPPING THE EXISTING FABRIC A MINIMUM OF 300mm.
7. WHERE NECESSARY, A MINIMUM 100mm LAYER OF FINE GRAVEL, AGGREGATE OR SAND SHOULD BE PLACED OVER THE FABRIC TO PROTECT IT FROM DAMAGE.
8. PLACEMENT OF ROCK SHOULD FOLLOW IMMEDIATELY AFTER PLACEMENT OF THE FILTER LAYER. PLACE ROCK SO THAT IT FORMS A DENSE, WELL-GRADED MASS OF ROCK WITH A MINIMUM OF VOIDS.
9. PLACE ROCK TO ITS FULL THICKNESS IN ONE OPERATION. DO NOT PLACE ROCK BY DUMPING THROUGH CHUTES OR OTHER METHODS THAT CAUSE SEGREGATION OF ROCK SIZES.
10. THE FINISHED SURFACE 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.
11. IMMEDIATELY UPON COMPLETION OF THE CHANNEL, VEGETATE ALL DISTURBED AREAS OR OTHERWISE PROTECT THEM AGAINST SOIL EROSION.
12. WHERE SPECIFIED, FILL ALL VOIDS WITH SOIL AND VEGETATE THE ROCK SURFACE IN ACCORDANCE WITH THE APPROVED PLAN.

MAINTENANCE

1. DURING THE CONSTRUCTION PERIOD, INSPECT ALL CHUTES PRIOR TO FORECAST RAINFALL, DAILY DURING EXTENDED PERIODS OF RAINFALL, AFTER SIGNIFICANT RUNOFF PRODUCING STORM EVENTS, OR OTHERWISE ON A WEEKLY BASIS. MAKE REPAIRS AS NECESSARY.
2. CHECK FOR SCOUR OR DISLODGED ROCK. REPAIR DAMAGED AREAS IMMEDIATELY.
3. CLOSELY INSPECT THE OUTER EDGES OF THE ROCK PROTECTION. ENSURE WATER ENTRY INTO THE CHANNEL OR CHUTE IS NOT CAUSING EROSION ALONG THE EDGE OF THE ROCK PROTECTION.
4. INVESTIGATE THE CAUSE OF ANY SCOUR, AND REPAIR AS NECESSARY.
5. CAREFULLY CHECK THE STABILITY OF THE ROCK LOOKING FOR INDICATIONS OF PIPING, SCOUR HOLES, OR BANK FAILURES.
6. REPLACE ANY DISPLACED ROCK WITH ROCK OF A SIGNIFICANTLY (MINIMUM 110%) LARGER SIZE THAN THE DISPLACED ROCK.
7. ENSURE SEDIMENT IS NOT PARTIALLY BLOCKING FLOW ENTRY INTO THE CHUTE. WHERE NECESSARY, REMOVE ANY DEPOSITED MATERIAL TO ALLOW FREE DRAINAGE.
8. DISPOSE OF ANY SEDIMENT IN A MANNER THAT WILL NOT CREATE AN EROSION OR POLLUTION HAZARD.
9. WHEN MAKING REPAIRS, ALWAYS RESTORE THE CHUTE TO ITS ORIGINAL CONFIGURATION UNLESS AN AMENDED LAYOUT IS REQUIRED.

Drawn:	Date:		
GMW	May-10	Chutes - Rock Linings	CH-06

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FIGURE 8: CHUTE LINING NOTES (FROM IECA, 2018).

CONSTRUCTION

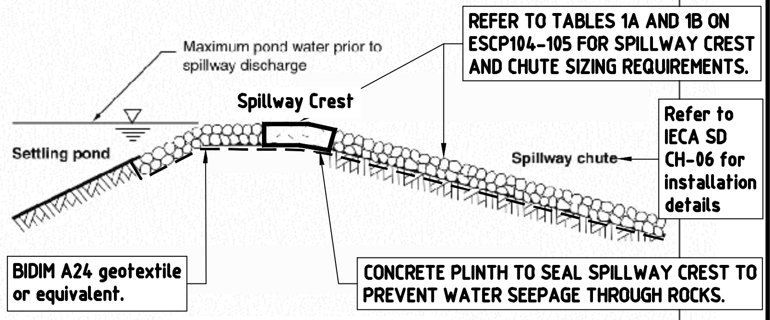
1. THE SPILLWAY MUST BE EXCAVATED AS SHOWN ON THE PLANS, AND THE EXCAVATED MATERIAL IF CLASSIFIED AS SUITABLE, MUST BE USED IN THE EMBANKMENT, AND IF NOT SUITABLE IT MUST BE DISPOSED OF INTO SPOIL HEAPS.
2. ENSURE EXCAVATED DIMENSIONS ALLOW ADEQUATE BOXING OUT SUCH THAT THE SPECIFIED ELEVATIONS, GRADES, 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.
3. 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.
4. IF A SYNTHETIC FILTER FABRIC UNDERLAY IS SPECIFIED, PLACE THE FILTER FABRIC DIRECTLY ON THE PREPARED FOUNDATION. IF MORE THAN 1 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.

MAINTENANCE

1. DURING THE CONSTRUCTION PERIOD, INSPECT THE SPILLWAY PRIOR TO FORECAST RAINFALL, DAILY DURING EXTENDED PERIODS OF RAINFALL, AFTER SIGNIFICANT RUNOFF PRODUCING STORM EVENTS, OR OTHERWISE ON A WEEKLY BASIS. MAKE REPAIRS AS NECESSARY.
2. CHECK FOR MOVEMENT OF, OR DAMAGE TO, THE SPILLWAY'S LINING, INCLUDING SURFACE CRACKING.
3. CHECK FOR SOIL SCOUR ADJACENT THE SPILLWAY. INVESTIGATE THE CAUSE OF ANY SCOUR, AND REPAIR AS NECESSARY.
4. WHEN MAKING REPAIRS, ALWAYS RESTORE THE SPILLWAY TO ITS ORIGINAL CONFIGURATION UNLESS AN AMENDED LAYOUT IS REQUIRED.

REMOVAL

1. TEMPORARY SPILLWAYS SHOULD BE REMOVED WHEN AN ALTERNATIVE, STABLE, DRAINAGE SYSTEM IS AVAILABLE.
2. REMOVE ALL MATERIALS AND DEPOSITED SEDIMENT, AND DISPOSE OF IN A SUITABLE MANNER THAT WILL NOT CAUSE AN EROSION OR POLLUTION HAZARD.
3. GRADE THE AREA IN PREPARATION FOR STABILISATION, THEN STABILISE THE AREA AS SPECIFIED IN THE APPROVED PLAN.



Seepage control on spillway crest

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GMW	Dec-09	Emergency Spillways	ES-1

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FIGURE 9: EMERGENCY SPILLWAY - CROSS-SECTION AND STANDARD INSTRUCTIONS (FROM IECA, 2018).

ALL BASIN DESIGNS ARE IN ACCORDANCE WITH IECA (2008).

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PROJECT TITLE

INDUSTRIAL ESTATE
LOTS 20-23 IN DP 255560 &
LOTS 30-32 IN DP 258949
ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE

TYPICAL EMERGENCY SPILLWAY DETAILS SHEET 7 OF 8

PROJECT NO.	SUB-PR NO.	DRAWING NO.	REV
22000119	P01	ESCP07	A

TYPICAL OUTLET (ENERGY DISSIPATER) DETAILS

ALL BASIN DESIGNS ARE IN ACCORDANCE WITH IECA (2008).

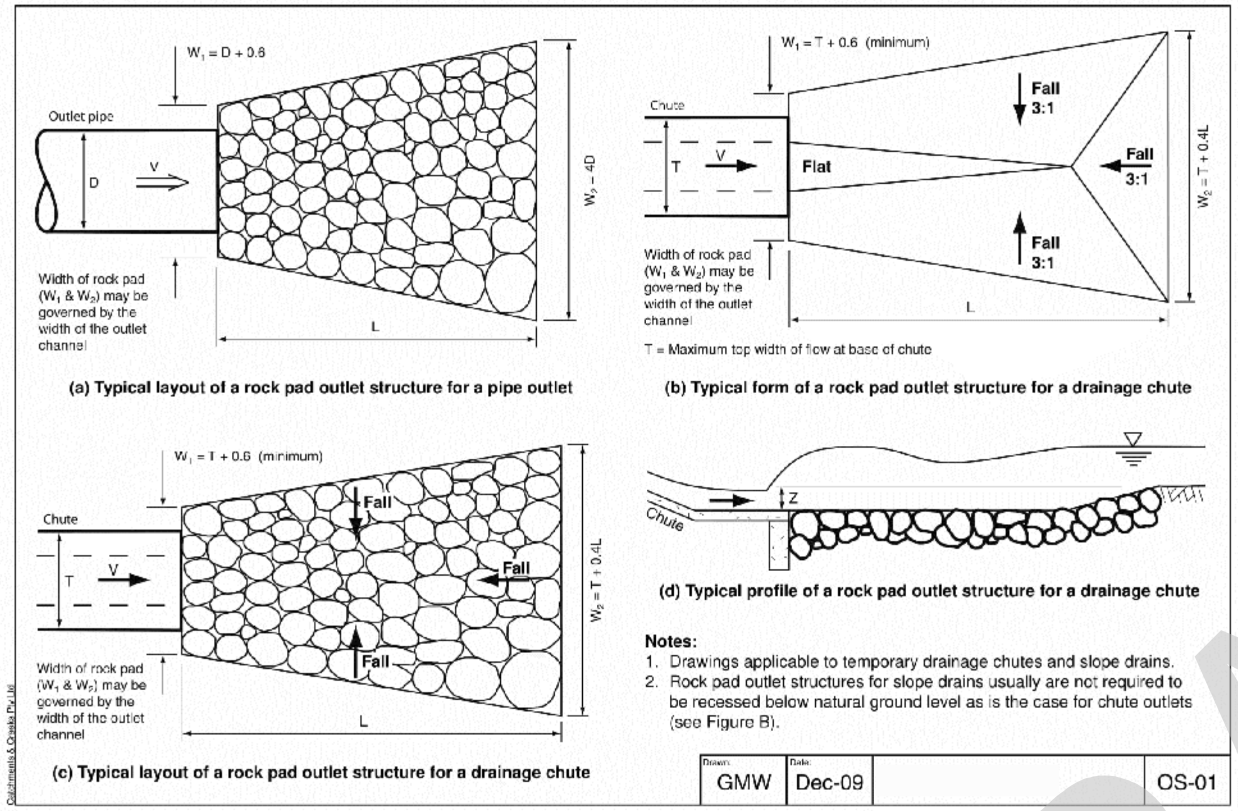

FIGURE 10: OUTLET SCOUR PROTECTION (FROM IECA, 2008).

NOTE: Consult project geotechnical engineer to determine appropriate measures to minimise the risk of piping failure (i.e. seepage collars) if a low flow outlet pipe is adopted.

MATERIALS (ROCK PADS)

ROCK: HARD, ANGULAR, DURABLE, WEATHER RESISTANT AND EVENLY GRADED WITH 50% BY WEIGHT LARGER THAN THE SPECIFIED NOMINAL ROCK SIZE AND 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. SPECIFIC GRAVITY TO BE AT LEAST 2.5.

GEOTEXTILE FABRIC: HEAVY-DUTY, NEEDLE PUNCHED, NON WOVEN FILTER CLOTH, MINIMUM BIDIM A24 OR EQUIVALENT.

INSTALLATION (ROCK PADS)

1. REFER TO APPROVED PLANS FOR LOCATION 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.

2. THE DIMENSIONS OF THE OUTLET STRUCTURE MUST ALIGN WITH THE DOMINANT FLOW DIRECTION.

3. EXCAVATE THE OUTLET PAD FOOTPRINT TO THE SPECIFIED DIMENSION SUCH THE WHEN THE ROCK IS PLACED IN THE EXCAVATED PIT THE TOP OF THE ROCKS WILL BE LEVEL WITH THE SURROUNDING GROUND, UNLESS OTHERWISE DIRECTED.

4. IF THE EXCAVATED SOILS ARE DISPERSIVE, OVER-EXCAVATED THE ROCK PAD BY AT LEAST 300mm AND BACKFILL WITH STABLE, NON-DISPERSIVE MATERIAL.

5. LINE THE EXCAVATED PIT WITH GEOTEXTILE FILTER CLOTH, PREFERABLY USING A SINGLE SHEET. IF JOINTS ARE REQUIRED, OVERLAP THE FABRIC AT LEAST 300mm.

6. ENSURE THE FILTER CLOTH IS PROTECTED FROM PUNCHING OR TEARING DURING INSTALLATION OF THE FABRIC AND THE ROCK. REPAIR ANY DAMAGE BY REMOVING THE ROCK AND PLACING WITH ANOTHER PIECE OF FILTER CLOTH OVER THE DAMAGED AREA OVERLAPPING THE EXISTING FABRIC A MINIMUM OF 300mm.

7. ENSURE THERE ARE AT LEAST TWO LAYERS OF ROCKS. WHERE NECESSARY, REPOSITION THE LARGER ROCKS TO ENSURE TWO LAYERS OF ROCKS ARE ACHIEVED WITHOUT ELEVATING THE UPPER SURFACE ABOVE THE PIPE INVERT.

8. ENSURE THE ROCK IS PLACED IN A MANNER THAT WILL ALLOW WATER TO DISCHARGE FREELY FROM THE PIPE.

9. ENSURE THE UPPER SURFACE OF THE ROCK PAD DOES NOT CAUSE WATER TO BE DEFLECTED AROUND THE EDGE OF THE ROCK PAD.

10. IMMEDIATELY AFTER CONSTRUCTION, APPROPRIATELY STABILISE ALL DISTURBED AREAS.

MAINTENANCE

1. WHILE CONSTRUCTION WORKS CONTINUE ON THE SITE, INSPECT THE OUTLET STRUCTURE PRIOR TO FORECAST RAINFALL, DAILY DURING EXTENDED PERIODS OF RAINFALL, AFTER SIGNIFICANT RUNOFF PRODUCING RAINFALL, AND ON AT LEAST A WEEKLY BASIS.

2. REPLACE ANY DISPLACED ROCK WITH ROCK OF A SIGNIFICANTLY (MINIMUM 110%) LARGER SIZE THAN THE DISPLACED ROCK.

REMOVAL

1. TEMPORARY OUTLET STRUCTURES SHOULD BE COMPLETELY REMOVED, OR WHERE APPROPRIATE, REHABILITATED SO AS NOT TO CAUSE ONGOING ENVIRONMENTAL NUISANCE OR HARM.

2. FOLLOWING REMOVAL OF THE DEVICE, THE DISTURBED AREA MUST BE APPROPRIATELY REHABILITATED SO AS NOT TO CAUSE ONGOING ENVIRONMENTAL NUISANCE OR HARM.

3. REMOVE MATERIALS AND COLLECTED SEDIMENT AND DISPOSE OF IN A SUITABLE MANNER THAT WILL NOT CAUSE AN EROSION OR POLLUTION HAZARD.

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Drawn: GMW | Date: Dec-09 | OS-02

FIGURE 11: INLET SCOUR PROTECTION NOTES (FROM IECA, 2008).

PHOTO 1: TYPE A AND B SEDIMENT BASIN EXAMPLE, SHOWING FOREBAY CHAMBER, LEVEL SPREADER, MAIN CHAMBER, DECANTING ARMS AND EMERGENCY SPILLWAY. NOTE DECANTING ARMS ARE NOT REQUIRED IN TYPE B SEDIMENT BASINS.

PHOTO 2: TYPE A SEDIMENT BASIN EXAMPLE, SHOWING SINGLE DECANTING ARMS AND EMERGENCY SPILLWAY.

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PROJECT TITLE: INDUSTRIAL ESTATE LOTS 20–23 IN DP 255560 & LOTS 30–32 IN DP 258949 ALDINGTON ROAD, KEMPS CREEK

DRAWING TITLE: SEDIMENT BASIN OUTLET STRUCTURE DETAILS AND PHOTOS 1 & 2 – SHEET 8 OF 8

PROJECT NO.	SUB–PR NO.	DRAWING NO.	REV
22000119	P01	ESCP08	A

Plot Date: Monday, 11 April 2022 10:54:05 AM   CAD File Name: M:\22000119 Aldrington Road Kemps Creek – HES Basins\Drawings\22000119_P01_ESCP_REV A.dwg

Appendix C

Control measure fact sheets

Catch Drains Part 1: General Information

DRAINAGE CONTROL TECHNIQUE

Low Gradient	✓	Velocity Control		Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] The design of permanent catch drains requires consideration of issues not discussed within this fact sheet, such as maintenance requirements. This fact sheet should not be used for the design of permanent drains.

Symbol → CD →

Photo 1 – Unlined catch drain

Photo 2 – Large rural catch drain (channel-bank)

Key Principles

1. Catch drains typically have standardised cross-sectional dimensions. Rather than uniquely sizing each catch drain to a given catchment, standard-sized drains are used based on a maximum allowable catchment area for a given rainfall intensity.
2. The **maximum** recommended spacing of catch drains down a slope (Table 3) is based on the aim of avoiding rill erosion within the up-slope drainage slope. It should be noted that the **actual** spacing of catch drains down a given slope may need to be less than the specified maximum spacing if the soils are highly erosive soils, or if rilling begins to occur between two existing drains.
3. The critical design parameters are the spacing of the drains down a slope, the maximum allowable catchment area, the choice of lining material (e.g. earth, turf, rock or erosion control mats), and the required channel gradient.

Design Information

Catch drains are drainage structures, as such, their design (i.e. maximum catchment area and horizontal spacing) must be based on local hydrologic and soil conditions.

Catch drains must have sufficient cross-sectional dimensions to fully contain the design flow with a minimum freeboard of 0.15m. This fact sheet provides design information on three standard parabolic-profile catch drains referred to as Type-A, Type-B and Type-C, and three triangular-profile V-drains; Type-AV, Type-BV and Type-CV.

The minimum dimensions of these catch drains are provided in Tables 1 and 2.

The cross-sectional profile can be parabolic (U-shape), trapezoidal, or triangular (V-drain). Cut slopes (channel banks) should be no steeper than 1.5:1(H:V) and fill slopes (typically associated with a down-slope embankment) no steeper than 2:1 (H:V).

Table 1 – Dimensions of <u>standard</u> parabolic catch drains (Figures 1 & 3)

Catch drain type	Max top width of flow (T)	Maximum flow depth (y)	Top width of formed drain [1]	Depth of formed drain	Hyd. rad. (R) at max flow depth	Area (A) at max flow depth
Type-A	1.0m	0.15m	1.6m	0.30m	0.094m	0.100m^2
Type-B	1.8m	0.30m	2.4m	0.45m	0.186m	0.360m^2
Type-C	3.0m	0.50m	3.6m	0.65m	0.310m	1.000m^2

[1] Top width of the formed drain assumes the upper bank slope is limited to a maximum of 2:1.

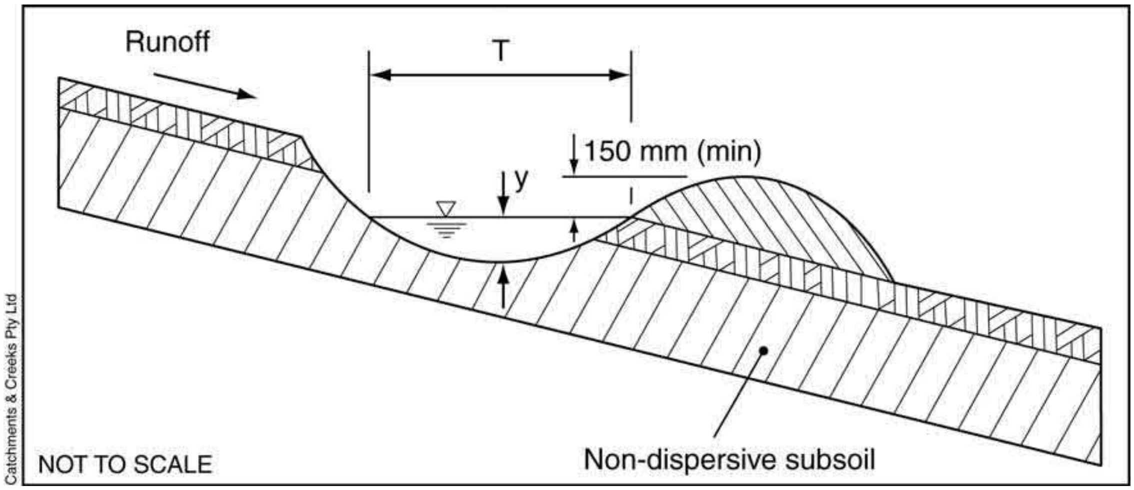


Figure 1 – Parabolic catch drain with bank

Table 2 – Dimensions of <u>standard</u> triangular V-drains (Figure 2)

Catch drain type	Max top width of flow (T)	Maximum flow depth (y)	Top width of formed drain	Depth of formed drain	Hyd. rad. (R) at max flow depth	Area (A) at max flow depth
Type-AV	1.0m	0.15m	2.0m	0.30m	0.072m	0.075m^2
Type-BV	1.8m	0.30m	2.7m	0.45m	0.142m	0.270m^2
Type-CV	3.0m	0.50m	3.9m	0.65m	0.237m	0.750m^2

Maximum spacing of catch drains:

Maximum recommended spacing of catch drains down slopes is presented in Table 3. The actual spacing specified for a given site may need to be less than that presented in Table 3 if the soils are highly susceptible to erosion, or if intense storm events are expected (i.e. northern parts of Australia during the wet season).

Table 3 – <u>Maximum</u> recommended spacing of catch drains down slopes

Open Earth Slopes						Vegetated Slopes		
Slope	**Horiz.**	**Vert.**	**Slope**	**Horiz.**	**Vert.**	**Slope**	**Horiz.**	**Vert.**
1%	80m	0.9m	15%	19m	2.9m	< 10%	No maximum	
2%	60m	1.2m	20%	16m	3.2m	12%	100m	12m
4%	40m	1.6m	25%	14m	3.5m	15%	80m	12m
6%	32m	1.9m	30%	12m	3.5m	20%	55m	11m
8%	28m	2.2m	35%	10m	3.5m	25%	40m	10m
10%	25m	2.5m	40%	9m	3.5m	30%	30m	9m
12%	22m	2.6m	50%	6m	3.0m	> 36%	Case specific	

Table 4 – Drain profile parameters for catch drains

Parabolic: $y = C_1.T^2$	C_1	V-drain: $y = C_2.T$	C_2
Type-A	0.1500	**Type-AV**	0.1500
Type-B	0.0926	**Type-BV**	0.1667
Type-C	0.0556	**Type-CV**	0.1667

Channel lining:

If high flow velocities are expected, then the drain must be appropriately stabilised with geotextile fabric, *Erosion Control Mats/Mesh*, grass or rock. Alternatively, *Check Dams* can be placed at appropriate intervals to control the flow velocity; however, the impact of these *Check Dams* on the hydraulic capacity of the drain **must** be considered.

Photo 3 – Rock lined catch drain

Photo 4 – Permanent catch drain

Gradient:

The longitudinal gradient of catch drains primarily depends on the allowable flow velocity and Manning's roughness of the drainage channel. Excess channel gradient can initiate undesirable erosion (Photos 5 & 6).

Photo 5 – Upper limit of erosion within a catch drain

Photo 6 – Velocity-induced bed scour within a catch drain

Outlet Structures:

Catch drains must discharge to a stabilised outlet, such as a road, permanent drainage channel, *Chute*, *Slope Drain*, or *Level Spreader*. *Level Spreaders* are used when the flow is to be released as 'sheet' flow.

At the immediate outlet of the catch drain it may be necessary to construct an energy dissipater or rock pad to control soil scour (refer to the Fact Sheet on *Outlet Structures*).

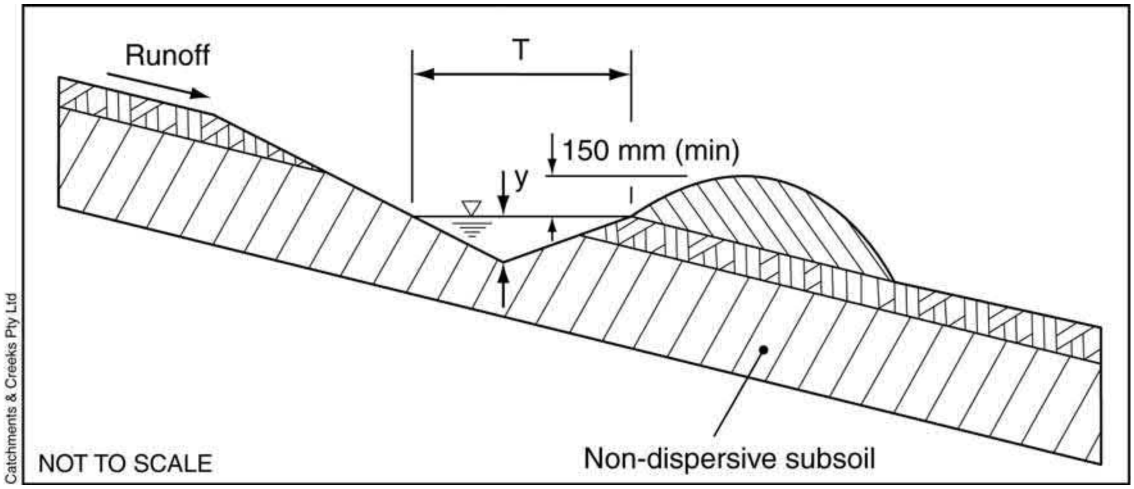


Figure 2 – Triangular V-drain with down-slope bank

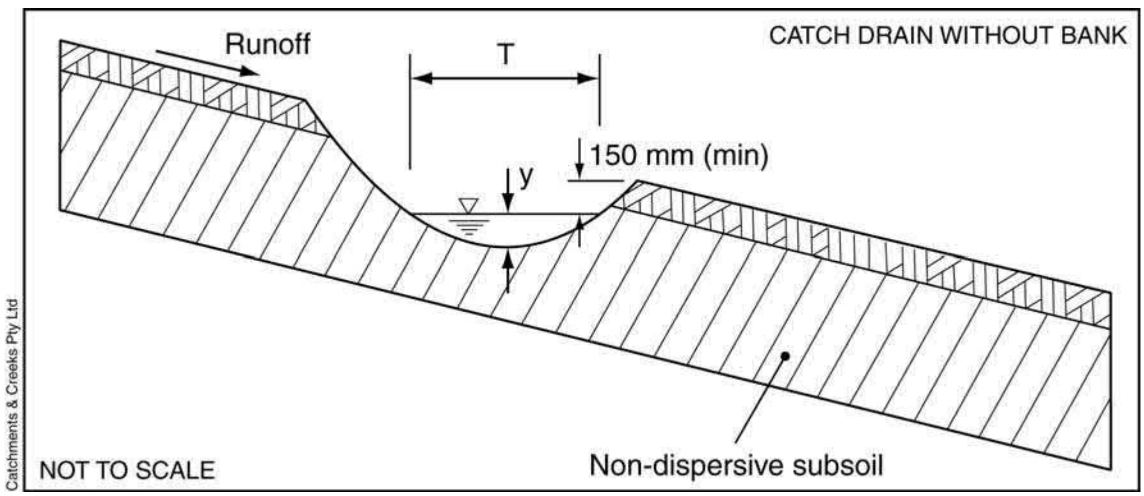


Figure 3 – Parabolic catch drain without bank

Types of drains:

The following provides a brief description of some of the drains used within rural and construction land management.

Berm drain:	A drain formed by a berm located between the top and bottom of a batter.
Catch drain:	A drain adjacent to a batter or embankment.
	Also, the generic term used for all temporary drains on construction sites.
Contour drain:	A drain formed along the contour (zero fall). Such drains act as infiltration trenches, similar (but not the same) as contour furrowing or deep ripping.
Cross drain:	A drain directing surface runoff across a road or track.
Diversion drain:	A drain used to collect and divert water from an adjacent catchment.
Mitre drain:	A drain used to direct road runoff away from the road alignment.
Spoon drain:	A minor drain of semi-circular cross-section and no associated embankment.
Table drain:	A drain that has one bank consisting of the shoulder of a roadway.
Windrow drain:	A drain formed by an earth windrow located along the edge of a road or trail.
Rubble drain:	A sub-surface drain formed by a gravel-filled trench.

Description

Catch drains are small open channels formed at regular intervals down a slope, or immediately up-slope or down-slope of a soil disturbance. They are usually excavated with a grader blade, or U-shaped cutting/excavation tools.

Catch drains can be formed with or without an associated down-slope bank. The inclusion of a down-slope bank significantly increases the hydraulic capacity of the drain; however, these banks are susceptible to damage by vehicles resulting in hydraulic failure of the drain.

Channel-banks (push-down) catch drains are formed by pushing the excavated material down-slope of the drain. These drains should only be used in areas that have good, erosion-resistant subsoils.

'Back-Push' banks are formed by pushing the excavated material up-slope to form a *Flow Diversion Bank*. In such cases the diverted water flows up-slope of the embankment instead of within the excavated trench (refer to the fact sheet on *Flow Diversion Banks*).

Back-push banks are used in preference to catch drains in areas that have highly erosive or dispersible subsoils.

Catch drains are usually significantly smaller than formally designed *Diversion Channels*.

The term 'catch drain' is also used in the stormwater industry to refer to permanent drainage channels placed above cut batters to prevent uncontrolled discharge down the batter.

Purpose

Catch drains can be used to:

- direct stormwater runoff around a soil disturbance, or an unstable slope;
- collect sheet-flow runoff from an unstable slope before it is allowed to concentrate and cause rill erosion;
- collect sediment laden runoff down-slope of a disturbance and direct it to a sediment trap;
- collect and divert up-slope water around stockpiles and excavations.

Limitations

Catch drains are only suitable for relatively small flow rates. For the management of high flow rates a formally designed *Diversion Channel* may be required.

The maximum catchment area depends on the type of drain (i.e. Type A/AV, B/BV or C/CV), and the local hydrologic conditions.

Advantages

Quick and inexpensive to establish, or re-establish if disturbed.

Usually do not require complex formal design if based on standard design tables.

If constructed at appropriate gradients, flow velocities are usually small enough to avoid the need for special channel linings.

Disadvantages

Can cause significant erosion problems and flow concentration if overtopped during heavy storms.

Can restrict the movement of earthmoving equipment around the site, including access to stockpiles. Thus, catch drains may have limited use within active construction areas until earthworks are completed.

Common Problems

Installed at incorrect gradient. If the gradient is too shallow, it causes a reduction in the hydraulic capacity, if too steep it causes an increase in flow velocity.

Damage to associated flow diversion bank (rutting) caused by vehicles.

Catch drains that do not discharge to a stable outlet, causing downstream erosion, or initiating scour within the drain (Photo 5).

Special Requirements

The erosion-resistance of the local subsoils should be investigated before planning or designing any excavated drains.

Straw bales or other sediment traps should **not** be placed within these drains due to the risk of causing surcharging of the drain.

Catch drains need to be appropriately stabilised (e.g. compacted and/or lined with a suitable channel lining) within a specified period from the time of construction.

Catch drain should drain to a suitable sediment trap if the diverted water is expected to contain sediment. 'Clean' water should divert around sediment traps.

The drain must have positive gradient along its full length to allow free drainage.

Sufficient space must be provided to allow maintenance access.

Location

Typically used up-slope of cut batters, intermittently down long, exposed slopes, and up-slope of those stockpiles located within overland flow paths.

Catch drains are generally required up-slope of all cut and fill batters with a height greater than 2 metres and where run-on water is expected.

Site Inspection

Check that the drain has a stable, positive grade along its length.

Check for a stable drain outlet.

Check if the associated embankment is free of damage (e.g. damage caused by construction traffic).

Check that the drain has adequate hydraulic capacity given the catchment area (general observations based on past experience).

Check if rill erosion is occurring within the catchment area up-slope of the drain. If rilling is occurring, then the lateral spacing of the drains will need to be reduced. However, some degree of rill erosion should be expected if recent storms exceeded the intensity of the nominated design storm.

Inspect for evidence of water spilling out (overtopping) of the drain, or erosion down-slope of the drain.

Inspect for erosion along the bed (invert) of the drain. Investigate the reasons for any erosion before recommending solutions. Bed erosion can result from either excessive channel velocities, or an unstable outlet, which causes bed erosion (head-cut) to migrate up the channel.

Possible solutions to channel erosion include:

- reduce effective catchment area;
- increase channel width;
- increase channel roughness;
- stabilise bed with mats or mesh;
- stabilise bed with turf or rock;
- stabilise the outlet.

Check the channel lining (if any) for damage or displacement. If *Erosion Control Mats* have been used, check that they are correctly overlapped in direction of flow.

If the drain is lined with rock, check that the rock is not reducing the drain's required hydraulic capacity.

Check Dam Sediment Traps

SEDIMENT CONTROL TECHNIQUE

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

[1] Generally considered a 'supplementary' sediment trap that should not be used as a site's primary sediment trap; however, substantial check dam sediment traps can be constructed (e.g. Photo 2).

Symbol

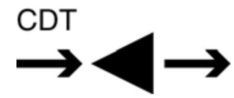


Photo 1 – Sandbag check dam sediment traps

Photo 2 – Rock check dam sediment traps

Key Principles

1. Check dams are primarily used as drainage control devices for the control of flow velocity; however, most check dams will also collect small qualities of sediment.
2. The sediment trapping ability of check dams can be improved by excavating a sediment collection pit up-slope of the dams.
3. The critical design parameter is the total surface area of ponding up-slope of the dams.
4. The critical operational issues relate to the frequency of sediment removal from the traps. If the check dams are being used as sediment traps, then they must be de-silted on a regular basis.

Design Information

This fact sheet specifically addresses the design of check dam sediment traps. For guidance on the design of flow control check dams, refer to the separate drainage control fact sheet on Check Dams.

Check dams can be constructed from rock, sandbags, plastic grids (*Triangular Ditch Checks*), or compost-filled *Filter Socks*. Compost-filled socks provide the added advantage of being able to adsorb some dissolved and fine particulate matter. Straw/hay bales must **not** be used.

As a rock check dam increases in size (say, height > 500mm) it begins to function as a *Rock Filter Dam*, in which case the design rules specified for *Rock Filter Dams* applies.

If used for velocity control, check dams should be spaced down the drain such that the **toe** of the check dam is level with the **crest** of the immediate downstream check dam.

If used primarily as a sediment trap, the check dams should be installed such that the total surface area of ponding (Figure 1) upstream of the check dams is maximised.

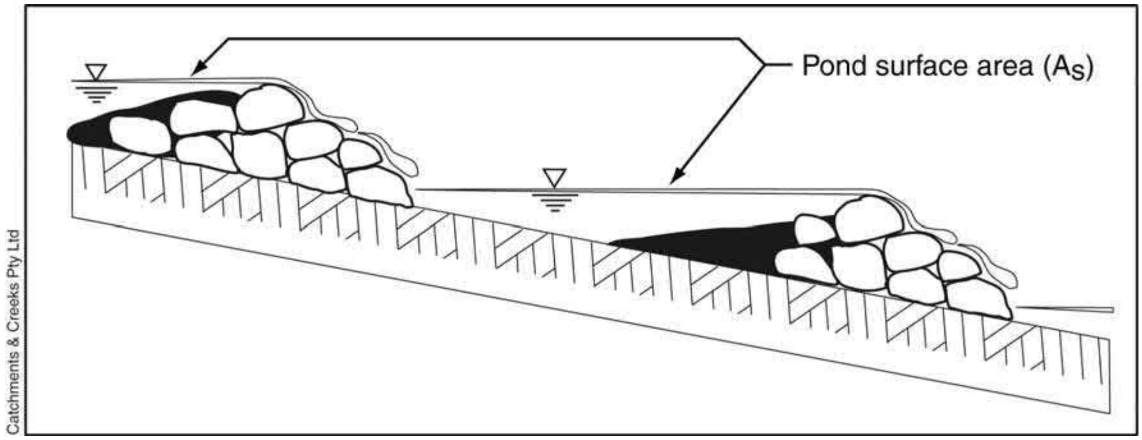


Figure 1 – Check dam sediment trap

Maximum allowable channel gradient is 10% (1 in 10).

Maximum recommended crest height of around 500mm. Check dams with a height exceeding 500mm should be checked for hydraulic stability.

The crest invert should be at least 150mm lower than outer edges (Figure 2). This is to reduce the potential for water to bypass around the edge of the check dam, and to allow the concentration of flow in the centre of the channel.

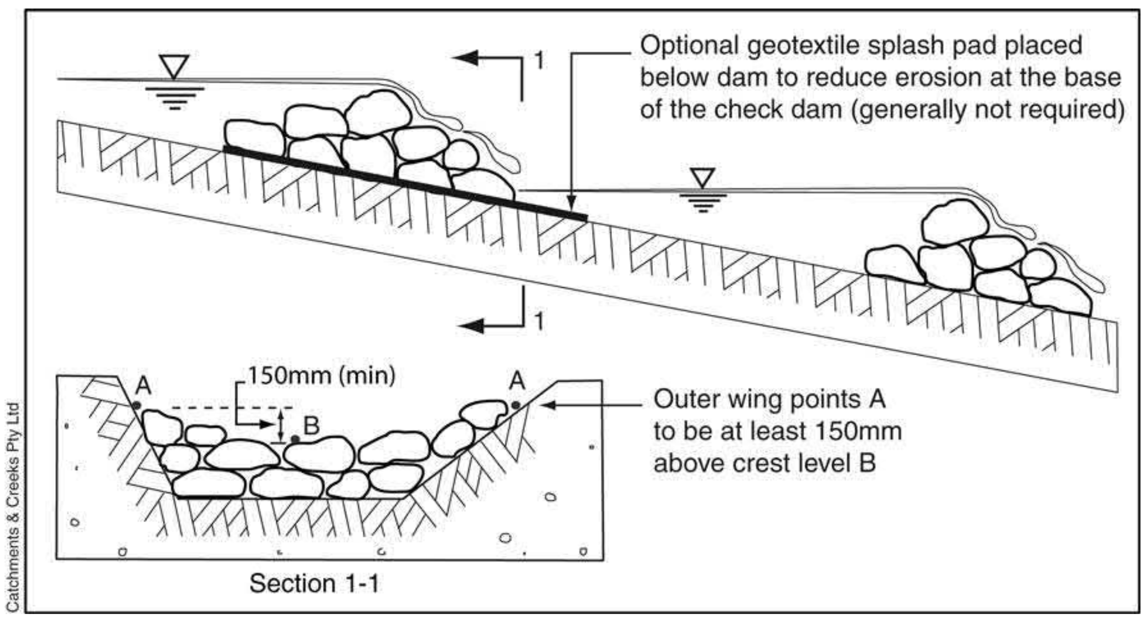


Figure 2 – Profile of rock check dam

The crest of the check dam should be curved (vertically) such that flow first spills over the centre of the dam. Ideally, the crest of each dam should be at least 150mm lower than the bank elevation at the outer edges of the structure.

The purpose of a curved crest profile is to:

- minimise the quantity of water bypassing around the edge of the check dam; and
- to concentrate flow into the centre of the channel.

Use of a flat crest profile can cause erosion (rilling) down the banks of the drain.

Maximum bank slope of rock face is 2:1 (H:V). For check dams higher than 0.5m the slope of the downstream face may need to be significantly flatter than a 2:1 slope.

If a check dam is likely to significantly choke a drainage channel causing water to overtop the channel, and if such overtopping is likely to cause drainage or erosion problems, then the hydraulic capacity of the check dam and channel should be checked. Refer to guidelines provided within the fact sheets for drainage control *Check Dams* for advice.

(a) Rock size (rock check dams):

Typical rock size of 150 to 350mm.

(b) Compost-filled socks:

Typical sock diameter of 200 to 250mm.

Placed in a U-shape pointing downstream and embedded at least 100mm into the soil or otherwise anchored to prevent water passing under the socks. The larger socks generally have the ability to seal well on solid and earth surfaces without additional anchorage.

The crest of the sock **must** be at least 100mm lower than the lowest ground level immediately adjacent to the ends of the sock.

(c) Erosion control at toe of check dams:

Erosion downstream of each check dam will be minimised if the dams are correctly spaced such that the crest of each dam is level with the toe of the nearest upstream dam.

Where necessary, the risk of erosion at the toe of each check dam may be reduced by forming each check dam on a sheet of geotextile fabric (e.g. filter cloth or woven fabric) that extends downstream of the dam a distance at least equal to the height of the dam (Figure 1).

(d) Optimisation of sediment trapping performance:

Sediment collection may be optimised by:

- excavating a sediment collection pit up-slope of the dam (Figure 3); however, always check potential safety issues;
- using compost-filled filter socks in place of rock or sandbags.
- placing a layer of clean aggregate on the up-slope face of the dam (minor improvement in performance);
- placing a layer of filter cloth on the upstream face of the check dam.

Also refer to the sediment control fact sheet for *Rock Filter Dams* for the design of Type 2 sediment traps.

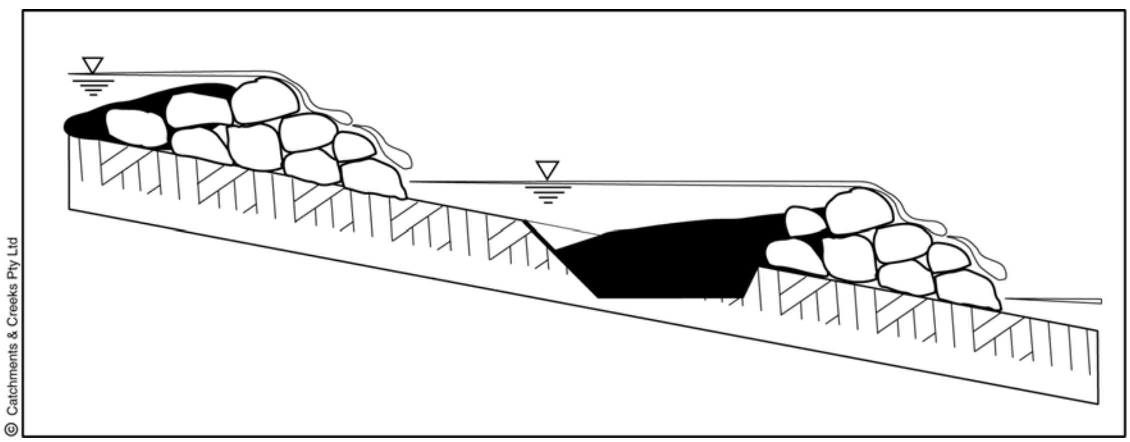


Figure 3 – Check dam sediment trap with optional sediment collection pit

Warning:

Check dams should **not** be used to control erosion within drains formed from dispersive soil. In circumstance where it is unavoidable, then the exposed dispersive soil should be covered with non-dispersive soil, and stabilised with an appropriate channel liner. Refer to guidelines provided within the fact sheets for drainage control *Check Dams* for further advice.

Description

Check dam sediment traps can be constructed from either semipervious or impervious materials typically rock, sandbags, or compost-filled filter socks.

Check dams should not be constructed from straw bales.

Purpose

Check dams are primarily used for drainage control purposes to control invert erosion within minor drainage channels.

However, check dam can also be used as minor sediment traps to supplement a site's sediment control system.

Limitations

Check dam sediment traps have relatively low sediment trapping efficiency and are generally only suitable for the capture of coarse sediment.

Limited to drain slopes less than 10%.

Not suitable for use in watercourses.

Should not be placed directly on dispersive soils, or within drains cut into dispersive soils.

Advantages

Quick and inexpensive to install and maintain.

Compost-filled filter socks can adsorb limited quantities of dissolved and fine particulate matter from that portion of the water passing through the socks.

Disadvantages

Can cause damage to grass cutting equipment if the rocks are not removed from the drainage channel after vegetation establishment.

Problems often occur when rock check dams are specified in shallow drains (<500mm deep). In such cases, the dams can significantly reduce the flow capacity of the drain.

Special Requirements

Installation of an excavated sediment collection pit can reduce maintenance.

Public safety issues must be addressed.

Care must be taken to prevent failure caused by water undermining or bypassing the dams.

Straw bales must **not** be used to form the dams.

Common Problems

Hydraulic problems often occur when rock check dams are specified in shallow drains.

Sediment not removed from the check dams on a regular basis (only required when the check dams are specifically used as sediment traps).

Site Inspection

Ensure the sediment traps are appropriate for the type of channel.

Ensure the crest is below the height of the outer wings of each dam.

Ensure the dams are appropriately spaced.

Check for potential safety risks.

Check if the sediment traps need de-silting.

Materials

- Rock: 150 to 300mm equivalent diameter, hard, erosion resistant rock.
- Sandbags: geotextile bags (woven synthetic, or non-woven biodegradable) filled with clean coarse sand, clean aggregate, or compost.

Installation (Rock Check Dam)

1. Refer to approved plans for location and installation details. If there are questions or problems with the location or method of installation contact the engineer or responsible on-site officer for assistance.
2. Prior to placement of the sediment trap, ensure the drainage channel is deep enough to prevent water being unsafely diverted out of the drain once the check dams are installed.
3. Locate each check dam sediment trap as directed within the approved plans, or otherwise at such a spacing to achieve the required sediment trapping outcomes.
4. If the check dams are also being used to control erosion within the drainage channel, then locate each successive check dam such that the crest of the immediate downstream dam is level with the channel invert at the immediate upstream check dam.
5. Construct each check dam to the dimensions and profile shown within the approved plan.
6. Where specified, the check dams must be constructed on a sheet of geotextile fabric used as a downstream splash pad.
7. Each check dam must be extended up the channel bank (where practicable) to an elevation at least 150mm above the crest level of the dam.

Installation (Compost-filled socks)

1. Refer to approved plans for location and installation details. If there are questions or problems with the location or method of installation contact the engineer or responsible on-site officer for assistance.
2. Prior to placement of the sediment trap, ensure the drainage channel is deep enough to prevent water being unsafely diverted out of the drain once the check dams are installed.
3. Locate each sock as directed within the approved plans, or otherwise at such a spacing to achieve the required sediment trapping outcomes.
4. Place each sock to the lines and profile shown in the approved plan or as directed by the site supervisor.
5. Ensure each sock extends up the channel banks (where practical) to a level at least 100mm above the crest level of the check dam.

Maintenance

1. Inspect each check dam and the drainage channel at least weekly and after runoff-producing rainfall.
2. Correct all damage immediately. If significant erosion occurs between any of the check dams, then check the spacing of the dams and where necessary install intermediate check dams or a suitable channel liner.
3. Check for displacement of the check dams.
4. Check for soil scour around the ends of each check dam. If such erosion is occurring, consider extending the width of the check dam to avoid such problems.
5. If severe soil erosion occurs either under or around the check dams, then seek expert advice on an alternative treatment measure.
6. De-silt sediment trap if the sediment level exceeds 1/3 the crest height.
7. Dispose of collected sediment in a suitable manner that will not cause an erosion or pollution hazard.

Removal

1. When construction work within the drainage area above the check dams has been completed and disturbed areas sufficiently stabilised to restrain erosion, the dams must be removed, unless the sediment traps are to remain as a permanent feature.
2. Remove collected sediment and dispose of in a suitable manner that will not cause an erosion or pollution hazard.
3. Remove and appropriately dispose of all materials including any geotextile fabric.
4. Stabilise the disturbed channel with a lining of fabric and rock, or establish vegetation as appropriate.

Diversion Channels

DRAINAGE CONTROL TECHNIQUE

Low Gradient	✓	Velocity Control		Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] The design of permanent diversion channels requires consideration of issues not discussed within this fact sheet, such as safety and maintenance requirements.

Symbol → DC →

Photo 1 – Temporary diversion channel collecting 'dirty' water down-slope of a soil disturbance

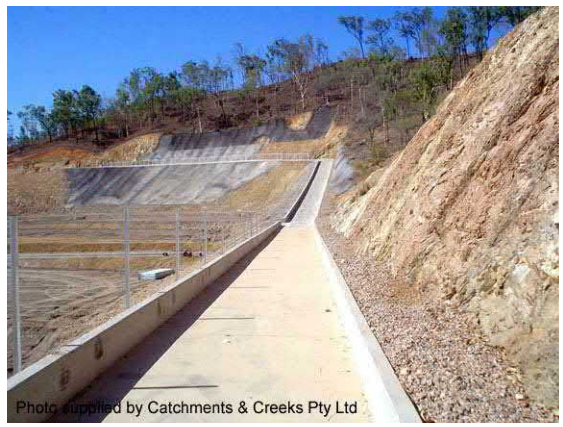


Photo 2 – Permanent diversion channel collecting stormwater runoff up-slope of a subdivision

Key Principles

1. Diversion channels are sized for a specific design flow rate based on the catchment area, topography, soil and hydrologic conditions.
2. Critical design parameters are the choice of surface lining, hydraulic capacity and stability of the discharge point.
3. Critical operation issues are usually related to controlling sediment, vegetation and debris collection within the channel, and maintaining a stable outlet.

Design Information

Diversion channels are usually major hydraulic structures requiring design input from an experienced hydraulics specialist. This fact sheet does **not** provide sufficient information to allow diversion channels to be designed by inexperienced persons.

The design of permanent drainage channels requires consideration of issues not discussed within this fact sheet, such as safety and maintenance requirements.

The design discharge (Q) must reflect the specified drainage control standard of the site. Refer to the relevant regulating authority for relevant design standards. Where such standards do not exist, then refer to IECA (2008) Chapter 4 – *Design standards and technique selection*.

Typical design standards are presented in Table 1.

Refer to the various fact sheets under the sub-heading *Channel Linings* for velocity calculations and guidelines on the design of rock, grass or mat lining of the channel.

Recommended maximum bank slopes are provided in Table 2.

Table 1 – Typical design standards for temporary diversion channels

Parameter	Design standard
Design discharge	• Refer to IECA (2008) Table 4.3.1, Chapter 4 – *Design standards and technique selection*
Channel depth	• Minimum channel depth of 300mm
Freeboard	• Minimum freeboard being the greater of 150mm, 10% of channel depth, or the velocity head ($V^2/2g$) • Allow embankment settlement of 10% of fill height (in addition to freeboard) if the embankment's design life exceeds 1 year
Embankment	• Optional embankment formed down-slope of the channel (Figure 1). • Minimum crest width of 600mm, and down-slope bank gradient of 2:1 for reasons of stability against overtopping flows
Safety	• Safety requirements, such as the depth*velocity product (d.V), generally do not apply to drainage channels • Safety considerations generally focus on allowing good egress from the channel, and ensuring safety risks are obvious
Maintenance berm	• Desirable 1.5m wide (min) maintenance berm on at least one side of the channel (not always practicable in short-term projects)

Table 2 – Typical maximum bank slopes [1]

Site conditions	Max bank slope (H:V)
Highly compacted clay (hard, pick required)	1:1 to 1.25:1
Medium compact sandy clay	1.2:1 to 1.5:1
Slightly compact silty clay or sandy clay (soft, spade required)	1.5:1 to 2:1
Non-cohesive fine sandy soil or soils with humus or peat content	2:1 to 3:1
Non mowable vegetated slopes	3:1
Permanent, mowable, grass slopes (maximum grade)	4:1
Permanent, mowable grass slopes (recommended grade)	6:1
Rock lined channels	1.5:1 [2]

[1] Bank slopes provided as a guide only. Actual bank slope should be based on geotechnical and landscaping advice wherever practicable.

[2] Desirable maximum bank slope is 2:1 for dumped rock; however, with increased placement effort and skills, rock may be placed on bank slopes up to 1.5:1 in low velocity channels.

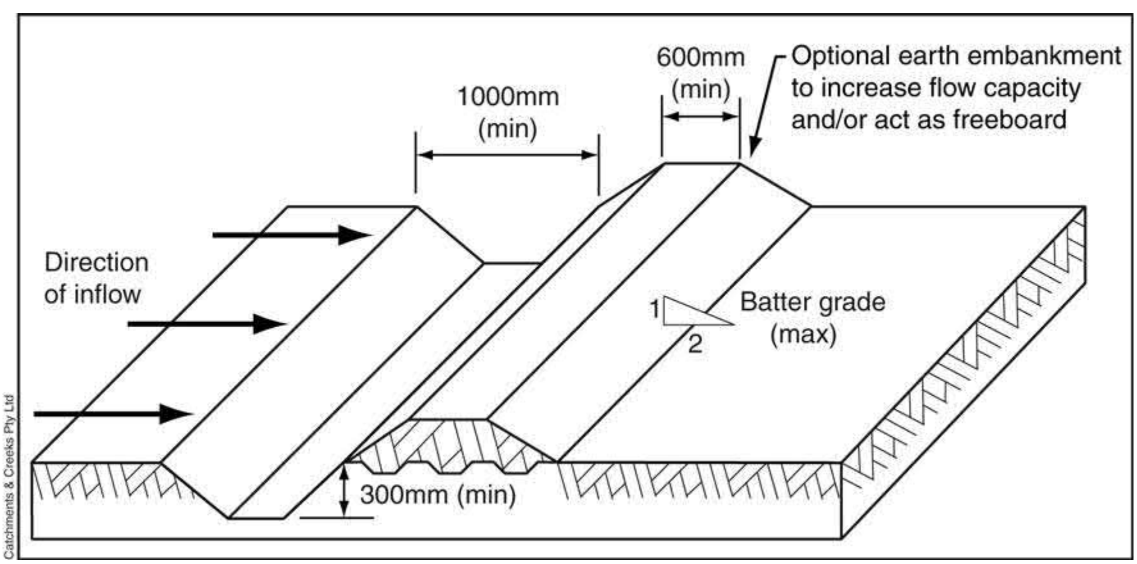


Figure 1 – Typical profile of temporary diversion channels

Hydraulic design of diversion channels:

Step 1 Determine the required design discharge (Q).

If the channel gradient varies significantly along its length, then it may be desirable to split the channel into individual sections and determine an appropriate design discharge at the downstream end of each of these sections.

Step 2 Nominate the channel profile: parabolic or triangular (V-drain). Parabolic channel are generally less susceptible to invert erosion.

Step 3 Choose the preferred surface condition of the channel (e.g. earth, grass, rock).

The design information provided in the *Catch Drain* fact sheets can be used as a guide in selecting a surface lining and trial channel size.

Step 4 Select a bank slope (m) using Table 2 as a guide. Do **not** necessarily select the maximum bank slope, but consider such issues as safety and maintenance access.

Step 5 Determine the Manning's roughness (n) and allowable flow velocity (V_{allow}) using the relevant fact sheet (refer to channel linings) or Tables A17 to A20, and Tables A23 to A28 in IECA 2008, Appendix A – *Construction site hydrology and hydraulics*.

For grass and rock-lined channels it may be necessary to estimate a channel depth, and hydraulic radius (Steps 6 to 8) before determining Manning's roughness.

Step 6 Determine the minimum required flow area ($A = Q/V_{allow}$).

The design flow area does not have to be equal to this minimum flow area, but of course it must not be less than this area. It depends on how confident the designer is in the determination of the design discharge and the allowable flow velocity.

Step 7 Choose a trial channel size (depth, y; bed width, b; and flow top width, T) and the required freeboard (refer to Table 1).

Ultimately this may require an iterative process where various channel profiles are tested for hydraulic capacity.

Step 8 Determine the hydraulic radius (R) of the channel (based on flow area, **not** the overall channel dimension, which would include freeboard). Refer to Table A30 in IECA (2008) Appendix A.

Step 9a **If the channel gradient is <u>not</u> set by site conditions, then:**

Determine the channel gradient (S) using Manning's equation.

$$S = (n\,.V)^2/(R)^{4/3} \qquad \text{(S has units of m/m)}$$

Step 9b **If the channel gradient is set by site conditions, then:**

Determine the actual flow velocity (V) and compare this with the allowable flow velocity (V_{allow}).

$$V = (1/n)\,R^{2/3}\,S^{1/2}$$

If $V < V_{allow}$, then accept the design, or repeat Steps 7 & 9 for a smaller channel.

If $V > V_{allow}$, then repeat Steps 7 & 9 selecting a larger channel.

Step 10 Confirm final freeboard requirements given final depth and velocity head (Table 1).

Step 11 Ensure suitable conditions exist (e.g. machinery access) to construct and maintain the channel, otherwise a narrower channel width may be required.

Step 12 Given the final channel depth and velocity, check the required freeboard.

Specify the overall dimensions of the diversion channel, including freeboard.

Step 13 Ensure appropriate, non-erosive, flow conditions exist at the points of flow entry into the channel.

Step 14 Ensure the channel discharges to an appropriate, stable outlet structure.

Step 15 Appropriately consider all likely safety issues, and modify the channel design and/or surrounding environment where required.

Design example:

Design an earth-lined channel of trapezoidal cross-section to carry $0.5 m^3/s$ located within a moderately erodible soil.

Step 1 The required design discharge is given as, $Q = 0.5 m^3/s$.

Step 2 The question specifies a trapezoidal channel profile.

Step 3 The surface condition has been specified as earth-lined.

Step 4 For a slightly compacted soil (typical for a temporary drain), the maximum bank slope is likely to be around 1.5:1 or 2:1 (from Table 2).

If the drain was going to be deep (say, y > 0.5m) a flatter slope of 3:1 would be desirable for reasons of safety; however, this drain is likely to be relatively shallow, so choose a bank slope of 2:1 (i.e. m = 2).

Warning: 'm' is the term used for both bank slope, and the metric unit of metres!

Step 5 Select a Manning's "n" for an earth lined channel, n = 0.02 from Table A17 of IECA (2008) Appendix A – *Construction site hydrology and hydraulics*.

For a moderately erodible soil, choose a maximum allowable velocity, $V_{allow} = 0.6 m/s$ from Table A23 of Appendix A.

Step 6 The minimum required flow area, $A_{min} = Q/V_{allow} = 0.5/0.6 = 0.833 m^2$.

Step 7 For this example it will be assumed that the designer has confidence in the determination of the design discharge and the selection of an allowable flow velocity for the given soil conditions. Therefore, a design flow area of $0.84 m^2$ is chosen (only slightly greater than the minimum value determined in Step 6).

Choose: $A = 0.84 m^2$

Trial flow depth and bed width: Given that maximum depth of the excavated channel may be limited by existing site conditions, a first guess of the channel dimensions can be obtained by adopting one of the following options:

(i) try a <u>flow</u> depth, y = maximum allowable channel depth - 150mm; or

(ii) try a bed width, $b = (A/(1 + m))^{1/2}$

If we choose the latter option, then: $$b = \sqrt{\frac{A}{(1+m)}} = \sqrt{\frac{0.84}{(1+2)}} = 0.53\text{m}$$

For small channels it is good practice to select a bed width equal to the width of a typical excavator bucket. The most common bucket widths are 450, 600 and 900mm. So, for this example a bed width, b = 0.6m will be chosen.

If a flow depth (y) is chosen, then $$b = \frac{A}{y} - y(m)$$

If a bed width (b) is chosen, then: $$y = \frac{\sqrt{(b^2 + 4(m)A)} - b}{2m}$$

Thus for this example: $$y = \frac{\sqrt{(0.6^2 + 4(2)0.84)} - 0.6}{2(2)} = 0.515\text{m}$$

Step 8 From Table A30 of Appendix A, the hydraulic radius (R) is given by:

$$R = \frac{y(b + my)}{b + 2y\sqrt{(1+m^2)}} = \frac{0.515(0.6 + (2)0.515)}{0.6 + 2(0.515)\sqrt{(1+2^2)}} = 0.289\text{m}$$

Step 9a If its assumed that the channel slope is not governed by existing site conditions (i.e. the designer is free to determine a preferred channel slope), then the desired channel slope can be determined from Manning's equation:

Desired channel slope: $$S = \frac{n^2.V^2}{R^{4/3}} = \frac{(0.02)^2.(0.6)^2}{(0.289)^{4/3}} = 0.00075$$

The above equation provides slope in units or [m/m], thus the channel slope is equivalent to, S = 0.075%.

Step 10 Freeboard requirements will be defined by the greater of:

(i) 150mm

(ii) 10% of channel depth, = 0.1(0.515 + 0.15) = 0.067m, or

(iii) the velocity head ($V^2/2g$) = $(0.6)^2/19.6$ = 0.018m

Therefore, choose a freeboard of 150mm.

Final channel dimension:

Discharge, Q = 0.5m^3/s

Channel slope, S = 0.075%

Bank slope, m = 2 or (2:1) (H:V)

Maximum design flow depth, y = 0.515m

Freeboard = 0.15m

Excavated channel depth = 0.515 + 0.15 = 0.665m

Bed width, b = 0.6m

Top width of excavated channel = 0.6 + 2(2)(0.515 + 0.15) = 3.26m

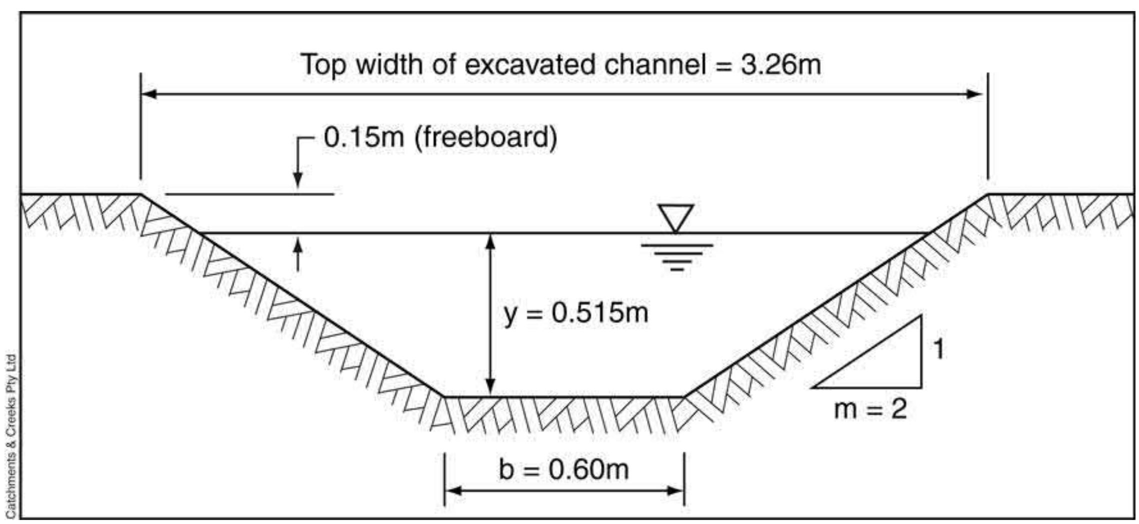


Figure 2 – Final channel dimensions

Description

Diversion channels are formally designed temporary or permanent excavated drainage channels usually with well-defined bed and banks.

Diversion channels are normally stabilised with a healthy and complete coverage of vegetation, primarily consisting of grasses. However, this should not prevent the use of alternative channel lining as appropriate for the site conditions.

Diversion channels can be formed with or without an associated down-slope flow diversion bank. The inclusion of a down-slope bank can significantly increase the hydraulic capacity of the channel.

Purpose

Diversion channels are used to:

- collect and transport stormwater runoff around or through a work site;
- collect sediment laden runoff down-slope of a disturbance and direct it to a sediment trap;
- temporarily divert a existing drainage channel while construction activities are occurring.

Limitations

Channel size and gradient are governed by the allowable flow velocity of the surface material.

Advantages

Low maintenance requirements.

On larger catchments, the cost savings resulting from the diversion of uncontaminated 'clean' flow around a soil disturbance and/or sediment trap can be significant.

Disadvantages

May restrict vehicular movements around the site, possibly requiring the construction of *Temporary Watercourse Crossings* over the channel.

Can cause significant erosion problems and flow concentration if overtopped during heavy storms.

Common Problems

The low channel gradient can cause long-term ponding and mosquito breeding.

Soil erosion at points of water inflow and at the channel outlet.

Special Requirements

The erosion-resistance of the local subsoils should be investigated before planning or designing any drainage channels.

Diversion channels should be vegetated if the expected working life exceeds 30 days. Exception may apply in arid and semi-arid regions.

If the channel is to be vegetated using grass seeding, then the channel should be established well before high flows are expected within the channel.

All diversion channels **must** have a stable outlet.

The channel must have positive gradient along its full length to allow free drainage.

Sufficient space must be provided to allow construction and maintenance access.

Site Inspection

Check that the drain has a stable, positive grade along its length.

Check for a stable drain outlet.

Check if the associated embankment is free of damage (e.g. damage caused by construction traffic).

Check that the drain has adequate hydraulic capacity given the catchment area (general observations based on past experience).

Check for sediment accumulation within the channel.

Check for excessive settlement of any associated fill embankments.

Check the channel lining (if any) for damage or displacement. If *Erosion Control Mats* have been used, check that they are correctly overlapped in direction of flow.

If the channel is lined with rock, check that the rock is not reducing the channel's required hydraulic capacity.

Installation

1. Refer to approved plans for location, extent, and construction details. If there are questions or problems with the location, extent, or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Ensure all necessary soil testing (e.g. soil pH, nutrient levels) and analysis has been completed, and required soil adjustments performed prior to planting.
3. Clear the location for the channel, clearing only what is needed to provide access for personnel and construction equipment.
4. Remove roots, stumps, and other debris and dispose of them properly. Do not use debris to build any associated embankments.
5. Excavate the diversion channel to the specified shape, elevation and gradient. The sides of the channel should be no steeper than a 2:1 (H:V) if constructed in earth, unless specifically directed within the approved plans.
6. Stabilise the channel and banks immediately unless it will operate for less than 30 days. In either case, temporary erosion protection (matting, rock, etc.) will be required as specified within the approved plans or as directed.
7. Ensure the channel discharges to a stable area.

Additional requirements for turf placement:

1. Turf should be used within 12 hours of delivery, otherwise ensure the turf is stored in conditions appropriate for the weather conditions (e.g. a shaded area).
2. Moistening the turf after it is unrolled will help maintain its viability.
3. Turf should be laid on a minimum 75mm bed of adequately fertilised topsoil. Rake the soil surface to break the crust just before laying the turf.
4. During the warmer months, lightly irrigate the soil immediately before laying the turf.
5. Ensure the turf is not laid on gravel, heavily compacted soils, or soils that have been recently treated with herbicides.
6. Ensure the turf extends up the sides of the drain at least 100mm above the elevation of the channel invert, or at least to a sufficient elevation to fully contain expected channel flow.
7. On channel gradients of 3:1(H:V) or steeper, or in situations where high flow velocities (i.e. velocity >1.5m/s) are likely within the first two week following placement, secure the individual turf strips with wooden or plastic pegs.
8. Ensure that intimate contact is achieved and maintained between the turf and the soil such that seepage flow beneath the turf is avoided.
9. Water until the soil is wet 100mm below the turf. Thereafter, watering should be sufficient to maintain and promote healthy growth

Maintenance

1. During the site’s construction period, inspect the diversion channel weekly and after any increase in flows within the channel. Repair any slumps, wheel track damage or loss of freeboard.
2. Ensure fill material or sediment is not partially blocking the channel. Where necessary, remove any deposited material to allow free drainage.
3. Dispose of any collected sediment or fill in a manner that will not create an erosion or pollution hazard.

Removal

1. When the construction work above a temporary diversion channel is finished and the area is stabilised, the area should be appropriately rehabilitated.
2. Dispose of any collected sediment or fill in a manner that will not create an erosion or pollution hazard.
3. Grade the area and smooth it out in preparation for stabilisation.
4. Stabilise the area as specified in the approved plan.

Dust Control

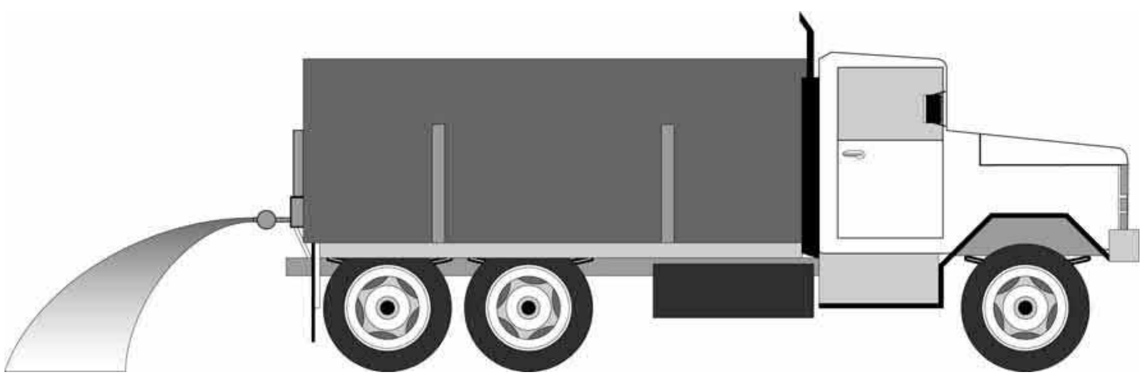
EROSION CONTROL TECHNIQUE

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

Emergency Spillways (Sediment basins)

DRAINAGE CONTROL TECHNIQUE

Low Gradient		Velocity Control		Short-Term	✓
Steep Gradient	✓	Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] The design of permanent spillways may require consideration of issues not discussed here.

Symbol → ES →

Photo 1 – Rock-lined sediment basin spillway with low-flow pipe outlet

Photo 2 – Rock mattress-lined sediment basin emergency spillway

Key Principles

1. The critical design components of a spillway are the flow entry into the spillway, the maximum allowable flow velocity down the face of the spillway, and the dissipation of energy at the base of the spillway.
2. The critical operational issues are ensuring unrestricted flow entry into the spillway, ensuring flow does not undermine or spill over the edge of the spillway, and ensuring soil erosion is controlled at the base of the spillway.
3. Failure of a spillway is likely to result from one or more of the following issues: inadequate rock size (if used), inadequate depth of the spillway chute, piping erosion caused by dispersive and/or poorly compacted soils, or failure of the energy dissipater.

Design Information

The material contained within this fact sheet has been supplied for use by persons experienced in hydraulic design.

This fact sheet addresses issues associated with the design of open channel spillways used in association with temporary sediment basins.

Design procedures and guidelines on the design of the spillway's chute can be obtained from the separate fact sheets presented for drainage *Chutes*. However, all references to the design of *Outlet structures* within these fact sheets do **not** apply to the design of spillway energy dissipaters. In addition, the recommended freeboard on spillway chutes is 300mm.

Design procedures and guidelines for energy dissipater located at the base of the temporary sediment basin spillways can be obtained from the separate fact sheet on *Energy dissipaters*.

Warning, sediment basin spillways and their associated energy dissipaters are usually major hydraulic structures requiring design input from experienced hydraulics specialists. This fact sheet does **not** provide sufficient information to allow these structures to be designed by inexperienced persons.

The recommended minimum design storm for sizing the emergency spillway is defined in Table 1. Designers should confirm the design standard with the appropriate regulatory authority.

Table 1 – Recommended design standard for emergency spillways on temporary sediment basins [1]

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)

[1] Alternative design requirements may apply to Referable Dams in accordance with State legislation, or as recommended by the Dam Safety Committee (ANCOLD 2000a & 2000b)

The crest of the emergency spillway should be in accordance with the following (default values), unless otherwise supported by appropriate investigation, risk assessment, and design:

- 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 1 is at least:

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

Recommended freeboard for the spillway chute is 300mm (note; this is an increase from the 150mm freeboard recommended for drainage chutes).

Anticipated wave heights generated within the settling pond can be determined from the procedures presented in the *Shore Protection Manual* (Department of the Army, 1984).

The hydraulic design of the spillway chute (Figure 1) is outlined within the separate fact sheets for *Chutes*.

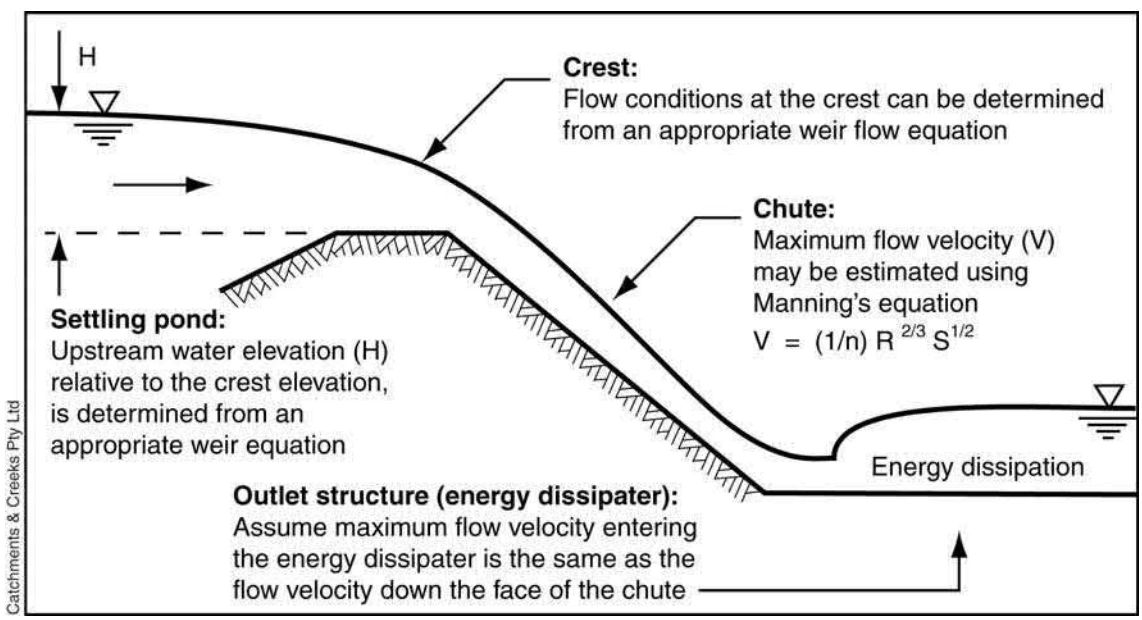


Figure 1 – Hydraulic components of a sediment basin spillway

Design of the flow entry conditions into the spillway:

All reasonable and practicable efforts must be taken to construct the spillway in virgin soil, (Photo 4 & Figure 2) rather than within a fill embankment (Photos 1, 2, 7 & 8). Placement of an emergency spillway within a fill embankment can significantly increase the risk of failure of the embankment.

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 2. 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.

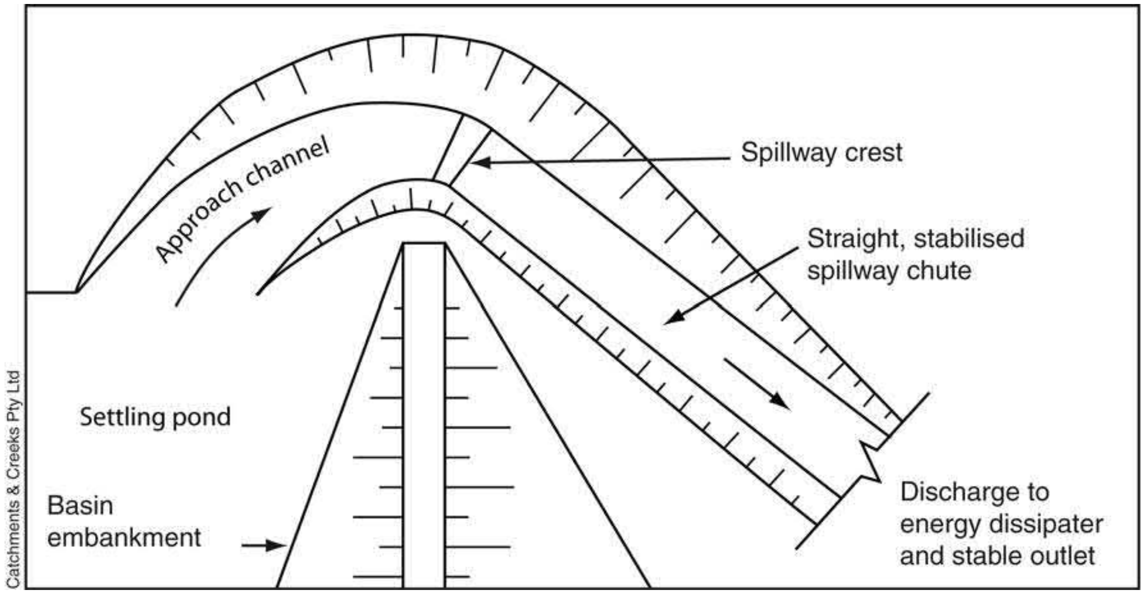


Figure 2 – Emergency spillway (plan view)

If the spillway crest length (L) and its approach channel are short, then friction loss upstream of the spillway crest can be ignored and the water level within the sediment basin 'H' (relative to the spillway crest) can be determined directly from the appropriate weir equation. Figure 3 shows flow approaching a spillway crest along a short approach channel.

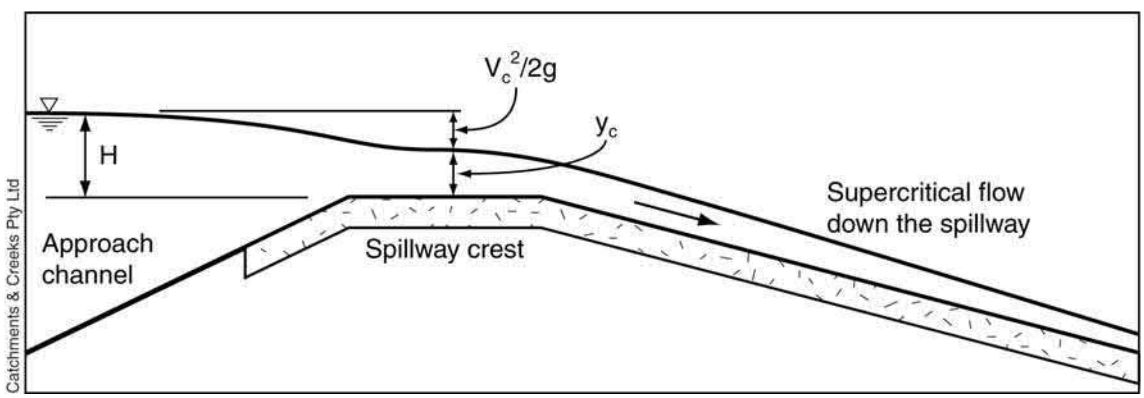


Figure 3 – Hydraulic profile for spillway crest where friction loss within the approach channel is insignificant

In those circumstances where the approach channel is short, the upstream water level (H) relative to the weir crest can be determined from the equations presented in Table 2.

Table 2 – Weir equations for short spillway crest length where friction loss in the approach channel is negligible

Weir cross sectional profile	Side slope (H:V)	Weir equation
Rectangular (b = base width)	vertical sides	$Q = 1.7\ b\ H^{1.5}$
Triangular	m:1	$Q = 1.26\ m\ H^{2.5}$
Trapezoidal	1:1	$Q = 1.7\ b\ H^{1.5} + 1.26\ H^{2.5}$
where : b = base width	2:1	$Q = 1.7\ b\ H^{1.5} + 2.5\ H^{2.5}$
and m = side slope	3:1	$Q = 1.7\ b\ H^{1.5} + 3.8\ H^{2.5}$
(see Figure 4)	4:1	$Q = 1.7\ b\ H^{1.5} + 5.0\ H^{2.5}$
	m:1	$Q = 1.7\ b\ H^{1.5} + 1.26\ m\ H^{2.5}$

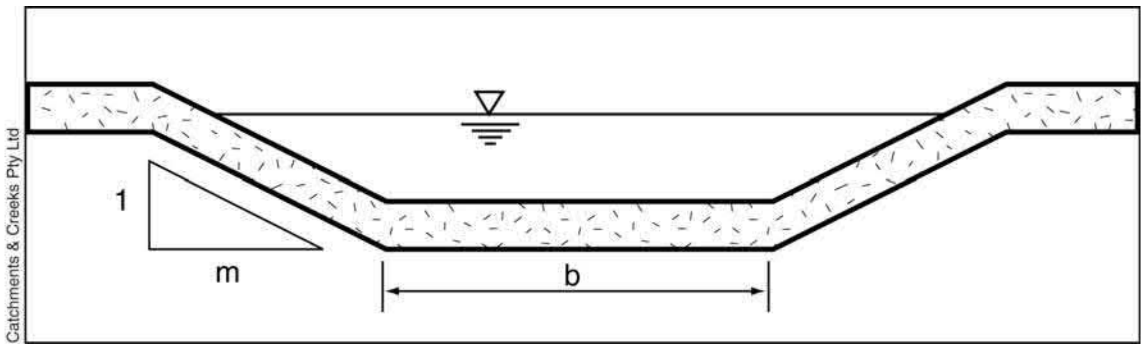


Figure 4 – Trapezoidal spillway (weir) crest

For some sediment basin spillways, however, friction loss within the approach channel is significant and cannot be ignored. In such cases an allowance must be made for this friction loss when determining the relationship between basin water level and spillway discharge. Figure 5 shows flow approaching a spillway crest where friction loss within the approach channel is significant.

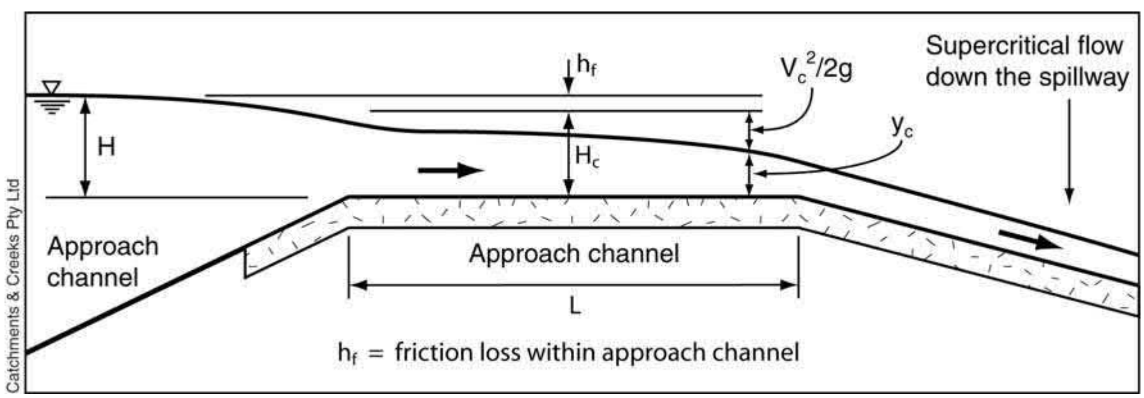


Figure 5 – Hydraulic profile for a spillway where friction loss within the approach channel is significant

A numerical backwater model (e.g. HecRas) should be used to determine the water level profile along the length of the approach channel and thus the anticipated maximum water level within a sediment basin. Such models can also be used to determine flow velocities down the face of the spillway chute. Alternatively, water levels within the basin (H) relative to the spillway crest can be determined from Equation 1.

$$H = H_c + h_f \quad \text{(Eqn 1)}$$

where:

- H = water level within *Sediment Basin* relative to spillway crest [m]
- H_c = total head (energy level) at the spillway crest = $y_c + V_c^2/2g$ [m]
- y_c = critical depth at spillway crest [m]
- V_c = critical flow velocity at spillway crest [m/s]
- g = acceleration due to gravity = $9.8 m/s^2$
- h_f = friction loss within the approach channel and across the crest width [m]

Friction loss (h_f) within the approach channel can be estimated using Equation 2.

$$h_f = \frac{V^2 n^2 L}{R^{4/3}} \quad \text{(Eqn 2)}$$

where:

- V = average flow velocity within the approach channel (if unknown, then assume a velocity of half the critical flow velocity (V_c) [m/s]
- n = Manning's roughness of the approach channel
- L = length of the approach channel upstream of the spillway crest [m]
- R = average hydraulic radius of the approach channel [m]

In circumstances where friction within the approach channel is significant, but the determination of peak water level within the sediment basin is **not** critical, the total upstream head (H) can be estimated from the equations presented in Table 3.

Table 3 – Approximate weir equations for spillways with a long approach channel where friction loss is significant

Weir cross sectional profile	Side slope (H:V)	Weir equation
Rectangular (b = base width)	N/A	$Q = 1.6\, b\, H^{1.5}$
Triangular	m:1	$Q = 1.2\, m\, H^{2.5}$
Trapezoidal (b = base width)	m:1	$Q = 1.6\, b\, H^{1.5} + 1.2\, m\, H^{2.5}$

To maintain the desired maximum allowable water level within the settling pond, concrete capping (sealing) of the spillway crest (Figure 6) is usually required if porous materials, such as loose rock or rock-filled mattresses, are used to line the spillway crest.

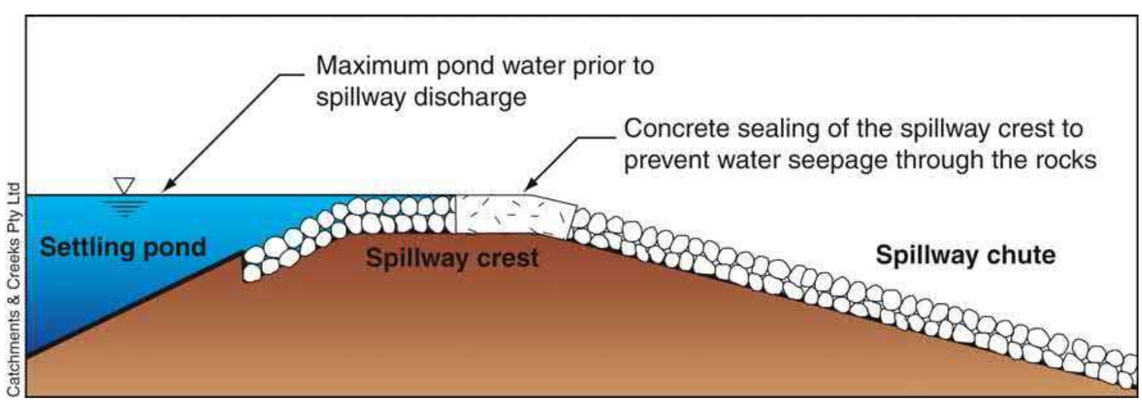


Figure 6 – Concrete sealing of the spillway crest to control seepage through the rock lining

Wherever practical, the spillway should be cut into virgin soil away from any fill embankment as shown in Photo 4.

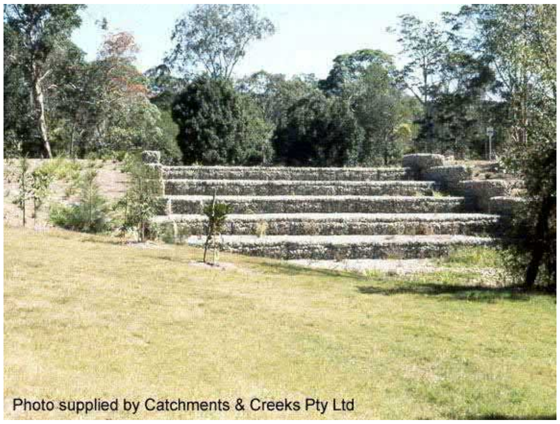


Photo 3 – Permanent, gabion-lined stepped spillway located on a detention basin

Photo 4 – Rock-lined spillway cut into virgin soil (note the spillway is curved up to the crest, after which it remains straight)

Recessing the entire basin into the natural soil (Photo 5) will avoid the need to construct an expensive spillway structure.

Photo 5 – Recessing the basin into the ground allows the natural ground level to become the spillway

Photo 6 – Spillways lined with loose rock generally have a high risk of failure compared to concrete and rock mattress linings

Spillways must have a well-defined cross-section that can fully contain the expected discharge.

Photo 7 – Spillways <u>must</u> have a well-defined profile to fully contain the flow

Photo 8 – A suitable energy dissipater <u>must</u> exist at the base of the spillway

Description

An open channel either passing over or around a sediment basin embankment.

If the basin is fully recessed below natural ground level, the spillway may consist of the natural ground surface.

Spillways are typically lined with materials such as rock, rock-filled mattresses, and concrete.

Purpose

Spillways are used to discharge excess flows from a sediment basin.

The term 'emergency spillway' implies that a primary spillway is incorporated into the low-flow (riser pipe) outlet structure.

Limitations

Bitumen or asphalt is generally not suitable for lining the spillway.

Grass-lined spillways are generally only suitable when the spillway is formed directly on a low-gradient, natural surface.

Common Problems

Inappropriate inlet geometry can cause flow to bypass and/or undermine the spillway.

Severe rilling along the sides of the spillway can be caused by splash. It is noted that spillways generally have a minimum freeboard of 300mm instead of the 150mm applied to minor drainage chutes.

Erosion at the base of the spillway caused by inadequate energy dissipation. Energy dissipation at the base of spillways generally involves complex 3-dimensional hydraulic design.

Common Problems (rock-linings)

Severe erosion problems if rocks are placed directly on dispersive soil. To reduce the potential for such problems, dispersive soils should be covered with a minimum 200mm layer of non-dispersive soil before rock placement.

Failure of rock-lined chutes due to the absence of a suitable filter cloth or aggregate filter layer beneath the primary armour rock layer.

Special Requirements

The spillway and associated energy dissipater must be fully contained within the related property.

An underlying geotextile or rock filter layer is generally required unless all voids are filled with soil and pocket planted (thus preventing the disturbance and release of underlying sediments through these voids).

The upper rock surface should blend with surrounding land to allow water to freely enter the channel.

Site Inspection

Check flow entry conditions to ensure no bypassing, undermining, sedimentation or erosion.

Ensure the spillway chute downstream of the crest is straight.

Check for erosion around the edges of the spillway (top and sides).

Ensure the energy dissipater and the channel downstream of the dissipater are appropriately stabilised.

Ensure the rock size and shape agrees with approved plan.

Check the thickness of rock application and the existence of underlying filter layer.

Check for excessive vegetation growth that may restrict the channel capacity.

Construction

1. 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.
2. 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.
3. 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.
4. If a synthetic filter fabric underlay is specified, place the filter fabric directly on the prepared foundation. If more than 1 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.
5. 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.
6. 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.
7. 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.
8. 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.
9. 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.

Maintenance

1. During the construction period, inspect the spillway prior to forecast rainfall, daily during extended periods of rainfall, after significant runoff producing storm events, or otherwise on a weekly basis. Make repairs as necessary.
2. Check for movement of, or damage to, the spillway's lining, including surface cracking.
3. Check for soil scour adjacent the spillway. Investigate the cause of any scour, and repair as necessary.
4. When making repairs, always restore the spillway to its original configuration unless an amended layout is required.

Removal

1. Temporary spillways should be removed when an alternative, stable, drainage system is available.
2. Remove all materials and deposited sediment, and dispose of in a suitable manner that will not cause an erosion or pollution hazard.
3. Grade the area in preparation for stabilisation, then stabilise the area as specified in the approved plan.

Filter Fence

SEDIMENT CONTROL TECHNIQUE

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

[1] Capture rate of fine clay-sized particles may be poor, but can be improved through the use of thicker, heavy-duty filter cloth.

Symbol FF

Photo 1 – Filter fabric

Photo 2 – Filter fence placed down-slope of earth stockpile

Key Principles

1. Primary treatment mechanism is the *filtration* of medium to coarse-grained particles from stockpile runoff, rather than gravity-induced settlement. The process will not remove turbidity (colour) from the passing water.
2. The fabric must consist of a non-woven geotextile, **not** woven fabric.
3. Only suitable for use in the de-watering of stockpiles, and only when compost filter berms/tubes are not practical or available.
4. A filter fence is **not** a suitable replacement for a traditional *Sediment Fence*, unless installed immediately down-slope of an earth stockpile.

Design Information

Non-woven geotextile fabric, ‘bidim’ A34 or the equivalent.

Maximum support post spacing of 1.5m, or 2m if a wire mesh support frame is used (not wire ties).

Filter fences may also be supported by a continuous (i.e. closely butted) row of straw bales, anchored one stake per bale. The filter cloth must fold over the top of the bales, with the anchor post staked through the fabric and bale.

The filter cloth may also be wrapped around a 400mm high (min) berm formed from composted material. Such designs typically provide higher treatment during de-watering operations.

In all cases, the lower 300mm of filter cloth must be buried in a 200mm (min) deep trench (backfilled and compacted), or a continuous 200mm high (min) sand or aggregate berm.

Preference should be given to the use of compost filter berms/tubes wherever practical.

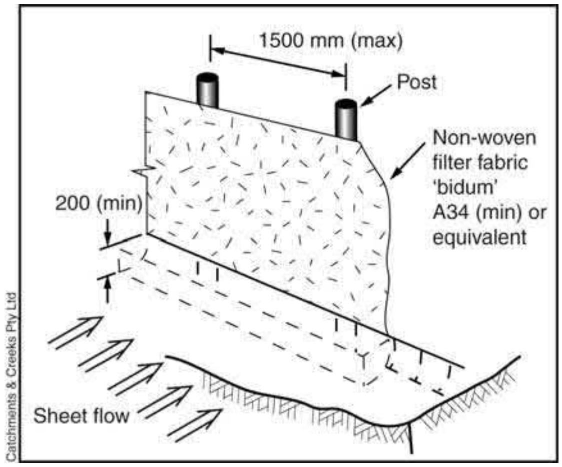


Figure 1 – Installation of filter fence without wire mesh backing

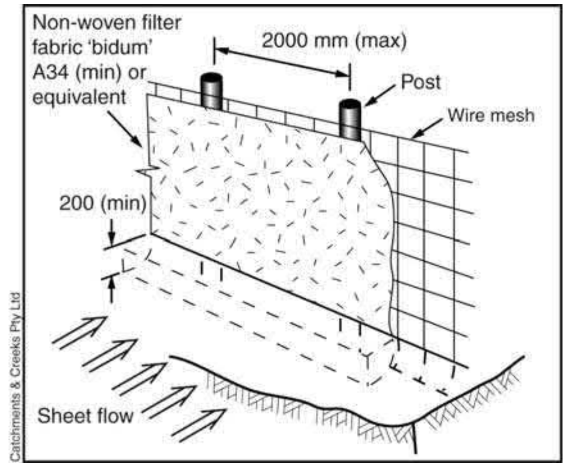


Figure 2 – Installation of filter fence with wire mesh backing

Description

A filter fence is a type of filter barrier consisting of non-woven geotextile fabric staked as a vertical fence.

Various design options exist similar to the various side wall structures found in the formation of a de-watering *Filter Pond*.

In its simplest form, a filter fence consists of heavy-duty, non-woven filter cloth staked at maximum 1.5m centres. Alternative design options include:

- filter cloth backed with wire mesh;
- filter cloth backed with straw bales;
- filter cloth wrapped around a 400mm (min.) high compost berm.

Purpose

Used to filter medium to coarse-grained sediment from storm runoff originating from earth stockpiles, and process water originating from the de-watering of excavated materials.

Limitations

Only suitable for very low flow rates.

Generally has very limited control over turbidity levels, unless incorporated with a suitable grassed *Buffer Zone* down-slope of the filter fence.

Advantages

Quick to install.

Provides better capture of medium-grained sediments than a traditional *Sediment Fence*.

Various design options exist that can improve the filtration process.

Disadvantages

The process will generally not remove turbidity (colour) from the passing water.

Special Requirements

If space is limited, then placing a row of straw bales between the stockpile and the filter fence will help to prevent direct contact between the stockpiled material and the filter fence.

Common Problems

Water passing under poorly buried fabric.

Stockpiled material leaning up against the filter fence (Photo 2), causing the fence to collapse.

Location

Only for use down-slope of earth stockpiles.

Not for use as a general sediment trap.

Site Inspection

Check for signs of water bypassing the structure.

Check for material leaning against the fence.

Materials

- Geotextile fabric: non-woven filter cloth (minimum 'bidim' A34 or the equivalent). Wide strip tensile strength (AS3706.2) minimum 15 kN/m in both directions. Pore size (EOS, O_{95}, AS 3706.7) less than 110 µm. Mass per unit area (AS3706.1) minimum 200gsm.
- Support posts/stakes: 1500mm^2 (min) hardwood, 2500mm^2 (min) softwood, or 1.5kg/m (min) steel star pickets suitable for attaching fabric.
- Backing mesh: plastic or steel mesh with a maximum mesh opening of 200mm.

Installation

1. Refer to approved plans for location, and construction details. If there are questions or problems with the location or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Unless otherwise directed by the responsible on-site officer, excavate a 200mm wide by 200mm deep trench along the proposed alignment of the filter fence, placing the excavated material up-slope of the fence.
3. If the filter fence is to be staked without a mesh backing, then secure the support posts into the ground at a spacing no greater than 1.5m.
4. If the filter fence is to be staked with a mesh backing, secure the support posts into the ground at a spacing no greater than 2.0m, then securely attach the backing mesh to the up-slope side of the support posts from a continuous length of mesh. Extend the mesh into the excavated trench.
5. If the filter fence is the be supported by straw bales, then after suitable anchoring the bottom 300mm of fabric, place a continuous row of straw bales immediately down-slope of the fabric and wrap the fabric over the top of the straw bales. Securely anchor the filter fence with a single stake driven through the fabric and centre of each bale.
6. Using a continuous length of non-woven geotextile, securely attach the fabric to the up-slope side of the support posts or backing mesh, with the fabric extended at least 200mm into the trench.
7. Backfill the trench and tamp the fill to firmly anchor the bottom of the fabric to prevent displacement of the fabric and to prevent the free movement of water under the fabric.
8. In all cases, install the filter fence in a manner that will minimise the risk of sediment-laden water flowing around the fence.

Maintenance

1. Inspect the filter fence regularly and at least daily during de-watering operations. Make repairs as needed to the fabric and support frame.
2. Inspect the fabric for obvious leaks resulting from holes, tears or joint failure in the fabric.
3. Check that water has not overtopped the fence at low points.
4. Repair any torn sections with a continuous piece of fabric placed inside the old fabric, extending at least from support post to support post.
5. Check for materials leaning up against the filter fence. Make repairs as needed to the fabric and support frame.

Removal

1. Remove all accumulated sediment and dispose of it in a suitable manner that will not cause an erosion or pollution hazard.
2. Remove all materials and repair damage to the ground surface as necessary.
3. Appropriately rehabilitate (e.g. revegetate) the ground as necessary to minimise the risk of an ongoing erosion hazard.

Flow Diversion Banks Part 1: General

DRAINAGE CONTROL TECHNIQUE

Low Gradient	✓	Velocity Control		Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	[1]

[1] Flow diversion banks are not commonly used as permanent drainage structures.

Symbol → DB →

Photo 1 – Flow diversion bank down-slope of a future pipeline installation

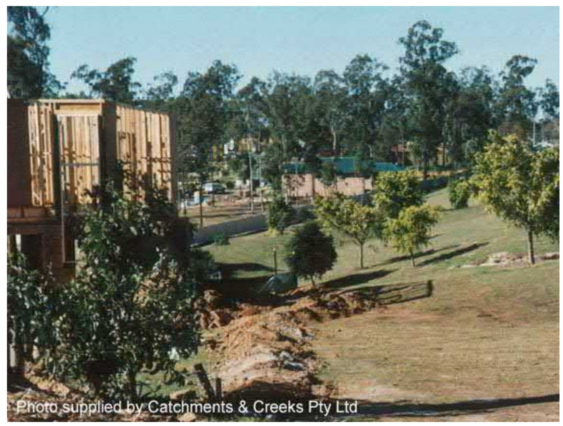


Photo 2 – Flow diversion bank up-slope of a building site

Key Principles

1. Key design parameters are the effective flow capacity of the structure, and the scour resistance of the embankment material.
2. The critical operational issue is usually preventing structural damage to the embankment as a result of high velocity flows or construction traffic.
3. Flow diversion banks are often favoured over *Catch Drains* in areas containing dispersive subsoil because their construction does not require exposure of the subsoils.

Design Information

Dimensional requirements of flow diversion banks and berms vary with the type of embankment. The recommended values are outlined in Table 1.

Table 1 – Recommended dimensional requirements of flow diversion banks/berms

Parameter	Earth banks	Compost berms [1]	Sandbag berms
Height (min)	500mm	300mm (450mm)	N/A
Top width (min)	500mm [2]	100mm (100mm)	N/A
Base width (min)	2500mm [2]	600mm (900mm)	N/A
Side slope (max)	2:1 (H:V)	1:1 (H:V)	N/A
Hydraulic freeboard	150mm (300mm) [3]	100mm	50mm

[1] Values in brackets apply to berms placed across land slopes steeper than 4:1 (H:V).

[2] Top width may be reduced in those non-critical situations in which overtopping will not cause excessive erosion and the banks are unlikely to experience damage from construction equipment.

[3] A minimum freeboard of 300mm applies to non-vegetated earth embankments.

Free standing earth embankments may be stabilised with rock, vegetation, or *Erosion Control Blankets*; however, unprotected topsoil embankments are also acceptable for short-term applications.

Maximum recommended spacing of flow diversion banks down long continuous slopes is provided in Table 2. The actual spacing specified for a given site may need to be less than that presented in Table 2 if the soils are highly susceptible to erosion, or if intense storm events are expected (i.e. northern parts of Australia during the wet season).

Table 2 – Maximum recommended spacing of flow diversion banks down slopes

Open Earth Slopes						Vegetated Slopes		
Slope	**Horiz.**	**Vert.**	**Slope**	**Horiz.**	**Vert.**	**Slope**	**Horiz.**	**Vert.**
1%	80m	0.9m	15%	19m	2.9m	< 10%	No maximum	
2%	60m	1.2m	20%	16m	3.2m	12%	100m	12m
4%	40m	1.6m	25%	14m	3.5m	15%	80m	12m
6%	32m	1.9m	30%	12m	3.5m	20%	55m	11m
8%	28m	2.2m	35%	10m	3.5m	25%	40m	10m
10%	25m	2.5m	40%	9m	3.5m	30%	30m	9m
12%	22m	2.6m	50%	6m	3.0m	> 36%	Case specific	

Photo 3 – Flow diversion berm used to minimise road runoff flowing down a steep, unstable section of the embankment

Photo 4 – Sandbag flow diversion berm used to minimise surface flow over a recently seeded embankment

Photo 5 – Earth flow diversion bank used to direct runoff towards the entrance of a *Slope Drain*

Photo 6 – Turf-lined flow diversion bank with grass-lined outlet chutes at regular intervals along the embankment

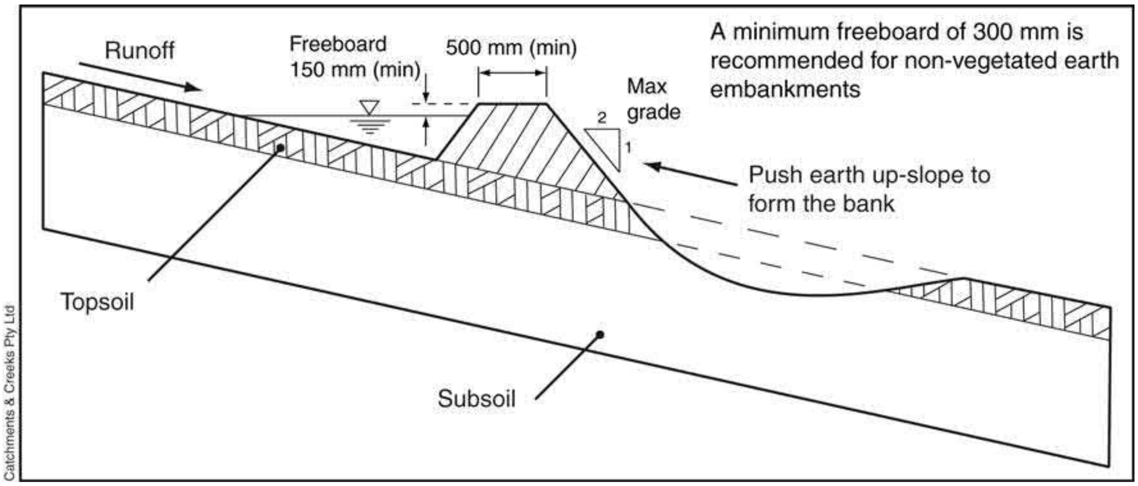
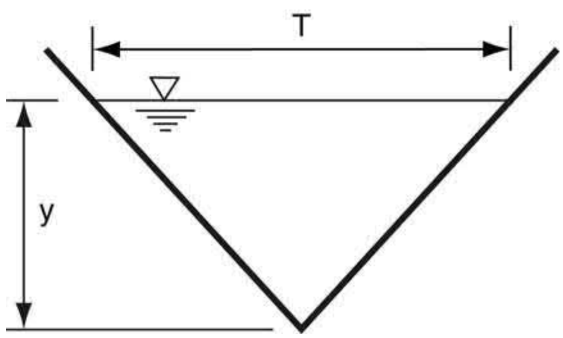
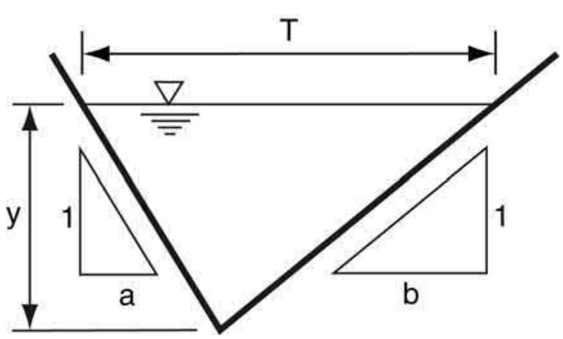


Figure 1 – Profile of 'back-push' bank

The hydraulic capacity of a flow diversion bank normally needs to be assessed on a case-by-case basis; however, the associated fact sheets *"Part 2: On earth slopes"* and *"Part 3: On grassed slopes"* provide the hydraulic capacity for drains with a standard triangular profile established on earth and grassed slopes respectively.

The geometric properties of triangular drainage channels formed by the construction of a flow diversion bank are provided in Table 3.

Table 3 – Geometric properties of triangular drainage profiles

Symmetrical or asymmetric V-drain:  	**Area (A):** $A = 0.5\,T\,y$ **Wetted perimeter (P):** $P = \sqrt{T^2 + 4y^2}$ **Hydraulics radius (R):** $R = \frac{Ty}{2\sqrt{T^2 + 4y^2}}$
Asymmetric V-drain: **where flow top width, T = y(a + b)**  	**Area (A):** $A = \left(\frac{a+b}{2}\right)y^2$ **Wetted perimeter (P):** $P = y\left[\sqrt{(1+a^2)} + \sqrt{(1+b^2)}\right]$ **Hydraulics radius (R):** $R = \frac{0.5(a+b)y}{\sqrt{(1+a^2)} + \sqrt{(1+b^2)}}$

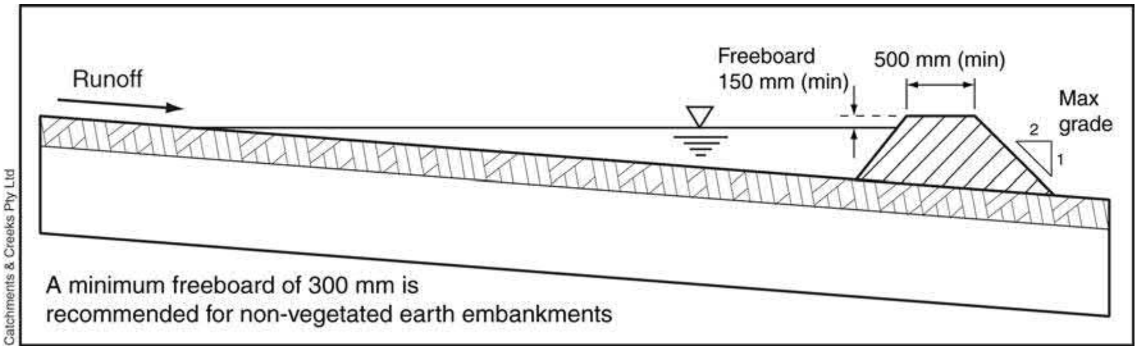


Figure 2 – Flow diversion bank formed from earth

Photo 7 – Flow diversion banks placed each side of drainage line passing through road construction site

Types of flow diversion banks:

The following provides a brief description of some of the flow diversion banks used within rural and construction land management.

Absorption bank	A level bank turned up at each end to promote water infiltration.
Back-push bank	A bank formed by moving in-situ earth up a slope.
Conventional bank	A bank formed by moving in-situ earth down thus forming an excavated drain up-slope of the bank. Also known as a 'catch bank'.
Diversion bank	A graded bank used to collect and divert water away from a soil disturbance, or to a dam, drainage channel, or sediment trap.
Graded bank	A bank constructed with a positive gradient to promote water movement.
Level bank	A bank constructed along a contour. Discharge usually occurs at each end of the bank.
Perimeter bank	A bank located along the upper or lower perimeter of a well-defined area, such as a building site, or along the top edge of a batter.
Trainer bank	A bank used to divert water away from unstable land.
Water-spreading bank	Banks used to collect and distribute surface runoff over an increased flow width. Typically used on low-gradient, marginal arable land.

Description

Flow diversion banks typically consist of a raised earth embankment normally placed along level or near level ground. Minor flow diversion berms can also be formed from tightly packed sandbags, or compost.

Short-term flow diversion banks can also be constructed from tightly packed straw bales. Such banks are often constructed prior to an impending storm.

The term *perimeter bank* is often used to describe an embankment constructed around the 'perimeter' of a work site. These are used to either prevent clean water entering the site, or to prevent the uncontrolled release of dirty water from a site.

The term *back-push bank* is used to describe an embankment formed by pushing in-situ soils up a slope to from an earth embankment.

Purpose

Flow diversion banks and berms are used as temporary drainage systems to:

- collect sheet runoff (clean or dirty) from slopes and transport it across the slope to a stable outlet (Photo 1);
- divert up-slope runoff around a stockpile or soil disturbance (Photo 2);
- divert stormwater away from an unstable slope (Photos 3 & 4);
- direct water to the inlet of a *Chute* or *Slope Drain* (Photos 5 & 6);
- control the depth of ponding around a sediment trap such as a stormwater drop (field) inlet.

Flow diversion banks can also act as a form of topsoil stockpile. Topsoil can be stripped from a site and used to form flow diversion banks either up-slope and/or down-slope of the soil disturbance (Photo 1). Such a practice can be very space effective when conducting 'strip' construction such as roadways and pipeline installation.

Limitations

Catchment area is limited by the allowable flow capacity of the diversion bank and the allowable flow velocity of the surface material.

Not used on slopes steeper than 10% (10:1).

Advantages

Quick to establish or re-establish if disturbed.

Generally inexpensive to construct and remove.

Allows for the management of stormwater flow without the need to excavate a drainage channel. This can be a significant advantage in areas that have highly erosive or dispersive subsoils.

Disadvantages

Can cause sediment problems and flow concentration if overtopped during a severe storm.

Can restrict the movement of equipment around the site.

Can be highly susceptible to damage by construction equipment.

Common Problems

Damaged by construction traffic.

Scour along the base of the embankment caused by excessive flow velocity or an unstable outlet.

Overtopping flows caused by the deposition of sediment up-slope of the bank.

Special Requirements

All flow diversion banks must have a stable outlet.

Flow diversion banks should be seeded and mulched if their working life is expected to exceed 30 days, or as required by the erosion control standard.

Banks should **not** be constructed of unstable, non-cohesive, or dispersive soil.

Location

When flow diversion banks are required and their locations are not shown on the approved plans, their location on the ground should be determined after taking into consideration the following:

- the bank must discharge to a stabilised outlet;
- the bank should drain to a sediment trap if the diverted water is expected to be contaminated with sediment;
- stormwater must not be unnaturally diverted or concentrated onto an adjacent property.

Site Inspection

Check for slumps, wheel track damage, or loss of freeboard.

Check for excessive sediment deposition.

Check for erosion along the bank.

Installation

1. Refer to approved plans for location, extent, and construction details. If there are questions or problems with the location, extent, or method of installation, contact the engineer or responsible on-site officer for assistance.
2. Clear the location for the bank, clearing only the area that is needed to provide access for personnel and equipment.
3. Remove roots, stumps, and other debris and dispose of them properly. Do not use debris to build the bank.
4. Form the bank from the material, and to the dimension specified in the approved plans.
5. If earth is used, then ensure the sides of the bank are no steeper than a 2:1 (H:V) slope, and the completed bank must be at least 500mm high.
6. If formed from sandbags, then ensure the bags are tightly packed such that water leakage through the bags is minimised.
7. Check the bank alignment to ensure positive drainage in the desired direction.
8. The bank should be vegetated (turfed, seeded and mulched), or otherwise stabilised immediately, unless it will operate for less than 30 days or if significant rainfall is not expected during the life of the bank.
9. Ensure the embankment drains to a stable outlet, and does not discharge to an unstable fill slope.

Maintenance

1. Inspect flow diversion banks at least weekly and after runoff-producing rainfall.
2. Inspect the bank for any slumps, wheel track damage or loss of freeboard. Make repairs as necessary.
3. Check that fill material or sediment has not partially blocked the drainage path up-slope of the embankment. Where necessary, remove any deposited material to allow free drainage.
4. Dispose of any collected sediment or fill in a manner that will not create an erosion or pollution hazard.
5. Repair any places in the bank that are weakened or in risk of failure.

Removal

1. When the soil disturbance above the bank is finished and the area is stabilised, the flow diversion bank should be removed, unless it is to remain as a permanent drainage feature.
2. Dispose of any sediment or earth in a manner that will not create an erosion or pollution hazard.
3. Grade the area and smooth it out in preparation for stabilisation.
4. Stabilise the area by grassing or as specified in the approved plan.

Mulch Filter Berms

SEDIMENT CONTROL TECHNIQUE

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

[1] Mulch filter berms provide limited capture of clay-sized particles occurs.

Symbol MFB

or MB

Photo 1 – Large mulch filter berm

Photo 2 – Suitable mulch fibres

Key Principles

1. Sediment trapping is primarily achieved through gravity-induced settlement resulting from ponding up-slope of the berm; however, significant filtration is achieved on water passing through the berm.
2. Primarily used to collect the coarser sediment particles. This technique has limited ability to capture the finer silt and clay-sized particles.
3. The key performance objective is to maximise the surface area of ponding up-slope of the berm such that coarse sediments are allowed to settle under gravity. Thus it is essential for the berm to be placed along the contour in order to gain maximum benefit.
4. Mulch filter berms placed across the slope (i.e off the contour) will act as *Flow Diversion Banks*, thus reducing their sediment trapping ability.
5. The mulch must be obtained from a tub grinding (or similar) process that fractures the woody vegetation into interlocked fibres rather than chipping the vegetation.

Design Information

Mulch must comply with the requirements of AS4454.

Mulch must be produced only from green waste won from on-site clearing and grubbing.

Mulch must be generating through either horizontal or tub grinder, **not** chipping.

Grade 3 mulch is recommended, i.e. mulch containing 90% by mass of material with a maximum size of 150mm (Table 3).

Maximum drainage area of 250m^2 per 10m length of berm in sheet flow conditions.

Table 1 provides the recommended maximum spacing of mulch filter berms down long slopes.

Table 1 – Recommended maximum spacing of mulch filter berms down slopes

Land slope (H:V)	Bank slope (%)	Maximum spacing (m)
flatter than 50:1	flatter than 2%	30m
20:1	5%	25m
10:1	10%	15m
5:1	20%	8m
steeper than 4:1	steeper than 25%	not recommended

Table 2 provides the recommended minimum bank heights for mulch filter berms. The base width of berms should be at least twice its formation height.

Table 2 – Recommended dimensions of mulch filter berms

Conditions	Land slope perpendicular to bank	
	Less than 5%	Greater than 5%
Minimum bank height at time of formation	750mm	1000mm
Minimum bank height after natural settlement and organic breakdown	500mm	500mm
Top width of bank (min)	100mm	100mm
Base width (min)	1600mm	1600mm
Side slope (max)	1:1 (H:V)	1:1 (H:V)

Table 3 provides a classification system for mulches used within the sediment control industry.

Table 3 – Classification of mulches for use in sediment control activities

Grade 1	Grade 2	Grade 3
90% by mass of material with a maximum size of 60 mm	90% by mass of material with a maximum size of 100 mm	90% by mass of material with a maximum size of 150 mm

Photo 3 – Smaller berms are best formed from composted material

Photo 4 – Mulch filter berms need to be sufficiently large (high) to allow for possible slumping and damage by foot traffic

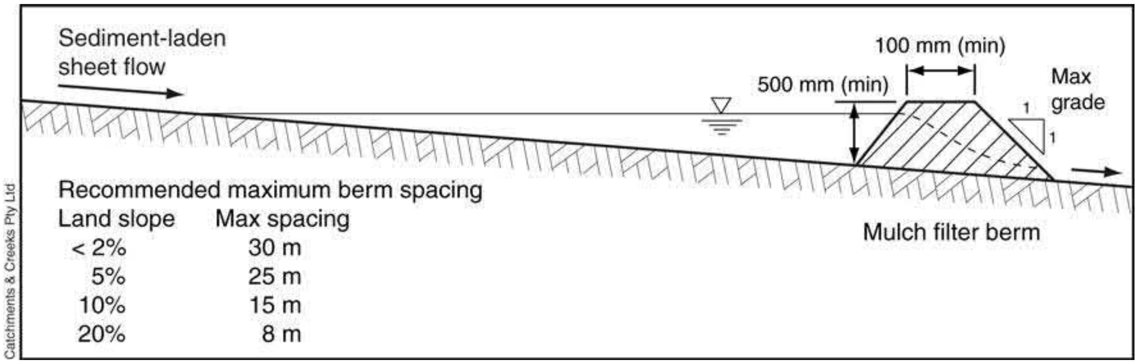


Figure 1 – Placement of mulch filter berms

Description

A sediment filter berm formed from site-generated green waste. Mulch filter berms are generally constructed along the contour to allow the even filtration of sediment-laden sheet runoff.

Also known as *Filter* Berms and *Mulch Berms*.

Purpose

Used to 'filter' and 'settle' sediment from sheet flow.

Used as an alternative to a *Sediment Fence* and *Compost Filter Berm* in areas of sheet flow.

Can be used for flow diversion under controlled conditions—more commonly referred to as *Flow Control Berms*.

Limitations

Not suitable for land subjected to concentrated flow.

Not suitable to active work areas where the berm is likely to be damaged by pedestrian or vehicular traffic.

Advantages

Mulch filter berms can filter medium to coarse sediments from low-discharge, sheet flows.

Good use of cleared vegetation.

Unlike a *Sediment Fence*, mulch filter berms are usually left in-situ to become an integral part of the vegetated slope. In such cases, the berm must be identified within the permanent drainage plan and/or site revegetation (landscape) plan.

Mulch filter berms generally represent a lower safety risk compared to a *Sediment Fence*.

No risk of importing weed seed as the material must be formed only from site material. If the site material contains weed seed, then the material should not be used.

Disadvantages

Cannot be used if the site contains no suitable green waste (i.e. cleared woody vegetation).

Can cause the concentration of stormwater runoff if poorly located.

Lower sediment trapping efficiency compared to *Compost Filter Berms*.

Common Problems

Berms placed along the top of cut slopes (i.e. off the contour) cause flow diversion rather than sediment capture.

Low berms can be easily damaged allowing flows to breach the berm.

Special Requirements

Mulch certification must comply with the requirements of AS4454.

Application is usually by pneumatic systems using a special berm-forming device.

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

Location

Mulch filter berms should ideally be located along the contour (i.e. a line of constant land elevation).

Best used as a sediment control system in locations where:

- stormwater runoff does not contain fine, particulate or dissolved pollutants; or
- there is the potential for ongoing sediment-laden runoff for a limited period after vegetation establishment.

Site Inspection

Ensure the berm has been placed such that ponding up-slope of the berm is maximised.

Check for damage to the berm, and actual or potential wash-outs points.

Materials

- Mulch must comply with the requirements of AS4454.
- Maximum soluble salt concentration of 5dS/m.
- Moisture content of 30 to 50% prior to application.

Installation

1. Refer to approved plans for location and extent. If there are questions or problems with the location, extent, material type, or method of installation contact the engineer or responsible on-site officer for assistance.
2. When selecting the location of a mulch filter berm, to the maximum degree practical, ensure the berm is located:
   - totally within the property boundaries;
   - along a line of constant elevation (preferred, but not always practical);
   - at least 1m, ideally 3m, from the toe of a fill embankment;
   - away from areas of concentrated flow.
3. Ensure the berm is installed in a manner that avoids the concentration of flow along the berm, or the undesirable discharge of water around the end of the berm.
4. Ensure the berm has been placed such that ponding up-slope of the berm is maximised.
5. Ensure both ends of the berm are adequately turned up the slope to prevent flow bypassing prior to water passing over the berm.
6. Ensure 100 per cent contact with the soil surface.
7. Where specified, take appropriate steps to vegetate the berm.

Maintenance

1. During the construction period, inspect all berms at least weekly and after any significant rain. Make necessary repairs immediately.
2. Repair or replace any damaged sections.
3. When making repairs, always restore the system to its original configuration unless an amended layout is required or specified.
4. Remove accumulated sediment if the sediment deposit exceeds a depth of 100mm or one-third the height of the berm.
5. Dispose of sediment in a suitable manner that will not cause an erosion or pollution hazard.

Removal (if required)

1. When disturbed areas up-slope of the berm are sufficiently stabilised to restrain erosion, the berm may be removed.
2. Remove any 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.

Sediment Basins

SEDIMENT CONTROL TECHNIQUE

Type 1 System	✓	Sheet Flow		Sandy Soils	✓
Type 2 System		Concentrated Flow	✓	Clayey Soils	✓
Type 3 System		Instream Works		Dispersive Soils	✓

Symbol

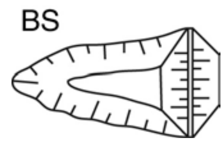


Photo 1 – Type A basin

Photo 2 – Type C basin

Key Principles

1. Sediment trapping is primarily achieved through particle settlement. Some basins may incorporate a filtration system within the outlet structure, but these filters are generally unreliable. Consequently the focus should always remain on achieving effective particle settlement.
2. Achieving optimum particle settlement relies upon achieving uniform flow conditions across the settling pond, and if chemical dosing is required, selecting the most appropriate flocculant and/or coagulant, and then achieving effective ‘mixing’ **prior** to the treated flows entering the settling pond.
3. The size of the settling pond is directly related to the ‘volume’ of runoff and/or peak design ‘discharge’. Pond volume is critical for basins operate as plug flow systems; while the pond surface area is critical for sediment basins that operate as continuous flow systems. Both pond volume and surface area are critical for Type A basins.
4. It should be noted that even if a basin is full of water, it can still be effective in removing coarse sediments from inflows. Therefore, unlike permanent stormwater treatment ponds, flows in excess of the design storm should still be directed through the sediment basin.

Design Information

A sediment basin is a purpose built dam designed to collect and settle sediment-laden water. It usually consists of an inlet chamber (forebay), a primary settling pond, a decant system, and a high-flow emergency spillway.

This fact sheet summaries the design requirements for four types of sediment basins, Type A, Type B, Type C and Type D basins. Detailed discussion on the design procedures is provided in Book 2’s Appendix B (June, 2018).

Design Procedure

Step 1 Assess the need for a sediment basin

Step 2 Select basin type

Step 3 Determine basin location

Step 4 Divert up-slope 'clean' water

Step 5 Select internal and external bank gradients

Step 6a Sizing Type A basins

Step 6b Sizing Type B basins

Step 6c Sizing Type C basins

Step 6d Sizing Type D basins

Step 7 Define the sediment storage volume

Step 8 Design of flow control baffles

Step 9 Design the basin's inflow system

Step 10 Design the primary outlet system

Step 11 Design the emergency spillway

Step 12 Assess the overall dimensions of the basin

Step 13 Locate maintenance access (de-silting)

Step 14 Define the sediment disposal method

Step 15 Assess the need for safety fencing

Step 16 Define the rehabilitation process for the basin area

Step 17 Define the basin's operational procedures

Step 1: Assess the need for a sediment basin

The application of Type 1 sediment controls (i.e. sediment basins) is presented in Table 1. Table 1 supersedes Table 4.5.1 presented within the 2008 edition of Chapter 4.

Table 1 – Sediment control standard (default) based on soil loss rate

Catchment Area (m^2) [1]	Soil loss (t/ha/yr) [2]			Soil loss (t/ha/month) [3]		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	[4]	N/A	N/A	[4]
1000	N/A	N/A	All cases	N/A	N/A	All cases
2500	N/A	> 75	75	N/A	> 6.25	6.25
>2500	> 150	150	75	> 12.5	12.5	6.25
> 10,000	> 75	N/A	75	> 6.25	N/A	6.25

Notes:

[1] Area is defined by the catchment area draining to a given site discharge. Sub-dividing a given drainage catchment shall not reduce its 'effective area' if runoff from these sub-areas ultimately discharges from the site at the same general location. The 'area' does not include any 'clean' water catchment that bypasses the sediment trap. The catchment area shall be defined by the 'worst case' scenario, i.e. the largest effective area that exists at any instance during the soil disturbance.

[2] Soil loss defines the maximum allowable soil loss rate (based on RUSLE analysis) from a given catchment area. A slope length of 80 m should be adopted within the RUSLE analysis unless permanent drainage or landscape features reduce this length.

[3] RUSLE analysis on a monthly basis shall only apply in circumstances where the timing of the soil disturbance is/shall be regulated by enforceable development approval conditions. When conducting monthly RUSLE calculations, use the worst-case monthly R-Factor during the nominated period of disturbance.

[4] Refer to the relevant regulatory authority for assessment procedures. The default standard is a Type 3 sediment trap.

[5] Exceptions to the use of sediment basins shall apply in circumstances where it can be demonstrated that the construction and/or operation of a sediment basin is not practical, such as in many forms of linear construction where the available work space or Right of Way does not provide sufficient land area. In these instances, the focus must be erosion control using techniques to achieve an equivalent outcome. The 'intent' shall always be to take all reasonable and practicable measures to prevent or minimise potential environmental harm.

Step 2: Select basin type

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

Table 2 – Selection of basin type

Basin type	Soil and/or catchment conditions [1]
Type A	The duration of the soil disturbance, within a given drainage catchment, exceeds 12 months. [2, 3, 4]
Type B	The duration of the soil disturbance, within a given drainage catchment, does not exceed 12 months. [2, 3, 4]
Type C	Less than 33% of soil finer than 0.02 mm (i.e. d_{33} > 0.02 mm) and no more than 10% of soil dispersive. [5, 6]
Type D	An alternative to a Type A or B basin when it can be demonstrated that automatic chemical flocculation is not reasonable nor practicable. [3]

Notes:

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

[2] The duration of soil disturbance shall include only those periods when there is likely to be less than 70% effective ground cover (i.e. C-Factor of 0.05 or higher, refer to Appendix E (IECA, 2008)).

[3] Because the footprints of Type A, B and D basins are similar, the issue of reasonableness and practicability comes down to whether or not effective automated dosing can be implemented. Situations where this is not practical are likely to occur only when the physical layout results in multiple inflow locations, and alternative configurations are not achievable.

[4] Alternative measures such as batched sediment basins (i.e. enlarged Type D) may be implemented in lieu of Type A or B basins where it can be shown that such measures will achieve a commensurate performance outcome. Alternative designs should be able to demonstrate through long-term water-balance modelling: (i) the equivalent water quality outcomes of existing Type A basins in the local area; (ii) if local data on the performance of Type A basins is not available, at least 80% of the annual average runoff volume can achieve the specified WQO.

[5] A Type C basin shall not be used if the adopted Water Quality Objectives (WQOs) specify turbidity levels and/or suspended solids concentrations for the site's discharged waters are unlikely to be achieved by a Type C basin. Particle settlement testing is recommended prior to adopting a Type C basin to confirm unassisted sediment settling rates, and to ensure that the Type C design will achieve the desired discharge water quality.

[6] The percentage of soil that is dispersive is measured as the combined decimal fraction of clay (<0.002 mm) plus half the percentage of silt (0.002–0.02 mm), multiplied by the dispersion percentage (refer to Appendix C – Soils and revegetation).

[7] For highly sensitive receiving environments, where higher than normal water quality standards are required, the solution maybe one or a combination of: a focus on erosion control, larger retention times (i.e. larger basin volume), and/or more efficient flocculants/coagulants.

[8] The most appropriate flocculant/coagulant is likely to vary with the type of exposed soil. Consequently, there is need to proactively review the efficacy of these products over time.

In some situations, analysis of the soil and water characteristics will also guide the selection of the basin type. If the local soil and water characteristics hinder the effective operation of a Type A or B basin, then sufficient justification must be provided documenting why an alternative sediment basin type has been adopted.

The sediment basin components and methodology utilised for Type A and B basins should always be adopted wherever practical. Even without a treatment system, the design approach promotes more effective settling compared to Type D basins that do not normally incorporate automatic dosing, forebays and hydraulically efficient settling pond designs. If automated chemical treatment is not incorporated into the operation of a basin, then the operational requirements will need to be modified to that presented for Type A and B basins.

Jar testing is required in order to determine the chemical dosing requirements of sediment basins. It is recommended that this analysis is undertaken prior to designing the basins as the findings may influence the strategies adopted. It should be noted that the most suitable flocculant and/or coagulant is likely to vary with different soil types. Consequently, there is the need to proactively review the efficacy of these products over time as soil characteristics change during the various construction phases of the project.

Step 3: Determine basin location

All reasonable and practicable measures must be taken to locate sediment basins within the work site in a manner that maximises the basin's overall sediment trapping efficiency. Issues that need to be given appropriate consideration include:

(i) Locate all basins within the relevant property boundary, unless the permission of the adjacent land-holder has been provided.

(ii) Locate all basins to maximise the collection of sediment-laden runoff generated from within the site throughout the construction period, which extends up until the site is adequately stabilised against soil erosion, including raindrop impact.

(iii) Do not locate a sediment basin within a waterway, or major drainage channel, unless it can be demonstrated that:

- the basin will be able to achieve its design requirements, i.e. the specified treatment standard (water quality objective);
- settled sediment will not be resuspended and washed from the basin during stream flows equal to, or less than, the 1 in 5 year ARI (18% AEP);
- the basin and emergency spillway will be structurally sound during the design storm specified for the sizing of the emergency spillway.

(iv) Where practical, locate sediment basins above the 1 in 5 year ARI (18% AEP) flood level. Where this is not practical, then all reasonable efforts must be taken to maximise the flood immunity of the basin.

(v) Avoid locating a basin in an area where adjacent construction works may limit the operational life of the basin.

(vi) Assess and minimise secondary impacts such as disturbance to tree roots, particularly of significant individual trees. These impacts may extend to trees on adjacent lands (refer to AS4970 - *Protection of trees on development sites).*

(vii) Ensure basins have suitable access for maintenance and de-silting.

If the excavated basin is to be retained as a permanent land feature following the construction period—for example as a stormwater detention/retention system—then the location of the basin may in part be governed by the requirements of this final land feature. However, if the desired location of this permanent land feature means that the basin will be ineffective in the collection and treatment of sediment-laden runoff, then an alternative basin location will be required.

Discussion:

It should be remembered that it is not always necessary to restrict the site to the use of just one sediment basin. In some locations it may be highly desirable to divide the work site into smaller, more manageable sub-catchments, and to place a separate basin within each sub-catchment.

It is generally undesirable to divide a basin into a series of two or more in-line basins. Several small basins operating in series can have significantly less sediment trapping efficiency than a single basin. This is because of the remixing that occurs when flow from one basin spills into, or is piped into, the subsequent basin. There are exceptions to this rule, such as:

- Type A basins where the combined basin volume satisfies the minimum volume requirement, and at least one of the basins is able to, on its own, satisfy the minimum surface area requirement.
- Type D basins where at least one of the basins has sufficient surface area and length to width ratio to satisfy the requirements of a Type C basin. The combined settling volume of the basins must not be less than that specified for a Type D basin.
- A series of Type C or D basins where each settling pond is connected by several pipes or culverts evenly spaced across the full width of the basin. Such a design must minimise the effects of inflow jetting from each pipe/culvert and allow an even distribution of flow across the full basin width. In such cases the minor sediment remixing that occurs as flow passes through the interconnecting pipes/culverts is usually compensated for by the improved hydraulic efficiency of the overall basin surface area.

Step 4: Divert up-slope 'clean' water

Wherever reasonable and practicable, up-slope 'clean' water should be diverted around the sediment basin to decrease the size and cost of the basin, and increase its efficiency. If flow diversion systems are used to divert clean water around the basin, then these systems will usually need to be modified 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.

The *intent* is to minimise the volume of uncontaminated water flowing to a basin at any given time during the operation of the basin.

Discussion:

One of the primary goals of an effective erosion and sediment control program is to divert external run-on water and any uncontaminated site water around major sediment control devices such as sediment basins.

The effective catchment area may vary significantly during the construction phase as areas of disturbance are first connected to a sediment basin, then taken off-line as site rehabilitation occurs. It is considered best practice to prepare a Construction Drainage Plan (CDP) for each stage of earth works.

Step 5: Select internal and external bank gradients

It is usually necessary to determine the internal bank gradients of sediment basins before sizing the basin because this bank gradient can alter the mathematical relationship between pond surface area and volume.

Recommended bank gradients are provided in Table 3.

Table 3 – Suggested bank slopes

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

In circumstances where the consequence of failure of the basin wall has significant consequences for life and/or property, then all earth embankments in excess of 1 m 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's internal banks are steeper than 1:5 (V:H), and the basin will not be fenced, then a suitable method of egress during wet weather needs to be installed. Examples include a ladder, steps cut into the bank, or at least one bank turfed for a width of at least 2 m from the top of bank to the toe of bank.

Step 6: Sizing the settling pond of sediment basins

Step 6 has been divided into separate discussions on each type of sediment basins:

Step 6a – Sizing Type A basins

Step 6b – Sizing Type B basins

Step 6c – Sizing Type C basins

Step 6d – Sizing Type D basins

Step 6a: Sizing Type A basins

The settling pond within a Type A sediment basin is divided horizontally into three zones:

- upper settling zone
- free water zone
- sediment storage zone.

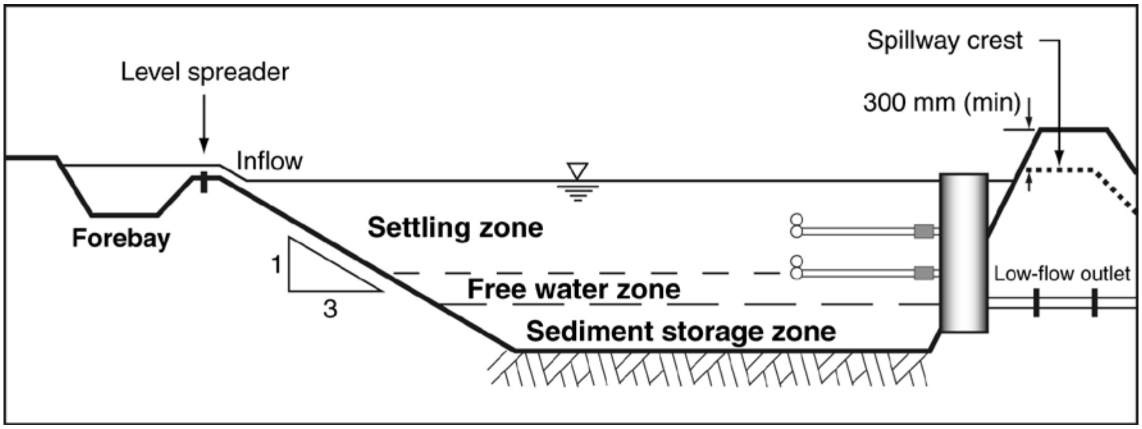


Figure 1 – Long-section of a typical Type A basin

The sizing of a Type A basin is governed by achieving or exceeding a minimum settling volume (V_S), and a minimum settling zone surface area (A_S). It is generally advisable to optimise the basin's dimensions such that both the pond volume and surface area are minimised, thus resulting in a basin that requires the minimum space and construction cost.

For a given low-flow decant rate (Q_A), there is an 'optimum' settling zone depth (D_S) that will allow the minimum settling volume and minimum settling zone surface area requirements to be achieved concurrently. Conversely, for a given settling zone depth, there is an 'optimum' low-flow decant rate that will also allow both of these design requirements to be achieved concurrently.

If site conditions place restrictions on the total depth of the sediment basin (D_T), then this will directly impact upon the maximum allowable depth of the settling zone (D_S); however, the relationship between the settling zone depth and the total pond depth is complex, and depends on a number of factors.

If it is possible to determine, or nominate, a desirable settling zone depth (D_S), then the optimum low-flow decant rate may be determined from Equation 1.

$$Q_{A\,(optimum)} = (K \,.\, I^{1.8})/(K_S \,.\, D_S) \qquad (1)$$

where:

- Q_A = the low-flow decant rate per hectare of contributing catchment [m^3/s/ha]
- K = equation coefficient that varies with the design event (X) and the low-flow decant rate (Q_A) refer to Table 7
- I = $I_{X\,yr,\,24\,hr}$ the average rainfall intensity for an X-year, 24-hour storm [mm/hr]
- K_S = inverse of the settling velocity of the critical particle size (Table 8)
- D_S = depth of the settling zone measured from the spillway crest [m]

For a 1 year ARI design event, the coefficient 'K' may be estimated from Equation 2:

$$K = 0.6836\, Q_A^{\,-0.6747} \qquad (2)$$

This means the 'optimum' low-flow decant rate can be estimated from Equation 3.

For a 1 yr ARI design: $$Q_{A\,(optimum)} = 0.8\,(I^{1.08})/(K_A \,.\, D_S)^{0.6} \qquad (3)$$

It is currently recommended that the low-flow decant rate should be limited to a maximum of 0.009 $m^3/s/ha$ (9 L/s/ha) to avoid settled sediment being drawn (lifted) towards the low-flow decant system, causing a decant water quality failure. It is this maximum low-flow decant rate that will govern in most parts of northern Australia. The recommend trial value of the low-flow decant rate (Q_A) is presented in Table 4 for various locations.

Table 4 – Suggested 'trial value' of the optimum low-flow decant rate, Q_A

Likely optimum Q_A	Locations
4 L/s/ha	Mildura, Adelaide, Mt Gambier (D_S = 1.0 to 1.5 m)
5 L/s/ha	Wagga, Melbourne, Bendigo, Ballarat, Hobart (D_S = 1.0 m) Bourke, Dubbo, Bathurst, Goulburn (D_S = 1.5 m)
6 L/s/ha	Bourke, Bathurst, Canberra, Perth (D_S = 1.0 m) Toowoomba (based on D_S = 2.0 m)
7 L/s/ha	Dubbo, Tamworth, Goulburn (based on D_S = 1.0 m) Roma, Toowoomba (based on D_S = 1.5 m)
8 L/s/ha	Dalby, Roma, Armidale (based on D_S = 1.0 m)
9 L/s/ha	Darwin, Cairns, Townsville, Mackay, Rockhampton, Emerald, Caloundra, Brisbane, Toowoomba (D_S = 1.0 m), Lismore, Port Macquarie, Newcastle, Sydney, Nowra

Alternatively, the designer may choose to nominate a low-flow decant rate (Q_A) based on the desired number of floating decant arms, then determine an optimum settling pond depth (D_S).

For all ARI events: $$D_{S\,(optimum)} = (K \,.\, I^{1.8})/(K_S \,.\, Q_A) \qquad (4)$$

For a 1 yr ARI design: $$D_{S\,(optimum)} = 0.684\,(I^{1.8})/(K_S \,.\, Q_A^{1.67}) \qquad (5)$$

For the Auckland-type decant system:

Q_A = 0.0045 (number of decant arms) / (catchment area) [$m^3/s/ha$]

The total basin depth is made-up of various 'layers' or zones, as described in Table 5.

Table 5 – Components of the settling pond depth and volume (Type A basin)

Component			Term	Minimum depth	Term	Min. volume as a percentage of the settling volume, V_S
Total depth	Settling zone		D_S	0.6 m	V_S	100%
	Retained water zone	Free water	D_{FW}	0.2 m	V_F	—
		Sediment storage zone	D_{SS}	0.2 m	V_{SS}	30%

Design procedure for sizing a Type A sediment basin:

Step 1A: Determine the design event from Table 6 *(see below)*

Step 2A: Select a trial low-flow decant rate (Q_A) from Table 4

Alternatively, use equations 1 or 3 to determine an optimum decant rate—this is the low-flow decant rate at maximum water level when all decant arms are operational.

A maximum decant rate of 9 L/s/ha is currently recommended until further field testing demonstrates that higher rates will not cause scour (lifting) of the settled sediment.

Step 3A: Determine the optimum settling pond depth using either equations 4 or 5

Step 4A: Choose a 'design' settling zone depth (D_S)

To obtain a sediment basin with the least volume and surface area, choose a settling zone depth equal to the optimum depth determined in Step 3A.

A minimum settling zone depth of 0.6 m is recommended because it ensures a pond residence time in the order of around 1.5 hours at the peak low-flow decant rate; and it reduces the risk of settled sediment being drawn up towards the floating decant arms.

If a greater settling zone depth is chosen, then the minimum surface area requirement will dominate, which will prevent the basin from being made smaller; however, the increased volume should improve the basin's overall treatment efficiency. A maximum settling zone depth of 2.0 m is recommended.

If a smaller settling zone depth is chosen, then the required minimum settling zone volume will dictate the basin's design, and the basin will have a surface area greater than that required by Step 5A. A settling zone depth of less than 0.6 m is not recommended.

Step 5A: Calculate the minimum, average, settling zone surface area (A_S)

Calculate the minimum, average, settling zone surface area based on Equation 11 (below) and the following design conditions:

- the expected settling rate of the treated sediment floc
- the expected water temperature within the pond during its critical operational phase.

It is noted that the water temperature within the settling pond is normally based on the temperature of rainwater at the time of year when rainfall intensity is the highest.

The minimum settling zone surface area as generated by Equation 11 is referred to as the 'average' surface area, meaning that when multiplied by the settling zone depth, it will equal the settling zone volume (V_S). In most cases it can be assumed that this average surface area is the same as the surface area at the mid-depth of the settling zone (A_{Mid}); however, this is not always technically correct (even though the differences are usually minor).

Technically, the volume of the settling zone is not equal to the mid surface area times the depth, but instead is a product of the Simpson's Rule, Equation 6.

$$V_S = (D_S/6).(A_{Top} + 4.A_{Mid} + A_{Base}) \qquad (6)$$

Step 6A: Calculate the minimum settling zone volume (V_S) based on Equation 7 *(below)*

Step 7A: Nominate the depth of the free water zone

The free water zone is used to separate the settled sediment from the low-flow decant system to prevent settled sediment from being drawn into the decant system at the start of the next storm.

The free water zone is required to be at least 0.2 m in depth.

Step 8A: Check for the potential re-suspension of settled sediment

Currently the maximum allowable supernatant (clear liquor) velocity upstream of the overflow spillway has been set at 1.5 cm/s (0.015 m/s) based on decant testing of settled sludge blankets in wastewater treatment plants (best available information).

This means that a minimum free water depth of 0.2 m is recommended for the Auckland-type, low-flow decant system, which has a decant rate of 2.25 L/s/m (i.e. 4.5 L/s via a 2 m wide arm).

Designers should check that at the maximum decant rate (i.e. when all the decant arms are active) the velocity of the clear supernatant above the settled sediment blanket (assumed to be around 0.6 m below the water surface) does not exceed 1.5 cm/s.

If a multi-arm decant system is used, then this velocity check should be performed for each increment in the decant rate.

Step 9A: Determine the length and width of the settling zone

General requirement: settling zone length (L_S) > 3 times its width (W_S).

It is recommended that the length of the settling zone at the elevation of the spillway crest (i.e. at near maximum water level) should be at least three times the width of the settling zone at the elevation of the spillway crest.

For simplicity, designers may choose to set the length of the settling zone at the mid-elevation of the settling zone as equal to three times the mid-elevation width, then determine all other dimensions from these values.

Step 10A: Determine the remaining dimensions of the sediment basin

Once the volume and dimensions of the settling zone are known, the remaining basin dimensions need to be determined based on the sizing requirements outlined in Table 5.

It is recommended that the bank slope of the inflow batter (adjacent the forebay) is 1 in 3.

Technical notes B2 to B4 within Appendix B (June 2018) outline a method for the determination of the minimum depth of the sediment storage zone; however, if this type of analysis is to be performed on a regular basis, then it can be worth utilising a simple spread sheet analysis to determine the basin's dimensions.

(i) Design event

The recommended design event varies with the type of soil disturbance. It should be noted that nominating a particular design event does not necessarily guarantee that the sediment basin will achieve the desirable performance outcomes during all storms up to that recurrence interval. The design event is used as a nominal design variable, not a performance standard. Recommended design events are provided in Table 6.

Table 6 – Recommended design event for Type A basins

Design	Type of soil disturbance
1 yr	• Short-term soil disturbances, e.g. civil construction and urban development.
5 yr	• Long-term soil disturbances, such as landfill sites, quarries and mine sites.

(ii) Minimum settling zone volume, V_S

The minimum settling volume shall be determined from Equation 7:

$$V_S = K \cdot A \, (I_{X\,yr,\,24\,hr})^{1.8} \qquad (7)$$

where:

V_S = minimum settling volume [m^3]

K = equation coefficient that varies with the design event (X) and the chosen low-flow decant rate (Q_A) refer to Table 7

A = area of the drainage catchment connected to the sediment basin [ha]

$I_{X\,yr,\,24\,hr}$ = the average rainfall intensity for an X-year, 24-hour storm [mm/hr]

X = the nominated design event (ARI) expressed in 'years' (Table 6)

Table 7 – Type A basin sizing equation coefficient 'K'

Low-flow decant rate 'Q_A'		Coefficient 'K' for specific design events		
L/s/ha	**m^3/s/ha**	**1 year**	**2 year**	**5 year**
2	**0.002**	45.0	46.0	46.9
3	**0.003**	34.5	36.7	39.5
4	**0.004**	28.4	30.8	33.9
6	**0.006**	22.7	22.9	26.0
8	**0.008**	17.6	18.8	20.9
9	**0.009**	16.2	17.4	19.3

For low-flow decants outside of the range of 2 to 9 L/s/ha, the value of the equation coefficient (K) can be estimated using the following equations; however, precedence must be given to the values presented in Table 7.

X = 1 year ARI: $K = 0.684\, Q_A^{-0.675}$ (8)

X = 2 year ARI: $K = 0.784\, Q_A^{-0.660}$ (9)

X = 5 year ARI: $K = 1.159\, Q_A^{-0.604}$ (10)

(iii) Minimum surface area requirement, A_S

The minimum, average, surface area of the **settling zone** (A_S) is provided by Equation 11.

$$A_S = K_S\, Q_L \qquad (11)$$

where: A_S = minimum, average, surface area of the settling zone [m^2]

K_S = sediment settlement coefficient = inverse of the settling velocity of the critical particle size [s/m]

Q_L = the maximum low-flow decant rate prior to flows overtopping the emergency spillway = Q_A*A [m^3/s]

Q_A = the low-flow decant rate per hectare of contributing catchment [m^3/s/ha]

A = area of the drainage catchment connected to the basin [ha]

Based on the results of *Jar Testing*, as per Appendix B, Section B3(v), select an appropriate value of 'K_S'. from Table 8. If Jar Test results are not available, then choose K_S = 12,000.

Table 8 – Assessment of a design coefficient (K_S) from Jar Test results

Jar test settlement after 15 min (mm)	**50**	**75**	**100**	**150**	**200**	**300**
Laboratory settlement rate (m/hr)	0.20	0.30	0.40	0.60	0.80	1.20
Factor of safety	1.33	1.33	1.33	1.33	1.33	1.33
Design settlement rate, v_F (m/hr)	0.15	0.23	0.30	0.45	0.60	0.90
Design settlement coefficient, K_S (s/m)	24000	16000	12000	8000	6000	4000
Minimum depth of the settling zone:						
Minimum settling zone depth, D_S (m)	0.6	0.6	0.6	0.68	0.90	1.35

Typical water temperatures for capital cities are provided in Table 9. The water temperature within the settling pond is likely to be equal to the temperature of rainwater (approximately the air temperature during rainfall) at the time of year when rainfall intensity is the highest.

Table 9 – Suggested water temperature

Capital City	Suggested water temperature (°C)
Darwin	30
Brisbane	20
Sydney	15
Canberra	10
Melbourne	10
Hobart	10
Adelaide	15
Perth	15

Step 6b: Sizing Type B basins

The settling pond within a Type B sediment basin is divided horizontally into two zones: the upper settling zone and the lower sediment storage zone as shown in Figure 2.

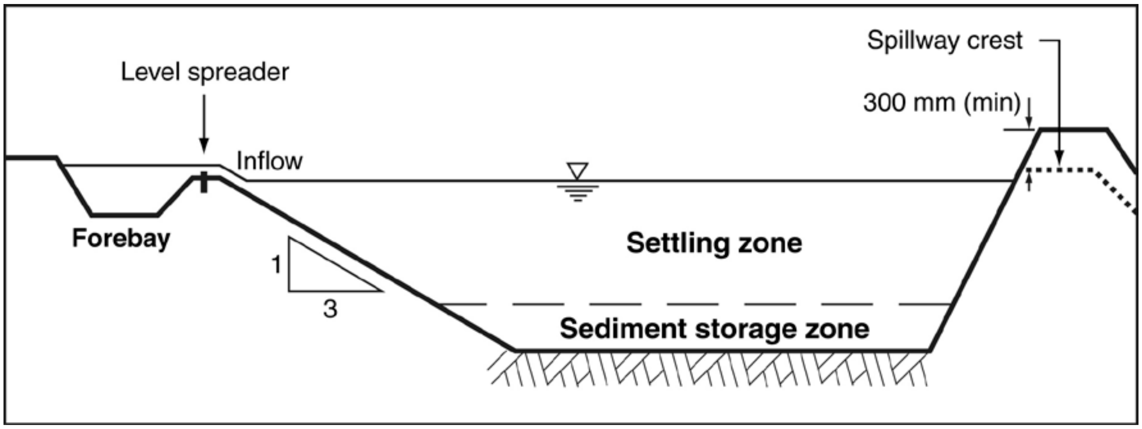


Figure 2 – Long-section of a typical Type B basin

There are two design options for sizing Type B basins, as outlined below:

(i) Option 1B is based on setting a minimum settling pond surface area (A_S) and depth (D_S) such that the settled sediment has sufficient settlement time to reach the floor of the basin, which means the sediment floc is able to form a 'compact' sediment blanket. It is assumed that such a sediment blanket would have a greater resistance to the effects of 'scour' caused by the flowing supernatant.

(ii) Option 2B is based on providing sufficient time to allow the sediment floc to settle at least 600 mm below the floating decant arms, thus avoiding the risk of this, still suspended sediment floc, being lifted towards the low-flow decant system. This design option allows for the design of basins with a greater depth, but smaller surface area than option 1B.

Design procedure for a Type B, Option 1B:

Step 1B: Determine the design discharge, Q

The design discharge may be governed by state, regional or local design standards; however, if such standards do not exist, then the recommended design storm is 0.5 times the peak 1 year ARI discharge.

$$Q = 0.5\, Q1 \qquad (12)$$

where: Q1 = peak discharge for the 1 in 1 year ARI design storm [m^3/s]

This peak design discharge should be based on the critical storm duration for the maximum drainage catchment likely to be connected to the basin.

Step 2B: Determine a design value for the sediment settlement coefficient (K_S)

Determine a design value for the sediment settlement coefficient (K_S) based on appropriate local information about the settlement characteristics of the chemically treated sediment floc.

Based on the results of Jar Testing, select an appropriate value of 'K_S'. from Table 10.

Step 3B: Calculate the minimum required 'average' surface area (A_S) of the settling zone

Calculate the minimum required 'average' surface area (A_S) of the settling zone.

$$A_S = K_S\, Q \qquad (13)$$

where: A_S = minimum, average, settling zone, surface area [m^2]

K_S = sediment settlement coefficient (Table 10)

= inverse of the settling velocity of the treated sediment blanket

Q = the design discharge = 0.5 Q1 [m^3/s]

Unlike the design procedure for a Type C basin, Equation 13 does not include a 'hydraulic efficiency correction factor' (H_e) because it is a requirement of Type B basins that the inflow conditions produce low-turbulence, uniform flow across the basin.

Table 10 – Sediment settlement characteristics for design option 1B

Jar test settlement after 15 min (mm)	**50**	**75**	**100**	**150**	**200**	**300**
Laboratory settlement rate (m/hr)	0.20	0.30	0.40	0.60	0.80	1.20
Factor of safety	1.33	1.33	1.33	1.33	1.33	1.33
Design settlement rate, v_F (m/hr)	0.15	0.23	0.30	0.45	0.60	0.90
Design settlement coefficient, K_S (s/m)	24000	16000	12000	8000	6000	4000
Minimum depth of the settling zone:						
Minimum settling zone depth, D_S (m)	0.5	0.5	0.5	0.68	0.90	1.35
Critical settling zone length before Step 5B begins to dictate the basin size:						
Critical settling zone length (L_S) before Step 5B and Equation 16 begin to dictate the basin size (m)	180	120	90	81	81	81

Step 4B: Determine the minimum depth of the settling zone (D_S) from Table 10

If the sediment-flocculant partnership results in a poor sediment settlement rate, such as less than 100 mm in 15 minutes, then the minimum depth of the settling zone (D_S) is governed by the minimum recommended depth of 0.5 m, which increases the volume of the settling zone compared to those basins that utilise an more effective flocculant.

Step 5B: Check for the potential re-suspension of the settled sediment

A Type B basin does not incorporate a low-flow decant system, and thus the overflow spillway functions as the sole point of discharge during storm events.

To avoid the re-suspension of the settled sediment, the clear water (supernatant) flow velocity (v_C) should not exceed 0.015 m/s (1.5 cm/s).

$$v_C = Q/(D_S \cdot W_S) \quad \text{[m/s]} \qquad (14)$$

where: v_C = flow velocity of the clear water supernatant [m/s]

D_S = depth of the settling zone [m]

W_S = average width of the settling zone [m]

For design option 1B, the supernatant velocity check outlined in Equation 14 will only become critical when the length of the settling zone (L_S) exceeds the critical value given by Equation 15 (also see Table 10).

$$L_{S(critical)} = 0.015 \cdot K_S \cdot D_S \quad \text{[m]} \qquad (15)$$

where: L_S = average length of the settling zone [m]

If a larger sediment basin is required, then the settling zone must be re-sized with Equation 14 dictating the basin size rather than Equation 13. Thus the settling zone surface area (A_S) determine in Step 3B is no longer appropriate.

If the clear water supernatant velocity (v_C) is set at the maximum allowable value of 0.015 m/s, then Equation 14 can be rewritten as:

$$D_S \cdot W_S = 66.7(Q) \quad \text{[m}^2\text{]} \qquad (16)$$

This means that either the depth (D_S) and/or the width (W_S) must be increased above the values obtained in Step 3B.

Increasing the depth (D_S) means increasing the basin volume, but not the surface area (A_S).

Increasing the width (W_S) means increasing the basin volume, length (L_S) and surface area (A_S).

It is recommended that the width of the settling zone at the top water level (W_T) should not exceed a third of the length of the settling zone at the top water level (L_T).

For convenience it is conservative to set the average length of the settling zone (L_S) as three times the average width of the settling zone (W_S), thus:

$$L_S = 3\ W_S \tag{17}$$

Step 6B: Determine the width of the overflow spillway

In order to reduce the risk of the re-suspension of settled sediment, the overflow spillway on Type B basins should be the maximum practical width.

Ideally the maximum allowable supernatant velocity upstream of the overflow spillway should be 1.5 cm/s (0.015 m/s) during the basin's design storm (i.e. Q = 0.5 Q1); however, this may not always be practical for Type B basins. In such cases, designers should take all reasonable measures to achieve a spillway crest width just less than the top width of the settling zone.

Design procedure for a Type B, Option 2B:

Step 1B: Determine the design discharge, Q

The design discharge may be governed by state, regional or local design standards; however, if such standards do not exist, then the recommended design storm is 0.5 times the peak 1 year ARI discharge.

$$Q = 0.5\ Q1 \tag{18}$$

where: Q1 = peak discharge for the 1 in 1 year ARI design storm [m^3/s]

This peak design discharge should be based on the critical storm duration for the maximum drainage catchment likely to be connected to the basin.

Step 2B: Nominate the depth of the settling zone (D_S), and the floc settling depth (D_F)

For this design option, the depth of the settling zone is not limited to the nominated floc settling depth (D_F) as used in Step 2B above.

$$D_F \geq 0.6 \tag{19}$$

The minimum settling zone depth is 0.6 m, which is an increase from the 0.5 m used in design option 1B. This is because in this design option the sediment floc is considered to be still settling as it approaches the overflow spillway, whereas in design option 1B the sediment floc is assumed to have fully settled, and thus more resistant to disturbance.

D_S is the effective depth of the settling zone (i.e. the maximum water depth above the sediment storage zone). Increasing this depth will reduce the forward velocity of the settling sediment floc, which increases the residence time and therefore the time available for the sediment floc to settling the required floc settling depth, D_F.

$$D_S \geq D_F \tag{20}$$

The nominated settling zone depth can be within the range of 0.6 to 2.0 m. The greater the nominated depth, the smaller the required surface area of the basin, but the volume of the settling zone (V_S), and consequently the total basin volume, will essentially remain unchanged.

Step 3B: Calculate the 'average' surface area (A_S) of the settling zone

The required 'average' surface area (A_S) of the settling zone is given by Equation 21.

$$A_S = (D_F/D_S)\ K_S\ Q \tag{21}$$

where: A_S = minimum, average, settling zone, surface area [m^2]

K_S = sediment settlement coefficient (Table 11)

= inverse of the settling velocity of the treated sediment blanket

Q = the design discharge = 0.5 Q1 [m^3/s]

Table 11 – Sediment settlement characteristics for design option 2B

Jar test settlement after 15 min (mm)	**50**	**75**	**100**	**150**	**200**	**300**
Laboratory settlement rate (m/hr)	0.20	0.30	0.40	0.60	0.80	1.20
Factor of safety	1.33	1.33	1.33	1.33	1.33	1.33
Design settlement rate, v_F (m/hr)	0.15	0.23	0.30	0.45	0.60	0.90
Design settlement coefficient, K_S (s/m)	24000	16000	12000	8000	6000	4000

Step 4B: Check for the potential re-suspension of the settled sediment

A Type B basin does not incorporate a low-flow decant system, and thus the overflow spillway functions as the sole point of discharge from the basin.

To avoid the re-suspension of the settling sediment floc, the clear water (supernatant) flow velocity (v_C) should not exceed 0.015 m/s (1.5 cm/s).

$$v_C = Q/(D_F \, . \, W_{SF}) \quad [m/s] \qquad (22)$$

where: v_C = flow velocity of the clear water supernatant [m/s]

D_F = depth of the settled sediment floc [m]

W_{SF} = average basin width of the clear water above the floc (i.e. measured over a depth of D_F, not D_S) [m]

This is the least understood operating condition of a Type B basin (option 2B), and there is currently no certainty that satisfying Equation 22 will always achieve optimum basin performance during high flows.

In order to satisfy Equation 22, the minimum average basin width (W_{SF}) can be determined from Equation 23.

$$W_{SF} = 66.7(Q/D_F) \quad [m] \qquad (23)$$

Increasing the width of the settling zone (W_{SF}) can be problematic because it usually requires an increase the length of the settling zone (L_S).

In any case, the length of the settling zone (L_C) should ideally be at least three times the width of the settling zone (W_C) measured at the overflow weir crest elevation, thus:

$$L_C \geq 3 \, W_C \qquad (24)$$

Step 5B: Determine the width of the overflow spillway

In order to reduce the risk of the re-suspension of settled sediment as flows spill over the outlet weir, the width of the overflow spillway on Type B basins should be the maximum practical, and ideally at least equal to the average clear water width, W_{SF}.

Table 12 – Typical Type B dimensions for a total pond depth of 2.0 m

Type B basin geometry with sediment storage volume = 30% (V_S):						
Inlet bank slope, 1 in 3	All other bank slopes, 1 in 2			Total depth, D_T = 2.0 m		
Typical basin dimensions based on a length:width ratio of 3:1 at top of the settling zone:						
Settling zone surface area [m^2]	**150**	**300**	**600**	**1200**	**2400**	**4800**
Settling zone volume, V_S [m^3]	154	373	815	1705	3506	7131
Total basin volume, V_T [m^3]	200	484	1058	2215	4553	9262
Settling zone depth (D_S) [m]	1.02	1.23	1.35	1.42	1.46	1.48
Ratio D_S/D_T as a percentage	51%	62%	68%	71%	73%	74%
Sediment storage (D_{SS}) [m]	0.98	0.77	0.65	0.58	0.54	0.52
Ratio D_{SS}/D_T as a percentage	49%	38%	32%	29%	27%	26%
Top length of settling zone [m]	25.6	35.3	48.2	66.1	91.1	126
Top width of settling zone [m]	8.5	11.8	16.1	22.0	30.4	42.1

* The settling zone surface area represents the 'average' surface area, $A_S = V_S/D_S$.

Table 13 – Typical Type B dimensions for a total pond depth of 3.0 m

Type B basin geometry with sediment storage volume = 30% (V_S):						
Inlet bank slope, 1 in 3	All other bank slopes, 1 in 2			Total depth, D_T = 3.0 m		
Typical basin dimensions based on a length:width ratio of 3:1 at top of the settling zone:						
Settling zone surface area [m^2]	**300**	**600**	**1200**	**2400**	**4800**	**9600**
Settling zone volume, V_S [m^3]	438	1094	2416	5086	10475	21343
Total basin volume, V_T [m^3]	569	1421	3138	6605	13605	27720
Settling zone depth (D_S) [m]	1.44	1.81	2.00	2.11	2.18	2.22
Ratio D_S/D_T as a percentage	48%	60%	67%	70%	73%	74%
Sediment storage (D_{SS}) [m]	1.56	1.19	1.00	0.89	0.82	0.78
Ratio D_{SS}/D_T as a percentage	52%	40%	33%	30%	27%	26%
Top length of settling zone [m]	36.2	50.2	68.6	93.9	129	179
Top width of settling zone [m]	12.1	16.7	22.9	31.3	43.1	59.7

Step 6c: Sizing 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 3.

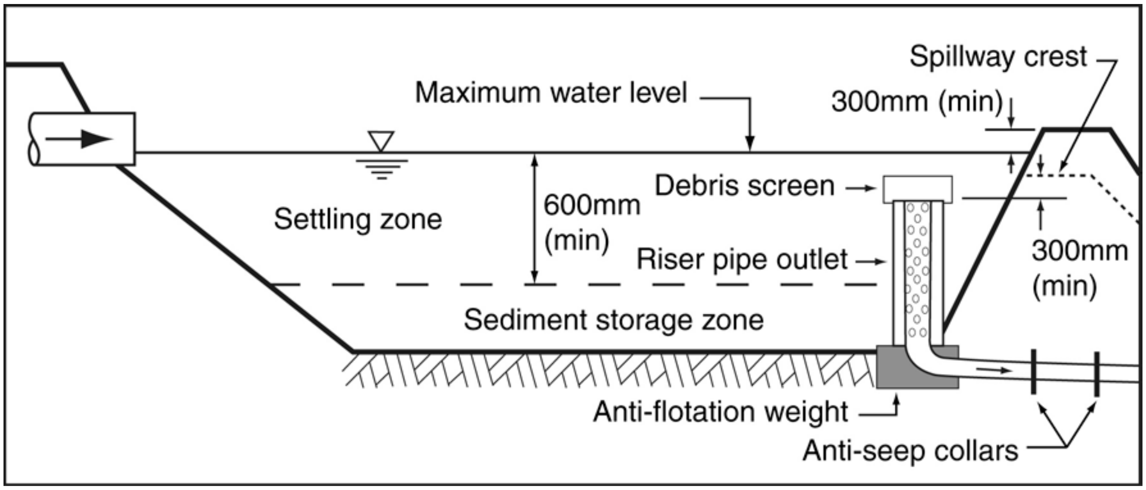


Figure 3 – Type C sediment basin with riser pipe outlet (long section)

The minimum 'average' surface area of the settling zone (A_S) is given by Equation 25.

$$A_S = K_S\, H_e\, Q \qquad (25)$$

where:
- A_S = average surface area of settling zone = V_S/D_S [m^2]
- K_S = sediment settlement coefficient = the inverse of the settling velocity of the 'critical' particle size (Table 14)
- H_e = hydraulic efficiency correction factor (Table 15)
- Q = design discharge = 0.5 Q1 [m^3/s] (default design storm—refer to government)
- $Q1$ = peak discharge for the critical storm duration 1 in 1 year ARI event
- V_S = volume of the settling zone [m^3]
- D_S = depth of the settling zone [m]

Table 14 provides values for the sediment settlement coefficient (K_A) for a 'critical particle size, d = 0.02 mm (0.00002 m), and various water temperatures and sediment specific gravities. The hydraulic efficiency correction factor (H_e) depends on flow conditions entering the basin, and the shape of the settling pond. Table 15 provides values of the hydraulic efficiency correction factor.

The minimum recommended depth of the settling zone (D_S) is 0.6 m. The desirable minimum length to width ratio at the mid-elevation of the settling zone is 3:1. Internal baffles may be required in order to prevent short-circuiting if the length-to-width ratio is less than three.

Table 14 – Sediment settlement coefficient (K_S)

Water temperature (degrees C)	**5**	**10**	**15**	**20**	**25**	**30**
Kinematic viscosity (m^2/s x 10^6)	1.519	1.306	1.139	1.003	0.893	0.800
Critical particle characteristics	**Sediment settlement coefficient (K_S)**					
d = 0.02 mm and s = 2.2	5810	4990	4350	3830	3410	3060
d = 0.02 mm and s = 2.4	4980	4280	3730	3290	2930	2620
d = 0.02 mm and s = 2.6 (default)	4360	3740	3270	2880	2560	2290
d = 0.02 mm and s = 2.8	3870	3330	2900	2560	2280	2040
d = 0.02 mm and s = 3.0	3480	3000	2610	2300	2050	1840
d = 0.02 mm and s = 3.2	3170	2720	2380	2090	1860	1670

Table 15 – Hydraulic efficiency correction factor (H_e)

Flow condition within basin	Effective [1] length:width	H_e
Uniform or near-uniform flow 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 (refer to Step 9).	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 inflows.	1:1	1.2
	3:1	1.1

[1] The effective length to width ratio for sediment basins with internal baffles (Step 8) 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 (refer to Step 9).

Table 16 – Typical Type C & D dimensions for a total pond depth of 2.0 m

Type C & Type D basin geometry:						
Sediment storage = 50% (V_S)	**All bank slopes, 1 in 2**		**Total depth, D_T = 2.0 m**			
Typical basin dimensions based on a length:width ratio of 3:1 at mid-elevation of settling zone:						
Settling zone surface area [m^2]	**150**	**300**	**600**	**1200**	**2400**	**4800**
Settling zone volume, V_S [m^3]	121	304	680	1444	2995	6128
Total basin volume, V_T [m^3]	181	454	1015	2155	4470	9146
Settling zone depth (D_S) [m]	0.81	1.01	1.13	1.20	1.25	1.28
Ratio D_S/D_T as a percentage	40%	51%	56%	60%	62%	64%
Sediment storage (D_{SS}) [m]	1.19	0.99	0.87	0.80	0.75	0.72
Ratio D_{SS}/D_T as a percentage	60%	49%	44%	40%	38%	36%
Mid length of settling zone [m]	21.2	30.0	42.4	60.0	84.9	120
Mid width of settling zone [m]	7.1	10.0	14.1	20.0	28.3	40.0

* The settling zone surface area represents the 'average' surface area, $A_S = V_S/D_S$.

Table 17 – Typical Type C & D dimensions for a total pond depth of 3.0 m

Type C & Type D basin geometry:						
Sediment storage = 50% (V_S)	**All bank slopes, 1 in 2**		**Total depth, D_T = 3.0 m**			
Typical basin dimensions based on a length:width ratio of 3:1 at mid-elevation of settling zone:						
Settling zone surface area [m^2]	**350**	**500**	**1000**	**1500**	**3000**	**6000**
Settling zone volume, V_S [m^3]	433	706	1634	2577	5450	11276
Total basin volume, V_T [m^3]	646	1054	2438	3847	8135	16830
Settling zone depth (D_S) [m]	1.23	1.40	1.63	1.71	1.81	1.88
Ratio D_S/D_T as a percentage	41%	47%	54%	57%	60%	63%
Sediment storage (D_{SS}) [m]	1.77	1.60	1.37	1.29	1.19	1.12
Ratio D_{SS}/D_T as a percentage	59%	53%	46%	43%	40%	37%
Mid length of settling zone [m]	32.4	38.7	54.8	67.1	94.9	134.2
Mid width of settling zone [m]	10.8	12.9	18.3	22.4	31.6	44.7

Step 6d: Sizing Type D basins

The settling pond within a Type D sediment basin is divided horizontally into two zones: the upper *settling zone* and the lower *sediment storage zone* as shown in Figure 4.

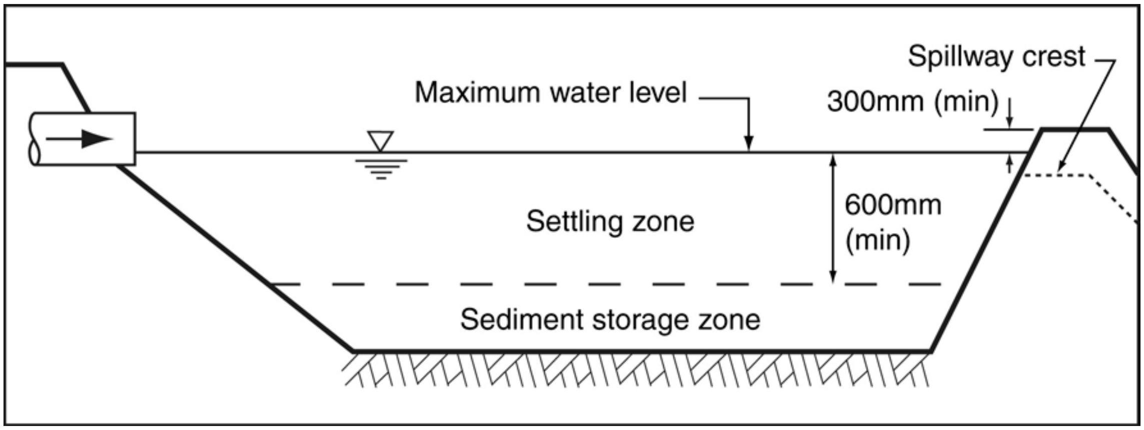


Figure 4 – Settling zone and sediment storage zone

The minimum volume of the upper settling zone is defined by Equation 26.

$$V_s = 10 . R_{(Y\%,5\text{-day})} . C_v . A \qquad (26)$$

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 (refer to Table 19)
- A = effective catchment surface area connected to the basin [ha]

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

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

Equation 27 and Appendix B of Book 2 provide $R_{(Y\%,5\text{-day})}$ values for various locations. It is highly recommended that revised $R_{(Y\%,5\text{-day})}$ be determined for each region based on analysis of local rainfall records wherever practicable.

$$R_{(Y\%,5\text{-day})} = K_1 . I_{(1yr,\ 120hr)} + K_2 \qquad (27)$$

where:
- K_1 = Constant (Table 18)
- K_2 = Constant (Table 18)
- $I_{(1yr,\ 120hr)}$ = Average rainfall intensity for a 1 in 1 year ARI, 120 hr storm [mm/hr]

Recommended equation constants are provided in Table 18.

Table 18 – Recommended equation constants

Recommended application	Y%	K_1	K_2
Basins with design life less than 6 months	75%	12.9	9.9
Basins with a design life greater than 6 months	80%	17.0	11.2
Basins discharging to sensitive receiving waters.	85%	23.2	12.6
At the discretion of the regulatory authority	90%	33.5	14.2
At the discretion of the regulatory authority	95%	56.7	14.6

Type 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. The use of a shorter time period usually requires application of fast acting flocculants. The use of a longer time period will require the construction of a significantly larger basin.

Unlike permanent stormwater treatment ponds and wetlands, Type D basins are not designed to allow high flows to bypass the basin. Even when the basin is full, sediment-laden stormwater runoff continues to be directed through the basin. This allows the continued settlement of coarse-grained particles contained in the flow.

The volumetric runoff coefficient (C_v) is **not** the same as the discharge runoff coefficient (C) used in the Rational Method to calculate peak runoff discharges. Typical values of the volumetric runoff coefficient are presented in Table 19. For impervious surfaces a volumetric runoff coefficient of 1.0 is adopted.

Table 19 – Typical single storm event volumetric runoff coefficients [1]

Rainfall (mm) [2]	Soil Hydrologic Group [3]			
	Group A Sand	Group B Sandy loam	Group C Loamy clay	Group D Clay
10	0.02	0.10	0.09	0.20
20	0.02	0.14	0.27	0.43
30	0.08	0.24	0.42	0.56
40	0.16	0.34	0.52	0.63
50	0.22	0.42	0.58	0.69
60	0.28	0.48	0.63	0.74
70	0.33	0.53	0.67	0.77
80	0.36	0.57	0.70	0.79
90	0.41	0.60	0.73	0.81
100	0.45	0.63	0.75	0.83

Notes: [1] Sourced from Fifield (2001) and Landcom (2004).
[2] Rainfall depth based on the nominated 5-day rainfall depth, $R_{(Y\%,5\text{-day})}$.
[3] Refer to Section A3.1 of Appendix A for the definition of Soil Hydrologic Group.

The coefficients presented in Table 19 apply **only** to the pervious surfaces with a low to medium gradient (i.e. < 10% slope). Light to heavy clays compacted by construction equipment should attract a volumetric runoff coefficient of 1.0. For loamy soils compacted by construction traffic, adopt coefficient no less than those values presented for Group D soils.

For catchments with mixed surface areas, such as a sealed road surrounded by soils of varying infiltration capacity, a composite coefficient must be determined using Equation 28.

$$C_{V(\text{comp.})} = \frac{\Sigma(C_{V,i} \cdot A_i)}{\Sigma(A_i)} \tag{28}$$

where:

$C_{V\,(\text{comp.})}$ = Composite volumetric runoff coefficient
$C_{V,i}$ = Volumetric runoff coefficient for surface area (i)
A_i = Area of surface area (i)

The volumetric runoff coefficient for impervious surfaces directly connected to the drainage system (e.g. sealed roads discharging concentrated flow to a pervious or impervious drainage system) should be adopted as 1.0. The volumetric runoff coefficient for impervious surfaces **not** directly connected to the drainage system (e.g. a footpath or sealed road discharging sheet flow to an adjacent pervious surface) should be adopted as the average of the runoff coefficients for the adjacent pervious surface and the impervious surface (assumed to be 1.0).

Step 7: Determine the sediment storage volume

The sediment storage zone lies below the settling zone as defined in Figure 5. In the case of a Type A basin, the sediment storage zone also lies beneath the free water zone, which exists to separate the low-flow decant arms from the settled sediment.

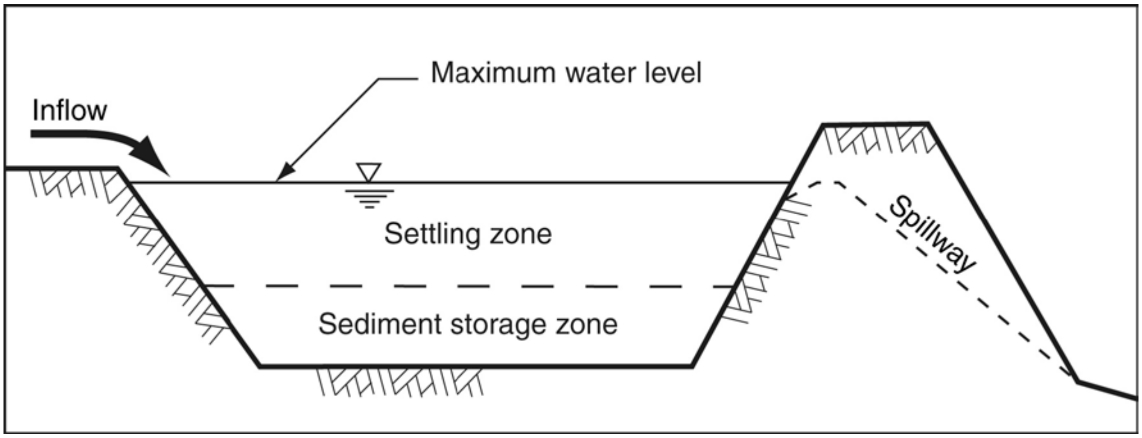


Figure 5 – Settling zone and sediment storage zone

The recommended sediment storage volume may be determined from Table 20. Increasing the volume of the sediment storage zone will likely decrease the frequency of required de-silting operations, but will increase the size and cost of constructing the basin.

Table 20 – Sediment storage volume

Basin type	Sediment storage volume
Type A and Type B	30% of settling volume
Type C	50% of settling volume
Type D	50% of settling volume

Alternatively, the volume of the sediment storage zone may be determined by estimating the expected sediment runoff volume over the desired maintenance period.

Step 8: Design of flow control baffles

Baffles may be used for a variety of purposes including:

- energy dissipation (e.g. inlet chambers, refer to design Step 9)
- the control of short-circuiting (e.g. internal baffles)
- minimising sediment blockage of the low-flow outlet structure (outlet chambers).

For Type C & D basins, the need for flow control baffles should have been established in Step 6 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 Type C basins, thus reducing the size of the settling pond through modifications to the hydraulic efficiency correction factor.

Outlet chambers are technically not flow control baffles, but are instead used to prevent sediment settling around, and causing blockage to, certain types of decant structures. When placed around riser pipe outlet systems (Type C basins), these chambers can reduce the maintenance needs of the riser pipe.

When placed around low-set, floating skimmer pipes, these chambers can prevent settled sediment stopping the free movement of these decant pipes. Outlet chambers are not required on Type A basins because the floating decant system sits above the maximum allowable elevation of the settled sediment.

(i) Internal baffles – flow redirection

Internal baffles are used to increase the effective length-to-width ratio of the basin. Figure 6 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 as defined in Table 21.

Table 21 – Sediment scour velocities

Critical particle diameter (mm)	Scour velocity (m/s)
0.10	0.16
0.05	0.11
0.02	0.07

The crest of these baffles should be set level with, or just below, the crest of the emergency spillway in order to prevent the re-suspension of settled sediment during severe storms.

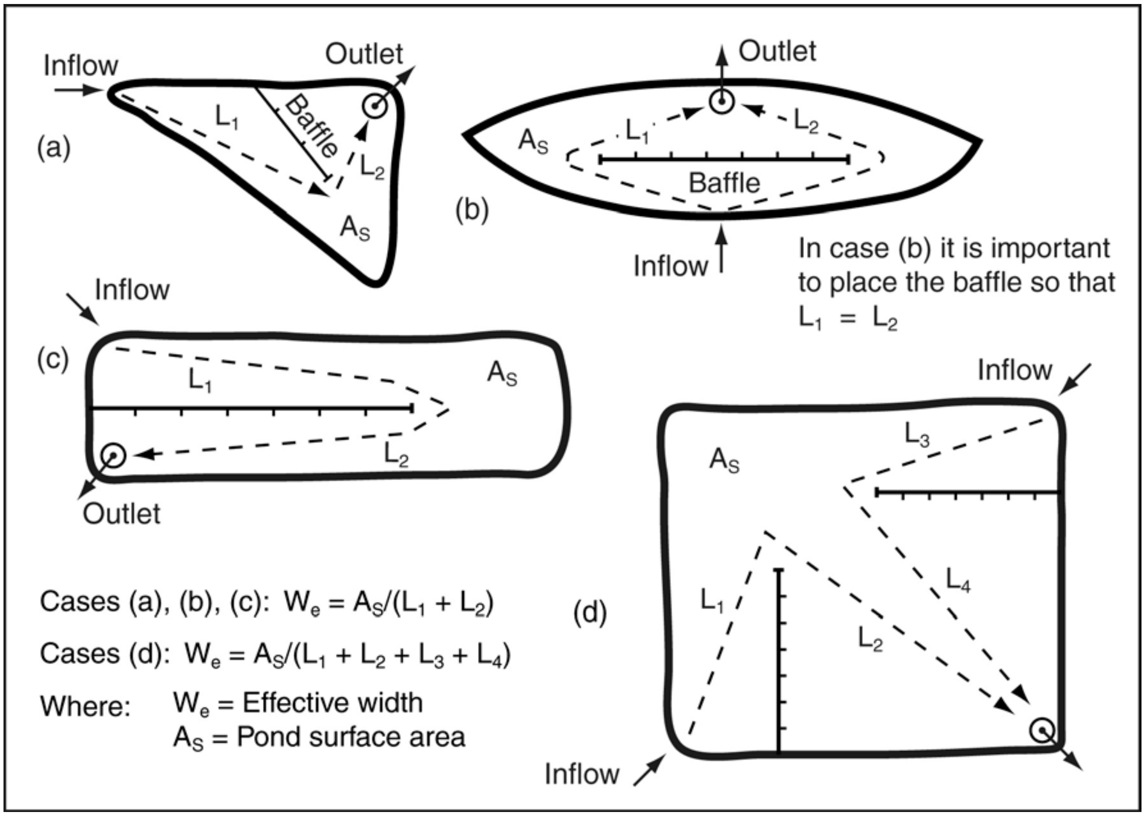


Figure 6 – Typical arrangement of internal flow control baffles (after USDA, 1975)

(ii) Internal baffles – in-line permeable

Internal baffles can also be used to ensure uniform flow through a basin. These permeable internal baffles can assist performance of all basin types even in standard basin shapes. The use of permeable internal baffles is especially recommended for Type A and Type B basins as they assist in limiting any short circuiting and can also assist in settling of flocs through against the mesh.

Permeable in-line baffles can typically be constructed using a fixed or floating system. Fixed systems will typically incorporate posts mounted in the floor and wall of the basins with a mesh attached to the posts. The height of the posts and mesh should be at approximately the same height as the emergency spillway to avoid a concentrated flow on the upper layer of the water column above the baffle. An alternative option is to use a baffle incorporating floats to keep the mesh on the top of the water column and weighting to fix the baffle to the floor of the basin. This can be generally be achieved by utilising proprietary silt curtains.

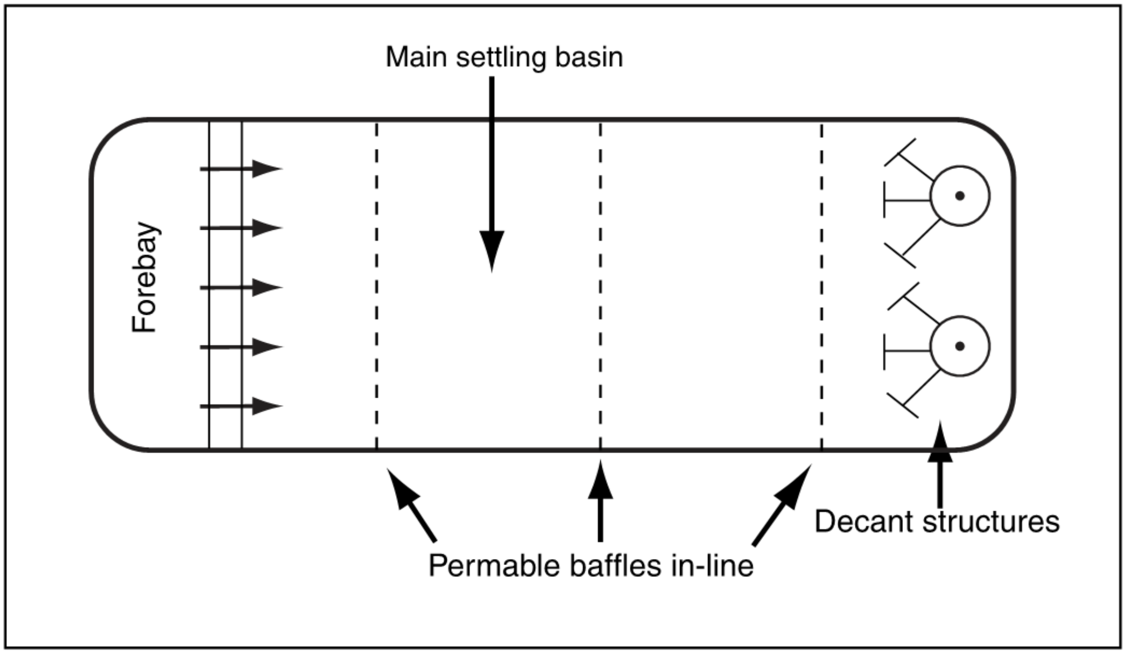


Figure 7 – Typical arrangement of in-line permeable baffles

A critical component of in-line permeable baffles is the open area of the product. Too tight a weave and the baffles will actually hinder performance, with too open a weave providing little benefit. A 75% weave shade cloth or equivalent open area is recommended for in-line permeable baffles. Note this is significantly more open than typical silt curtains used on construction sites.

(iii) Outlet chambers

Outlet chambers (Figures 8) 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.

Maintenance of a sediment basin can be expensive if the basin's low-flow outlet system becomes blocked with sediment, or if the outlet is damaged during the de-silting operation. A sediment control barrier constructed around the outlet system limits the deposition of coarse sediment around the outlet structure, thus reducing maintenance costs and improving the long-term hydraulics of the basin.

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

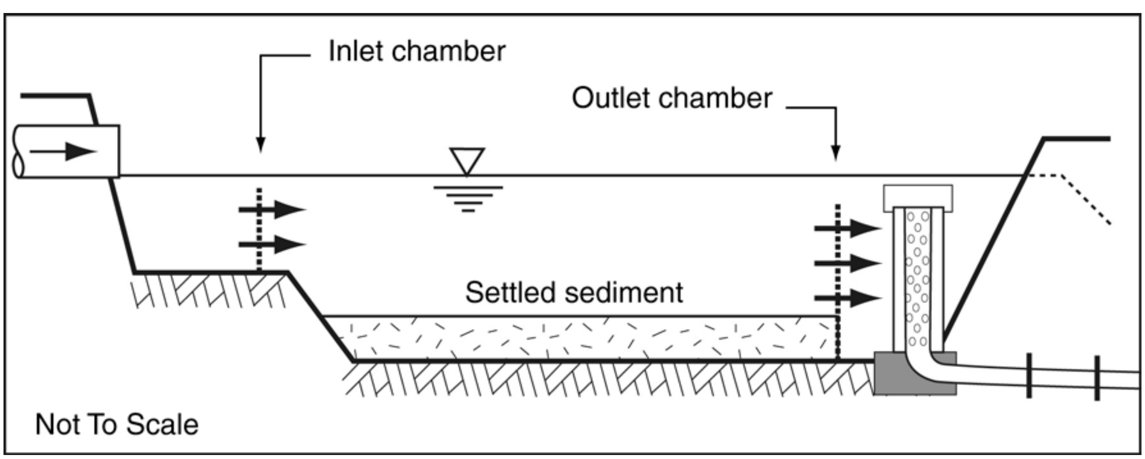


Figure 8 – Typical arrangement of outlet chamber (long section)

Step 9: Design 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, then an appropriately lined chute will need to be installed at each inflow point to control scour. For Type A and B basins it is necessary to establish energy dissipation and an inlet chamber to promote mixing of the coagulant or flocculant and promote uniform flow into the main basin cell through the use of a level spreader.

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 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.

(i) Inlet chamber – Type A and B basins

For Type A and B basins it is necessary to establish an inlet chamber for energy dissipation, and to promote mixing of the coagulant or flocculant, and a level spreader to promote uniform flow into the main basin cell . It is critical that runoff enters the inlet chamber and not the main basin cell to ensure mixing of the coagulant and to avoid short-circuiting.

Topography and site constraints may dictate the location and number of inflow points. The optimum approach is to have a single inflow point as shown in Figure 9 to promote chemical mixing and flexibility in selection of the chemical dosing system.

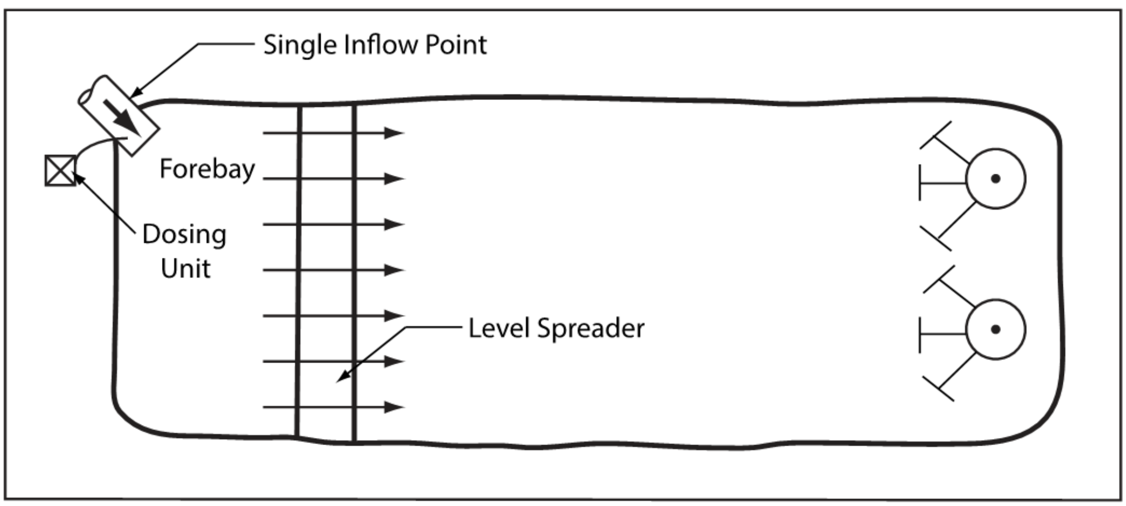


Figure 9 – Single inflow to Type A and B basin

Where constraints do not allow a single inflow point, runoff can be discharged into the forebay in multiple locations as shown in Figure 10. Multiple inlets may constrain the type, or govern the number of chemical dosing units required. In a multiple inlet location, the objective is for thorough mixing of the coagulant with all runoff. Consequently, where a single dosing system is adopted, inflow direction and location should be designed to optimise mixing of all runoff in the forebay.

In some circumstances a catchment will be able to enter the main basin from the side. In these situations, a bund or drain should be placed along the length of the basin to direct runoff to the inflow point where feasible as shown in Figure 11. This situation is likely to frequently occur on linear infrastructure projects and can be managed through informative design and an understanding of progressive earthworks levels.

If all runoff cannot practicably be diverted back to the forebay, then a drain or bund should be constructed to divert the maximum catchment possible. The remaining catchment that cannot be diverted to the inflow point can then be managed through erosion control, or localised bunding to capture that runoff.

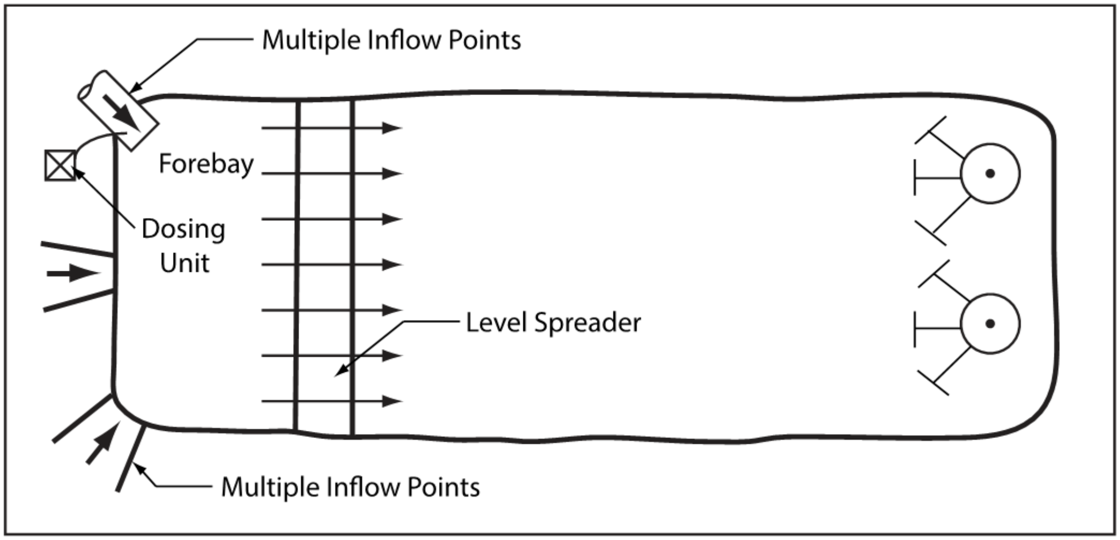


Figure 10 – Multiple inflows to a Type A or B basin

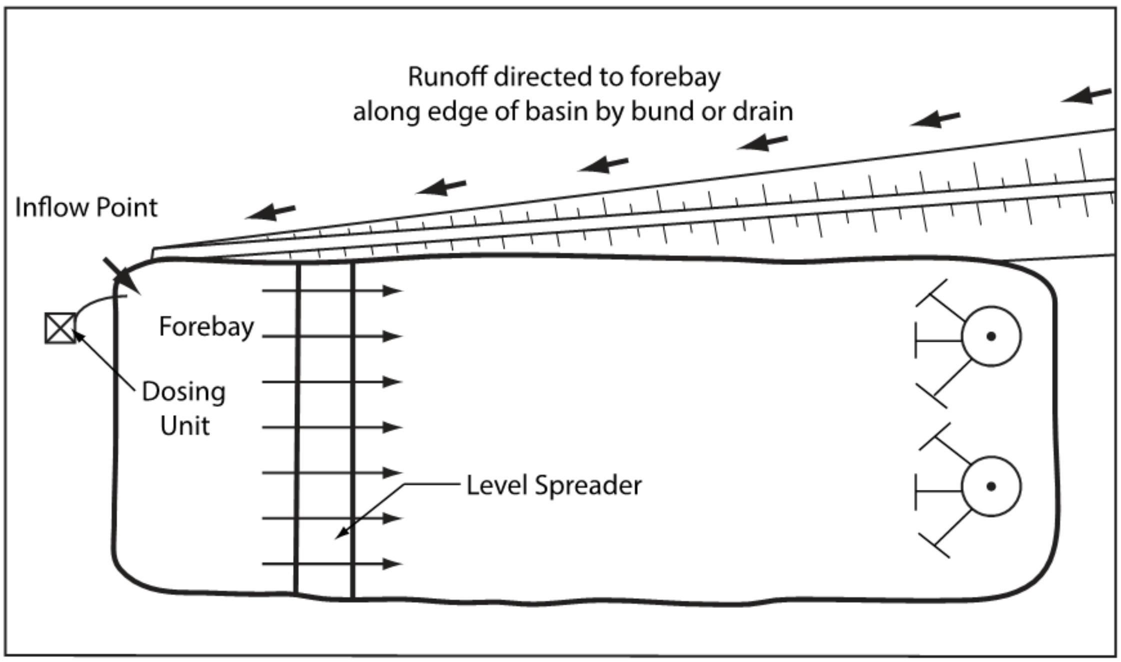


Figure 11 – Multiple inflows to a Type A or B basin

The inlet chamber (or forebay) should be sized at approximately 10% of the size of the main basin cell, and have a minimum length of 5 m unless site constraints preclude this size. To avoid re-suspension of floc particles a minimum depth of 1.0 m is recommended. Where site constraints do not allow the construction of a forebay to the recommended dimensions, monitoring of the performance of the forebay should be undertaken to determine the requirement for any modifications.

A critical component of the inlet chamber is to spread flow into the main basin cell to promote uniform flow to the outlet. To achieve uniform flow the construction of a level spreader is required. The level spreader can be constructed of a range of material including timber, concrete and aluminium. A typical detail of a level spreader is provided in Figure 12, however alternative approaches can be adopted as long as the design intent is achieved. Care is to be undertaken to minimise any potential for scour on the down-slope face of the level spreader. Protection of the soil surface will be required with concrete, geotextile, plastic or as dictated by the soil properties, slope of the batter face and flow velocity. The level spreader is to be constructed 100–200 mm above the emergency spillway level or as required to ensure the level spreader functions during high events and is not flooded due to water in the main basin cell.

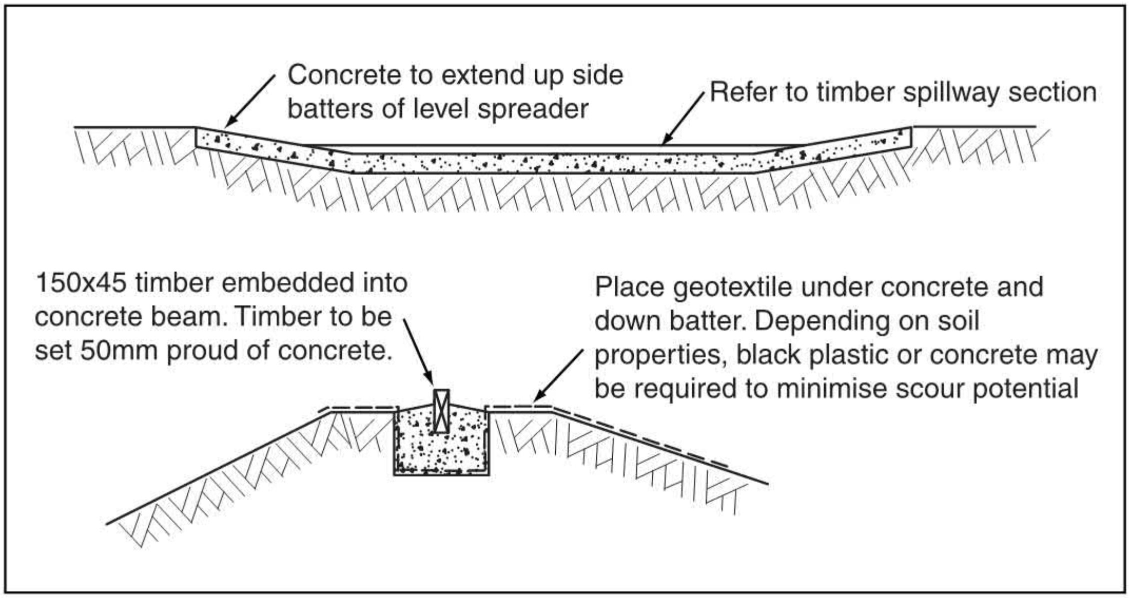


Figure 12 – Typical detail for a Type A and B basin level spreader

It is critical that the spreader is level because any minor inaccuracy in construction can direct flow to one side of the main basin cell resulting in short-circuiting and a significant reduction the performance of the basin. Where long spreaders are installed, the use of a multiple V-notch weir plate (Figure 13) is recommended to overcome difficulties with achieving the required construction tolerances. A multiple V-notch weir plate can be fixed to a piece of timber embedded in concrete.

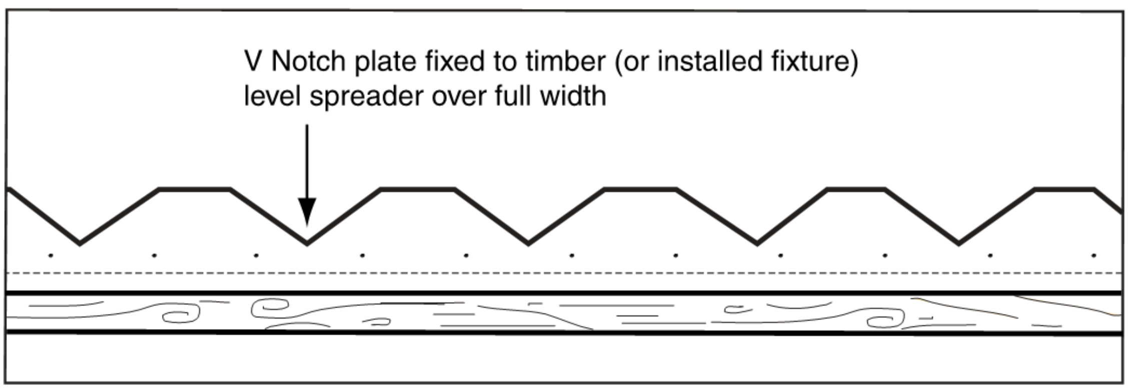


Figure 13 – Typical detail for multiple V-notch weir plate

(ii) Inlet chamber – Type C and D basins

Flow control baffles or similar devices may be placed at the inlet end of a sediment basin to form an inlet chamber in Type C and D basins (Figures 14 to 17). 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 width of the settling pond.

These types of inlet chambers are only applicable to Type C and D basins. For Type A and B basins it is necessary to establish energy dissipation and an inlet chamber. In Type C basins, inflow jetting can also promote the formation of dead water zones significantly reducing the hydraulic efficiency of the settling pond. As the length to width ratio decreases, the impact of these dead water zones increases.

Inflow jetting can also be a problem in Type D basins even though the sediment-laden water is normally retained for several days following the storm. During those storms when inflows exceed the storage volume of the basin, it is still important for the basin to be hydraulically efficient in order to maximise the settlement of the coarse sediment.

It is therefore always considered important to control the momentum of the inflow to:

- retain coarse sediments at the inlet end of the basin
- limit the re-suspension of the finer, settled sediments
- reduce short-circuiting within the basin
- reduce the frequency and cost of basin maintenance.

The main disadvantage of using an inlet chamber is that it can complicate the de-silting process, especially in small basins. Conversely, when used in large basins, an inlet chamber can reduce the long-term cost of de-silting operations by retaining the bulk of the coarse sediment within the inlet chamber where it can be readily removed by equipment such as a backhoe. In large basins, the inlet chamber effectively operates as a pre-treatment pond.

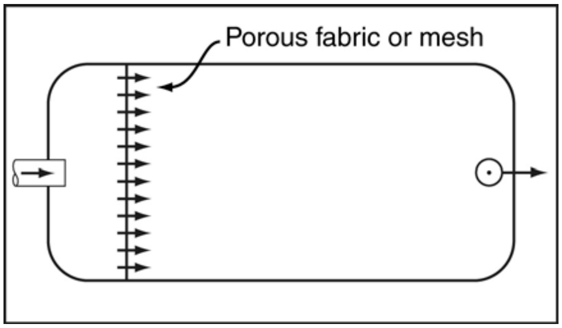


Figure 14(a) – Porous barrier inlet chamber

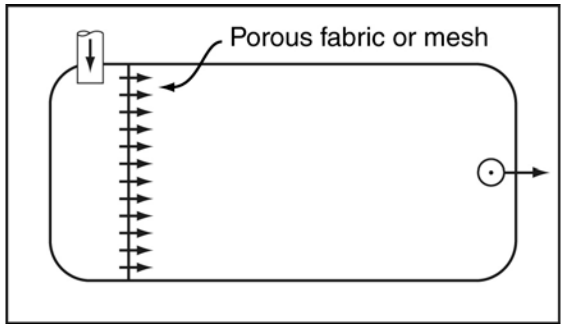


Figure 15(a) – Porous barrier with piped inflow entering from side of basin

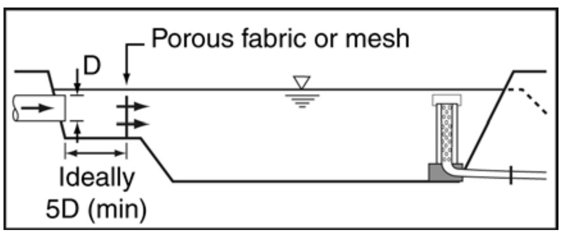


Figure 14(b) – Typical layout of inlet chamber with opposing inlet pipe (Type C basin)

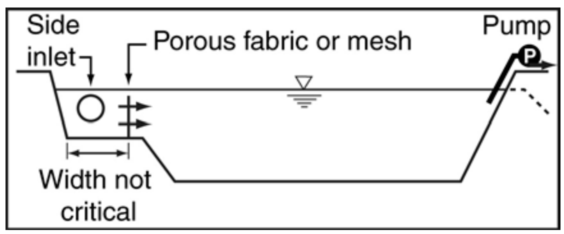


Figure 15(b) – Typical layout of inlet chamber with side inlet (Type D basin)

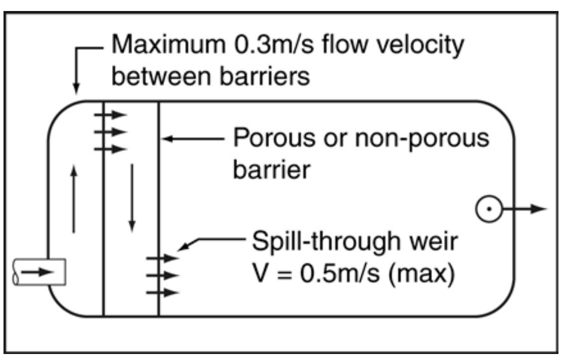


Figure 16(a) – Alternative inlet chamber

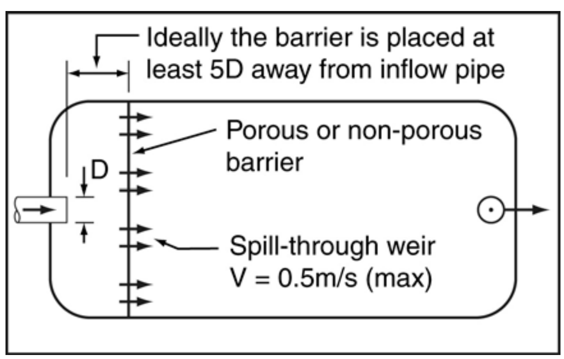


Figure 17(a) – Alternative inlet chamber

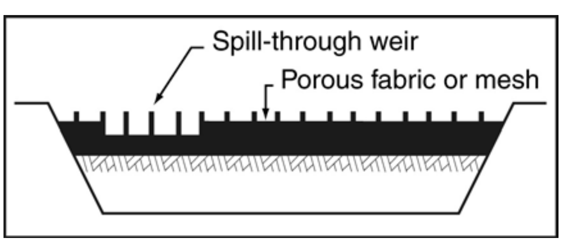


Figure 16(b) – Barrier with single spill-through weir per barrier

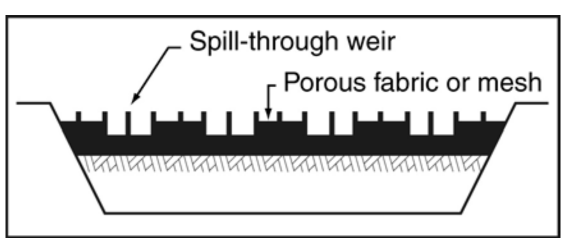


Figure 17(b) – Barrier with multiple spill-through weirs

The use of an inlet chamber is usually governed by the need to adopt a low hydraulic efficiency correction factor (H_e). The incorporation of inlet baffles should be given serious consideration within Type C basins if the expected velocity of any concentrated inflows exceeds 1 m/s. Table 22 summaries the design of various inlet chambers.

Table 22 – Design of various inlet chambers

Baffle type	Description
Shade cloth	An inlet chamber formed by staking coarse shade cloth across the full width of the settling pond. Typical spacing between support posts is 0.5 to 1.0 m depending on the expected hydraulic force on the fence.
Perforated fabric	An inlet chamber formed from heavy-duty plastic sheeting or woven fabric. The sheeting/fabric is perforated with approximately 50 mm diameter holes at approximately 300 mm centres across the full width and depth of the settling pond (Figure 18). Typical spacing between support posts is 0.5 to 1.0 m depending on the expected hydraulic force on the fence.
Solid porous or non-porous barrier, with or without spill-through weirs	A porous or non-porous barrier constructed across the full width of the settling pond. If the inlet pipe is directed towards the barrier, then the barrier should ideally be located at least 5 times the pipe diameter away from the inflow pipe. The barrier is designed to ensure that the inflow is distributed evenly across the width of the basin and that the velocity of flow passing over the barrier does not exceed 0.5 m/s during the 1 in 1 year peak discharge.

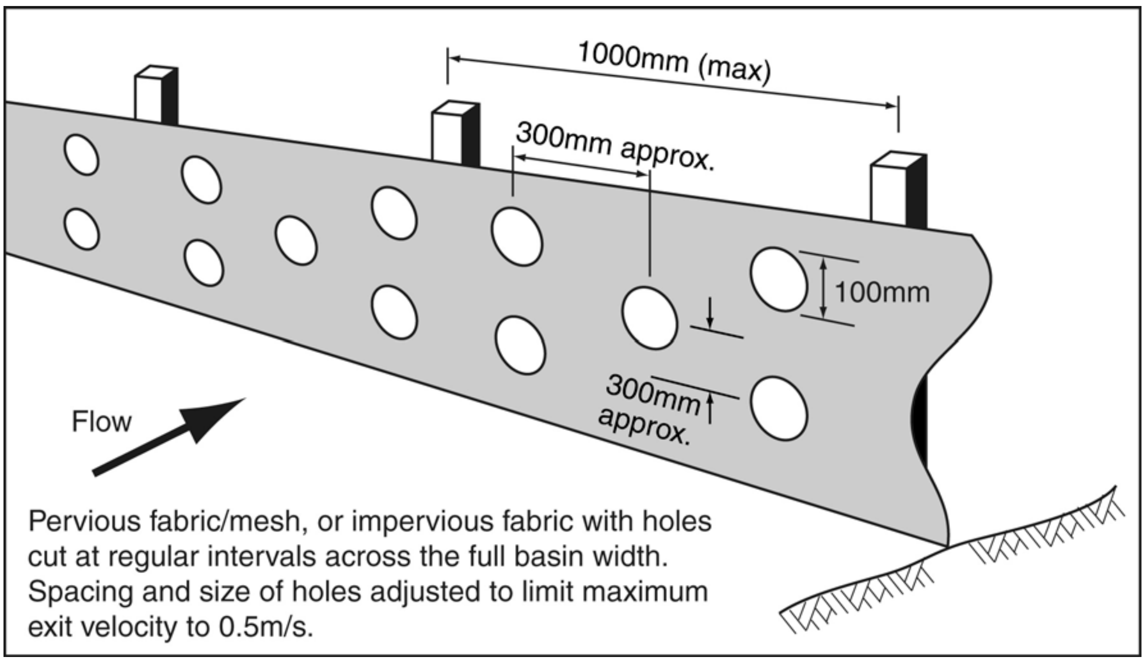


Figure 18 – Example arrangement of perforated fabric inlet baffle

The inlet chamber may have a pond depth less than the depth of the main settling pond (Figures 14b & 15b) in order to allow for easy installation and maintenance of the barrier. An inlet chamber depth of around 0.9 m will allow the use of standard width *Sediment Fence* fabric as the baffle material.

The use of shade cloth (width of around 2.2 m) will allow the formation of a deeper inlet chamber, thus potentially reducing the frequency of de-silting operations.

Inflow pipes should ideally have an invert well above the floor of the inlet chamber to avoid sedimentation within the pipe.

Step 10: Design the primary outlet system

Historically, sediment basins were described as either 'dry' or 'wet' basins. This classification system can be seen as confusing because it refers only to the existence of an automatic draining system, and not to the option to retain water within the basin after storms so that the water can be used for on-site purposes. The traditional definition of wet and dry basins is provided below.

- Dry basins are free draining basins that fully de-water the settling zone after each storm. These usually include Type A and C basins.
- Wet basins are not free draining, but are designed to retain the stormwater runoff for extended periods in order to provide the basin with sufficient time for the gravitational settlement of fine sediment particles. These basins can include Type A, Type B, and Type D basins. Type A basins are included because the automatic decant system can be shut down if the basin's discharge fails to meet the pre-determined water quality objectives.

Type A basins require a floating low-flow decant system as described below.

Type B basins may not require a formal decant system, other than that required to de-water the basin prior to the next storm, or to extract the water for usage on the site.

Type C basins require a free-draining outlet system in the form of either a riser pipe outlet, or floating decant system. Gabion wall, *Rock Filter Dam*, and *Sediment Weir* outlet systems are **not** recommended unless a Type 2 sediment retention system has been specified.

Type D basins usually require a pumped discharge system similar to Type B basins. If a piped outlet exists, then a flow control valve must be fitted to the outlet pipe to control the discharge.

(i) Floating decant system for Type A basins

Floating siphon outlet systems are designed to self-prime when the basin's water exceeds a predetermined elevation. These systems decant the basin by siphoning water from the top of the pond, thus always extracting the cleanest water. This also extends the settlement period by commencing decant procedures only when the pond level reaches the predetermined elevation.

Self-priming skimmer pipes are difficult to design and optimise. The Auckland-type, floating decant systems is depicted in Figure 19. This outlet system achieve 4.5 L/s per decant arm. Each decant arm has six rows of 10 mm diameter holes drilled at 60 mm spacings (totalling 200 holes) along the 2 m width of the decant arm.

If larger flow rates are required, multiple decants structures are to be installed. Flow rates can be controlled through the sizing and number of holes in the decant, or by using an orifice plate based on appropriate hydraulic calculations.

For small catchments, a single decant may be sufficient to achieve the required outflow rate. A single decant arm can connect directly into a pipe through the sediment basin wall negating the need for a manhole. Proprietary skimming systems are available and can be used as long as they adhere to the design intent, and will not draw up floc particles due to concentrated flow.

(ii) Perforated riser pipe outlets (Type C basins)

Key components of a perforated riser pipe outlet are listed below:

- Anti-flotation mass = 110% of the displaced water mass.
- Combined trash rack and anti-vortex screen placed on top of open riser pipe.
- Minimum outlet pipe size of 250 mm.
- Anti-seep collars (minimum of 1) placed on the buried outlet pipe.
- Designed to drain the basin's full settling zone volume in not less than 24 hours (to allow adequate settlement time).

Other types of outlet systems are described in Appendix B of Book 2 (IECA, 2008).

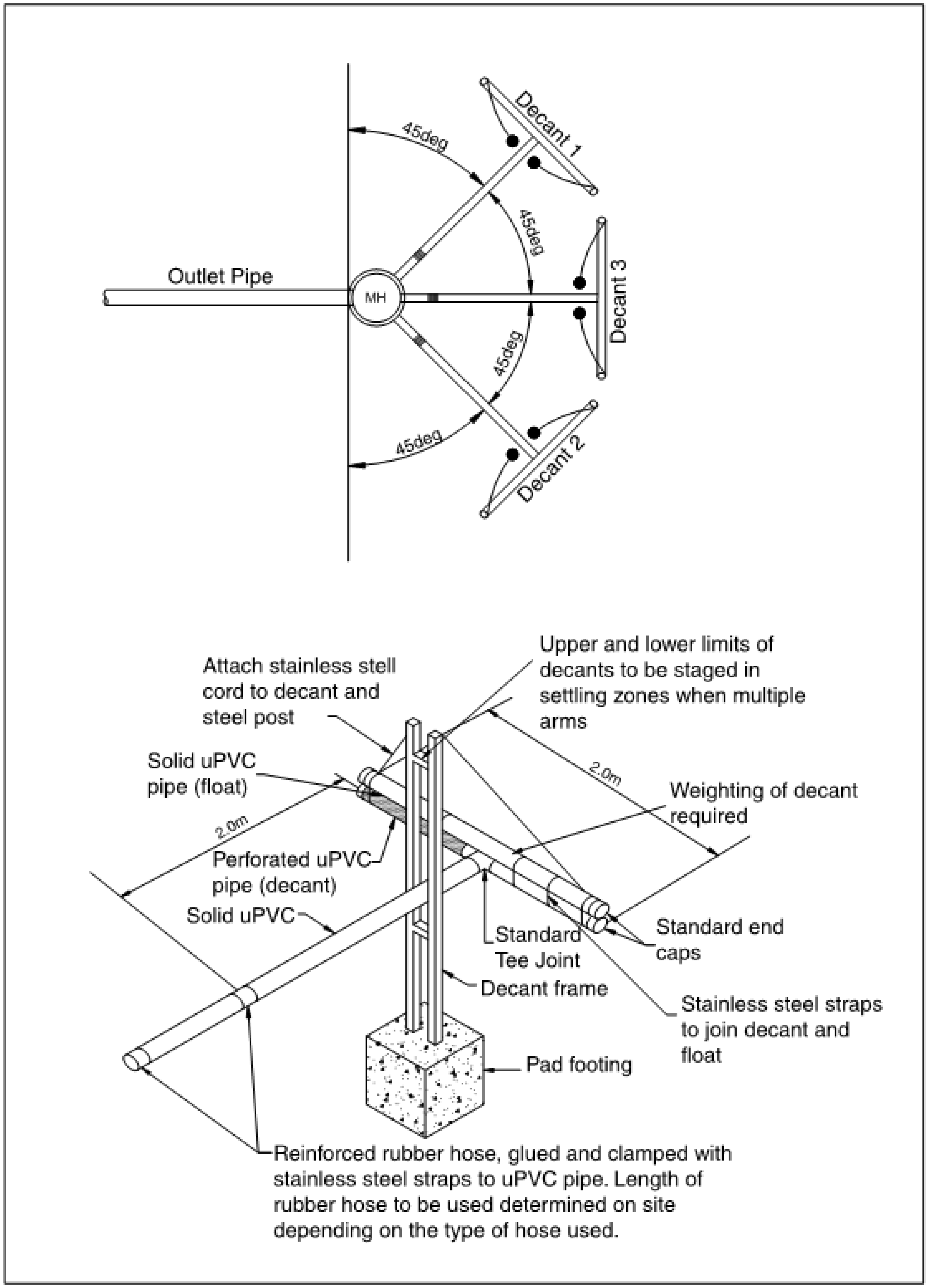


Figure 19 – Auckland-type floating decant system for Type A basins

Photo 3 – Type A decant at low water level

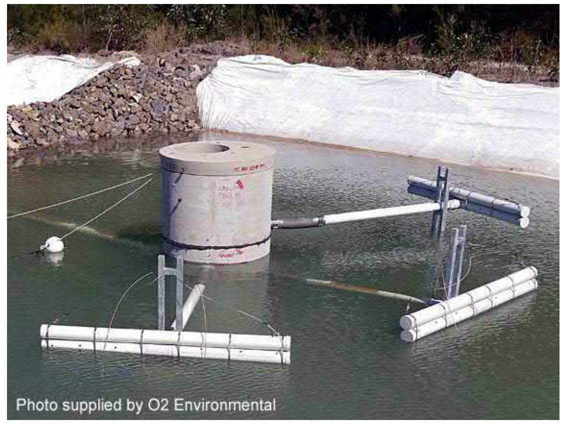


Photo 4 – Floating arm decant system

Photo 5 – Riser pipes under construction

Photo 6 – Riser pipe with aggregate filter

Photo 7 – Skimmer outlet system

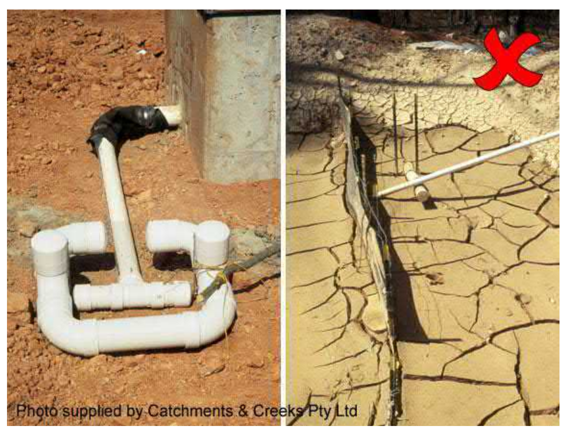


Photo 8 – Skimmer pipes must be protected from sediment build-up

Photo 9 – Sand filter outlet

Photo 10 – Sand filter outlet

Step 11: Design the emergency spillway

The minimum design storm for sizing the emergency spillway is defined in Table 23.

Table 23 – Recommended design standard for emergency spillways [1]

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)

[1] Alternative design requirements may apply to Referable Dams in accordance with state legislation, or as recommended by the Dam Safety Committee (ANCOLD).

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

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

Recommended freeboard down the spillway chute is 300 mm.

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 23 is at least:

- 300 mm below a basin embankment formed from fill
- 150 mm plus expected wave height for large basins with significant fetch length (note; significant wind-generated waves can form on the surface of large basins).

The approach channel can be curved upstream of the spillway crest, but must be straight from the crest to the energy dissipater. 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.

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

Anticipated wave heights may be determined from the procedures presented in the *Shore Protection Manual* (Department of the Army, 1984).

The hydraulic design of sediment basin spillways is outlined in Section A5.4 of Appendix A – *Construction Site Hydrology and Hydraulics* (IECA, 2008).

The downstream face of the spillway chute may be protected with 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.

Care needs to be taken to ensure that flow passing through voids of the crest of a rock or rock mattress spillway does not significantly reduce the basin's peak water level, or cause water to discharge down the spillway before reaching the nominated spillway crest elevation.

Unlike permanent stormwater treatment ponds and wetlands, construction site sediment basins are not designed to allow high flows to bypass the basin. Even if the basin is hydraulically full, sediment-laden stormwater runoff should continue to be directed through the basin. This allows the continued settlement of coarse-grained particles contained in the flow. Thus a side-flow channel does not need to be constructed to bypass high flow directly to the spillway.

Photo 11 – Emergency spillway located within the fill embankment

Photo 12 – 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 14) can be used to control excess seepage flows.

Photo 13 – Fully recessed basin with natural ground forming the spillway

Photo 14 – 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 16 shows a spillway crest with inadequate depth or flow profile.

Photo 15 – Spillway rock protection sits above the embankment height

Photo 16 – Spillway crest with inadequate depth or profile

Spillway design features

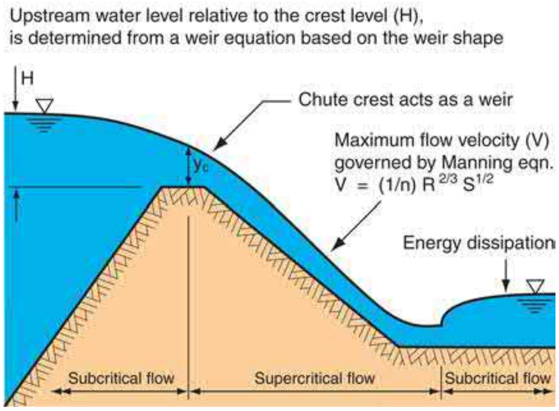


Figure 20 – Basin spillway hydraulics

Hydraulic design

- Basin spillways are hydraulic structures that need to be designed for a specified design storm using standard hydraulic equations.
- The hydraulic design can be broken down into three components:
  - design of the spillway inlet using an appropriate weir equation
  - sizing rock for the face of the spillway based on Manning's equation velocity
  - sizing rock for the spillway outlet.

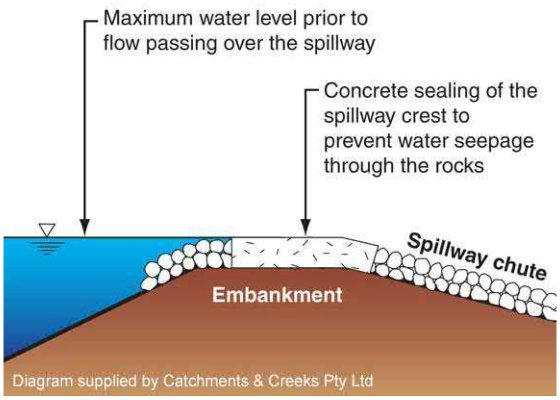


Figure 21 – Sealing of spillway crest

Design of spillway crest

- Flow conditions at the spillway crest may be determined using an appropriate weir equation.
- It is important to ensure that the maximum potential water level within the dam at peak discharge will be fully contained by the basin's embankments.
- The sealing of the spillway crest is necessary to maximise basin storage and prevent leakage through the rock voids.

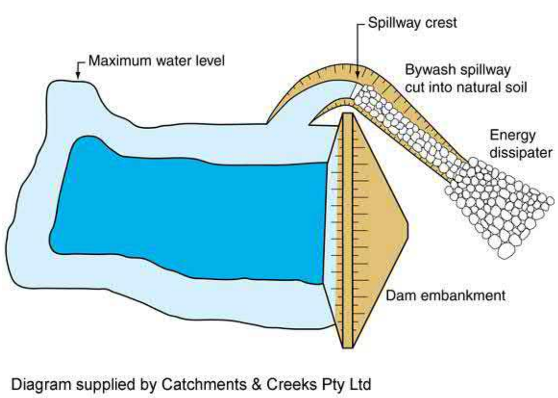


Figure 22 – Spillway cut into virgin soil

Design of spillway chute

- Determination of rock size on the spillway is based on either the maximum unit flow rate (q) or the maximum flow velocity (v) down the spillway.
- The upstream segment of the spillway's inflow channel can be curved (i.e. that section upstream of the spillway crest).
- Once the spillway descends down the embankment (i.e. where the flow is supercritical) the spillway **must** be straight.

Photo 17 – Energy dissipation pond

Design of energy dissipater

- A suitable energy dissipater or outlet structure is required at the base of the spillway.
- The design of the energy dissipater **must** be assessed on a case-by-case basis.
- It may or may not always be appropriate to use the standard rock sizing design charts presented elsewhere in this document.
- The photo (left) shows a 'wet' dissipation pond, which is not typical for construction sites.

Step 12: Determine the overall dimensions of the basin

If a Sediment basin is constructed with side slopes of say 1:3 (V:H), then a typical basin may be 5 to 10 m longer and wider than the length and width of the settling pond determined in Step 6. It is important to ensure the overall dimensions of the basin can fit into the available space.

The minimum recommended embankment crest width is 2.5 m, 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 appropriately higher standard to compensate. If the basin's settling pond surface area/volume is less than that required in Step 6, than the basin must be considered 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 1:6 (ideally 1:10, V:H) 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 basin.

If a coagulant or flocculant has been used in the treatment of runoff within the basin, guidance should be sought from the chemical supplier on the requirements for sludge removal or placement to ensure that any residual chemical bound to soil particles is managed appropriately and in accordance with the regulating authority requirements.

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 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 18 – Sediment basin with poor access for de-silting operations

Photo 19 – Temporary fencing of a construction site sediment basin

Step 16: Define the rehabilitation process 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, bio-retention 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.

Detention/retention basins and wetlands can operate as pollution containment systems by modifying the outlet structure such that emergency services (e.g. EPA or fire brigade) can manually shut-off the outlet (usually with stop boards or sandbags) thus containing any pollutants within the basin.

Sediment basins that are to be retained or transformed into part of the permanent stormwater treatment system, may be required to pass through a staged rehabilitation process. In those circumstances where it is necessary to temporarily protect newly constructed permanent stormwater treatment devices (such as bio-retention systems and wetlands) from sediment intrusion, there are a number of options as outlined in Appendix B of Book 2.

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 as discussed in Step 9. The pre-treatment pond can remain as a coarse sediment trap during the maintenance and building phases, thus protecting the newly formed wetland or bio-retention 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. Ultimately, the responsibility for the achievement of specified (operational phase) water quality objectives rests with the current land owner or asset manager.

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 20 – Permanent sediment basin within residential estate

Photo 21 – Sediment basins converted to permanent stormwater treatment ponds on highway project

Step 17: Define the basin's operational procedures

The following discussion provides guidance on the preparation of the basin's *Operational Procedures,* which instruct the basin operator how to review the basin's performance, and how to take appropriate actions to improve the basin's performance.

(i) Preparing the 'operating procedures' for basins

The operator of a sediment basin must be provided with a set of recommended *Operating Procedures* for that basin that have been prepared, or at least endorsed by, the designer of the basin. These operating instructions must include, as a minimum, the following information:

- decant water quality objectives
- description of proposed chemical treatment of the basin, including minimum Jar Testing performance requirements
- performance assessment procedures
- guidance on corrective measures based on water quality monitoring outcomes
- description of de-watering 'triggers', including triggers for the temporary shut-off of the decant system in the event of poor water quality (applicable to Type A basins)
- description of de-silting 'triggers'
- description of those circumstances and/or weather conditions that would trigger the de-watering of the basin prior to an imminent storm
- For Type C basins: description of the 'triggers' for the chemical treatment of Type C basins (or the conversion of Type C basins to a Type B or Type D operation).

Table 24 provides an overview of the typical operational conditions of the various basins.

Table 24 – Typical operational conditions of various *Sediment Basins*

<table>
<tr><th>Attribute</th><th>Type A</th><th>Type B</th><th>Type C</th><th>Type D</th></tr>
<tr><td>Desirable basin water level before a storm</td><td>Fully drained settling zone</td><td>Fully drained settling zone</td><td>Ideally fully drained, but may retain water</td><td>Fully drained</td></tr>
<tr><td>Allowable inter-storm basin water level during specific seasonal or weather conditions</td><td>May retain water between storms, but must be de-watered prior to any storm that is likely to produce runoff</td><td colspan="2">May retain water between storms, but under certain conditions, must be de-watered prior to an imminent storm. These 'conditions' may include a specified wet season, or when weather forecasting predicts a significant storm event.</td><td>May retain water between storms, but must be de-watered prior to any storm that is likely to produce runoff</td></tr>
<tr><td>De-watering system</td><td>Floating</td><td>N/A</td><td>Free-draining</td><td>Pump, siphon or floating decant</td></tr>
<tr><td>Chemical treatment</td><td>Automatic</td><td>Automatic</td><td>None</td><td>Automatic or manual dosing</td></tr>
</table>

(ii) Water quality objectives

Prior to the discharge of water from a sediment basin, it is essential for the water quality to comply with all specified water quality objectives (e.g. water pH, suspended sediment and/or turbidity). In the absence of state guidelines, the recommended water quality standard for waters released from sediment basins is presented in Table 25.

Table 25 – Recommended discharge standard for de-watering operations

Site conditions	Long-term discharge water quality standard
Default discharge water quality objective for Type A and Type B sediment basins	90 percentile total suspended solids (TSS) concentration not exceeding 50 mg/L.
Desired discharge water quality of free draining sediment basins (e.g. free draining Type C basins)	Take all reasonable and practicable measures to operate and/or modify the basin to achieve a 90 percentile total suspended solids concentration not exceeding 50 mg/L.
Post-storm de-watering of sediment basins (all basin types)	90 percentile total suspended solids (TSS) concentration not exceeding 50 mg/L.
All basins, all circumstances	Water pH in the range 6.5 to 8.5

Whenever possible, water samples collected from the sediment basin must be tested in a laboratory before discharge to prove that the suspended solid content is below recommended level. It is strongly recommended that sufficient water testing is conducted in order to enable a site-specific calibration between suspended solids concentrations (mg/L) and NTU turbidity readings. This would allow utilisation of the turbidity meters to determine when water quality is likely to have reached the equivalent of 50 mg/L.

In order to develop a site-specific relationship between suspended solids concentrations (mg/L) and NTU, there should be an absolute minimum number of five water samples (ideally 9+), all in the range of 20 – 150 mg/L. If the samples have a wider range of suspended sediments, such as 10 – 2000 mg/L, then the resulting relationship will be less reliable.

Table 26 is presented as an alternative NTU-based water quality standard for sediment basins.

Table 26 – Alternative discharge standard for de-watering operations

Site conditions	Long-term discharge water quality standard
Default discharge water quality objective for Type A and Type B sediment basins	90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 100, and 50 percentile NTU reading not exceeding 60.
Desired discharge water quality of free draining sediment basins (e.g. free draining Type C basins)	Take all reasonable and practicable measures to operate and/or modify the basin to achieve a 90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 100, and 50 percentile NTU reading not exceeding 60.
Post-storm de-watering of sediment basins (all basin types)	90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 100, and 50 percentile NTU reading not exceeding 60.
All basins, all circumstances	Water pH in the range 6.5 to 8.5

If the basin's operation is managed through the use of a specified or determined NTU reading, then water samples must still be taken daily during de-watering operations to determine the total suspended solids (TSS) concentration. Both the TSS and NTU values must be recorded and reported as appropriate.

(iii) Use of coagulants and flocculants

The appropriate chemical treatment of a sediment basin is required if the potential release water does not satisfy the specified water quality objectives. A discussion on use of coagulants and flocculants is provided in the following section.

(iv) De-watering procedures

Unless specific allowed by the regulating authority, Type A and Type D basins must be fully drained after each storm event to provide the necessary storage volume for subsequent storms (refer to Table 24). Authorities may stipulate a period of the year (typically the dry season) when Type A basins can retain water after storm events for the purpose of on-site usage; however, these basins must be drained prior to any storm that is likely to produce significant (i.e. measurable) basin inflows.

In the case of a Type A basin, the term 'fully drained' means the basin has drained to the bottom rest position of the floating decent system.

Technical Note 1: Recommended operational procedure for the retention of water within Type A basins

If inflow to the basin has ceased, or the potential for basin overtopping is insignificant' the valve on the outlet pipe can be closed to hold runoff in the basin

If, prior to further rainfall, the water level has not been lowered to the bottom of the settling zone, the valve should be opened, provided that the water quality is within the discharge limits. This process should occur well in advance of rainfall occurring, as de-watering will take some time.

An alternative method is to raise the lower decant arms prior to a rainfall event occurring to ensure runoff is captured in the basin. This process should only occur if it is reasonable to expect that the basin capacity will not to be exceeded in the forecast rainfall event (i.e. forecast rainfall has a 90% chance of being less than 50% of the basin's available capacity).

Theoretically, Type B and Type C basins may be full, or partially-full, immediately prior to a storm, but it is still desirable for these basins to be fully drained prior to accepting further inflows in order to optimise the basin's overall performance.

Technical Note 2: Recommended operational procedure for the retention of water within Type B basins

The basin shall be fully de-watered if the forecast rainfall has a 90% chance of being less than 50% of the basin's available capacity.

If the long-term operation of Type C basins within a given region identifies the presence of fast and efficient settling sediments, and good water quality outcomes, then the low-flow drainage system can be ignored/decommissioned, and the basins can be operated as a 'wet ponds'.

Even if soil conditions satisfy the initial selection of a Type C basin, this does not guarantee that the water quality achieved by the basin will satisfy the required environmental objectives. If a Type C basin fails to regularly achieve the required water quality objectives, then the basin may need to be converted to, or operated as, a Type B or Type D basin in order to satisfy specified water quality objectives.

The operation of Type D basins is similar to Type A basins. In ideal circumstances, the treated water can be retained within these basins for use on site, but the basins must be drained prior to any storm that is likely to produce significant (i.e. measurable) basin inflows.

(v) De-silting procedures

An appropriately marked (e.g. painted) de-silting marker post must be installed in the basin to indicate the top of the sediment storage zone. The basin must be de-silted if the next storm is likely to cause the settled sediment to rise above this marker point, or if the settled sediment is already above this marker point.

Table 27 provides the recommended de-silting trigger points for sediment basins.

Table 27 – Recommended basin de-silting trigger points

Basin type	De-silting triggers
All basin types	• If the next storm is likely to cause the settled sediment to rise above the nominated marker point. • The settled sediment has exceeded 90% of the nominated sediment storage volume.
Type A basins	• As above for all basins. • The top of the settled sediment is less than 300 mm below the bottom rest position of the floating decant arms. *This means the basin should be de-silted before the settled sediment reaches the critical elevation of 200 mm below the decant arms (i.e. the theoretical top of the sediment storage zone).*

(vi) Performance assessment procedures

A performance review of should be carried out on all basins that utilise chemical treatment. For Type A and B basins, a performance report should be completed after each storm event that results in discharge from the basin. A template for a *Basin Performance Report* is provided in this section. This template has been prepared for Type A basins, but can be adapted to other types of sediment basins.

Although it is desirable for sediment basins to achieve the desired water quality standard during every storm, circumstances can exist that will cause uncontrolled discharges to exceed these standards. Due to the inherent complexity and variability of rainfall events, and variations in the performance of flocculants, it is possible for discharges above, say 50 mg/L, to occur. This of course does not necessarily make such discharges either lawful or unlawful. The resulting legal issues are complex and will likely vary from site to site.

Sediment basins are not designed to achieve a specific water quality; rather, they are designed to either capture and treat a specific volume of runoff, or to treat discharges up to a specified peak flow. A specific water quality cannot be guaranteed solely through the ‘sizing’ of the basin, but must be achieved in association with site-specific water quality management practices, such as those discussed above (Step 17). Sediment basins cannot perform in an appropriate manner without the attentive input from suitably trained site personnel.

Irrespective of the circumstances, the operator should regularly inspect the critical design features of the basin, and should review the basin’s performance against its design expectations. If a water quality failure is observed, then the operator should endeavour to take multiple samples during these releases to document the duration of such exceedances. Adjustments to the basin, and the basin’s operation, should occur after each observed failure. The use of such adaptive management practices is critical to achieving the optimum performance of any sediment basin.

Being able to demonstrate that adaptive management practices are being implemented at the site is an important consideration noted by regulators when determining whether all things reasonable and practicable are being done to minimise sediment releases.

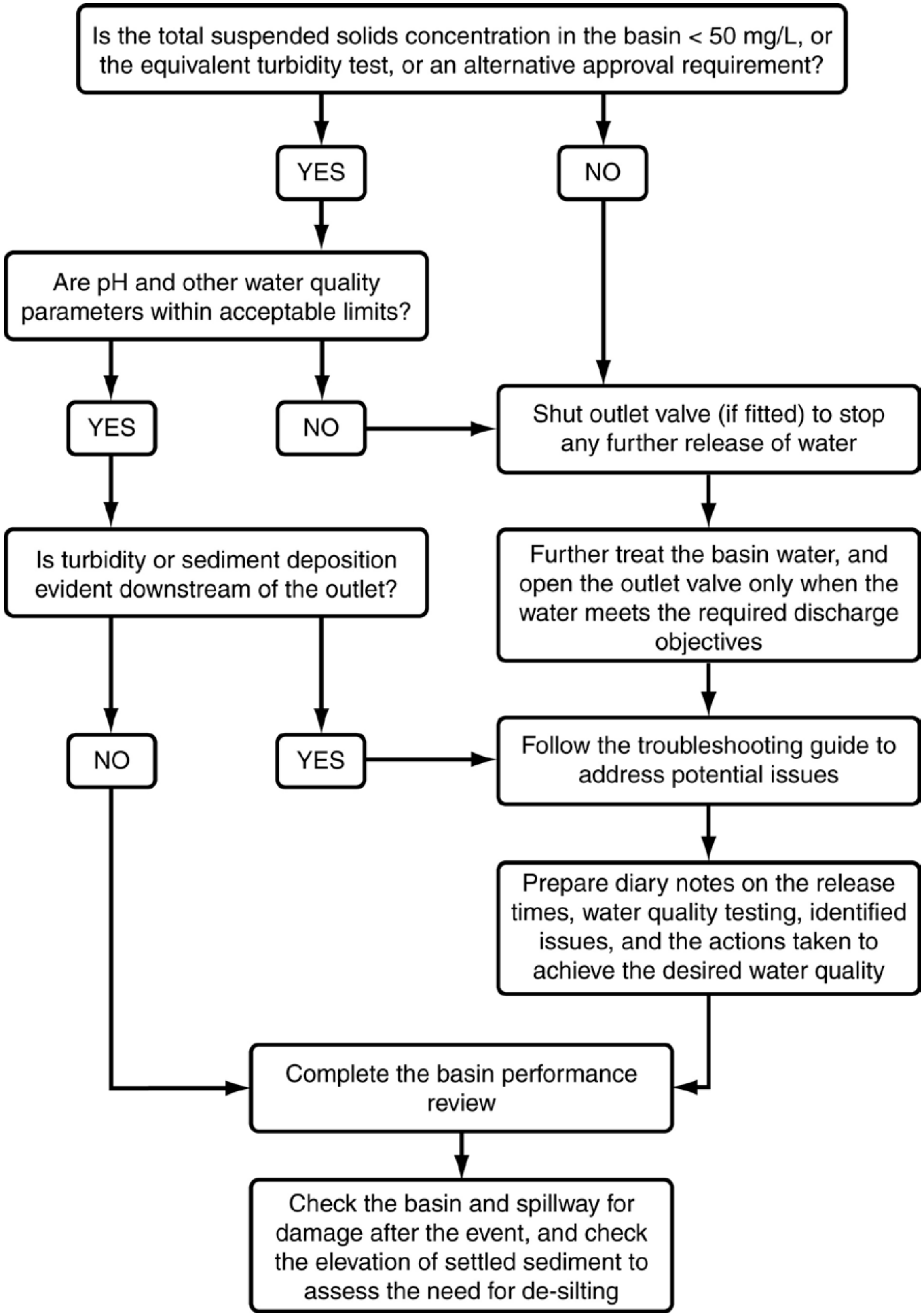


Figure 23 – Basin performance assessment process

Coagulants and flocculants

The following is a brief discussion on the use of coagulants and flocculants to enhance the settling characteristics of sediment-laden water. Readers should refer to the associated Book 4 design fact sheet – *Chemical coagulants and flocculants* for the latest technical information on the testing, selection and use of these products.

(i) Coagulation

A coagulant is utilised to neutralise or destabilise the charge on clay or colloidal particles. Most clay particles in water are negatively charged and therefore any positive ion (cation) can be used as a coagulant.

Charge neutralisation in water can occur very rapidly; therefore, mixing is important for effective treatment of turbid water. After a short time, the ions form hydroxide gels which trap particles, or bridge between particles creating a floc that may settle.

There is always the possibility of overdosing with coagulants and building up excess positive charge, hence complying within the optimum dosage range is critical. When a cationic coagulant is overdosed, the clay and colloidal particles will take on a positive charge and repel each other and limit any settling. The dosage range of a coagulant will vary depending on site water chemistry. Different coagulants also have an optimum pH range over which they are effective and pH buffering may be required depending on the coagulant and water chemistry.

The flocs generated by coagulation are generally small and compact. They can also be broken down under high velocity or high shear conditions.

(ii) Flocculation

Flocculation is a process of contact and adhesion whereby the particles of a dispersion form larger-size clusters. Flocculation can occur through the use of a coagulant, flocculant, or both. Coagulants achieve flocculation through charge neutralisation where as flocculants physically bind clay and colloidal particles together.

The use of natural and synthetic polymeric flocculants can be used to generate larger more stable flocs and may reduce treatment times. This is achieved by bringing dispersed particles together increasing the effective particle size. Flocculants can be used alone, or in combination with coagulants.

(iii) Ecotoxicity

The by-products of coagulants and flocculants can, in certain circumstances, become toxic to aquatic life. A high or low water pH is often the trigger for the release of these materials in a toxic form.

It is generally accepted that dissolved aluminium at a concentration between 0.050 and 0.100 mg/L and a pH between 6.5 and 8.0 presents little threat of toxicity. However, at lower pH, the toxicity increases with an effect of possible major concern being the coagulation of mucus on the gills of fish.

There is limited published data on the aquatic ecotoxicity of calcium based coagulants such as calcium sulphate and calcium chloride.

Designers of chemical treatment systems must always seek the latest advice on the potential impacts of coagulants and flocculants on receiving waters, and must have an adequate understanding of the types of receiving water associated with any sediment basin design.

Ecotoxicity information has been adopted from the Auckland Regional Council TP226 and TP227 documents.

Chemical specific ecotoxicity information should be sought from chemical suppliers in accordance with the regulating authority's requirements.

(iv) Jar testing

The purpose of jar testing is to select appropriate coagulants and/or flocculants along with determining their optimum dose rates. The recommended testing procedure is described below.

Jar tests are conducted on a four or six-place gang stirrer. Jars (beakers) with different treatment programs or the same product at different dosages are run side-by-side, and the results compared to an untreated beaker. Where access to a laboratory is not practicable field tests can be undertaken following a similar process to that described in the procedure with stirring and settling timeframes in multiple beakers. Testing should be undertaken by a suitably qualified person in the use of coagulants and flocculants.

Preference is given to the use of raw water collected on site which is representative of runoff (including water temperature, which affect settlement characteristics) during the life cycle of the sediment basin. Where raw water is not available representative soil from the site is to be mixed with water to create indicative runoff water chemistry. To create a water sample from soil, a recommended procedure is provided below.

Soil / water solution procedure:

Step 1. Obtain a soil sample from representative soils to be exposed during the life cycle of the sediment basin. Where multiple soil types are likely to be encountered within the life cycle of the basin, jar tests should be undertaken for the range of soil types.

Step 2. Crush the soil (if dry) and shake through a 2 mm sieve to remove any coarse material.

Step 3. Place approximately 100 grams of soil into 10 litres of water. Ensure the water has the same temperature as the expected water temperature within the sediment basin during the settling phase.

Step 4. Stir rapidly until soil particles are suspended.

Step 5. Leave solution for 10 minutes.

Step 6. Stir rapidly to resuspend any settled material.

Step 7. Decant into beakers for jar testing.

Jar testing procedure:

Step 1. Fill the appropriate number of (matched) 1000 mL transparent beakers with well-mixed test water, using a 1000 mL graduate. Record starting pH, temperature and turbidity.

Step 2. Place the filled beakers on the gang stirrer, with the paddles positioned identically in each beaker.

Step 3. Mix the beakers at 40–50 rpm for 30 seconds. Discontinue mixing until coagulant or flocculant addition is completed.

Step 4. Leave the first beaker as a control, and add increasing dosages of the first coagulant/flocculant to subsequent beakers. Inject coagulant/ flocculant solutions as quickly as possible, below the liquid level and about halfway between the stirrer shaft and beaker wall.

Step 5. Increase the mixing speed to 100–125 rpm for 15–30 seconds (rapid mix).

Step 6. Reduce the mixing to 40 rpm and continue the slow mix for up to 5 minutes.

Step 7. Turn the mixer off and allow settling to occur.

Step 8. After settling for a period of time, note clarity and record on *Floc Performance Report*. Record pH and turbidity.

Step 9. Remove the jars from the gang stirrer, empty the contents and thoroughly clean the beakers.

Step 10. Repeat the procedure as required for different chemicals, dose rates or soil/water mixtures.

Floc Performance Report

BASIN IDENTIFICATION CODE/NUMBER: . . . .

SITE / PROJECT: . . . .

PREPARED BY: . . . . **DATE:** . . . .

Chemical name:	**Soil description:**					
Dose rate:	0.00 Control					
Starting pH						
Starting turbidity						
Clarity[1] after 5 mins (mm)						
Clarity[1] after 15 mins (mm)						
Clarity[1] after 30 mins (mm)						
Clarity[1] after 60 mins (mm)						
Final pH						
Final turbidity						

Chemical name:	**Soil description:**					
Dose rate:	0.00 Control					
Starting pH						
Starting turbidity						
Clarity[1] after 5 mins (mm)						
Clarity[1] after 15 mins (mm)						
Clarity[1] after 30 mins (mm)						
Clarity[1] after 60 mins (mm)						
Final pH						
Final turbidity						

Note:

[1] For the purposes of a floc report, 'clarity' is defined as a level of turbidity. Clarity can be estimated visually or with the use of a turbidity meter.

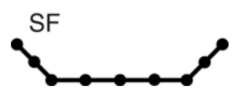
Sediment Fence

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 

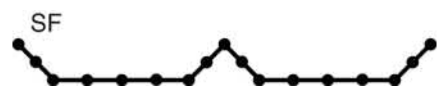
or 

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.

Maximum **horizontal** slope length (m) = $100/(\text{batter slope }(\%))^{0.64}$ (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.

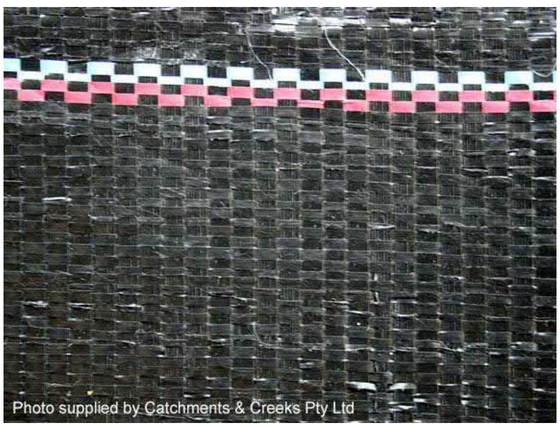


Photo 3 – Traditional woven sediment fence fabric

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).

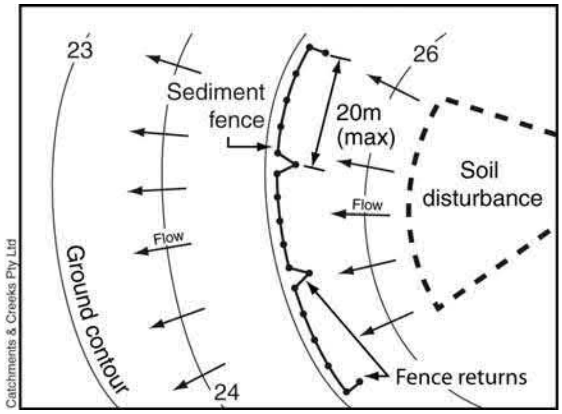


Figure 1 – Fence installed along the contour

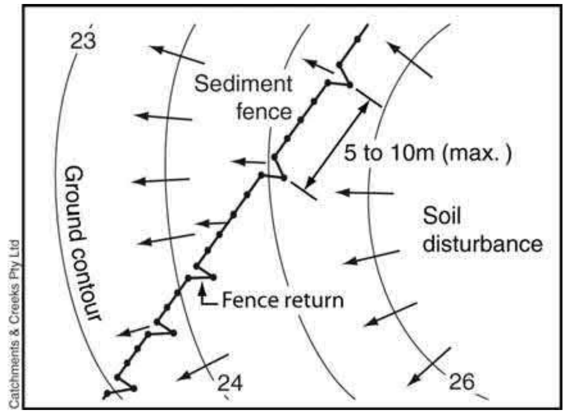


Figure 2 – Fence install down a slope

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.

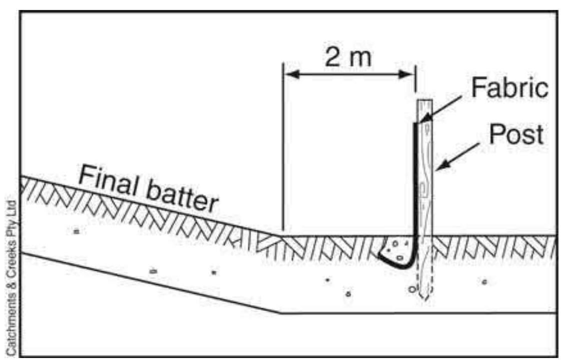


Figure 3 – Fence installation at base of slope

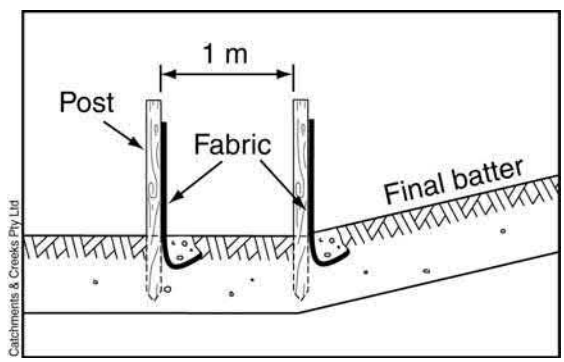


Figure 4 – Double sediment fence installed at the based of a fill slope

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.

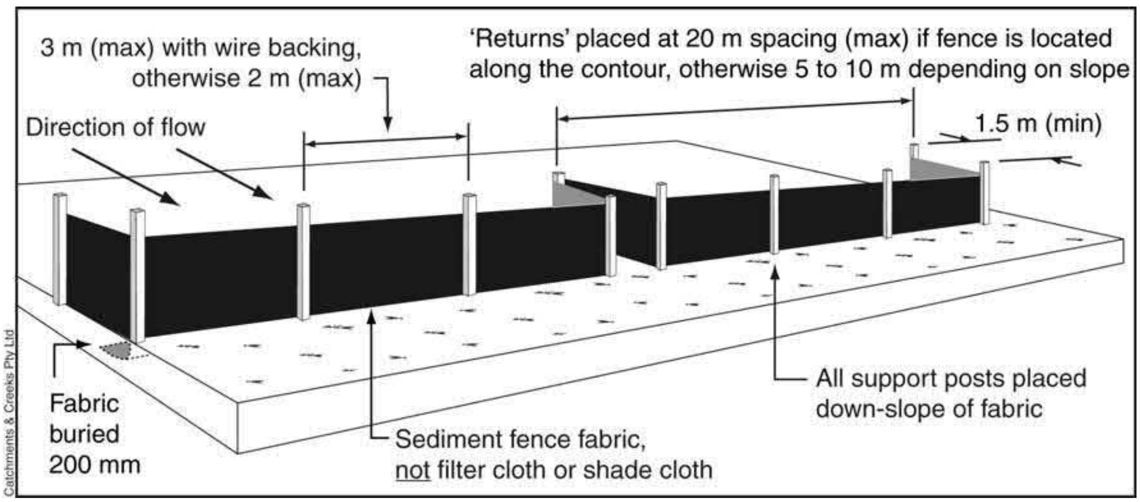


Figure 5 – Typical installation of a sediment fence

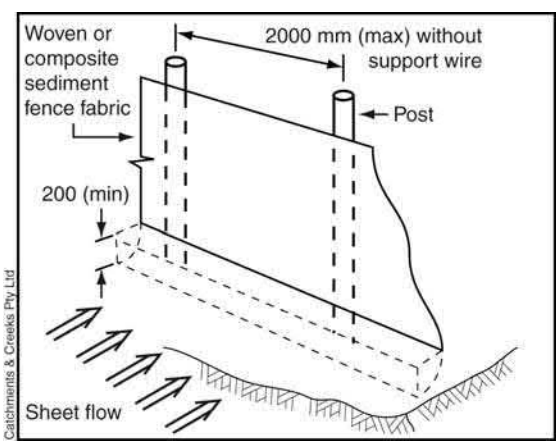


Figure 6 – Installation of a sediment fence without wire backing

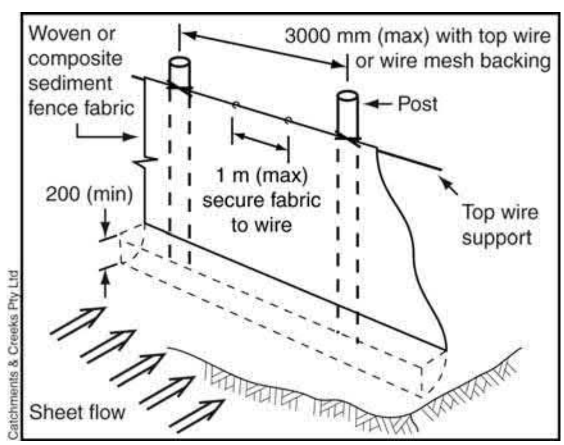


Figure 7 – Installation of a sediment fence with top wire support

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).